**Republic of Yemen**

# Sana'a Basin Integrated Water Resources Management

Action Oriented Policy Paper

Assessment of Phase I
(*supported under the Sana'a Basin Water Management Project and from other sources*)
and suggestions for Phase II

June 30th, 2010

**Acronyms**

| | |
|---|---|
| AOP | Annual Operating Plan (WSSP) |
| AOPP | Action Oriented Policy Paper |
| EPA | Environmental Protection Agency |
| ET | Evapotranspiration |
| GARWSP | General Authority for Rural Water Supply Projects |
| GSCP | Groundwater and Soil Conservation Project |
| GTZ | German technical cooperation |
| IWRM | Integrated water resource management |
| JICA | Japanese aid |
| LC | Local Corporation (for water supply and sanitation) |
| M&E | Monitoring and evaluation |
| MAI | Ministry of Agriculture and Irrigation |
| MWE | Ministry of Water and Environment |
| NIP | National Irrigation Program |
| NWRA-SB | NWRA Sana'a Branch |
| PAD | Project Appraisal Document (World Bank) |
| PIU | Project Implementation Unit |
| SBWMP | Sana'a Basin Water Management Project |
| SFD | Social Fund for Development |
| WEC | Water and Environment Centre (Sana'a University) |
| WUA | Water User Association |
| WUG | Water User Group |
| WSSP | Water Sector Support Program |

**Sana'a Basin Integrated Water Resources Management**
**Action Oriented Policy Paper**

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## Summary

### 1. Background

In 2003, Yemen committed itself to a long term process of integrated water resources management in the Sana'a Basin, where critical water problems were pressing. A fifteen year time horizon was selected, and divided into three five year phases. The first phase, designed to test technologies, demand and supply management approaches, and institutional arrangements, is ending in 2010. This *Action Oriented Policy Paper* (AOPP) evaluates achievements and the challenges at the threshold of the second phase.

### 2. Governance

Legal framework for basin management. Yemen has passed a water law that provides a sound legal framework for basin management. However, the law is being only partially implemented. The by-laws need to be issued, and the provisions of the protection zone should be adapted to the varying characteristics of the different sub-basins.

The Sana'a Basin Committee. To date, the Basin Committee has not been empowered and has been largely ineffectual. To make the Committee more effective, membership could be made more inclusive of key stakeholders, and the Committee's mandate could be strengthened to cover allocation of both water and financial resources.

The Basin Committee could then become the supreme water governance authority in the basin, in tandem with local councils as the second line of authority, and WUAs as the front line resource managers, with NWRA-SB strengthened as adviser and secretariat.

Local councils. Local councils have only very partially fulfilled their statutory role of 'managing and controlling water resources in their area'. The role of local councils as second in line water resource managers - between the Basin Committee and the WUAs – needs to be more clearly defined, and their capacity strengthened.

Water user associations (WUAs). WUAs have developed well in the basin and have the potential for a sustainable role as front line water managers, in partnership with local councils and the Basin Committee. Institutional arrangements for consistent capacity building and empowerment need to be put in place. Nationwide, experience on WUAs needs to be pooled and the pathway to self-sustaining status needs to be traced out.

NWRA Sana'a Basin Branch. Despite a fairly large staff and some support under SBWMP, NWRA-SB is struggling to fulfil its current limited mandate in regulation and monitoring. Careful planning and strong management will be necessary as a larger IWRM mandate is confided to the branch.

An improved governance architecture for the Sana'a basin. If the improvements mentioned are implemented, an integrated governance structure would be in place that

would decentralize water resource management responsibility to the lowest accountable levels, in line with best IWRM practice (see box).

**Suggested improvements to the governance architecture**

- To make the Water Law operational
- To delegate responsibility for water management to a trio of inter-related institutions: the Basin Committee to be the supreme water governance authority in the basin, in tandem with local councils as the second line of authority, and WUAs as the front line resource managers.
- To make the Basin Committee more inclusive, especially of representative user associations, and to empower it for both financial and water resource allocation
- To activate the local council role in water regulation
- To empower WUAs as front line water managers
- To adopt the sub-basin as the primary unit of water management, and to move towards institutional groupings at the sub-basin or district level that can adopt and implement water management strategies
- To greatly strengthen NWRA-SB to fulfil its role as planner and adviser, in partnership with other stakeholders and institutions

## 3. Water Resources Management

Quantification and trends in water resources. The water resources assessment conducted under the first phase has made available the basic data for practical planning at the sub-basin level. The assessment shows that, although all sub-basins are deficit, some have the potential to be returned to sustainability with careful strategic management.

Monitoring. Despite considerable investment, monitoring is almost at a standstill. Radical strengthening of capability is essential, and partnerships to collect and share data need to be developed.

Regulation. Regulation of random drilling and drilling rigs has not slowed down the proliferation of illegal wells. Approaches that rely on a well-spacing rule of thumb and on community responsibility for regulating within their own area would be simpler and would place less burden on NWRA.

Formation of a professional drillers' association could help promote self-regulation. NWRA-SB could also focus on controlling the half dozen deep drilling rigs that could compromise the deep sandstone aquifer.

Towards integrated planning and management. Clear objectives need to be set for overall basin management, and reflected in detailed plans developed in a participatory way at the sub-basin level, working with stakeholders through the three part governance structure (Basin Committee – local councils – WUAs). A small but powerful basin planning unit needs to be set up in NWRA-SB to propose plans and to coordinate their implementation.

## 4. Supply Management

Recharge structures. Investment in recharge structures has only recently been completed, and a further monitoring period is needed before investing further. At first

sight, the progressive construction of a series of check dams starting from the upstream looks a better choice than reservoir dams.

Treated wastewater. Proper management of wastewater requires careful training and regulation of farmers. Safe reuse of effluent from the proposed new treatment plant should be built in from the outset.

Other potential sources. A rapid economic review of rooftop rainwater harvesting is suggested.

**5. Demand management**

Irrigation improvement. According to a SBWMP survey, improved irrigation allows farmers to use 40% less water whilst increasing incomes by 10%. Clearly, irrigation improvement is the most important conservation investment and it needs to be factored in to sub-basin plans – but only where economically justified. As responsibility for irrigation improvement in the basin is transferred to NIP, care will be required to preserve the integrated approach of water resources management coupled with irrigation improvement and extension.

Meeting urban water demand. The priority Yemen gives to drinking water requires that: (1) planning and regulation must be used to reserve the deep Tawilah Sandstone for domestic supply; and (2) the Local Corporation, private providers and GARWSP have to work together to ensure affordable and sustainable network water for the whole population of the basin.

**6. Moving to Phase II**

Budgeting and financing issues. A basin-level bottom up planning process is proposed for allocating WSSP resources each year. An urgent priority is therefore to establish an integrated programming mechanism for the Sana'a basin and to submit a coherent integrated proposal for financing in 2011.

Transition issues. The first phase is ending with no clarity on how IWRM is to be managed in the future. The key is to set up a strong IWRM planning function with assured financing and governance and supervision arrangements. The location of this planning function should be in NWRA-SB. The creation of the needed capacity will require high level support and substantial resources.

**7. Overall assessment and next steps**

In summary, the first phase has piloted IWRM approaches in the Sana'a basin, and has demonstrated that many of them can work. However, many adjustments are required if a second phase is to be successful. Essentially, there will need to be:

- a technical planning function responsible for putting together IWRM plans, and for monitoring implementation and results
- a governance function that brings all stakeholders together to set long term hydraulic and socio-economic objectives, to debate and adopt plans, and to evaluate progress

- a financing and implementation function that translates plans into facts on the ground

The matrix on the following pages summarizes the achievements and challenges at the end of the first phase, and the options and key questions for the second phase.

**The long-term program for water resources management in the Sana'a Basin**

**Moving from Phase I to Phase II**

| | Technical planning | Governance | Financing and implementation |
|---|---|---|---|
| **What did Phase I achieve?** | Prepared a Master Plan (JICA 2007) | Set up Basin Committee | Assured financing through a single integrated project |
| | Prepared water balance and models (Hydrosult) | Involved local councils | Integrated and efficient implementation through a PIU |
| | Set up monitoring and public awareness | Set up water user associations (WUAs) | NWRA-SB equipped for monitoring and regulation |
| | Demonstrated technical and economic value of water conservation in irrigation and recharge | | Integrated M&E at project/basin level by the PIU. Integrated supervision by government and donors. |
| | | | |
| **Challenges at the end of Phase I** | Need to set up a permanent planning function for the basin | Need to get the elements of the governance structure (Basin Committee, local councils, WUAs) working together | Need to find a financing mechanism for Phase II which keeps the integrated basin focus |
| | Need to adopt, adapt and implement the Master Plan | Need to empower all three elements of the governance structure by making their decision making powers clear and by capacity building | Need to implement through the responsible mandated agencies and to keep the integrated basin focus despite (1) varying track records of the agencies; and (2) lack of structural or hierarchical linkages between them |
| | Need to set clear water resource management objectives and prepare a 5 year plan and annual programs | | |
| | Need to link technical programs for water conservation to water resource management objectives | | Need arrangements for integrated M&E and supervision |

| | Technical planning | Governance | Financing and implementation |
|---|---|---|---|
| **Phase II options** | Proposal is to strengthen the planning function in NWRA-SB to:<br><br>- carry out continuous water resources assessment<br>- prepare integrated 5 year plan and annual programs, integrating all supply and demand elements<br>- conduct M&E of achievements against targets | Proposal is to consolidate a three part integrated and inclusive governance structure (Basin Committee, local councils, WUAs) that:<br><br>- decides on allocation and regulation of water resources and their development and uses<br>- decides on the basin plan and the allocation of financial resources<br>- takes responsibility for regulation | Proposal is to ensure a basin-level integrated approach to finance and implementation through:<br><br>- integrated plans and annual programs prepared by NWRA-SB, approved by the Basin Committee and financed by WSSP<br>- implementation of the plans and programs by mandated agencies strengthened as needed (NIP, NWRA-SB, Sana'a LC, GARWSP…..)<br>- M&E and supervision at the basin level by NWRA-SB reporting to the Basin Committee, and by GoY and donors under WSSP arrangements.<br><br>Phase II to be 'packaged' as a five year 'project' in order to have clear objectives, inputs and outputs, a clear five year action program, and assured financing and supervision for the entire Phase II |
| | | | |
| **Key questions** | If the difficult job of integrated planning for the basin is to be put in NWRA-SB, how to overcome all the many constraints to building effective institutional capacity in Yemen? | Can authority over (1) water resource allocation; and (2) financial resources be given to the Basin Committee?<br><br>Is Yemen ready for this level of stakeholder participation?<br><br>Can WUAs, local councils and the Basin Committee really work together to regulate use and stop illegal drilling? | Can an integrated focus be maintained without a 'project' vehicle?<br><br>As irrigation investment transfers to NIP, will the link between water resources planning and irrigation water conservation be cut?<br><br>Similarly, will NIP and NWRA-SB lose coherence on WUAs, as they have different approaches to WUA objectives? |

# 1. Introduction

## 1.1 Background

Developing good institutions and behaviour for sustainable, equitable and efficient water management is a long term process. In 2003, Yemen committed itself to this process in the Sana'a Basin, where critical water problems were pressing. A fifteen year time horizon was selected, and divided into three five year phases.

The first phase, which was supported by the Sana'a Basin Water Management Project (SBWMP) and from other sources, was designed to test out the full range of global best practice water management approaches known collectively as 'integrated water resources management' (IWRM). This was the first full scale application of IWRM practices in Yemen.

This first test phase is ending in 2010. Before embarking on a second phase, a thorough evaluation was commissioned by the government of Yemen with World Bank support in order to assess the results of the first phase, and to highlight lessons and make suggestions for improvements. This *Action Oriented Policy Paper* (AOPP) presents the results of this evaluation.

## 1.2 Objectives of the study

With the above background, the broad objectives of the AOPP study are to:

1. Summarize the nature of the water management challenges in the Sana'a Basin

2. Evaluate the success of the water governance and management model deployed under the first phase of IWRM in the basin

3. Identify constraints and areas where the model needs adjustment

4. Propose practical steps for the future to achieve sustainable, efficient and equitable water management in the basin

5. Draw any lessons for the application of integrated water resources management in the rest of Yemen

Detailed terms of reference for the AOPP study are annexed (Annex 3).

## 1.3 Conduct of the AOPP study

The AOPP study was undertaken by a multidisciplinary team comprising NWRA and SBWMP staff and consultants. Direction was provided by Eng. Saleh al Dubby, SBWMP Director, and overall steering was provided by Eng. Salem Bashuaib, Chairman of NWRA, and his staff. The World Bank also provided support and guidance. Team members were as follows:

**The AOPP Team**

| Theme | Team member |
|---|---|
| Participatory approach and stakeholder involvement | Dr Nasser Fadl |
| Water resources | Eng. Abdullah Saleh Saif |
| Irrigation and water supply | Dr. Taha Taher |
| Institutional | Dr. Omar Al-Sakaf |
| Water governance and capacity assessment | Eng. Muhammad Sultan |
| Bibliography and logistics | Eng. Salem Basuhay |
| Coordination and reporting | Christopher Ward |

The methodology comprised: (i) literature review; (ii) field visits; (iii) focus groups and key informant interviews; (iv) stakeholder consultations through a workshop and a conference; and (v) date analysis, evaluation and report drafting.

The AOPP team mobilised on March 20th, 2010, and kick-off meetings were held at SBWMP with NWRA and SBWMP on March 20th and March 27th, 2010. An initial literature review was completed on schedule on April 14th, 2010. An Inception Report and an accompanying Scoping Note were submitted on April 22nd, 2010. Thematic reports were prepared and discussed in detail at a workshop held at NWRA headquarters on May 12th, 2010.

On the basis of the thematic reports and the guidance of the May 12th, 2010 workshop, tentative findings and recommendations were consolidated into a zero draft summary report (May 24th, 2010). Highlights of the summary report were presented and discussed with the NWRA chairman on May 27th, 2010 (Thursday).

On May 30-31, 2010, a ***Project Completion Conference*** was held, attended by over 200 participants, including many farmers and other water sector stakeholders. AOPP findings and recommendations were presented by the team (see Annex 1) and lively debates ensued both in plenary sessions and in five break out groups. Overall, the ***Conference*** confirmed that the first phase of IWRM had indeed created a high level of awareness of water crisis and had introduced appropriate measures which were largely appreciated. Criticism was abundant for less successful aspects such as the regulatory effort and the weak empowerment of decentralized water management organizations, but overall the criticism was helpful and the improvements suggested were pragmatic. ***Conference*** outcomes are discussed throughout this report, and are summarized in Annex 2.

Following the ***Conference***, it was agreed (1) to finalize the AOPP report reflecting the guidance of the NWRA chairman and the discussions and recommendations of the ***Conference***; and (2) to prepare a proposal for a second phase of IWRM in the basin

('Phase II'). The present report is the final AOPP report; the proposal for Phase II is presented in a separate document.

# 2. Water governance, institutions and organizations

## 2.1 The problems to be addressed through IWRM approaches

Before the introduction of IWRM approaches in the Sana'a basin, water governance and institutions in the basin suffered the following weaknesses:

- Uncontrolled well drilling and groundwater abstraction, and competitive pumping between users in a 'race to the bottom'
- Shortages of bulk water for urban water supply
- Absence of an equitable, efficient and sustainable system for allocating water between users and sectors

## 2.2 The model adopted during the first phase of IWRM

The governance and management model adopted under SBWMP is essentially a full integrated water resource management (IWRM) model. It had the following main features:

- An overall legal and regulatory framework based on principles and practice of IWRM
- Stakeholder inclusion and a partnership approach throughout
- The basin as the unit of management, and a stakeholder Basin Committee to oversee water resources management within the basin
- User empowerment through water user associations (WUAs)
- A project unit responsible for implementation
- NWRA Sana'a Branch (NWRA-SB) responsible for monitoring and regulation
- Administrative decentralization, and management of water resources delegated to the lowest level, including local councils and WUAs as the lowest level of integrated management
- Economically efficient and socially acceptable management of supply and demand
- Integrated inter-sectoral management between MWE, MAI, the Sana'a Local Corporation etc

## 2.3 Analysis – lessons – options

### 231 The legal framework for basin management

- ❖ Yemen has passed a water law that provides a sound legal framework for basin management. However, the law is being only partially implemented.
- ❖ The by-laws need to be issued, and the provisions of the protection zone should be adapted to the varying characteristics of the different sub-basins.

The Water Law

The Water Law was passed in 2002. It incorporates principles of IWRM, emphasizing conservation and user involvement at all stages. However, the by-laws have not yet been issued. As a result, regulatory actions often lack the backing of the judiciary and it is hard to get a successful prosecution (see below, Section 333).

The Protection Zone

The creation of a protection zone provides for special regulatory powers to be vested in NWRA and the Basin Committee. The Sana'a Protection Zone was declared by Cabinet Decree in 2002.

Amongst the important statutory provisions of the Decree are: (1) that no licenses shall be given for the expansion of agriculture; and (2) that all wells and pumping quantities shall be registered within one year.

There is scant evidence that the key provisions of the Decree have been complied with, nor that the existence of a Protection Zone has made any difference.

**The legal framework for IWRM in the Sana'a basin**

- Water Law (No. 33, 2002) and its Amendments (No. 41, 2006)
- A Bylaw to the Water Law, prepared in 2006, approved by key stakeholders and submitted to the Cabinet for final approval in early 2009, but not yet issued.
- Cabinet Decree (No. 343, 2002) declaring Sana'a basin as a 'protected zone', and extension of the declaration for further 10 years (No. 184 for 2009)
- Prime Minister's Resolution No. 148, 2000 on the Executive Regulation of Law No. 26 on the Protection of the Environment
- Republican Resolution No. 26, 1995 on the Protection of the Environment
- NWSSIP Update 2009-2015 (NWSSIP I 2005-2009 updated in 2008)
- Some policies, guidelines and regulations developed, awaiting approval by the Minister of MWE ("Water Sector Legal Regulatory and Monitoring Framework", 2009, "Regulatory systems and procedures for water right management", 2009).
- Creation of Sana'a Basin Committee, Cabinet Resolution No. No. 263, 2002, amended in 2003, No.168, 2004, No. 54, and in 2009, No. 195.
- Establishing NWRA Sana'a Branch, Cabinet Resolution No. 58, 2003.

**Findings/lessons**

The weak legal and judicial backing of IWRM in the basin

Legal instruments to underwrite regulation are clearly lacking (in addition to the actual weakness of current enforcement approaches, on which see Section 333 below). Both the Water Law and the Protection Zone Decree can only be enforced if they are the subject of implementing instruments or executive regulations, which is not the case.

In addition, law enforcement and judiciary officials have rarely shown understanding or commitment to application of the law.

Although 'top down' law enforcement has not worked and is unlikely to work in the Yemeni situation (see Section 333), nonetheless, the legal situation should be clear and there should at least be the possibility of equitable and honest application of the law.

The blunt nature of the protection zone

The protection zone decree applies to the entire basin, whereas in practice different water management objectives and hence different approaches may be needed (see Section 334 below). In addition, the inclusion of clauses that have proved impossible to implement (e.g. registration of wells and pumping quantities) undermine the credibility of the instrument.

Cost recovery opportunities foregone

The proposed fees for licenses and services by NWRA to others are an excellent potential source of revenue, but they could be increased and better related to benefits. For example:

- The fee for an application form for licensing drilling, deepening or maintenance of an old well is very low (Rls 1,000 or $5)
- The annual licensing fee to be paid by drinking water/mineral water bottling factories is a flat fee of Rls 360,000. It could be linked to the production volume (per m3).
- No groundwater abstraction charging is proposed even where the abstractor is easy to register and is capable of paying: Sana'a Local Corporation, private water suppliers, high water consuming industries, five star hotels, … etc

**Options/Recommendations**

- The by-laws to the Water Law could be revised, preferably through a participatory process, to reflect recent changes and emerging issues. Issue of the by-laws and their implementation should be a priority.[1]

[1] A 'draft decree of decentralized basin-based management structures' has been prepared and discussed with stakeholders and, on the proposal of the Ministry of Legal Affairs, will 'go through the NWRA Chairman to the Minister of MWE for approval'. For the content of this draft decree, see Phase Proposal Annexe 1.

- The protection zone could be reviewed to adapt it to experience, and executive regulations could be issued adapted to the objectives, proven approaches and varying characteristics of different sub-basins.

- Equitable cost recovery provisions could be defined that would reinforce demand management and increase revenue to cover the costs of IWRM.

## 232 The Sana'a Basin Committee

- To date, the Basin Committee has not been empowered and its effectiveness has been limited.
- To make the Committee more effective, membership could be made more inclusive of key stakeholders, and the Committee's mandate could be strengthened to cover allocation of both water and financial resources.
- The Basin Committee could become the supreme water governance authority in the basin, in tandem with local councils as the second line of authority, and WUAs as the front line resource managers, with NWRA-SB strengthened as adviser and secretariat.

The Basin Committee is a high level body chaired by the Minister of Water. Its mandate is very broad.

According to its establishment decree, the Committee is mandated to:

- Approve annual water plans and determine allocations by sector
- Approve water development projects
- Review basin management strategy and its implementation

According to the Protection Zone decree, the Committee should also:

- Approve water withdrawal licenses
- Approve heavy water-using establishments
- Monitor depletion and intervene to prevent overdraft
- Approve water allocations and control the water balance

The Committee has been very active, meeting frequently. However, in practice, it has done little in line with its large mandate. The committee has no budget and has not been empowered to take and execute decisions. The committee has been largely consultative, coordinating and recommending, although it has also served as a 'platform' for open discussion. Its membership is largely of central government officials. The provision for members from WUAs and civil society has not been fulfilled. The Committee at present is largely a gathering of high officials, which runs counter to the IWRM principles of delegation and stakeholder participation.

Overall, the Committee members have not felt empowered, and are generally frustrated, feeling the committee is ineffectual.[2] In the absence of an agreed basin plan, the Committee's strategic vision is weakened.[3] Members report lack of clarity on objectives and powers, and a preoccupation with day to day 'fire fighting'. The

[2] These observations are based in part on Box 3 in *Yemen's Water Sector Reform Program – A Poverty and Social Impact Analysis* (PSIA, August 15th, 2007).
[3] NWRA regards the November 2007 *Water Resources Management Action Plan* (JICA) as the basin plan. However, the Plan has not yet been officially approved and is not yet being implemented in any coherent way (see 334 below).

Committee lacks authority over financial resource allocation, and has little authority to enforce its decisions.

Despite the strategic mandate of the Committee, it has never played a strategic role, and NWRA-SB has not provided the kind of support that would have enhanced this strategic role. Given that the IWRM concept and participatory planning and decision making are new paradigms, the work of the basin committee is inevitably a learning process. However, after five years it is time to take stock and make necessary adjustments.

Some recommendations that have been made by Hydrosult and JICA

Hydrosult and JICA both proposed the conversion of the Committee to become a 'basin authority' that would combine governance and execution functions:[4]

- Hydrosult proposed a multi-stakeholder governing body – a 'Basin Authority' - to be responsible for water allocation, and empowered to effectively enforce the Water Law.
- JICA recommended a progressive building up of the capacity of the Committee, with a view to converting it in the longer term into a Sana'a Basin Agency.

JICA also recommended expanding membership of the Committee, in particular to include traditional leaders influential on the traditional communities in water resource management.

Lessons from other basin committees' experience

It is not clear whether there is a good example of an empowered and effective basin committee in Yemen. Abyan is reported to be functioning well, although on paper its only substantive power is to approve the issue of licences. Otherwise it too is just a consultative body. The Abyan BC has issued numerous 'decrees' but it is not clear how effective these are.

**Options**

The simplest option would be to enhance the existing committee by making it a more representative body of all stakeholders, and empowering it further to take decisions over water resource allocation and financial budget allocation. This option seems quite feasible.

At the ***Conference***, stakeholders broadly supported making basin committee membership more inclusive, especially of WUAs and of women, and endorsed further empowerment. A specific ***Conference recommendation*** was that the committee should be chaired by the Sana'a Governor and Sana'a City Mayor (as was the case until 2005), rather than by the Minister of MWE, as at present.

An alternative would be to set up a Sana'a Basin Authority, as envisaged at appraisal of SBWMP and recommended by Hydrosult and JICA. This option is likely to take a

[4] The idea of a 'basin authority' is proposed in the SBWMP project design – see discussion at Section 612 below).

long time and to be expensive, as establishing new agencies in Yemen is an arduous process. There is no evidence that this model would be more effective, and it would be likely to create a parallel administration, impairing the authority of other mandated agencies without solving the problem. See the full discussion of this issue in Chapter 6 below (Section 612).

**Recommendations**

- Conduct a comparative review of experience in basin committees and basin governance across Ta'iz, Abyan, Amran, Sa'ada and Sana'a.

- Make membership of the Sana'a Basin Committee more inclusive, with WUAs, women and civil society. The Committee could also include the private sector: water suppliers (tankers owners), the drilling industry, and investors in water-directly-related industries (mineral water bottling factories, drinks factories) and also in high water demand industries (touristic establishments, building materials….).[5]

- The Basin Committee to be the supreme water governance authority in the basin, in tandem with local councils as the second line of authority (Section 233) and WUAs as the front line resource managers (Section 234).

- Basin Committee to be the mandated decision-taking body on: (1) the basin plan; (2) the basin annual operating program (AOP) under WSSP; and (3) regulation.

- The committee should be chaired by the Sana'a Governor and Sana'a City Mayor.

- Objectives and operating rules to be revised accordingly.

- Strengthening of the technical support role of NWRA-SB as the adviser and secretariat of the Committee.

- Training of the Committee in its role, and setting up a forum with other basin committees for professional exchanges.

[5] The latest decree (*Creation of Sana'a Basin Committee, Cabinet Resolution No. 195, 2009*) mentions also as members in the basin committee three members/personalities to be selected by the Prime Minister, who are not defined yet. Consideration could also be given to adding other line ministries: such as the Ministry of Legal Affairs, Ministry of Local Administration, Ministry of Social Affairs & Labour, and Ministry of Justice.

## 233 Local councils

- Local councils have only very partially fulfilled their statutory role of 'managing and controlling water resources in their area'.
- Their role as second in line water resource managers - between the Basin Committee and the WUAs – needs to be more clearly defined, and their capacity strengthened.

**Analysis**

According to the Local Authority Law of 2000, local councils have the 'right to manage and control the water resource in their area.'

During the first phase of IWRM in the basin, considerable effort was made to involve local councils. A counterpart was named within each council, and these counterparts helped implement some awareness raising activities. Regular meetings were held between the project and local councils, with the involvement of WUAs. Some direct links were made between councils and WUAs, and councils were co-signatories of project contracts with the WUAs.

All in all, engagement of local councils varied during the first phase. Some councils have been very active and have been champions. Others have shown lack of interest, or have been influenced by political considerations.

The role of local councils in regulation has been mixed, largely ineffectual. Often it is said that "*Powerful violators go free*."

**Options**

Empower the local councils to be the second line agencies responsible for local water resource management, between the Basin Committee and the WUAs, with training and technical support from NWRA-SB to be developed in conjunction with the Ministry of Local Administration.

Suggested roles for the local councils could be:

- To have an oversight role for WUAs in the district (as defined by the Local Authority Law), coordinating with WUAs on local water resource management plans in the district (see Section 334)
- To be the front line agency for dispute resolution, particularly for preventing random drilling of wells (as in the Amran model, see Section 333)
- To be a forum for discussion on water issues, and to coordinate awareness raising within the district

**Recommendations**

- In negotiation with local councils, define councils' role in water governance (in line with the Water Law and the Local Authority Law) as the intermediate level between the Basin Committee and WUAs.

- In conjunction with MoLA, train the local councils and staff to be the 'second line of water management'

## 234 Water user associations (WUAs)

- WUAs have developed well and have the potential for a sustainable role as front line water managers, in partnership with local councils and the Basin Committee.
- Institutional arrangements for consistent capacity building and empowerment need to be put in place as SBWMP comes to a close.
- Nationwide, experience on WUAs needs to be pooled and the pathway to self-sustaining status needs to be traced out.

WUAs play a key role in the basin IWRM model. Farmers are the front line water managers, and the project has worked hard to organize them. There are 58 active WUAs bringing together 1,149 WUGs and 11,546 farmers. Of these WUAs, 46 are primarily concerned with irrigation, and 13 have been set up to help develop and subsequently manage recharge structures (see the table below).

WUAs are working on aspects of water protection, management, self-regulation, and project implementation.

On the whole, the WUAs have been successful. SBWMP rates only nine of the WUAs established as unsuccessful. After evaluating the WUAs against nine criteria, SBWMP qualified 44 of them as 'sustainable' (see table below), and consequently invested in an office building and furniture for each of the qualified WUAs.

**WUAs under Phase I**

| | Set up | Dissolved | Active | 'Sustainable' |
|---|---|---|---|---|
| Irrigation | 52 | 6 | 46 | 33 |
| Recharge | 13 | 3 | 12 | 11 |
| **Total** | **67** | **9** | **58** | **44** |

Although each WUA sets its own goals, in general WUA objectives fall into two categories:

- Investment-related activities: Awareness, planning, implementation, training and operation of project-assisted investments
- Water management activities: Raising awareness of water crisis, controlling random drilling and the expansion of irrigated lands, liaising with NWRA-SB and the project on water data and information etc.

SBWMP administered training in (a) management; (b) law and awareness; and (c) irrigation modernization. A gender outreach program was conducted, and exposure visits to other successful WUAs in Yemen and Jordan were conducted. The Institute of Administrative Sciences and the WEC have developed capacity in administering WUA training.

The WUAs also acted as counterpart for SBWMP-supported agricultural and irrigation extension work.

Moves were made in 2009 to set up a basin-level union, but this process has stalled whilst questions are resolved over the relationship of a basin union to the recently registered national federation.

**Analysis**

All in all, WUAs have proved essential partners for IWRM. Many have played a key role in SBWMP project implementation, significantly reducing the cost of interventions (50% reduction in costs of installing modern irrigation). Some progress has been made on developing WUAs to play a water management role, with notable cases of WUAs intervening to control random drilling – see, for example, the box in Section 333.

WUAs are recognized under the Water Law as a means to 'involve user communities in regulating water resources'. However, they are registered under the NGO law. They thus have voluntary status and 'lack authority to make and enforce rules'.

Linkages between the WUA side and the formal establishment are not always working smoothly. The governance structure of which WUAs are a part is at present not clearly defined, and the role of different actors is not clear. NWRA is sometimes lukewarm towards WUAs and reluctant to delegate powers. NWRA-SB is 'not set up to deal with WUAs'. NWRA-SB and WUAs have cooperated poorly over monitoring and data exchange.[6] WUAs are not represented in the Basin Committee.

Links to local government are in place. However, these links may not be working too well – the AOPP review found that local councils 'easily get the message to do nothing'.

It is not clear how far WUAs have actually become water managers, nor what are the prospects. Experience from elsewhere in Yemen suggests that community action can regulate groundwater, but the itinerary towards a coherent role for WUAs as front line water managers is not yet traced out in the Sana'a basin.[7]

At the ***Conference***, scepticism about WUA potential was voiced by a number of officials, and NWRA management generally showed a rather cautious approach to WUA empowerment, emphasizing rather the responsibility of the state. However, WUA representatives at the ***Conference*** spoke up to underline the weak performance of the state in regulation and to emphasize WUA commitment to good 'self-management'. As the Chairman of the Al Maliki WUA said:

> *We are the ones to be affected! We believe WUAs should include the whole community, as improved irrigation is only part of the solution. We can do studies, planning, research…we need only technical support from NWRA.*

[6] The number of agricultural wells monitored and controlled by WUAs is limited, and WUAs have been very reluctant to take part in local monitoring. Some WUAs and farmers have even requested payment for these services.

[7] See, for example, the experience of CWMP and other cases (e.g. those in *Ward and Awlaqi*), which suggests that WUAs can gradually move towards water management responsibilities.

WUA membership is voluntary and confined to irrigators, and usually covers only the irrigated land around a settlement. As a result, WUAs rarely include all water users in a hydrological area or sub-basin. For these two reasons, a WUA cannot really agree and implement a coherent water management strategy. At the ***Conference***, it was proposed that WUAs should be inclusive of all water users around each settlement, and WUAs should work together at the sub-basin or district level to agree and implement water management strategies.

Links with traditional institutions and organizations for water management are not always clear. WUAs may need to be better grafted onto traditional set ups and rights. The co-existence of traditional and modern institutions may 'create multiple forums for dealing with disputes'.[8]

Are the incentives for farmers to take part sound, and will they outlast the project? How sustainable are these organizations? Globally, WUAs often disappear after project benefits have gone. As discussed above, about two thirds of WUAs in the basin passed SBWMP's 'litmus test' of sustainability, but whether these WUAs are on the path to autonomy and financial sustainability is unclear. Also, even where WUAs appear at present sustainable, global experience suggests that they will continue to need support, encouragement and empowerment for some years to come.

And perhaps most importantly, political support for WUAs is erratic, suggesting 'a real lack of political determination to solve or alleviate the water crisis'.

**Options**

There is a need to better articulate the 'three level governance structure', with clear definition of the roles of each actor (who does what, in detail): WUAs and their possible basin level union; the local councils (and perhaps groups of WUAs at the sub-basin or district level); and the Basin Committee.

The nature of future support to WUAs and the provider of that support need to be made clear. Three alternatives might be considered: (i) NWRA-SB to be strengthened and coached to support WUA development through a community participation and social mobilization unit; (ii) WUA development might be supported by a relevant civil society organization such as an apex WUA organization;[9] or (iii) NIP might take responsibility. Risks attach to all of these approaches:

- NWRA-SB has no capability or track record
- No qualified civil society or apex organization yet exists
- WUAs promoted under NIP for irrigation are unlikely to be sufficiently inclusive of all water users, and lack the broader IWRM perspective.

[8] This is a point made by the 2009 WUA study, which may apply in Sana'a Basin.
[9] WUA development and irrigation improvement in Niger, for example, is carried out through a national federation of WUAs (with donor support).

On balance, NWRA-SB is the best indicated agency to promote WUAs for water resource management, as this is NWRA's mandate. In addition, NWRA-SB could take over the community mobilization capacity created within the SBWMP project unit.

The WUA partnership with NWRA-SB needs in any case to be made clear. NWRA and WUAs can cooperate on planning, monitoring and information exchange at the sub-basin level, and this should normally form the heart of a productive relationship.

With a longish track record (about ten years) in WUA experience, Yemen should be in a position to pool experience from different WUA initiatives and trace out a more consistent and efficient institutional approach, and to begin to develop and empower WUAs as genuine 'water managers' rather than simply as instruments for project implementation.

**Recommendations**

- WUA empowerment: the powers and responsibilities of the WUAs within basin governance need to be clarified, together with the interface among WUAs, local councils and the Basin Committee. About five WUA representatives should sit on the Basin Committee.

- Develop a roadmap for future WUA autonomy (managerial, technical and financial).

- Strengthen NWRA-SB to help support and develop WUAs. Existing SBWMP capacity for this should be retained within NWRA-SB.

- Work out mechanisms for NWRA-SB to cooperate with NIP on WUA development, and clarify arrangements for collaboration between WUAs and the NIP.

- Building on the December 2009 report of Bruns and Taher, pool experience across basins and develop national 'basin water governance options' and 'national guidelines for WUA establishment and development'.[10]

- Building on experience, review the potential for strengthening the role of WUAs in water monitoring and (self-)regulation. This could begin with the conduct of the *Case Studies of Local Initiatives in Water Governance* recommended by Bruns and Taher. See also the attached listing of *Actions affecting groundwater that might be monitored and controlled by WUAs.*

- Draw up agreements between NWRA-SB and WUAs on the reciprocal provision of services, such as support and cooperation on sub-basin planning, data gathering and processing, information exchange, monitoring etc.

- Work out how WUAs and local councils can cooperate with NWRA to develop and implement sub-basin water management plans (see 334 below),

[10] See, for example, the recommendations of the November 1, 2009 WUA workshop, which recommended strengthening WUAs nationwide through three 'pillars': legislative, technical, and logistic.

including measures for WUAs to cooperate with each other on this (e.g. sub-basin level WUA federations)

- Impediments to the formation of the WUA union for the Sana'a basin should be examined and, if possible, any risks stemming from the uncertainties over the national federation should be managed. A federation or union could potentially have relations with donors, and deliver irrigation improvement services.

- Harmonize WUA training across basins, possibly with one or two training institutions recognized and supported as 'centres of excellence' (Institute of Administrative Sciences, WEC…..)

- Seek top level political support for WUAs role in water governance.[11]

[11] The 'Presidential Conference' to be held later in 2010 offers a chance to get this top level endorsement on a national level.

## Actions affecting groundwater that might be monitored and controlled by WUAs

| | VISIBILITY * | ACTION AFFECTING GROUNDWATER | EXAMPLES | IMPLICATIONS FOR INTERVENTION |
|---|---|---|---|---|
| 1 | High | **Drilling new wells** | Presence of drilling rig, moratorium on new wells | Potential to empower & support local controls, improve formal enforcement |
| 2 | | Deepening or replacing existing wells | Presence of drilling rig, existing well, and irrigation | "People have to live." Hard to stop |
| 3 | | **Spacing of wells** | Eg. 500 meters apart | Avoiding harm, already practiced |
| 4 | | **Selling water to tankers** | Forbidding export, requiring formal water rights and approval | Avoiding harm, local priority, some examples of restrictions |
| 5 | | Abstraction for domestic water | Hauled by people or donkeys, piped use can be metered | Priority for drinking, right of thirst, local regulation to protect sources |
| 6 | | **Crop type** | Ban bananas, alfalfa, or other crops with high water demand | (Potentially:) Waste, harm, denying water. Few examples so far. |
| 7 | | **Crop area** | Limits on expansion, | Productive use of resources, equity, agreements not to expand |
| 8 | | **Conveyance** | Canal or pipes | Incentives for saving. Avoiding waste |
| 9 | | **Delivery** | Flood, furrow, basin, sprinkler, bubbler, drip | Incentives for saving. Avoiding waste |
| 10 | Moderate | Duration of irrigation | Hours, seasons | Avoiding waste, community interests |
| 11 | | Fuel consumption | Liters of diesel | Cost, fuel price subsidies |
| 12 | | **Excess irrigation** | Runoff, weeds, non-beneficial evapotranspiration | Waste, productivity, hard to measure precisely, can estimate and inform |
| 13 | | Providing water to neighbors | Pipes, water flows | Hard to restrict |
| 14 | | **Community approval of well drilling** | Consultation and consensus by community & local council | Increasing community control |
| 15 | | **Government approval of well drilling** | Licenses. Uncertain quality of procedures and analysis. | Need for participation and transparency |
| 16 | | Depth to water table | Meters from surface | Can map and graph systematically to inform communities |
| 17 | | Well recovery rate | Hours to restore level | Can analyze and inform |
| 18 | | **Aquifer recharge** | Terracing, check dams, basins | Many existing examples. Can analyze technically and inform. |
| 18 | Low | Quantity abstracted | $m^3$ | Requires meter, hard to control, vulnerable to manipulation |
| 20 | | Impact on other wells and springs | Drying up nearby wells or springs, cone of depression | Often hard to prove, complicated to measure, sometimes obvious |
| 21 | | Aquifer transmissivity | Lateral flow, meters per unit of time | Can assess from local experience, Can analyze technically and inform |
| 22 | | Aquifer storage capacity | $m^3$ of water per $m^3$ | Can assess from local experience, Can analyze technically and inform |

Notes: Roughly ranked by visibility, specific cases may vary

Thanks to Bryan Bruns for this illuminating chart of options

## 235 NWRA Sana'a Basin Branch

- Despite a fairly large staff and support under SBWMP, NWRA-SB is struggling to fulfil its current limited mandate in regulation and monitoring.
- Careful planning and strong management will be necessary as a larger IWRM mandate is confined to the branch.

The role of the NWRA Sana'a branch (NWRA-SB) is: (1) water resources planning; (2) regulation and monitoring; (3) water demand management; and (4) water quality management.

Organization: In addition to two supporting departments (financial department and personnel affairs department), the branch has three technical departments: (1) the Studies and Information Department (formerly M&E Department); (2) the Licensing and Water Rights Department; and (3) the Awareness Raising and Mobilization Department.[12]

The functions of the departments have not yet been formally defined or settled in a by-law. The AOPP review found no documented roles, responsibilities or procedures, insufficient segregation of duties, no job descriptions, and no mechanism for ensuring staff accountability for processes or outputs.

Staff number 25 graduates and 17 diploma holders. This total of 42 staff is 18 short of the approved complement of 60 staff. The AOPP review considered that staff are insufficient in quality and quantity to conduct the assigned tasks and responsibilities, and that NWRA-SB has at present limited capacity to absorb financial support from donors. More than 50% of staff members are contracted, and there is frequent change in staffing, as employees leave due to 'de-motivation, inappropriate work environment, and insufficient remuneration.' The NWRA Chairman said that the best staff were 'poached' by donor projects and by oil companies. Incentives are not performance-based.

**Issues in NWRA-SB effectiveness: the case of the Data Bank Unit**

NWRA-SB's Data Bank Unit within the Department of Monitoring and Information used to have five staff members: one director/remote sensing, one GIS specialist, one database administrator, one server operator, and one librarian. All staff except one have left, and now only the director of the unit remains. Although the director is an experienced hydrologist specialized in remote sensing, he can do little by himself.

At present:

- 90% of devices and apparatus in the Unit are defective, and the server has been out of commission since 2007.
- The Database is frozen, with no input of monitoring data since 2007
- Annual budgets allocated for this unit are re-allocated to other purposes other than actual unit needs

*Source: OM II*

There are skills gaps and training needs.

[12] Source: recently published booklet/brochure on NWRA Sana'a branch, confirmed by staff met

The budget is inadequate for the branch to fulfil its work program. Almost all the operating budget goes on salaries (see Section 610 below).

In addition, spending against the agreed budget is very low, except for incentives (see table). A prime cause of this low spending has been the constraining Yemeni budget system, apparently not improved by donor support programs (Netherlands, SBWMP). In 2009, no financing was received until June, half way through the year, and the situation is as bleak in 2010.

**NWRA-SB spending against budget 2009 (YR millions)**

| Expenditure item | Budget | Spent | % |
|---|---|---|---|
| Water quality monitoring (Netherlands) | 1.50 | 0.09 | 6% |
| Well inventory | 3.70 | 0.17 | 5% |
| Data collection field visits (Netherlands) | 4.00 | 0.80 | 20% |
| Expansion of monitoring networks (SBWMP) | 0.08 | 0.01 | 12% |
| Incentives (Netherlands) | 4.47 | 4.95 | 111% |

*Source: NWRA-SB Accomplishments Report 2009*

The branch's main work program is in regulation and monitoring, including a certain (low) level of licensing and a few referrals of illegal drilling to the prosecutor. Follow up of licensed rigs through the satellite tracking system is done from NWRA headquarters and not from NWRA-SB. In 2008, NWRA-SB conducted a thorough review of private water supply wells in Sana'a city and proposed a pilot regulation scheme. There has, however, been no follow up to this good initiative.

**Assessment**

Despite having a relatively large staff (second largest of NWRA's branches, after Aden), and some investment and capacity building support under SBWMP[13], NWRA-SB has been very much under the shadow of the well-resourced and staffed SBWMP. Little or no institutional development seems to have taken place in the last five years, and results are disappointing. Monitoring has been weak (see Section 332), and regulation has had little impact in controlling random drilling (see Section 333).

NWRA-SB does not at present have the management systems or capacity to take on more demanding aspects of IWRM in the basin such as:

- Integrated planning
- Support to basin governance at the basin committee and local council level
- Support to setting up and developing WUAs
- Working in an integrated way with NIP and agricultural extension
- Working in an integrated way on planning, resource allocation and demand management with Sana'a LC and private providers

[13] NWRA-SB has consistently received the largest share of donor assistance of any NWRA branch (80% of the total 2004-6) [Y5]

Considerable further empowerment, recruitment and capacity building would be essential before NWRA-SB could shoulder the mandate of IWRM in the Sana'a basin. The ***Conference*** emphasized the need for a stronger NWRA-SB, both in terms of technical support to water management, and in terms of regulation.

**Options**

In summary, NWRA-SB would need much stronger capacity building and institutional development if it were to take on extra tasks required by IWRM. This extra support would include strengthening of existing departments, and setting up empowered and properly staffed and equipped departments for:

- integrated basin planning
- community participation, gender and social mobilization
- monitoring & evaluation

One option to reduce the burden on NWRA-SB could be to pursue partnerships with other institutions. This could work particularly well, for example, with monitoring (in particular with WUAs – see Section 234), and with regulation, where NWRA-SB plainly cannot do the job by itself (witness the results of the last five years - see Section 333). A combination of partnerships with the trio of governance institutions (Basin Committee, local councils, and WUAs) could reduce the burden on NWRA and increase effectiveness in controlling random drilling from the bottom up.

Similarly, 'top down' regulation could focus on 'professionalization of the drillers', with whom NWRA-SB could form some kind of partnership to develop a code of conduct and monitoring procedures.

Consideration could be given to income generation measures (through fees and charges) in order to finance a performance based incentives system (see Section 231).

**Recommendations**

Minimum conditions for improving the effectiveness of NWRA-SB would include:

- Careful definition and regularization of functions and of the resources (human, financial, logistical) needed to fulfil them

- Establishing specific functions with the personnel and resources adequate to allow them to perform effectively: (i) water resources planning; (ii) support to water governance; (iii) water resources monitoring and modelling; (iv) regulation; and (v) programming, M&E and reporting.

- A management audit to put in place systems of responsibility and accountability

- Increase in the operating budget matched to the work program [Y48A, 8.16A]

- Improved systems of budgeting and financial management to improve the low rate of budget utilization. One key aspect here (recommended by the Conference) would be to strengthen NWRA-SB's ability to develop and negotiate Annual Operating Plans (AOPs) with WSSP.

- Recruitment of experienced and highly qualified (MSc., PhD) staff as managers and department heads
- Improvement in the work environment, work procedures, housekeeping, work spaces, work place facilities, … etc
- Clearly defined partnerships and collaborations with all relevant stakeholders
- Raising staff commitment and effectiveness through performance-based incentives, a thoroughgoing and coherent training program based on a training needs assessment, and conversion from contract to staff status.[14] [Y49, 8.16A] [Staff capacity building is also a Hydrosult recommendation 2.2]

[14] A study on a sector-wide 'improved standardised incentives system' is being conducted under WSSP.

## 2.4 Towards an improved governance architecture

It will be clear from the discussion above that improvements to the governance and institutional structure could help deliver more effective IWRM outcomes in the basin. The improvements discussed in this chapter, which were endorsed by the ***Conference***, are essentially:

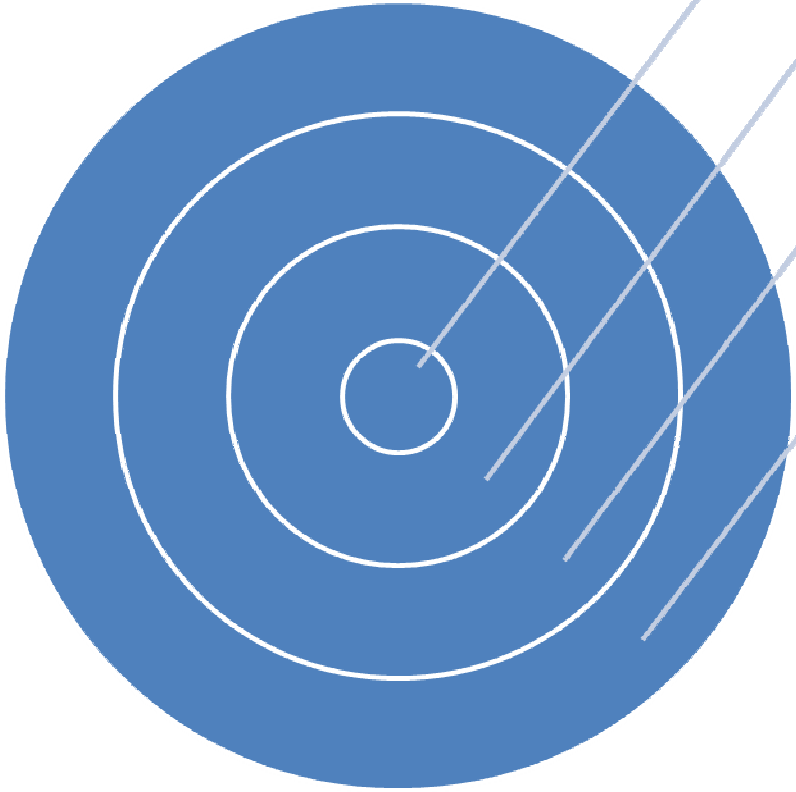
- To make the Water Law operational
- To delegate responsibility for water management to a trio of inter-related institutions: the Basin Committee to be the supreme water governance authority in the basin, in tandem with local councils as the second line of authority, and WUAs as the front line resource managers.
- To make the Basin Committee more inclusive, especially of representative user associations, and to empower it for both financial and water resource allocation
- To activate the local council role in water regulation
- To empower WUAs as front line water managers
- To adopt the sub-basin as the primary unit of water management, and to move towards institutional groupings at the sub-basin or district level that can adopt and implement water management strategies
- To greatly strengthen NWRA-SB to fulfil its role as planner and adviser, in partnership with other stakeholders and institutions

If these improvements are implemented, an integrated governance structure would be in place that would decentralize water resource management responsibility to the lowest accountable levels, in line with best IWRM practice. The chart below illustrates the respective and complementary roles that may be played by each level.

**Chart showing relations of the elements of basin governance, and their respective and complementary roles**

**NWRA-SB:**

- Secretariat to the Basin Committee
- Basin and sub-basin planning, water resources assessment
- Drafting of 5 year plan and annual programs, coordinating implementation, and M&E
- Support to governance structure on licensing and regulation.



**Basin Committee ( 22 members )**

- Supreme governance body, including representatives of all stakeholders
- Mandated decision taking body on: (1) basin master plan, 5 year plan and annual programs; (2) water resource allocation; and (3) regulation.

**Local Councils ( 8 districts + Sana'a city )**

- Counterparts of WUAs, coordinating local water resource management plans
- Front-line agency for dispute resolution and implementing the law
- Forum for discussion and awareness in the district

**WUAs (58)**

- First line of defence for stopping unlicensed drilling
- Approve any new water resource development in their area
- Conserve water through improved irrigation and recharge
- Develop and implement a sustainable management plan for their area

**WUGs (1149)**

# 3. Water resources

## 3.1 The problems to be addressed by IWRM approaches

Before the introduction of IWRM approaches in the basin, the problems to be addressed were:

- Abstraction of water greatly exceeded recharge, and there was constant depletion of groundwater reserves.
- The rate of abstraction had been increasing, whilst recharge may have diminished with urban expansion and under climate change.
- Information about the character of the aquifers and about the water balance was too patchy and contradictory to allow the development of a groundwater model and a rational groundwater management plan.

## 3.2 The actions during the first phase

Under its sub-component 3(d), SBWMP was to undertake 'development of specific hydro-geological and water resources monitoring, and investigation studies and capabilities, with and for the NWRA Sana'a Branch and MAI'. Together with other actions under Component 3 (Institutional Development and Capacity Building), the sub-component aimed at 'building a sound, efficient and sustainable institutional and managerial base for water resources management, both during the project period and beyond.' (Hydr: 58) The sub-component was implemented largely through a study carried out by Hydrosult Inc of Canada, with a final *Summary Report* of February 2010.

Non-SBWMP inputs included the Water Resources Management Study (JICA 2007), and monitoring and regulatory activities by NWRA-SB under its regular program.

## 3.3 Analysis – lessons - options

### 331 Quantification and trends in water resources

- ❖ Following Hydrosult, all basin data are available to start building simple models for practical planning at the sub-basin level.
- ❖ Although all sub-basins are deficit, some have the potential to be returned to near sustainability with careful strategic management.

Water resources assessment

SBWMP (through Hydrosult) has carried out the first ever comprehensive water resources assessment of the basin.

The evaluation by Hydrosult of the water balance separately for the 22 sub-basins is a key management tool

A revised groundwater model was prepared (but there are no staff currently trained to use it)

There are remaining questions over Hydrosult's data, methodology and results, and consequently the water balance, the estimated usable storage and the model are open to question.

Evaluation of the Hydrosult methodology

- Water resources assessments require a complex sequence of field work, analysis and interpretation.
- Building even a simple model takes at least five years of top level effort.
- Although Hydrosult focussed less on field work than might have been expected and the time allotted was insufficient, the study reached results that allow the start of IWRM planning.

Study reporting and supervision

- Hydrosult's compilation of data and report writing did not do justice to the work that had been put in.
- SBWMP and NWRA-SB lacked staff who could evaluate the model and define the required corrections.
- Supervision by SBWMP, NWRA and the World Bank was inadequate, concentrating on editing rather than substance and criticizing key aspects only after study completion.

Study results

- Hydrosult built on previous assessments, particularly SAWAS, and the study resulted in the first ever assessment of the entire Sana'a basin.

- As the evaluation of the deep sandstone aquifer was not included in Hydrosult's ToR, it is excluded from both depletion and recoverable storage calculations.

- Nonetheless, the sub-basin approach adopted by Hydrosult has developed information and tools that will permit planning at the sub-basin level. The box below indicates the information available for planning now at the sub-basin level.

**Information available for planning now at the sub-basin level**

- The general boundary of each sub basin.
- Aquifers underlying each sub basin.
- Water use in each sub basin (especially the estimation of agriculture water use)
- Recharge estimates in each sub-basin
- General water balance for each sub basin.
- Present high groundwater stress sub basins.
- Present modest groundwater stress sub basins.
- Relatively low groundwater stress sub basins.
- Main sector users in each sub basin.
- Main irrigated crop(s) in each sub basin.

*Source: AH*

Water balance

Hydrosult arrived at a water balance of 270 MCM abstraction and 79 MCM recharge, giving a 191MCM annual rate of depletion (see table below).

**Sana'a Basin Groundwater Balance ($Mm^3/y$)**

| | **Average** |
|---|---|
| Agriculture groundwater abstraction | 212 |
| Domestic groundwater abstraction | 58 |
| ***Total abstraction*** | ***270*** |
| | |
| Recharge from rainfall/runoff | 57 |
| Irrigation return flow | 20 |
| Domestic return flow | 2 |
| ***Total recharge*** | ***79*** |
| | |
| **Balance = Mining from groundwater storage** | **191** |

*Source: Hydrosult :6 and Hydrosult revised final report*

Hydrosult found that all sub-basins are deficit [Hydr: 15], but some are 'dry' whilst others could potentially be brought back towards balance if full modern irrigation techniques were applied. However, the situation is deteriorating rapidly, and urgent action is required if the aquifers are to recover even partially.

**Water balance for each sub-basin**

| **Sub-basin** | **Sub Basin Name** | **Water balance ($Mm^3$) Traditional/existing irrigation system** | **Water Balance ($Mm^3$) Modern irrigation system** |
|---|---|---|---|
| 1 | Wadi Al Mashamini | -0.04 | 0.0 |
| 2 | Wadi Al Madini | -2.36 | -0.5 |
| 3 | Wadi Al Kharid | -1.51 | -0.3 |
| 4 | Wadi Al Ma'adi | 0.00 | 0.0 |
| 5 | Wadi A'sir | -0.18 | -0.1 |
| 6 | Wadi Kulaqah | -0.77 | -0.2 |
| 7 | WADI Qasabah | -2.57 | -1.5 |
| 8 | Wadi Al Huqqah | -13.24 | -7.0 |
| 9 | Wadi Bani Huwat | -52.20 | -32.5 |
| 10 | Wadi Thumah | -0.52 | 0.0 |
| 11 | Wadi As Sirr | -24.59 | -13.6 |
| 12 | Wadi Al Furs | -9.49 | -5.7 |
| 13 | Wadi Al Iqbal | -19.32 | -10.7 |
| 14 | Wadi Zahr & Al Ghayl | -7.46 | -0.9 |
| 15 | Wadi Hamdan | -2.90 | -2.1 |
| 16 | Wadi Al Mawrid | -34.00 | -30.4 |
| 17 | Wadi Sa'wan | -10.26 | -5.9 |
| 18 | Wadi Shahik | -3.64 | -0.2 |
| 19 | Wadi Ghyman | -2.87 | -0.6 |
| 20 | Wadi Al Mulaikahy | -2.83 | -1.4 |
| 21 | Wadi Hazayaz | -1.57 | -0.5 |
| 22 | Wadi Akhwar | -0.40 | -0.1 |
| | **Total** | **-192.7** | **-114.2** |

*Source: Hydrosult 2:84*

Aquifer levels

Hydrosult record drops in the aquifer levels as follows:

| Aquifer type | Average Drop | Since |
|---|---|---|
| ▪ Alluvial aquifers | 3.4 m | 1973 |
| ▪ Volcanics | 51.2 m | 1985 |
| ▪ Outcropping Tawilah sandstone | 141.0 m | 1993 |

*Source: Hydrosult: 7*

Recoverable storage

Hydrosult original estimates of recoverable storage from the sandstone aquifer varied widely from previous estimates.

As a result, the AOPP team carefully checked the study data methodology, data and findings.

Estimation of recoverable groundwater storage should specify minimum and maximum expected values, and always base findings on minimum values for planning purposes.

At the time of report writing (June 2010), Hydrosult is recalculating the estimates of total and recoverable storage.

At present, Hydrosult data and the related model represent an input to a planning process. That process should then complete data collection and build simpler models than that developed by Hydrosult. These simpler models can then be used by NWRA planners to work with communities, WUAs, local councils etc. at the local level.

**Recommendations**

Despite reservations about some findings, basic data required to start to build the picture are available. Those data are presented in Hydrosult , SAWAS and JICA reports. Based on successful experience at Ibb, Al Hougalah, and Habeer in developing simplified models and using them for planning purposes, the following steps could be followed in water resources assessment for the Sana'a basin:

> Simple geological, hydrological, hydro geological and water use models should be constructed by a planning unit. Constructing these models will give a clear picture about the strength and weaknesses of the data and any gaps.
>
> Systematic data collection across the basin is then required. This includes all basic data: rainfall, water levels, water quality, aquifer characteristics etc.
>
> The data need to be systematically fed into the models, and then the results evaluated. During this process, new questions will inevitably arise, and further data can then be gathered.

After an iterative process over twelve months, substantive conclusions will begin to emerge.

Communities, WUAs, local councils etc. at the local level should be involved at all stages, including in monitoring and the development of the models, so that these can feed into management strategies at the sub-basin level.

Given the top priority of ensuring urban water supply, four key areas should be assessed in the first round of planning:

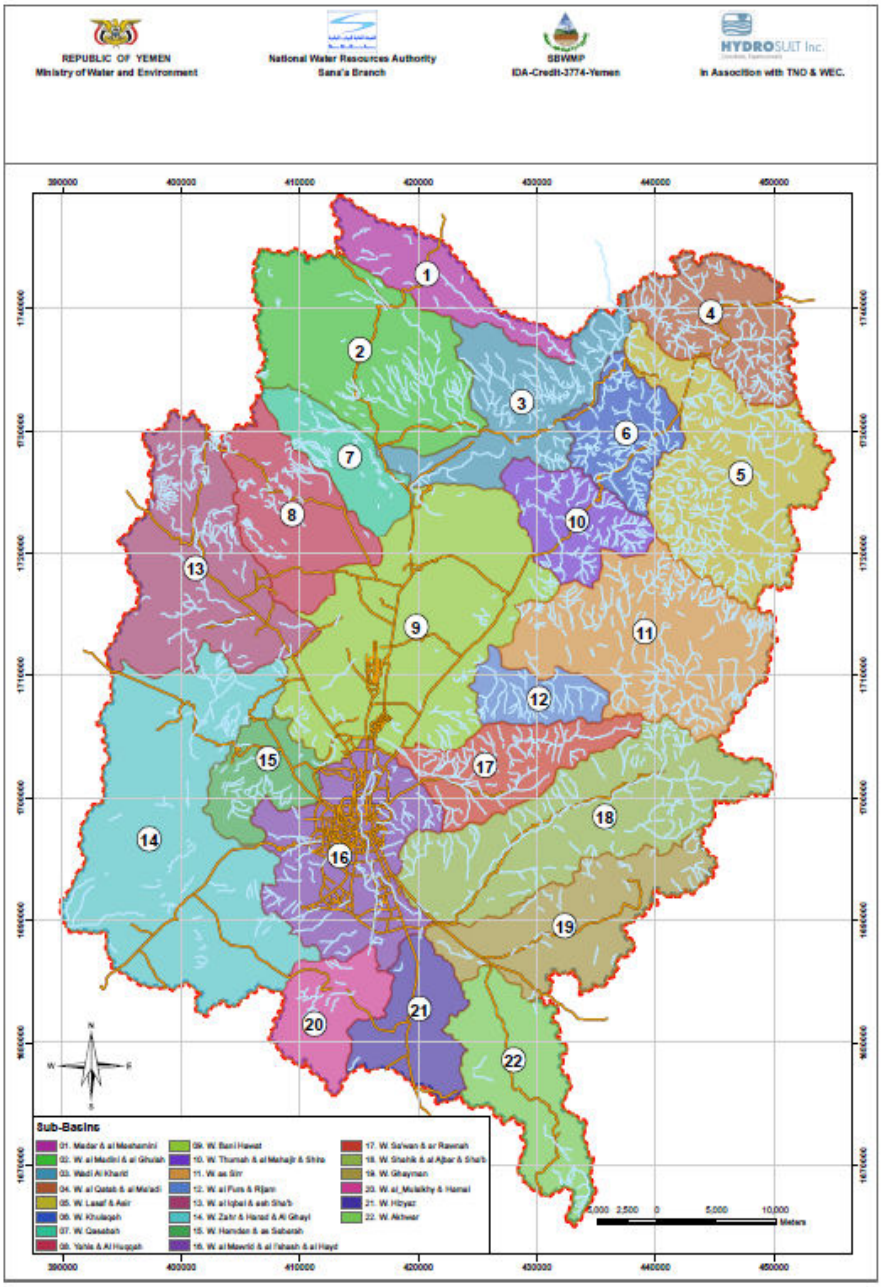
1. The remaining potential of the western and eastern LC well fields.

2. The urban supply potential of the deep sandstone aquifers starting with the central part of the aquifer in Nukum, Al Sabeen and Aser areas.

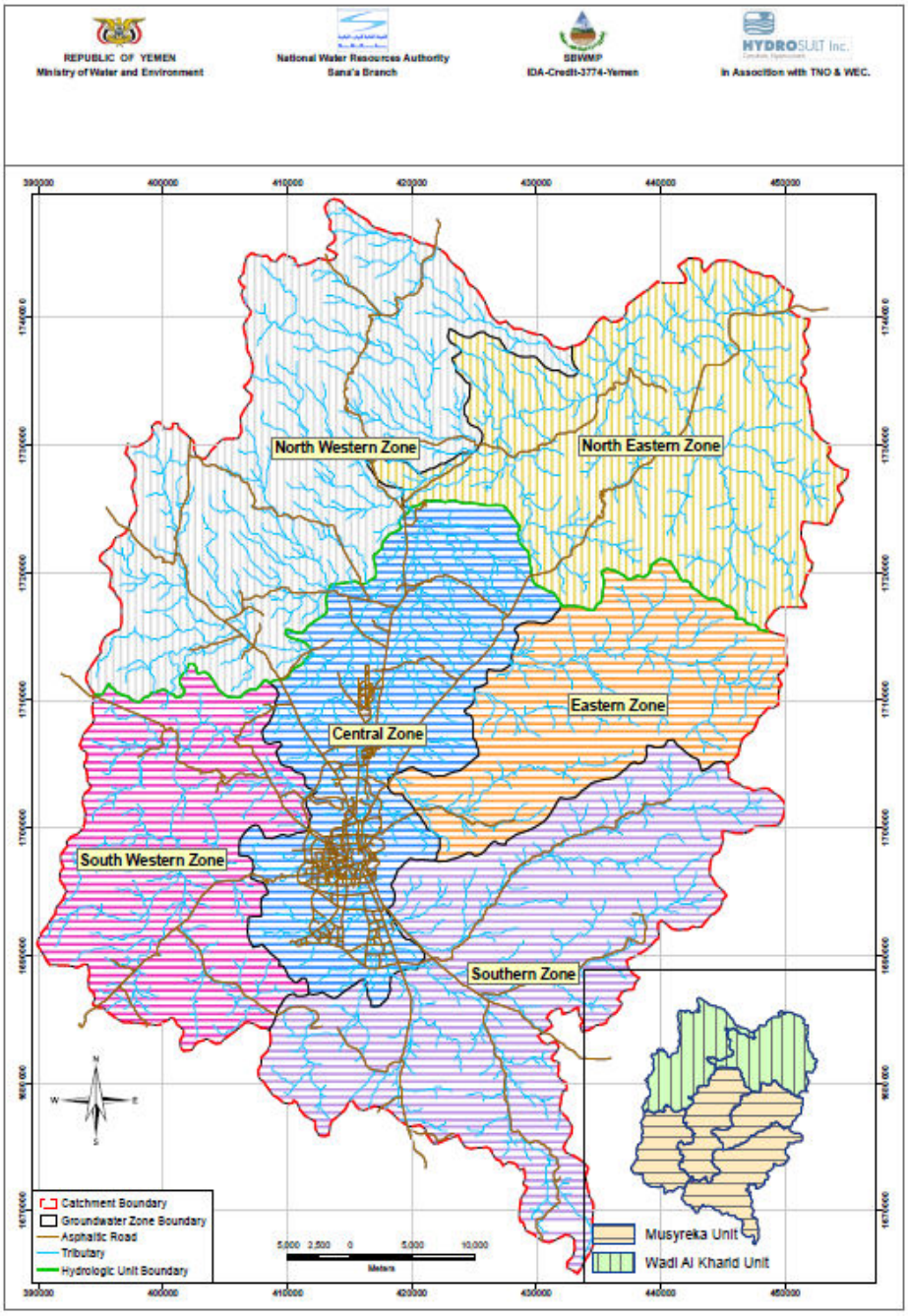
3. The potential of the deep sandstone in both the new and promising Al Swbahah area in the south west of the basin, and in the southern and southeastern edges of the basin. Deep geophysical investigations as well as deep exploratory drilling will be essential for future planning.

4. The hydrological case for reducing agricultural irrigation in the western LC well field, together with the regulatory and incentive package that could achieve this. As this zone is already part of the capital area, this may make things easy to resolve by negotiation e.g. by encouraging conversion of agricultural land to settlement, or by converting agricultural wells to licensed and regulated urban water supply.

**Major Wadi sub-basins (after WEC, 2001)**



**Hydrological units and groundwater zones within the Basin (after WEC, 2001**



## 332 Monitoring

- Despite considerable SBWMP investment, monitoring is almost at a standstill.
- Radical strengthening of capability is essential, and partnerships to collect and share data need to be developed.

WEC/NWRA conducted a well inventory in 2002, finding 13,425 water points. In 2007, NWRA-SB inventoried 212 wells selling water to the urban consumption market. Based on evidence of random well drilling since 2002, the AOPP review estimated that there are now some 14,200 water points in the basin.

NWRA-SB is responsible for monitoring in the basin, through its Studies and Information Department, which has five graduate staff and three diploma holders. A 2008 report describes them as 'enthusiastic about their roles' and as having capacity, but suffering from constraints of operating budget.

At the Sana'a branch, SBWMP and NWRA-SB have invested in monitoring for surface water and floods, rainfall, groundwater, irrigation, and water quality. During the Hydrosult study, extensive monitoring data were collected at the sub-basin level, including water quality data, and this allowed the sub-basin water balances to be calculated.

The current situation at NWRA-SB is disappointing. Some of the monitoring facilities are out of order (e.g. only 2 out of 8 automatic rainfall monitoring stations are working). According to the AOPP review, SBWMP provided forty monitoring assemblies to the branch, but 'only four to five of them have been installed'. WUAs and farmers are said to be uncooperative in delivering readings of monitoring stations, and even 'claiming incentives'.

Collection of data from the stations is partial and inadequate. Old NWRA data are hard to locate. A start was made to use satellite imagery for ET monitoring and to estimate cropping patterns and irrigated areas. This approach has not been followed up.

A data base system was set up by Hydrosult and installed in NWRA-SB. A 2008 report stated that the data bank had been built, and mapping was taking place for monitoring of random drilling and other purposes. However, the AOPP review found that the system has not worked since 2007. All but one staff members have left the unit, including the only staff member trained to manage the data base. The server has been out of commission since 2007.

Hydrosult developed and calibrated a highly complex (300 page) groundwater model. No staff member remains in NWRA-SB able to use this model. At time of writing (June 2010), Hydrosult had not yet handed over the model and software to the client.

**Options**

Gathering monitoring data is essential to basin planning and management. Monitoring has not been done properly in the Sana'a basin until now. Monitoring requires a long time series and sound analysis to generate good results. To date, a generally plausible picture is there but the solid conclusion based on monitoring is not. For example: (i) the eastern and southern area extension of the Tawilah deep sandstone aquifer is not known until now; (ii) the recharge estimation is not confirmed by groundwater monitoring; (iii) dry areas in the outcropping sandstone are not marked; (iv) urban and rural water supply abstractions are not measured; and (v) private and industrial groundwater abstractions are not measured. Good lessons could be drawn if monitoring intensified at the sub basin level for at least five years.

Sub-basin monitoring data will be key to the workability of sub-basin planning and monitoring.

Clearly, monitoring is a core function of NWRA-SB, and the branch has to be equipped, staffed and financed to do it. The challenge is how to set up a sustainable and effective monitoring and data gathering and treatment system, especially in the light of the disappointing performance in recent years.

Partnership arrangements could increase the relevance of the data and facilitate collection whilst reducing costs.

**Recommendations**

Set up a monitoring network for all monitoring parameters required for the water balance covering the whole basin and all four aquifers, including installation of the available monitoring equipment with SBWMP and NWRA-SB, plus additional stations. Hydrosult recommended 150 wells to be monitored, plus 14 run-off monitoring stations, plus three stations for waste water flows etc. The focus should be on areas thought to be of importance for urban water supply, and on providing key information to support sub-basin planning and management on a partnership basis. Abstractions for urban and rural water supply should also be monitored.

Strengthen the capacity of NWRA-SB for monitoring, ensure an adequate investment and operation and maintenance budget for monitoring purposes.

Conduct regular follow up satellite surveys to measure consumptive use of water in irrigation, and to track evolution of the irrigated area and of cropping patterns. Update of the satellite study will be useful by 2012. The study should include also the change of the irrigated areas between the period of 2006 and 2012 or 2014 as well as the cropping pattern changes.

Develop partnerships for monitoring, particularly with WUAs. WUAs could be involved in collecting and analysing information jointly with NWRA-SB, the information could be used to monitor and further develop sub-basin management plans (see Section 334), and WUAs, local councils and NWRA-SB could develop simple groundwater maps and models. If this can be done at sub-basin level, it will strengthen the sub-basin planning and management approach.

The use of schools and schoolteachers to collect primary data is common in other countries. This could perhaps be examined as a way of reducing costs in the basin. Local councils might also be encouraged to play a role.

## 333 Regulation

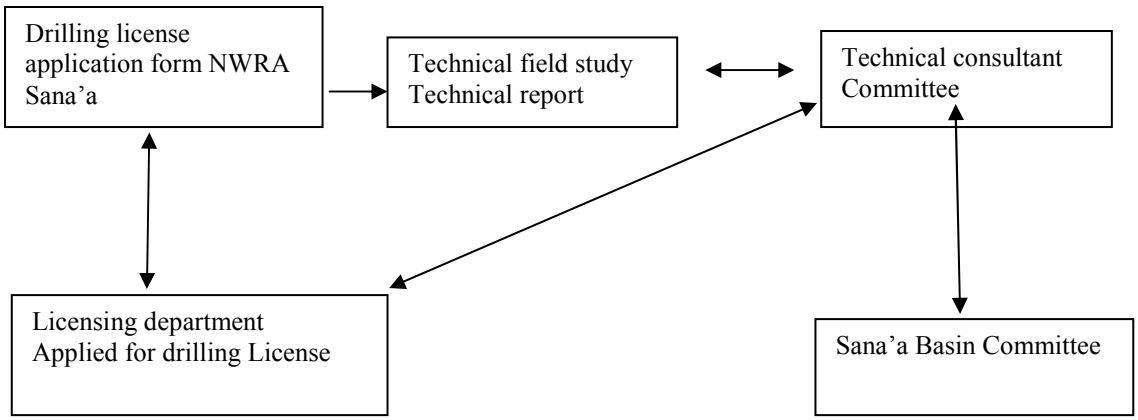
- Regulation of random drilling and drilling rigs has not slowed down the proliferation of illegal wells.
- Approaches that rely on a well spacing rule of thumb and on community responsibility for regulating within their own area would be simpler and would place less burden on NWRA.
- Formation of a professional drillers' association could help promote self-regulation.
- NWRA-SB could also focus on controlling the half dozen deep drilling rigs that could compromise the deep sandstone aquifer.

Well licensing[15]

For well licensing, NWRA-SB has a licensing and water rights department. There is a system for licensing – see flow chart below.

However only a few new wells have been registered, whilst drilling of illegal wells proceeds apace: 106 legal wells were registered 2005-9, whilst *614 illegal wells were recorded*. Registration of existing wells has not started, and no well is yet metered.

**System for issuing licenses in the Sana'a basin**




Drilling rigs

In the Sana'a Basin, drilling firm registration is done directly by NWRA HQ, whereas in other NWRA areas, the branch is responsible. Satellite tracking is supposed to be in operation, but this has not reduced the scale of violations, which are often quite blatant. At one point, three rigs were drilling separate illegal wells at Grban in Hamdan, all within clear view of the main road. In 2007, 141 violations were notified, just two cases were referred to the courts, and 'so far no action has resulted'.

[15] For a discussion of the legal framework underpinning regulation, see Section 231.

Water rights

Despite the requirement under the Protection Zone decree that all wells and pumping quantities should be registered within one year, water rights registration has not started in the Sana'a basin.

A study *Policy and procedures for national water rights management and administration* was prepared under the project in 2006, but recommendations have not been implemented.

**Options**

Throughout the AOPP review, it was clear that illegal drilling is the number one concern of all parties, and this was amply confirmed at the ***Conference***. It seems that top down regulation is having only a very limited impact, and that the situation is generally out of hand. The NWRA Chairman mentioned that the President had intervened to forbid illegal drilling in Ibb but that even this top level intervention had not slowed the proliferation of unlicensed wells. The legal framework, political support and technical capacity for NWRA to assess the case for issuing a licence objectively and without pressure or corruption are not present. Violators – especially powerful ones – walk free. Consideration might therefore be given to approaches that depend more on community responsibility rather than on a frail and under-powered technical agency.

Amran basin stakeholders, with technical support from GTZ, have prepared an Amran Basin Water Resources Management Plan (draft 2009) which provides for a simple bottom up process of vetting licences which depends essentially on: (1) acceptance of a minimum 500m space between each well (or 1 km from a public supply well); and (2) burden of proof on the applicant to show that the rule is respected. The process places only light responsibilities on NWRA, which does not have to make difficult judgements about hydrogeology, nor be subject to political pressure or moral hazard. The process also empowers the local authority and the basin committee.

The steps (see Chart 1 attached) include:

1. Neighbours (or NWRA in case of a public well) confirm that the request respects the 500 m (or 1 km) rule

2. The local council is responsible for publicity and for ensuring due process

3. The Basin Committee rules on the drilling application as the ultimate authority

Approaches that rely on a well spacing rule of thumb and on community responsibility for regulating within their own area would certainly be simpler and would place less burden on NWRA. Issuing such regulations could resolve part of the problem of licensing new wells but the approach would need to be adapted for the deepening of the old wells if the spacing is already broken. A flexible approach adapted to each basin or sub-basin is called for.

A similarly bottom up approach has also been proposed in Amran to control random drilling, under which: (1) local people or the local council can protest, reporting violations to the Basin Committee; (2) NWRA and the local security department visit and begin a process; (3) violators wells may be concreted; and (4) offending drillers and rigs are blacklisted. Chart 2 traces out the process step by step.

Both of these options from Amran – as well as the Management Plan itself - are said to have been prepared in a participatory way, creating a more knowledge-based plan, more responsive and practical regulatory measures, and better ownership and adherence.

During the ***Conference***, there was acceptance that regulation should be a shared responsibility between partners, and a ***Conference*** working group on regulation made detailed proposals in this respect, including for a 'water committee' at district level, so as to avoid conflicts that might arise if communities were required to settle conflicts at a lower level. The box below summarizes the recommendations of the ***Conference*** working group.

**Recommendations of Conference Working Group (3) on Regulation**

The group proposed a so-called "water committee" at the district level so as to avoid community conflicts. The procedures proposed by the group were as follows:

a) For License Applications:

- A farmer wishing to deepen a well or develop a new one completes the application form and presents it to his WUA
- The WUA further submits the application to "water committee" at the district that meets and agrees or disagrees, and notes its decision on the application form
- The local council is responsible for publicity and for ensuring due process. The local council and security department sign a minute including the decision of the water committee
- Application to be further forwarded to NWRA Sana'a Branch, which in turn presents it to the Basin Committee

b) To Control Random Drilling:

- Government should formally (through a decree) empower WUAs to play their role in the control of random drilling
- The WUA or any individual may protest to the "water committee" at the district
- The local council intervenes and requests the local security department to stop drilling rig
- NWRA branch begins a process at concerned court
- The local council implements the issued court decision

The following further recommendations were proposed:

- Checkpoints should be required not to allow passage of drilling rigs except with official permit
- All drilling rigs to be quarantined in definite places, so that they cannot leave except when having permit
- To avoid moral hazard, rigs owners should be required to hand over a guarantee
- The Prime Ministerial resolution regarding labelling/tagging rigs should be implemented/enforced

Essentially, the Amran Plan also takes a pragmatic rule of thumb approach to water rights. The Plan effectively recognizes a well as a water right, and encourages the

well owner to defend that right. This practical approach sidesteps all the legal, practical and ethical difficulties of having NWRA assign and enforce rights.

This kind of practical approach is essentially being practiced by some WUAs in the Sana'a basin (see Box).

**WUAs and tribal leaders in Bani al Hareth agree to ban illegal drilling**

In Bani al Hareth district, all WUA heads, under the supervision of the newly appointed head of the local council, have made a tribal agreement to ban random drilling in their district. The agreement has been signed by all the tribal leaders and WUA heads, and endorsed by the higher sheikhs above them.

*Source NI 3-4*

## Recommendations

- Conduct a participatory process to assess whether the Amran approach (modified by the ***Conference*** proposals, see box above) to licensing and control of random drilling could be applied in the rather different conditions of the Sana'a basin, at least in the rural areas. Check the legality of the process. If the outcomes are positive, propose the modified approach to the Basin Committee.

- Sana'a Basin Committee to be responsible for approving well drilling licences and for oversight of regulation. The cost of the drilling license application form (at present Rls 1,000) should increase to at least Rls 10,000, and the fee should go to NWRA.

- For drilling rigs: (i) assign responsibility for registration and follow up to the Basin Committee, supported by NWRA-SB; and (ii) work with the rig owners using carrots and sticks to professionalize them. Professional standards could include, for example: (a) all the drilling companies working in Sana'a basin should have a residential office; (b) each company should employ at least two geologists in each rig etc. A time limit for this 'self-regulation' approach should be given, after which sanctions would be imposed.[16]

- A complementary approach proposed by the AOPP review is to focus top down regulatory controls principally on the few rigs that are capable of drilling into the deeper sandstone aquifer. This is only a handful of rigs and operators (see Box).

[16] At the Conference, there was scepticism about this and the following recommendation, perhaps because of their novel and untried nature. By contrast, the NWRA Chairman felt they were 'worth a try'.

**Controlling the deep drilling rigs selectively**

The idea would be to focus controls on the few deep drilling rigs capable of compromising the deeper sandstone aquifer:

- Abu Meskah (one rig)
- Mansoor Al Dale (one rig)
- Mabkut Al Abrake (two rigs)
- Ali Mubark (one and the other still in the port)

All of these companies are located near to Julat Amran.

One option would be to require that all the rigs be gathered to a yard under the control of BC, NWRA-SB, and the local council.

Alternatively – or in parallel - the rigs could be bought if the company wants to go out of the drilling business in Sana'a basin.

*Source: AH*

- Review bottlenecks and catalyse the process to get the Water Law by-laws passed

- Revive agreed steps from the study *Policy and procedures for national water rights management and administration* as an input to the Presidential Conference on Water (November 2010)

- Water abstraction in Sana'a city should be more tightly controlled:

    - Sana'a city should be announced within Sana'a basin as a restricted zone for water supply only.
    - Gardens in Sana'a city should use only treated waste water.
    - All wells in Sana'a city including the local water supply corporation wells should renew their license yearly with payments linked to the quantity of water produced.

**Chart 1: Procedure for applying for a drilling permit**

*Note: the applicant only has to do the activities in the boxes with a double border.*

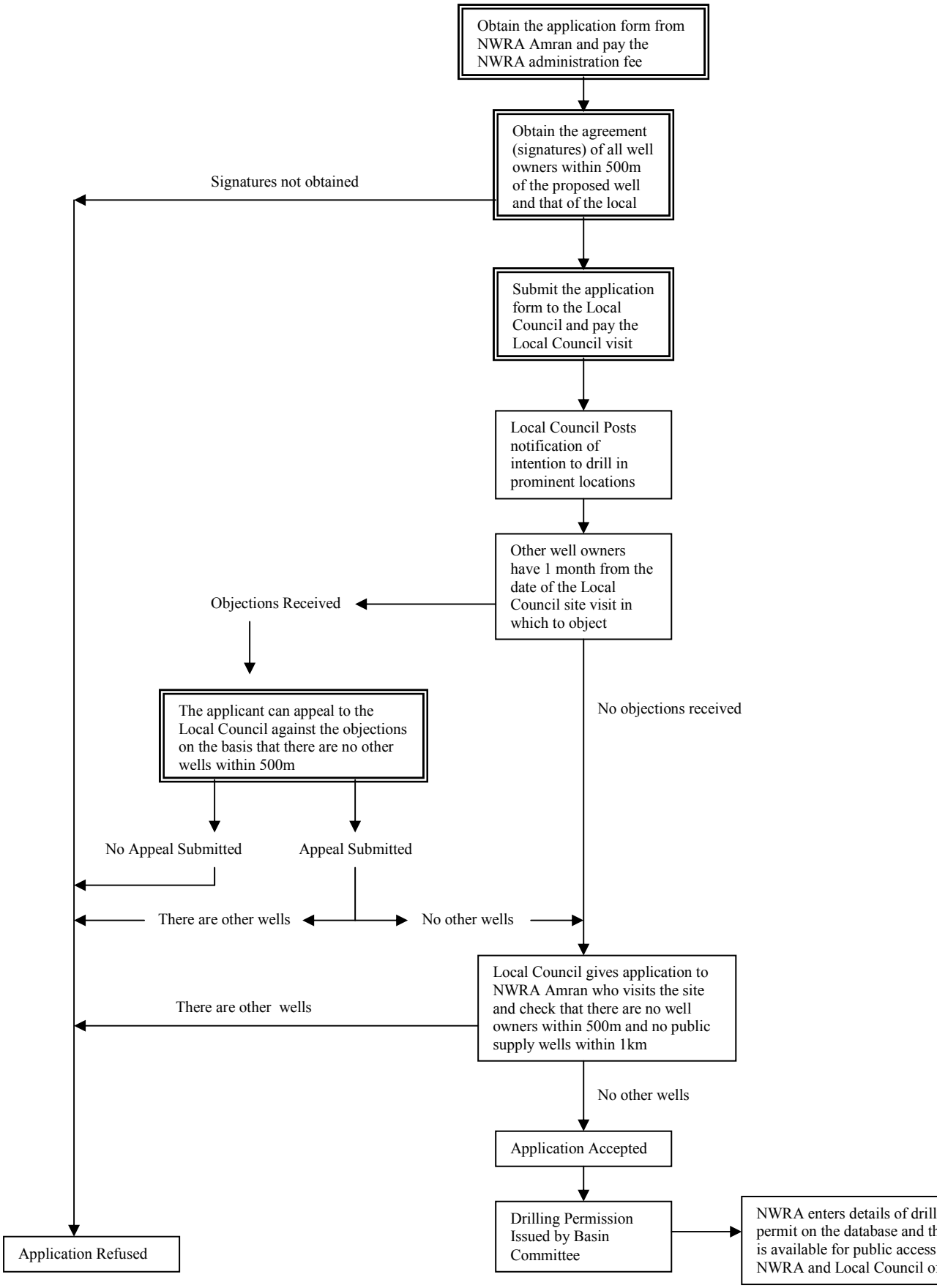
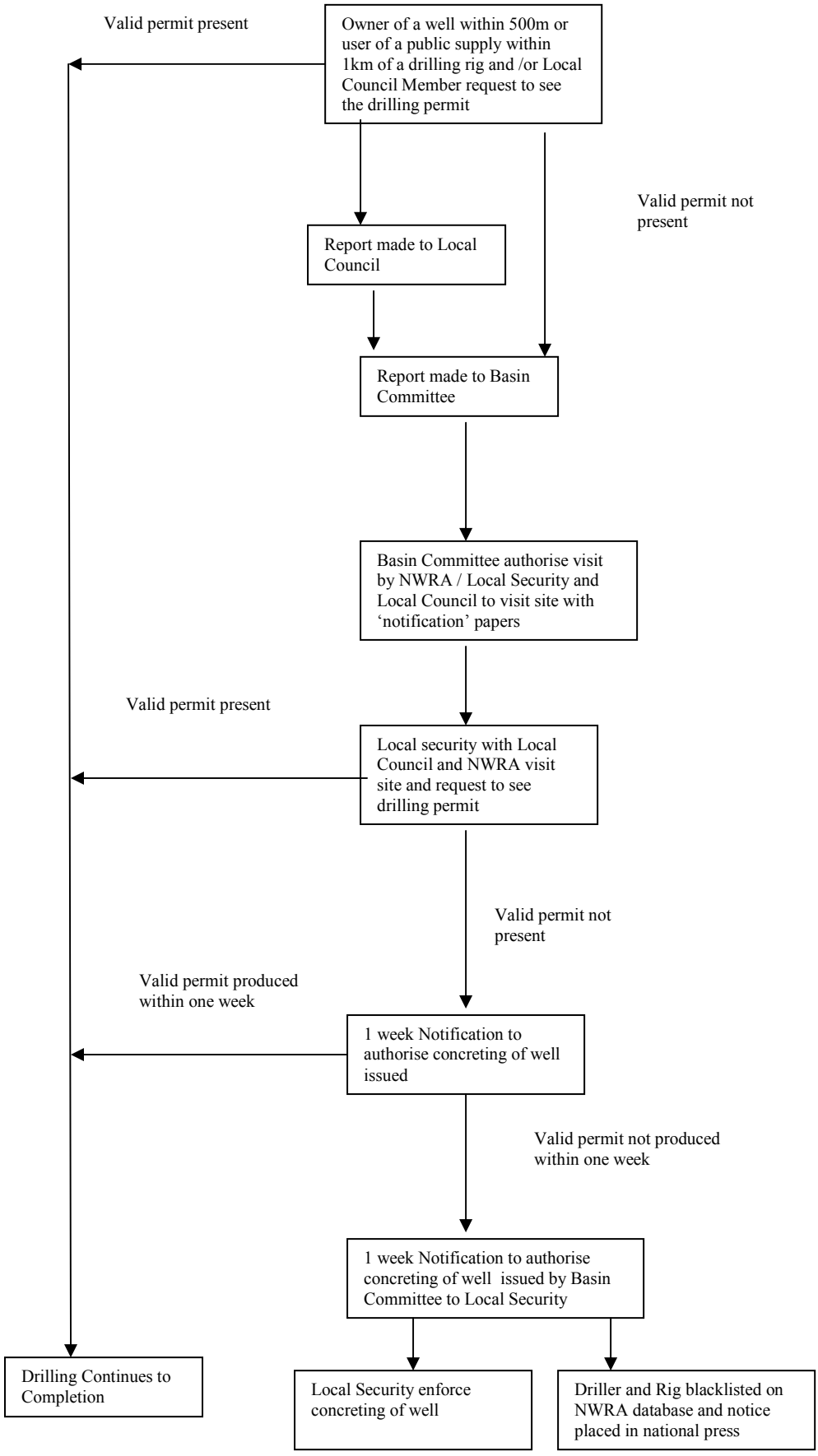


**Chart 2: Procedure for stopping illegal drilling**



## 334 Towards integrated planning and management

- ❖ Clear objectives need to be set for overall basin management, and reflected in detailed plans developed in a participatory way at the sub-basin level, working with stakeholders through the three part governance structure (Basin Committee – local councils – WUAs).
- ❖ A small but powerful basin planning unit needs to be set up within NWRA-SB.

**Analysis**

A draft *Water Resources Management Action Plan* has been prepared (JICA 2007), but this has not been officially adopted. The action plan has not been costed or reflected in annual programs.

Essentially, the IWRM plan in the basin has been the implementation of SBWMP, plus the monitoring and regulation tasks that have been assigned to NWRA-SB. There has been no process to implement the first phase of the long term plan proposed by JICA. Nonetheless, NWRA considers the JICA *Plan* to be the basin plan.

Meanwhile, in other basins, there has been experience in the development and implementation of basin plans. In Amran, for example, a participatory planning model has been adopted that empowers local people, local councils and the basin committee, with NWRA playing a technical supporting role.[17] The experience of Amran and other basins has not been brought together to trace out best practices for basin planning in Yemen.

Integrated basin planning – the heart of IWRM – requires:

- a technical planning function responsible for putting together proposals, and for monitoring implementation and results
- a governance function that brings all stakeholders together to set long term hydraulic and socio-economic objectives, to debate and adopt plans, and to evaluate progress
- a financing and implementation function that translates plans into facts on the ground

The elements of this structure exist – or could readily exist – in the Sana'a basin.

- The technical planning function could be set up within NWRA-SB, provided that the chronic problems limiting the effectiveness of NWRA-SB can be resolved (see Chapter 6 below).

[17] The Amran plan is quite modest, and only addresses two problems: controlling the future investments and growth of groundwater abstraction by controlling drilling; and improving the rural water supply especially for the villages. The challenges of the Sana'a basin are far more complex, and the solutions have to be correspondingly elaborate. Nonetheless, much might be learned from aspects of the Amran plan both in terms of the preparation process and from the practical solutions offered on the two key points of regulation and rural water supply.

- The governance structure could exist in the three part governance structure discussed above (Basin Committee – local councils – WUAs: see Chapter 2.3 above).
- The financing and implementation function could exist in the proposed programming arrangements for the water sector under WSSP, which are intended precisely to provide for the development of financing and implementation plans *at basin level*.

Planning periods could be: (i) the long term plan with a 20-25 year horizon; (ii) a five year 'bite sized' program; and (iii) annual action and investment programs to deliver each annual tranche of the five year program.

At the ***Conference***, a working group recommendation was for a refined concept of protection zone: deep wells to be for drinking water only; and a 'protected agricultural zone' to be set up where no transfer of water to urban areas could take place.

**Recommendations**

- Consider the following sharpened water resource management objectives:
  - Ensure affordable safe water for domestic and industrial use, with the deep Tawilah sandstone aquifer reserved for this purpose
  - Ensure sustainable farm incomes in 'greenbelt' areas reserved for farming
  - Ensure that any transfer of water between uses is done on a win-win basis, and that there is no uncompensated harm
- Adopt a 20-25 year, five year and one year planning time frame, and establish M&E accordingly
- Plan at sub-basin level, as well as for the basin as whole. Data should be split out by sub-basin, published and shared with stakeholders, and used as a tool for participatory planning at the sub-basin or district level
- Adopt different approaches for groups of sub-basins with different characteristics: urban, urbanizing, overlying the deep aquifer, greenbelt/farming area. The deep aquifer should be reserved for drinking water, and certain areas should be declared 'green belt' areas for farming and environmental protection (see also Section 532 below).
- Hold a conference to bring together practice in preparing and executing basin plans in Yemen, in order to draw up guidelines or best practice notes.
- (Preferably in the light of the findings of the above conference), design in detail a planning process along the lines discussed above:

1. Set up a small but effective IWRM basin planning unit in NWRA-SB (see Section 611), assisted by a decision support system and modelling capability, building on the JICA and Hydrosult studies to set water management goals

and objectives and to prepare a long term plan and five year and annual action programmes.

2. Develop the governance function as outlined and design and deliver necessary technical training.

3. Agree with Ministry of Finance and WSSP secretariat on the annual programming arrangements and on how financing and implementation programs can be integrated at the basin level (between NWRA, Sana'a-LC, NIP etc)

**Immediate steps** (next twelve months) could include:

- Hold the proposed conference to establish best practice

- Develop, discuss and adopt the three part planning procedure (technical – governance – financing and implementation)

- Determine what functions and skills are needed, and establish a basin planning department

- Starting from the JICA and Hydrosult studies and working in a participatory fashion, propose water resource management objectives, revise the long term plan, and prepare a five year plan 2011-5, together with an annual programme for 2011, for presentation to the basin committee and to WSSP.

- Develop procedures for integrated planning among:

    - NWRA-SB
    - Sana'a municipality
    - Sana'a LC
    - GARWSP
    - MAI+NIP.

- Conduct the further work on water resources assessment (see 331 above)

- Put in place the needed decision support systems, monitoring and simple modelling.

The Appendix to this section illustrates how sub-basin planning might work.

# Options for a management plan

Drawing on JICA and Hydrosult, the AOPP review drew up options for a management plan. The characteristics of the management plan would be:

1. **Clear objectives**: the plan could be designed to meet three vital and clear objectives of ensuring:

    - affordable safe water for domestic and industrial use, with the deep Tawilah sandstone aquifer reserved for this purpose

    - sustainable farm incomes in 'greenbelt' areas reserved for farming

    - that any transfer of water between uses is done on a win-win basis, and that there is no uncompensated harm

2. **Different approaches for groups of sub-basins with different characteristics**: The strategy could be targeted by being broken down into approaches by groups of sub-basins, for example:

| **Group of sub-basins** | **Priorities and objectives** |
|---|---|
| Urbanized | Aquifer protection |
| Urbanizing | Integrating water supply and sanitation planning into urban planning<br>Win-win transition planning for farmers |
| Overlying the deep aquifer | Protecting the deep aquifer by:<br>- Preventing deep drilling<br>- Incentives and regulation to protect incomes of users of the shallow aquifer |
| Green belt/farming area | Sustainable resource management<br>Maximizing farm incomes<br>Environmental protection |

3. **Separate management objectives and plans for each sub-basin, developed in a participatory way**: Each sub-basin could have its own management objectives and plan, discussed and agreed with the WUAs and the local councils. Table 3 shows the current situation of each sub-basin and the trends. Overlaying on this water information relevant data on urbanization and socio-economic activity would allow the development of sub-basin objectives and plans, ideally in a participatory way.

## Management measures that could be envisaged

**Demand management measures**

- Change to modern irrigation could solve most of the problem of many areas except the present high stress areas (8,9,11,12,13,14,16,17).

- The highest priority of modern irrigation development should be in areas where it is possible to extend the life of the outcropping sandstone for the water supply (13,16,15,17,12,11,8).

- Priority in modern irrigation should also be given to the wadis at the southern part of the basin in order to protect the deep sandstone aquifer for water supply use (14,20,21,22,19,18).

- Treated waste water should also be used for agriculture in certain wadis (8,9,16,12). In 16 it will be used for gardens and recharge, while in the others it will be used for agriculture to reduce groundwater abstraction (JICA, Main table 5.5)

**Protection measures**

- The southern part of the basin should be a highly protected area to conserve the deep aquifer for water supply.
- Control of random drilling should be: (a) bottom up (through partnership with WUAs and local councils); and (b) top down, through partnership and regulation with the drilling companies (see Section 333).

**Supply enhancement measures**

- Check dams are an option for groundwater recharge in certain wadis (14,20,21,22,19,18) in order to reduce the flow of the floods through Al Mawrid wadi, and to increase recharge for the volcanic and alluvial aquifers.

**Current situation of each sub-basin and the trends.**

| Sub-basin | Sub Basin Name | Water Balance ($Mm^3$) Traditional System | What will happen if nothing changes? |
|---|---|---|---|
| 1 | Wadi Al Mashamini | -0.04 | Limestone aquifer already shortage of water supply |
| 2 | Wadi Al Madini | -2.36 | Volcanic aquifer shortage, continuous draw down of water level. |
| 3 | Wadi Al Kharid | -1.51 | Limestone quality problem, shortage of water supply. |
| 4 | Wadi Al Ma'adi | 0.00 | Al ready shortage of water supply |
| 5 | Wadi A'sir | -0.18 | Limestone, sandstone, continue the drawdown of water levels. |
| 6 | Wadi Kulaqah | -0.77 | Limestone, shortage of water |
| 7 | WADI Qasabah | -2.57 | Volcanic, shortage of water, continue drawdown |
| 8 | Wadi Al Huqqah | -13.24 | Dry sandstone aquifer (2020) |
| 9 | Wadi Bani Huwat | -52.20 | Quality problem, high stress from water supply and irrigation |
| 10 | Wadi Thumah | -0.52 | Limestone, shortage of water, high drawdown |
| 11 | Wadi As Sirr | -24.59 | Dry sandstone aquifer in 2020 |
| 12 | Wadi Al Furs | -9.49 | Dry sandstone aquifer in 2020 |
| 13 | Wadi Al Iqbal | -19.32 | Dry sandstone aquifer in 2020 |
| 14 | Wadi Zahr & Al Ghayl | -7.46 | High draw down, water transfer for qat irrigation |
| 15 | Wadi Hamdan | -2.90 | dry sandstone aquifer |
| 16 | Wadi Al Mawrid | -34.00 | Dry sandstone aquifer water quality problem, shortage of water supply, high stress for the deep sandstone aquifer |
| 17 | Wadi Sa'wan | -10.26 | Dry sandstone aquifer in 2020 |
| 18 | Wadi Shahik | -3.64 | Shortage in the volcanic going deep to sandstone aquifer water transfer for qat irrigation |
| 19 | Wadi Ghyman | -2.87 | Shortage in the volcanic go deep to sandstone, water transfer |
| 20 | Wadi Al Mulaikahy | -2.83 | Shortage in volcanic go deep to sandstone, water transfer for qat irrigation |
| 21 | Wadi Hazayaz | -1.57 | Increase stress by water supply and water transfer for water supply and qat irrigation |
| 22 | Wadi Akhwar | -0.40 | Shortage in volcanic, go deep to sandstone, water transfer for irrigation |
| | **Total** | **-192.7** | |

# 4. Supply management

## 4.1 The problems to be addressed by IWRM approaches

Before introduction of IWRM approaches in the basin, the problem was essentially:

- Demand for water greatly exceeded renewable supply, and new supply options needed to be developed.

## 4.2 The actions during the first phase

Under its Component 2, SBWMP was to undertake 'supply management and recharge improvement'. The component aimed at dam safety and recharge improvements, and at sustainable institutional arrangements for dam safety and recharge systems management. (Hydr: 58)

## 4.3 Analysis – lessons – options

### 431 Recharge structures

- Recharge structures have only recently been completed, and a further monitoring period is needed before investing further.
- At first sight, the progressive construction of a series of check dams starting from the upstream looks a better choice than reservoir dams.

SBWMP rehabilitated and de-silted 11 dams in the Sana'a basin. Most of the structures were completed by the middle of 2009. Monitoring of groundwater levels in selected wells for some completed dams started shortly before the start of rehabilitation. The first results following rehabilitation show that, after floods, downstream groundwater levels rose immediately in the monitoring wells.

Three large recharge bunds were constructed by SBWMP, completed in November 2009. So far they have been dry.

SBWMP made a preliminary evaluation study for the dynamic recharge assessment of the rehabilitated dams (Al Derwish, 2010). The structures are just completed and the dynamic recharge mechanism cannot be evaluated in detail for each structure.

The preliminary evaluation used the available hydrological, geological, hydrological, hydro-geological, social, and agricultural information. It used the available water levels in the dams and ground water levels in order to construct simulation models for each dam and so estimate the silted and de-silted annual incremental groundwater recharge from each dam over the period of 2002-2009.

Using an economic value of water of Rls 250/m3,[18] the study calculated the payback period as:

- For dam construction, between three years (Tozan dam) and 28 years (Thoma dam).

- For desiltation, between one year (Al-Lujma dam) and six years (Thoma dam).

Preliminary findings suggest that:

- Proper monitoring needs to be designed from the start and to be sustained over a long enough period to evaluate results.

- The performance of dams depends on adequate arrangements for de-silting. De-siltation of the dam reservoirs is essential for increasing the groundwater recharge from the dams.

- WUAs are essential to the effective operation and maintenance of the dams.

- There are recharge effects already apparent, but these vary greatly from dam to dam. Direct recharge effects appear in the dug wells of the alluvium aquifer in the monitored sites.

- At first evaluation, construction of a series of check dams is technically a better choice for groundwater recharge than the construction of reservoirs. Check dams increase the chance for groundwater recharge, reduce the negative effect of de-siltation, and minimize the effect of evaporation.

- The economics of recharge structures is not yet clear.
- The construction of a series of check dams in the same wadi should be done progressively, starting from upstream, in order to be able to measure impacts and design lower structures in the series as justified by results.

**Options**

Hydrosult recommended 'promoting artificial recharge, beginning with a 'detailed study' [Hydrosult recommendation, 2.2A, 2.2D, Hydr: 39] [19]

A number of recharge structures have been upgraded or constructed during the project. Unfortunately, they have only just been brought into service, and a longer time series

[18] The cost of cubic meter of water was taken as Rls 250, following the 'cost of cubic meter of desalination water delivered to Sana'a'.
[19] Hydrosult also recommended promoting 'water harvesting, based on ongoing tests' and after a 'thorough evaluation' [Hydrosult recommendation, 2.2E, Hydr: 40.

is needed before valid conclusions about their economic and hydraulic value can be drawn.

In particular, there is a need to document what can be learned about the hydraulic relationships, including any *negative* impact further downstream on production or access to water. There also needs to be further economic and financial evaluation, including more evaluation of benefits in terms of well yields, use of the additional water, loss of value added downstream etc.

At the ***Conference***, the Deputy Minister of MAI stated that MAI is undertaking a study jointly with SFD of the effectiveness of dams.

**Recommendation**

- Monitor the results from the recharge structures for a long enough period (3-5 years) before investing further. The results of the MAI/SFD study should also be taken into account.

## 432 Treated wastewater

- Proper management of wastewater requires careful training and regulation of farmers.
- Safe reuse of effluent from the proposed new treatment plant should be built in from the outset..

**Analysis**

Waste water reuse was not a subject treated under SBWMP. Waste water effluent from the treatment plant (about 16 MCM annually) is of poor quality and not safe for reuse. Most waste water percolates to groundwater untreated from septic tanks.

Despite the unsafe quality, farmers downstream of the treatment plant are using the effluent to irrigate their crops. From 2007, NWRA-SB in collaboration with SBWMP began a public information and extension campaign to convince farmers not to use partly treated wastewater on crops for direct consumption by humans or animals.

**Options**

Hydrosult recommended use of treated wastewater and low quality water [Hydrosult recommendation, 2.2G, Hydr: 40][20]

Clearly, waste water is both a potentially valuable resource and a hazard to the environment, aquifer quality and human health. NWRA-SB, Sana'a-LC, MAI and the EPA need to address the issue in a coherent way. Continuing in the present way will have a severe negative effect on the environment as well as on the health of the people.

[20] Hydrosult claims 'the issue is public acceptance', which is doubtful. There is considerable material on wastewater reuse, after many conferences. JICA 2-6 has a summary.

## 433 Other potential sources

- ❖ Rapid economic review of rooftop rainwater harvesting is suggested.

Rooftop rainwater harvesting is feasible technically. In Taiz, rainwater harvesting facilities are mandatory for new construction in the city. However, rainwater harvesting may not be viable in the drier parts of the basin (< 250 mm). [2.6B]

- ➢ Rapid economic review of rooftop rainwater harvesting is suggested. This should involve the Local Corporation and the municipality. One important aspect is the economics, given the low rainfall (200-300 mm). The review should look at global experience, which generally suggests a cut-off point of 250 mm. The review would need to be very specific about feasibility, and also about what are the measures would need to be taken.[21]

[21] See discussion at UWSS PSIA Chapter 14.

# 5. Demand management

## 5.1 The problems to be addressed by IWRM approaches

The problems to be addressed by IWRM approaches were the heavy use of irrigation water in the basin, which was rapidly depleting the aquifer. Irrigation water demand had increased rapidly, much of it for qat. At the same time, Sana'a city is the third fastest growing city in the world (population in 2010 of 2.2 million, using 58 MCM [3.4C]) and was requiring more and more water. Demand needed to be managed in a practical way, preferably in a win-win way, so that water was saved for higher value urban use but farmers did not see their incomes drop. In addition, water supplies for urban consumption needed to be made available in a way that did not harm the interests of farmers.

## 5.2 The actions adopted under the first phase of IWRM

Under its Component 1, SBWMP was to achieve water savings by increasing water use efficiency in irrigation through subsidized modern systems and equipment on 4,000 ha, combined with (1) community based management through WUAs; and (2) training and extension, organized with MAI. (Hydr: 58)

## 5.3 Analysis – lessons – option

### 531 Irrigation improvement

- Improved irrigation allowed farmers to use 40% less water whilst increasing incomes by 10%.
- Irrigation improvement needs to be factored in to sub-basin plans – but only where economically justified.
- Future organizational arrangements must preserve the integrated approach of water resources management coupled with irrigation improvement and extension.

<u>Knowledge gains under the project</u>

SBWMP has made considerable advances in understanding of irrigated agriculture in the basin:

- Agricultural water use has been quantified as 221 MCM annually on 18,953 ha (= 11,700m3/ha).
- Cropping patterns have been documented.

- ET has been calculated through satellite imagery interpretation.

- Qat is the major irrigated crop in the basin which has an irrigated area of 11,471 ha (60% of the total area). Qat is, however, not a very high water consuming crop (ETc for qat is 840 mm), and accounts for less than half of basin irrigation water consumption (47%).

- Irrigation efficiencies have been calculated for traditional irrigation - and they are low.

Demonstrated effects of modernization

The project has demonstrated that irrigation modernization effects tremendous water savings – about 40%.

Piped conveyance was found to have reduced water use by 3,175 m3/ha, and localized on-farm systems to have reduced use by an average of 5,140 m3/ha. These reductions are greater than those measured for comparable investments under GSCP (see table below).

Pipe conveyance was found to bring efficiency up to 60%, modern irrigation networks up to 80-90% (drip = 90%, sprinklers= 80%). Both investments taken together were found to result in a combined efficiency of 70-75 %. These results are broadly comparable to those obtained under GSCP (see table).

**Comparison table of water savings under modern irrigation systems between SBWMP and GSCP**

| Type of system | SBWMP | | | | GSCP | | | |
|---|---|---|---|---|---|---|---|---|
| | **Water savings ('000 $m^3$)** | **Area (ha)** | **Water saving ($m^3$/ha)** | **Efficiency %** | **Water savings ('000 $m^3$)** | **Area (ha)** | **Water saving ($Mm^3$/ha)** | **Efficiency %** |
| Conveyance pipes | 9,907 | 3,120 | 3,175 | 60% | 30,119 | 19,198 | 1,569 | 70% |
| Localized on farm system | 8,671 | 1,687 | 5,140 | 80-90% | 2,698 | 598 | 4,512 | 80-90% |
| Total | 18,578 | 4,807 | | 70-75% | 32,817 | 19,796 | | 75-80% |

Very importantly, SBWMP has apparently demonstrated that farmers can get more income per drop – *participating farmers pumped 40% less water and still increased their incomes by 10%.* However, this finding is based on a small sample of farms and crops.

Reported annual savings of water from irrigation efficiency improvements supported by SBWMP equal 18.6 MCM annually from 4,807 ha.

In line with JICA estimations, the AOPP review found that if all 18,953 ha of irrigated area in the basin were modernized, savings from the whole basin could theoretically be 73.2 MCM annually. Irrigation water use might drop from 221 MCM to 148 MCM, and some sub-basins might return to living within the annual recharge.

Because many WUAs received training and installed their own systems, farmers and WUAs have acquired skills that can be used not only in maintenance but also in contracting to third parties.

Farmers attitudes to water conservation under the project have been on the whole positive. The SBWMP baseline survey (2005) showed that they are: (1) willing to adopt water saving technology and are willing to share the cost; (2) not keen to change their cropping patterns unless it increases their revenue; and (3) not keen on water sales or water trading, as they see it as a threat to their access to water and possibly making water more expensive.

**Analysis**

Results are incomplete

- There is a need for a beneficiary impact survey to determine what farmers think of the improvements, whether they will adopt them without subsidy, what they do with the extra water, whether they are changing their cropping patterns, whether yields have improved etc. At the ***Conference***, there was considerable discussion about the extent of water savings and benefits. The Secretary General of the Bani Hushaish district said that, despite some successes, improved irrigation was a 'failure on qat and grapes'. He also said that 'the well on the extension farm dried up'. By contrast, the chairman of the Al Mahdil WUA said that 'new irrigation is working well on grapes, peaches and qat'. A farmer chipped in: '*The benefit from irrigation networks is in the books only. It does not show in reality*.'

- There is a need to gather and analyse data to verify the extent of 'real water savings' i.e. what is the reduction in non-beneficial ET. Satellite imagery to measure ET needs to be employed on a regular basis in order to track water consumption, changes in cropping pattern etc.

- There is eternal doubt about what happens to the 'saved water'. Evidence from SBWMP is incomplete as to whether farmers simply expand irrigation on qat, or sell the water elsewhere, or whether the water is actually conserved in the ground. There is no monitoring data to show that groundwater levels have revived or fallen less slowly in areas where modern irrigation has been installed. On the other hand, in some areas (e.g. Bani al Hareth) aerial photography confirms that irrigated agriculture is already at its limit – there is no further land to irrigate. Still, the question remains, where is the 'saved water', and who will use it?

- There is a need to update the analysis of the costs and benefits of saving water by sub-basin or groups of sub-basins, and to input the results to future strategy.

Institutional arrangements for the future are a challenge

- With the end of SBWMP, planning and implementation of irrigation improvement has been transferred to NIP, separated from integrated water

resources planning and from institutional support to WUAs. This creates a risk of fragmentation and loss of the integrated approach.

- NIP plainly has a key role to play in water resources management improvements in the basin, but its programs need to be integrated with the overall basin WRM program.

- In addition, key operational linkages between NIP, extension and WUA development and support need to be strengthened substantially.

- Irrigation extension services are needed in line with the use of modern irrigation systems to maximize profit and save more water. SBWMP has recruited and trained dedicated irrigated agriculture extension workers, and ten of these have been working with SBWMP. This human capital needs to be conserved and further deployed. The future of these extensionists and their relation to NIP are in question. At the ***Conference***, MAI's Director General of Extension and Media complained that SBWMP had worked too independently, and could have saved effort by adopting materials etc. available within MAI.

- One side impact of SBWMP (and GSCP) has been to depress the local manufacture of irrigation equipment, which is reported to be higher price and lower quality than that imported under SBWMP. The chance of creating a vibrant local manufacture industry that would ultimately offer an appropriate range of quality and prices has been foregone.[22]

<u>The water resource conservation and economic justifications for subsidized irrigation improvement need to be clear</u>

- The water resource conservation and economic justifications for irrigation improvement need to be worked out in relation to overall WRM objectives

- Public subsidised programs for WUA development and water saving through irrigation improvement need to be justified and planned on a sub-basin basis with:

  (i) a clear idea (and economic evaluation) of what the water is being saved for (e.g. for agriculture, or for urban supply) and how it will be actually conserved for that use

  (ii) particular measures taken in the key areas for future urban water supply

  (iii) an assessment of the prospects of sustainability of irrigated agriculture in the sub-basin (e.g. a sub-basin that will be 'dry' in ten years may not justify investment in modern irrigation technology).

[22] See for example cases in India where subsidized projects have crowded out local competition. Also cases from Niger where public programs have set objectives of promoting competitive local industries.

**Recommendations**

- Immediately, carry out: (1) beneficiary impact survey; (2) verification of 'real water savings'; and (3) update of the economic and financial analysis.

- Review feasibility of phasing out the subsidy on irrigation equipment, combined with promotion of local manufacture and repair industries for irrigation equipment. Following this review, clarify policies with a view to strongly promoting unsubsidized adoption of efficient irrigation, through demonstration, extension, media, training of technicians, identification and removal of any obstacles to private suppliers, and try to shift norms and attitudes so that "inefficient" irrigation is seen as wasteful and harmful, as well as missing an opportunity to reduce costs and raise profits.

- Sharpen the strategic focus of the basin plan and NIP programs by linking irrigation improvement to sub-basin planning:

  - in sub-basins where the aquifer is extremely stressed and has a short life expectancy, it may not be worthwhile to invest in irrigation improvement
  - where the medium term future is urbanization or conversion to urban water supply, it may not be worthwhile to invest in irrigation improvement
  - where the aquifer is resilient if management measures are applied and there is a long term future for agriculture, investment in improved irrigation is likely to be a good investment

- Develop a mechanism that integrates within the overall basin planning framework: (a) planning by sub-basin; (b) delivery of irrigation improvement (through NIP or otherwise); and (c) support to WUAs. Ideally, NIP could adopt the 'SBWMP model', with its integrated approach.

- Strengthen research and extension on irrigated agronomy and water management and link it to the NIP irrigation improvement programme, so that farmers receive not just pipes but a transformational technical package, including advice on changes to less water intensive crops. Consideration could be given to WEC, perhaps with AREA, becoming a specialist training centre for irrigation management. [Bruns 64A, 64D]

## 532 Meeting urban water demand

- Planning and regulation must reserve the deep Tawilah Sandstone for domestic supply.
- The Local Corporation, private providers and GARWSP should work together to ensure affordable and sustainable network water for the whole population of the basin.

Urban water demand was not a direct consideration under SBWMP, although the entire program is based on the proposition that water saved in agriculture will extend the availability of water for urban use. Effectively, meeting urban demand equitably and sustainably without harming farmers should to form part of Sana'a Basin water resource management plans.

Water demand and supply

Sana'a is the third fastest growing city in the world

The Local Corporation (LC) supplies only half of the city's water needs. Although connection to a network is the most cost-effective and pro-poor option, Sana'a LC can expand networks only slowly due to high cost and shortage of water sources. Over the period up to 2015, the LC will invest to increase household water supply connections from 91,000 to 150,000 (and sewerage connections from 81,000 to 120,000). However, due to rapid population growth, this will only take coverage from 50% up to 55%. Most of the new connections will be in the south of the city, ending at the 50 m Road.

As the network expands, Sana'a LC plans to increase water production from current 25 MCM up to 52 MCM by 2015.

Private supply fills the gaps but is high cost and unregulated. A recent WEC study: *Analysis of Private Water Providers in Urban and Peri-Urban Areas in Sana'a: Field Survey of Service Providers* (Dr. Bilkis Zabara et al) shows the considerable potential of private supply for partnership and growth.

Taken together, pubic and private supply currently equal 50-60 MCM, equivalent to annual recharge in the basin.

Sources

LC develops and manages its well fields using its own specialists, but under licence from NWRA, and LC shares its information with NWRA.

LC is experiencing multiple problems of unsustainable sources (annually 10 wells go into the service and 6 wells go dry).

Farm wells are supplying urban fringe areas and the tanker trade.

**Options and recommendations**

Equitable, efficient and sustainable mechanisms for giving the LC access to water need to be worked out whilst ensuring that rural livelihoods and the environment are protected.

Sources

- Plan to reserve specific areas and depths of Tawilah for urban supply (see Section 334 above), and apply enhanced protection measures with incentives *in those areas*. This would mean that, in those areas, agricultural pumping would be confined to the alluvials and volcanics, if it could not be eliminated altogether. A socio-economic program to ensure 'no uncompensated harm' to those currently dependent on pumping in those areas for their livelihood would have to be worked out. [Hydrosult recommendation Hydr: 40]

- Stopping random drilling is key. Apply workable regulatory measures (see 333 above), in particular 'encouraging' the drillers, especially the deep drillers, to form a professional association with standards, and to follow agreed guidelines that will protect the deep aquifer reserved for urban use.

- Check 'dry wells' closed by the LC to verify whether in fact the problem is not incrustation or collapse.

- Licence agricultural WUAs and wells in key areas for urban supply, and support them in sustainable management.

Planning

- The Local Corporation and NWRA could work closely together on the aquifer assessment, including for the basin groundwater model. Modelling should prioritize areas reserved for public supply well fields, with continuous collection of data from public well fields. Where GARWSP is active, it too should be involved.

- NWRA-SB and the Local Corporation to plan together for meeting the city's water needs in an integrated way within the basin plan.

- Integrate planning for city water sources and supply into the urban planning process (city master plan)

Water supply

- Develop partnership mechanisms with the private sector, as recommended in the 2010 World Bank/WEC report:

  - Encourage private suppliers to form a professional association, with light (self-) regulation

- Promote public/private partnerships for private network supply, especially in fringe urbanization areas (following the Ibb model, or the 'output-based aid model being piloted at Qabel in Wadi Dahr)

- Factor in the needs of rural areas in the basin for sustainable low cost potable water. Equity of treatment between rural and urban areas is an issue (why should rural people pay more, when they are expected to somehow surrender water?). Cooperation needs to be worked out between NWRA-SB, Sana'a LC and GARWSP. The scope for multi-purpose WUAs (water supply – irrigation – water resources management) should be explored, and this could be a mechanism for further strengthening WUAs.

- Option of irrigation WUAs converting to become regulated water suppliers.[23]

Sanitation

- Action to increase sewerage and wastewater treatment is an environmental and health must

- NWRA needs to plan with the Local Corporation and MAI for wastewater reuse and its regulation

[23] See, for example, the discussion in *Issues in Decentralized Water Management* by Ward and al-Awlaqi 2008

# 6. Moving to a second phase of IWRM

## 610 Budgeting and finance issues

- A basin-level bottom up planning process is proposed for allocating WSSP resources each year.
- An urgent priority is to establish an integrated programming mechanism for the Sana'a basin and to submit a coherent integrated proposal for financing in 2011.

SBWMP closing and future planning and resource allocation procedures

The closing date of the SBWMP has been extended until June 30th 2010. Activities in IWRM and irrigation improvement which are now carried out by SBWMP will be evaluated as part of the Implementation Completion Report of the project.

The lessons learned from the project will provide the basis for the design of follow-up activities.

Current expectations are that NWRA-SB will be responsible for IWRM planning and management, and NIP will be responsible for irrigation improvement. The SWAp financing program, WSSP, is expected to finance the components.

A committee has been established between MAI, NWRA and SBWMP to prepare the transition and to identify the activities to be supported by WSSP. [R1]

WSSP is establishing its annual operating plan process (AOP), and will from 2010 test out a 'bottom up' approach by working with stakeholders on a basin by basin basis.

NWRA-SB financial resources

Over the period 2004-2008, NWRA-SB operating budget rose from Rls 8.6 million ($43,000) to Rls 12.6 million ($63,000). Over the same period, the proportion of the operating budget spent on salaries rose from 65% to 90%. [NW3]

NWRA-SB also received investment support from SBWMP: $25,000 in 2004, $72,000 in 2005, $150,000 in 2006.

WSSP financing

Indicative numbers in the WSSP documents suggest that:

(1) IWRM as a whole is well provided for under WSSP – in total, NWRA is expected to receive $40 million for IWRM activities over five years. NWRA receives $6.8 million under WSSP in 2010 allocations

(2) WSSP 'priorities' include all current IWRM practices except for recharge/watershed management, and public awareness

(3) NWRA-SB was allocated $173,000 of WSSP budget in 2010, to cover the operational cost of its programs.

**NWRA-SB budget under WSSP 2010**

| **Item** | **$ '000s** |
|---|---|
| 'Capacity development' (largely salaries of contract staff and incentive payments | 87.9 |
| NWRIS | 27.6 |
| Basin plan | 20.0 |
| Groundwater monitoring | 5.0 |
| Basin Committee | 10.0 |
| Social mobilization | 7.5 |
| Pilot water saving devices | 5.0 |
| Awareness campaigns | 10.0 |
| **Total** | **173.0** |

## Analysis

Basins that have coherent plans and thought out institutional arrangements for governance, planning, implementation and monitoring will be at an advantage in WSSP negotiations.

There are substantial risks that individual components will slip between the cracks, and that the components financed will not be well integrated into the overall basin management plan

There is a big risk that inadequate financing will be provided, particularly for recurrent costs and for 'soft' activities such as monitoring and capacity building. Some of the 2010 WSSP allocations (see table above) are plainly inadequate ($5,000 for groundwater monitoring, $7,500 for social mobilization).

Experience in 2009 with Netherlands financing, and in 2010 with WSSP financing, is that the existence of substantial donor financing does not easily translate into spendable funds at the NWRA branch level (see Section 235 above, recounting the six months delays in receipt of budget, and the related very low level of actual spending against budget).

## Recommendations

- Arrangements for integrated planning and programming for Sana'a basin under WSSP need to be put in place as a priority.

- A proposal should be prepared by June 30, 2010 for presentation to WSSP for an 'emergency program' to cover July-December, 2010. A full Annual Operating Plan (AOP) for 2011 should also be prepared by the same date.

- NWRA-SB needs strengthening and technical assistance to allow it to develop programs, including AOPs covering not only its own needs but also the basin-side water program. NWRA-SB also needs considerable strengthening to allow it to develop and manage its budgets more effectively.

## 611 Transition issues

- Although SBWMP was intended to develop ideas for a 'Sana'a Basin Agency' responsible for IWRM, the project is closing with no clarity on how IWRM is to be managed in the future.
- The key is to set up a strong IWRM planning function with assured financing and governance and supervision arrangements.
- The location of this planning function should be in NWRA-SB. The creation of the needed capacity will require high level support and substantial resources.

Transitioning implementation at the end of the first phase

With SBWMP support, a coherent first phase IWRM package has been implemented through a well-knit team with ample financing. If the second phase is to effectively build on the first, certain conditions are desirable:

- Clear objectives and a five year plan based on the JICA and Hydrosult studies, including a detailed programme for 2011 (see Sections 334 and 610 above).
- A strong IWRM planning function, with necessary decision support systems (see 334 above)
- Strengthening and support to core functions of NWRA-SB
- Planning and implementation of irrigation improvement integrated with IWRM planning and with support to WUAs
- Strong support to develop the water governance institutions

Even with these measures, risk remains of loss of integrated focus in planning, budgeting and implementation, and of loss of capacity built up.

Some specific transition issues

The public awareness and stakeholder mobilization functions have been located in the project unit, and arrangements need to be made for transfer of these functions and capacities to NWRA-SB.

'Reintegration' of SBWMP staff to NWRA-SB will encounter the problem of discrepancy in salaries. It is hoped that the 'improved standardised incentives system' being designed under WSSP will mitigate this risk.

Arrangements need to be made for the SBWMP vehicle pool and other material assets to transfer to NWRA-SB.

A number of staff, both in the project unit and in NWRA-SB, have been financed under SBWMP, and arrangements need to be made to retain this capacity as appropriate.

**Recommendations**

- Prepare a proposal for implementation of a second phase of IWRM in the Sana'a basin, reflecting all the lessons and recommendations of the AOPP.

- The transition issues of functions, staff and assets need to be covered in the 'emergency program' referred to above (Section 610).

## 612 Future institutional arrangements for IWRM in the Sana'a Basin

What was the original vision for sustained IWRM institutional arrangements?

SBWMP design recognized that IWRM for the Sana'a basin would take a long time to become a self-sustaining process, and that no one institution was able to coordinate the integrated planning and implementation required.

At the time of project appraisal, the agreement was that:

- a 'technical secretariat' would be set up as the implementing arm of the 'Sana'a basin commission', and this technical secretariat would implement the project, and all IWRM actions in the basin.

- NWRA-SB would be responsible for regulation and monitoring

The exact roles envisaged at appraisal for these proposed agencies are not clear, as at times the PAD states that NWRA-SB has the role of 'a basin water manager', whilst elsewhere it says 'the long term idea is to move towards basin water management through the creation of a 'Sana'a Basin Agency'. The 'feasibility and modalities' of a basin agency were to be studied during the early stages of project implementation. [PAD 11, 15]

The longer term vision thus appears to have been that the Sana'a basin commission, together with its technical secretariat, would be converted into the Sana'a Basin Agency, responsible for IWRM in the basin [PAD:11]

The PAD also states that the World Bank would engage for a 15 year term, with three consecutive projects supporting the development of best practice IWRM. The first phase project would test (i) technologies (ii) demand and supply management approaches and (iii) institutional arrangements.

How has the original vision been realized?

Although substantial progress has been made on demonstrating technologies and supply and demand management approaches, the objective of testing institutional arrangements has not been achieved.

There have been substantial changes both in the institutional landscape (NWRA-SB, WSSP) and in the institutional arrangements under the project (no technical secretariat, SBWMP sitting alongside NWRA-SB but reporting to the MWE).

In addition, the idea that subsequent phases would be supported by repeater projects has changed. The World Bank is reluctant to continue in the project mode, and is encouraging the financing of future IWRM activities in the Sana'a basin through WSSP.

**Evaluation**

No progress has been made towards defining or setting up follow-on institutional arrangements for IWRM.

Government's decision is that NWRA-SB will take over full responsibility for IWRM, liaising with NIP which will take over the irrigation improvement component. WSSP will provide the financing.

This decision presents several risks:

- Overall governance arrangements are still weakly defined so it will be hard to keep an integrated vision
- NWRA-SB presents several quite weak aspects that do not qualify it very well for its intended role
- No integrated planning capacity exists
- In the absence of strong integrated planning, WSSP may prove a weak instrument for bringing together individual components
- WSSP financing is allocated in an annual competition, and financing for a sustained long term program of IWRM interventions is not assured

**Recommendations**

- There is a need for a properly staffed and resourced IWRM planning function that can:
  - Set targets, be assured of inputs and financing, program outputs, conduct monitoring and evaluation of results, and be supervised by its governance structures and financiers
  - Take a long term approach, and be assured of stable financing of an integrated plan
  - Recruit and retain good quality staff
  - Be flexible in the face of change
  - Be owned by stakeholders and fit within the Yemeni institutional structure
- Design of the Phase II proposal will need to take account of the risks set out above, and ensure that needed strengthening and mitigation measures are well constructed and amply financed.

# 7. Overall assessment of achievements, challenges and next steps

**The long-term program for water resources management in the Sana'a Basin**

As discussed above (Section 612), the decision at the outset of the first phase of IWRM was to pursue IWRM in the Sana'a basin over a fifteen year period, in three phases, with the first phase essentially designed to develop and test IWRM measures prior to full IWRM implementation in a second phase.

Effective IWRM requires three sets of measures to be in place: (1) technical planning and management measures that accomplish the integrated management of water resources in pursuit of agreed goals; (2) inclusive governance institutions that engage all stakeholders in setting goals and in supporting the management process; and (3) financing and implementation arrangements that enable the efficient translation of agreed plans into action (see also Section 334 above).

This chapter reviews how far the first phase of IWRM in the Sana'a basin has succeeded in putting in place these measures, what are the challenges for the second phase, and what changes need to be made to meet those challenges.

**Achievements and challenges at the completion of the first phase of IWRM**

During the first phase, considerable gains were made in **technical planning and management**. A master plan was prepared (JICA 2007); a water resources assessment, and water balance and models were developed (Hydrosult); monitoring and public awareness functions were established; and the supply and demand management programs demonstrated the technical and economic value of water conservation in irrigation and recharge.

However, if IWRM is to continue into a second phase, significant challenges in technical planning and management remain to be met. There is a pressing need to set up a permanent IWRM planning function for the basin; the master plan still has to be adopted, adapted and – above all – implemented; clear water resource management objectives need to be debated and agreed; and realistic plans (five year plans and annual programs) need to be developed, approved and implemented. In these plans, there is a critical need to link technical programs for water conservation to water resource management objectives, which is not yet the case.

There were also strong gains under the first phase in developing basin **governance institutions**. The Basin Committee has been operational for five years, local councils have played a role, and a very active stakeholder involvement effort has led to the establishment of over 50 active water user associations (WUAs) involving almost 12,000 farm families.

But despite these impressive advances, the elements of the governance structure (Basin Committee, local councils, WUAs) have worked together only imperfectly,

which presents a serious challenge for a second phase. The Basin Committee has not been very effective as the 'supreme water governance authority'. Local councils have played only a modest role in regulation and management. WUAs have been effective in 'project implementation' but have achieved only frail autonomy and have progressed little towards real 'self-management' of water resources at the local level. There is a clear need to empower all three elements of the governance structure by making their decision making powers clear, by articulating the linkages between them, and by intensive capacity building.

**Financing and implementation arrangements** have benefitted during the first phase of IWRM from the easier conditions of a project structure. Financing has been assured through a single integrated project, and a PIU has ensured integrated and efficient implementation. Partnership arrangements were developed for SBWMP to strengthen NWRA-SB, which was equipped for monitoring and regulation. The integrated approach has been facilitated by both integrated M&E at project and basin level by the PIU, and by the integrated approach of supervision by government and donors.

At the end of the first phase, however, these easier conditions are set to change, and little preparation has been made to ensure a transition to sustainable operations in the second phase. WSSP financing of the second phase is proposed, but there has been no action to prepare the programming and budgetary instruments that could maintain an integrated basin focus under WSSP. Government's decision to transfer implementation responsibilities to the mandated agencies creates a significant risk of loss of the integrated basin focus especially in view of (1) the varying track records of the agencies (NIP is new, and NWRA-SB has encountered severe implementation constraints); and (2) lack of structural or hierarchical linkages between the agencies concerned. In addition, much of the implementation capacity created under the first phase risks disappearing if a transition plan is not put in place and financed immediately. Finally, no arrangements are in place to continue integrated M&E and supervision.

**Options and key questions for a second phase**

The AOPP report proposes the preparation of a second phase of IWRM for the Sana'a basin, with specific recommendations to meet the challenges and to manage the risks outlined above.

Regarding **technical planning and management**, the proposal is to (greatly) strengthen the planning function in NWRA-SB to: (i) carry out water resources planning, monitoring and assessment; (ii) prepare and implement or coordinate integrated five year plans and annual programs, integrating all supply and demand elements; and (iii) conduct M&E of achievements against targets.

This proposal will have to meet a very tough criterion: will the technical, human resource and financial support provided be adequate to overcome all the many constraints to building effective institutional capacity in Yemen in general – and in NWRA in particular?

Regarding **governance**, the AOPP proposal is to consolidate a three part integrated and inclusive governance structure (Basin Committee, local councils, WUAs),

supported by NWRA-SB as technical adviser. This governance structure would: (i) decide on allocation and regulation of water resources and their development and uses; (ii) decide on the basin plan and the allocation of financial resources; (and (iii) take responsibility for regulation.

This decentralized and participatory approach is designed to locate responsibility at the appropriate lowest level, in line with good IWRM practice. It faces, however, key questions that will have to find a positive answer if the proposal is to succeed. These questions include:

- Is government prepared to yield authority over (1) water resource allocation; and (2) financial resources to the Basin Committee?

- Is Yemen ready for this level of stakeholder participation?

- Can WUAs, local councils and the Basin Committee really work together to regulate water use? In particular, can they stop illegal drilling?

Finally, the AOPP proposal is to ensure a basin-level integrated approach to **financing and implementation** through: (i) integrated plans and annual programs prepared by NWRA-SB, approved by the Basin Committee and financed by WSSP; (ii) implementation of the plans and programs by mandated agencies strengthened as needed (NIP, NWRA-SB, Sana'a LC, GARWSP); and (iii) M&E and supervision at the basin level by NWRA-SB reporting to the Basin Committee, and by government t and donors under WSSP arrangements. The proposal is also to strengthen NWRA-SB for the 'community participation and social mobilization' and public awareness functions.

The AOPP also recommends that the second phase of IWRM be 'packaged' as a five year 'project' in order to have clear objectives, inputs and outputs, a five year action program, and assured financing and supervision for the entire phase. [***Note***: this does not mean that Phase II will be a project, only that it will be presented as an integrated ensemble and can be 'appraised' as such.]

Clearly, on financing and implementation, the second phase proposal will again have to meet a very high bar which can be summarised in three basic questions:

- Can NWRA-SB really keep an integrated focus for financing, implementation and monitoring and evaluation/supervision without a 'project' vehicle?

- NWRA-SB and NIP have no structural or hierarchical links to each other. As irrigation investment transfers to NIP, will the link between water resources planning and irrigation water conservation weaken?

- Similarly, is there a risk of loss of direction and energy on WUA development and empowerment, as NWRA-SB and NIP may have rather different approaches to WUA objectives.

**Summary**

In summary, the first phase has piloted IWRM approaches in the Sana'a basin, and has demonstrated that many of them can work. However, many adjustments are required if a second phase is to be successful. Most importantly, clear water management goals need to be set, IWRM measures need to be adjusted and made more effective in pursuit of those goals, and the effectiveness of governance structures and implementing agencies (especially NWRA-SB) needs to improve considerably.

This chapter has highlighted the considerable challenges and risks that a second phase will face, in particular the responsibility of the fledgling NWRA-SB to plan and coordinate the full range of IWRM activities within the more fluid conditions of WSSP. A proposal for the second phase is to be prepared. It will have to be judged against stiff criteria.

**Annex 1**

# Sana'a Basin Integrated Water Resources Management

Action Oriented Policy Paper

Presentations to the Project Completion Conference

May 31st, 2010

## 1. Introduction

Developing good institutions and behaviour for sustainable, equitable and efficient water management is a 15 year process

Five years ago, Yemen committed itself to this 15 year process in the Sana'a Basin…

…in three five year phases

Phase I (which was supported by SBWMP and from other sources) is ending….

….now Yemen is preparing for Phase II

AOPP's job was:

- To assess the results of Phase I
- Highlight lessons and make suggestions for Phase II

**Methodology**

- Literature review
- Field visits
- Focus groups
- Key person interviews
- Workshop
- Analysis
- Report drafting

**The AOPP Team**

| **Theme** | **Team member** |
|---|---|
| Participatory approach | Dr Nasser Fadl |
| Water resources | Eng. Abdullah Saleh |
| Irrigation and water supply | Dr. Taha Taher |
| Institutional | Dr. Omar Al-Sakaf |
| Water governance | Eng. Muhammad Sultan |
| Coordination | Christopher Ward |

## 2. Overview of the day

***9.00-10.30***

The AOPP team will make **short presentations on five key topics**

Each presentation will

- Assess the results of Phase I
- Make suggestions for Phase II
- Highlight questions where the team seeks guidance

The key topics

1. Water governance (Mohammad Sultan and Nasser Fadl)
2. Water resources management (Abdullah Saleh Saif)
3. Regulation (Omar Al-Sakaf)
4. Irrigation improvement (Taha Taher)
5. Meeting demand for water supply (Taha Taher)

A **final short presentation** will make suggestions and pose key questions about how to move ahead with design of Phase II (Christopher Ward)

Then there will be time for **questions and general discussion**

***10.30-11.00*** **Coffee Break**

***11.00-12.00*** **Group Discussions**

***12.00-13.00*** **Reporting Back**

***13.00-14.00*** **Summary and Next Steps**

***14.00*** **Lunch**

## TOPIC 1: Water Governance in the Sana'a Basin

Governance – what is it?

- Taking decisions over the development and use of water resources
- Taking decisions over the budget for investment and management of water in the basin

What has happened under Phase I

- The Basin Committee has been established
- Local councils have been involved in water management
- Water user associations have been set up

The following slides discuss each of these three levels of governance in turn.

The Basin Committee

**Evaluation of Phase I**

Sana'a Basin Committee has been very active, meeting frequently (46 times)

Stakeholders are only partially represented: WUAs and civil society are not members. Local councils do not always attend.

In the absence of an agreed basin plan, the Committee's strategic vision is weakened. The Committee lacks authority over financial resource allocation, and authority to enforce its decisions.

Members consequently feel disempowered.

**Suggestions for Phase II**

- Conduct a comparative review of experience in basin committees and basin governance across Ta'iz, Abyan, Amran, Sa'ada and Sana'a.
- Make membership of the Sana'a Basin Committee more inclusive, with WUAs, civil society, women and the private sector (including drillers, water suppliers, heavy water-using businesses).
- The Basin Committee needs to be the supreme water governance authority in the basin, in tandem with local councils as the intermediate line of authority and WUAs as the front line resource managers.
- Basin Committee to be the mandated decision taking body on: (1) the basin plan; (2) the basin annual operating program; and (3) regulation.
- Objectives and operating rules to be revised accordingly.
- Strengthening of the technical support role of NWRA-SB as the adviser and secretariat of the Committee.
- Training of the Committee in its role, and setting up a forum with other basin committees for professional exchanges.

Local Councils

**Evaluation of Phase I**

They are mandated to 'manage and control water resources in their area'

Many councils worked actively with Phase I…..

…..but their engagement has varied

'Powerful violators go free'

**Suggestions for Phase II**

- Empower the local councils to be the intermediate level in local water resource management
  - as the counterpart of WUAs in the district, coordinating with WUAs on local water resource management plans
  - as the front line agency for dispute resolution, particularly for regulating random drilling of wells
  - to implement the law to stop illegal drilling, in partnership with the security forces
  - as a forum for discussion on water issues, and to coordinate awareness raising within the district
- Training and technical support to local councils and staff from NWRA-SB.

Water User Associations (WUAs)

**Evaluation of Phase I**

58 WUAs and 1,149 WUGs have been formed

Of these, 44 are currently assessed as 'sustainable'

***WUAs under Phase I***

| | **Set up** | **Dissolved** | **Active** | **'Sustainable'** |
|---|---|---|---|---|
| Irrigation | 52 | 6 | 46 | 33 |
| Recharge | 13 | 3 | 12 | 11 |
| **Total** | **67** | **9** | **58** | **44** |

There is a proposal to establish a basin WUA federation

WUA capacity and prospects vary considerably:

- there are some progressive energetic ones that can become front line water managers in time (WUAs in Bani Hareth teamed up to prevent illegal drilling)
- some are more passive, set up largely to get project benefits

**WUAs can become 'front line water managers', managing their water sustainably for their children**

*Why would WUAs want to do this?*

- Because WUAs are made up of farmers who own wells and each farmer would like the water in his well to be sustainable

- Farmers by themselves can never solve the problem of depletion…
- …if one farmer saves water, the next farmer may pump it out

BUT

- Farmers working together **can** manage water sustainably

**Essentially most groundwater depletion in the basin is nobody's problem but the farmer's**

**Water resources in most sub-basins in the Sana'a Basin could become sustainable if all farmers worked together in WUAs to solve it**

**What can WUAs do to manage water sustainably?**

All members can agree together to stop unlicensed drilling

All members can agree together about whether a well should be deepened in their area, or a new well drilled, and the WUA's signature could be required on the application for a licence

Wells might only be developed by WUAs as a group, as in Mawiyyah.

All members can agree together to save water by installing improved irrigation and following less water consuming agricultural and irrigation practices

(Maybe) all members can develop and agree their own sustainable management plan for their own local area (sub-basin) – with support from NWRA-SB.

**What would WUAs need to become front line water managers?**

1. A partnership with NWRA-SB for exchange of information and for joint development of a sustainable management plan for the local area (sub-basin)
2. Empowerment through recognition that the WUA is responsible and accountable for managing the water, including monitoring and self-regulation
3. Continuous capacity building for monitoring, irrigation improvement etc.
4. Access to subsidized investment funds to help implement their program

**Suggestions for Phase II**

<u>Empowerment of Sana'a Basin WUAs as front line water managers</u>

- Partnership agreements between interested WUAs and NWRA-SB
- Plans for sustainability at the local level
- Empowerment of WUAs for monitoring and self-regulation
- Support in capacity building and investment as an integral part of a local sustainable water management plan
- About five WUA representatives should sit on the Basin Committee

<u>Suggestions beyond the basin</u>

- Pool experience across basins and develop national 'basin water governance options' and 'national guidelines for WUA establishment and development'.

- Review how to move forward on basin level unions and national federation for WUAs.

- Harmonize WUA training across basins, possibly with one or two training institutions recognized and supported as 'centres of excellence' (Institute of Administrative Sciences, WEC…..)

**So what would basin governance look like if these suggestions were accepted?**

**WUAs:**
- First line of defence for stopping unlicensed drilling
- Approve any new water resource development in their area
- Conserve water through improved irrigation and recharge
- Develop and implement a sustainable management plan for their area

**Local councils:**
- Counterparts of WUAs, coordinating local water resource management plans
- Front-line agency for dispute resolution and implementing the law
- Forum for discussion and awareness in the district

**Basin Committee:**
- Supreme governance body, including representatives of all stakeholders
- Mandated decision taking body on: (1) basin master plan, 5 year plan and annual programs; (2) water resource allocation; and (3) regulation.

**NWRA-SB:**
- Secretariat to the Basin Committee
- Basin and sub-basin planning, water resources assessment
- Drafting of 5 year plan and annual programs, coordinating implementation, and M&E
- Support to governance structure on licensing and regulation.

**Suggestions**

- Review the suggested governance structure in a wide consultation with stakeholders and then prepare a costed proposal for implementation of the agreed structure, including:

  - Any needed adjustment to the legal framework

  - Definition of needs for support for capacity building and empowerment

  - Capability to deliver the needed support to basin governance institutions

**Questions on <u>Topic 1: Governance</u> on which the team seeks guidance**

1. Can authority over water resource allocation be given to the Basin Committee?

2. Can authority over financial resource allocation be given to the Basin Committee?

3. Is Yemen ready for this level of stakeholder participation?

4. What legal and capacity building measures are needed?

5. Can WUAs really be front line water managers and manage their own water resources sustainably?

# TOPIC 2: Water Resources Management in the Sana'a Basin

**Evaluation of Phase I**

The first ever comprehensive water resources assessment has been completed

The water balance has been analysed separately for the 22 sub-basins

A revised groundwater model has been prepared

A draft basin master plan has been prepared (JICA 2007)…

Monitoring networks have been set up and some data is being collected and treated

A data base system has been set up

> ***Thus the essential tools for water resources planning and management have been prepared…..***
>
> ***The next step is to start using them for planning and management***

**What are the challenges now?**

To agree on clear water resource management objectives for sustainable, equitable and efficient water development and use

To set up a small but powerful planning function

To adapt, adopt and implement the basin master plan (JICA)

To translate the master plan (20 years) into a medium term (5 year plan) covering Phase II, and to prepare annual programs for financing and implementation

To integrate all sources and all uses into planning

**Suggestions**

- Consider the following sharpened water resource management objectives:
  - Ensure affordable safe water for domestic and industrial use
  - Ensure sustainable farm incomes in farming areas
  - Ensure that any transfer of water between uses is done on a win-win basis, and that there is no uncompensated harm
- Set up a small but effective planning function in NWRA-SB that would
  - Prepare and follow up on water resources plans and annual programs
  - Manage water resource assessment functions for the basin (monitoring, information and data processing and sharing, modelling)

**Questions on <u>Topic 2: Water Resources Management</u> on which the team seeks guidance**

1. Do stakeholders agree with the suggested water resource management objectives?
2. Can a really efficient planning function be set up in NWRA-SB?
3. How would that planning function in NWRA-SB relate to the Basin Committee? Could the Basin Committee instruct NWRA-SB what to do?

# TOPIC 3: Regulation

**Evaluation of Phase I**

Regulating wells

A clear process for licensing wells has been developed.

However, only 106 wells were licensed 2005-9…

…..while at least 614 illegal wells were recorded.

Regulating drilling rigs

Drilling firms are mostly registered (by NWRA HQ) but control is not effective

Legal framework

The Protection Zone has been set up…..

…..however, key provisions such as 100% well registration within one year have not been implemented.

The water by-laws have been prepared but are not yet approved

**Conclusion from the last five years:**

Regulation will only work if:

- Farmers and WUAs cooperate as the front line water managers
- Local councils work with WUAs and take their responsibility to control drilling rigs and stop illegal drilling
- The Basin Committee is prepared to take the issue of illegal drilling to the highest level
- Drillers cooperate as professional businesses

**Could WUAs effectively ensure more sustainable water management and less random drilling?**

Based on experience elsewhere in Yemen, two simple regulatory processes might be tried in the Sana'a Basin:

A possible simple bottom up process of vetting licence applications:

4. A farmer wishing to deepen a well or develop a new one competes the application form and presents it to his WUA
5. The WUA meets and agrees or disagrees, and notes its decision on the application form
6. The local council is responsible for publicity and for ensuring due process
7. The Basin Committee rules on the drilling application as the ultimate authority

A possible simple bottom up approach to control random drilling:

1. The WUA protests to the local council
2. The local council intervenes to halt drilling

3. NWRA and the local security department visit and begin a process

4. Violators' wells are concreted

5. Offending drillers and rigs are blacklisted.

**Suggestions for Phase II**

The governance structure - Basin Committee, local councils and WUAs - to take responsibility for regulation, including:

- WUAs as the first line of defence: to stop or report illegal drilling

- Local Councils to be the second line of defence, actively supporting WUAs in their struggle and invoking law and law enforcement as need be

- Sana'a Basin Committee to be responsible for approving well drilling licences and for oversight of regulation and for follow up at the highest level

Consult stakeholders to assess whether the suggested simple bottom up approaches to licensing and control of random drilling could be applied in the conditions of the Sana'a basin, at least in the rural areas. Check the legality of the process. If the outcomes are positive, propose the approaches to the Basin Committee.

For drilling rigs, work with the rig owners using carrots and sticks to professionalize them. Professional standards could include, for example: (a) all the drilling companies working in Sana'a basin should have a residential office; (b) each company should employ at least two geologists in each rig etc.

A complementary approach would be to focus both 'professionalization' and top down regulatory controls principally on the few rigs that are capable of drilling into the deeper sandstone aquifer. This is only a handful of rigs and operators, which are big businesses, for whom there could be advantages to cooperate with government in the lucrative business of deep drilling for public wells – and corresponding financial risks for non-cooperation.

Review bottlenecks and catalyse the process to get the by-laws passed

**Questions on <u>Topic 3: Regulation</u> on which the team seeks guidance**

1. Might the two 'simple bottom up approaches' work? What might help?

2. Might the 'professionalization' of drillers work? What might help?

3. And what about the special program for the deep drilling rigs? Might that work? What might help?

# TOPIC 4: Irrigation Improvement

**Evaluation of Phase I**

Pipe conveyance was found to bring efficiency up to 60%, modern irrigation networks up to 80-90%.

Farmers can get more income per drop – *participating farmers pumped 40% less water and still increased their incomes by 10%.*

Annual savings from irrigation efficiency improvements supported under Phase I equal 17 MCM annually from 4,135 ha.

If all 18,953 ha were modernized, savings from the whole basin could theoretically be 80 MCM annually. Irrigation water use might drop from 221 MCM to 133 MCM, and some sub-basins might return to living within the annual recharge.

Farmers and WUAs have acquired skills that can be used not only in maintenance but also in contracting to third parties.

Farmers attitudes to water conservation under the project have been on the whole positive.

**Challenges**

Irrigation water needs to be saved for some purpose: irrigation improvement needs to be economically justified and linked to sustainable water management through sub-basin planning and WUA involvement.

In the future, water resources planning and management, support to WUAs, agricultural extension and irrigation improvement will all need to be done in an integrated fashion even though different agencies may be involved (NWRA-SB, MAI extension, NIP…..)

**Suggestions for Phase II**

- Sharpen the strategic focus of the basin plan and NIP programs by linking irrigation improvement to sub-basin planning.

- Develop a mechanism that integrates within the overall basin planning framework: (a) planning by sub-basin; (b) delivery of irrigation improvement; (c) agricultural extension; and (d) support to WUAs.

- Strengthen research and extension on irrigated agronomy and water management. Could WEC, perhaps with AREA, become a specialist training centre for irrigation management?

**Questions on <u>Topic 4: Irrigation Improvement</u> on which the team seeks guidance**

1. Should irrigation improvement only be subsidized when the WUA signs up to a sustainable management plan for their area/sub-basin?

2. How could the different agencies responsible for irrigation improvement (NIP), extension (Agricultural Office), and promoting WUAs (NWRA-SB) work together, and how can irrigation improvement be integrated into sub-basin planning?

3. How should qat, which covers more than half the irrigated area in the basin, be handled in planning and programs for irrigation improvement?

# TOPIC 5: Water Supply

**Evaluation of Phase I**

Demand and water supply

Sana'a is the third fastest growing city in the world (9% a year)

The Local Corporation (LC) supplies only half of the city's water needs and the network is expanding only slowly

Connection to a network is the most cost-effective and pro-poor option.

Private supply fills the gaps but is high cost and unregulated.

Taken together, pubic and private supply currently equal 50-60 MCM, equivalent to annual recharge in the basin.

Sources

LC is experiencing multiple problems of unsustainable sources (6 wells go dry each year, 10 new ones are drilled), and cost of production is rising fast.

Farm wells are supplying urban fringe areas and the tanker trade

Into the long term, water supply in the Sana'a basin has to come from the good quality water of the deep sandstone aquifer.

**Suggestions for Phase II**

Equitable, efficient and sustainable mechanisms for water supply need to be worked out whilst ensuring that rural livelihoods and the environment are protected.

Sources

- Plan to reserve specific areas and depths of Tawilah sandstone aquifer for water supply, and apply enhanced protection measures with incentives *in those areas*.
- Absolute priority to stopping random drilling into the reserved areas of the deep sandstone aquifer.

Planning

- The Local Corporation and NWRA should work closely together on the aquifer assessment, including for the basin groundwater model.
- NWRA-SB and the Local Corporation to plan together for meeting the city's water needs in an integrated way within the basin plan.
- Integrate planning for city water sources and supply into the urban planning process (city master plan)

Water supply

- Develop partnership mechanisms with the private sector, as recommended in the 2010 World Bank/WEC report:
  - Encourage private suppliers to form a professional association, with light (self-) regulation

- Promote public/private partnerships for private network supply, especially in fringe urbanization areas (following the Ibb model, or the 'output-based aid model being piloted at Qabel in Wadi Dahr)

- Factor in the needs of rural areas in the basin for sustainable affordable potable water.

- Consider licensing agricultural WUAs to become water suppliers, and support them in sustainable management.

**Questions on <u>Topic 5: Water Supply</u> on which the team seeks guidance**

Is there any problem with reserving specific areas and depths of Tawilah sandstone aquifer for water supply? What measures could best help protect this source?

Which of the 'partnership mechanisms' looks most feasible? What are the constraints and how should the authorities proceed?

## Institutional Capacity Needs for Phase II

Phase II implementation would require greatly enhanced institutional capacity, above all in NWRA-SB.

The main areas where capacity needs to be created or strengthened are:

**1. The water resource planning and management function:**

- Planning, programming and follow up
- Water resources assessment (monitoring, information and data collection, treatment and sharing, and modelling)

**2. Providing support to basin water governance:**

- Capacity building and empowerment support to the Basin Committee, local councils and WUAs
- Public awareness

**4. Regulation**

In order for the basin plan to be implemented, this institutional capacity will have to be developed.

### How to Develop that Institutional Capacity

Government's proposal is to build on existing capacity that has been created within NWRA-SB and SBWMP.

This approach would require:

- Careful definition and regularization of functions and of the resources (human, financial, logistical) needed to fulfil them
- A management audit to put in place systems of responsibility and accountability
- Increase in the operating budget matched to the work program
- Recruitment of experienced highly qualified (MSc., Ph.D) staff as managers and department heads
- Improvement in the work environment, procedures, facilities… etc
- Clearly defined partnerships and collaborations with all relevant stakeholders
- Raising staff commitment and effectiveness through performance-based incentives, a thoroughgoing and coherent training program based on a training needs assessment, and conversion from contract to staff status.

**Questions on <u>institutional capacity needs</u> for Phase II on which the team seeks guidance**

1. Are the institutional capacity needs correctly defined?
2. How to overcome all the many constraints to building effective institutional capacity in Yemen?

## Designing and financing Phase II

In order to move from evaluation and suggestions to a workable program, the following steps are suggested:

- Step One: Develop a 'Phase II program document' setting out proposed objectives, activities and inputs, institutional responsibilities and outline costs of Phase II.

- Step Two: Discuss the Phase II document with stakeholders in the basin governance structure

- Step Three: Request government and donor appraisal of the Phase II document, with a view to agreeing five year financing through WSSP.

Annex 2

# Sana'a Basin Integrated Water Resources Management

## Action Oriented Policy Paper

**Outcomes of Completion Workshop May 30-31, 2010**


Summary

The workshop recommended that activities piloted by SBWMP be continued under WSSP, emphasizing the need for agencies to integrate implementation. Recommendations for adjustment including increasing the role of district councils and WUAs in sub-basin governance, simplifying procedures for well licensing and handling violations, tightening regulatory control over drilling rigs, greatly strengthening the Sana'a branch of NWRA, and public-private partnerships for water supply. Issues that may require further discussion include whether to subsidize irrigation modernization for qat, the roles of different organizations in controlling illegal drilling, and what power Basin Committees should have over financial allocation and well licensing.


### Workshop Report and Results

The Sana'a Basin Water Conference held on May 30-31 brought together a range of project stakeholders to review progress and discuss future directions. Participants came from the Ministry of Water Resources and Environment, Ministry of Agriculture and Irrigation, parliament, district councils, water user associations, and universities. A list of participants is attached.

*Topics.* Presentations on the first day covered the basin water assessment study; institutional development and capacity building for local communities and for planning and implementation agencies; raising public awareness; demand management and improvement of irrigation and of recharge, environmental management, and an example of WUA experience. One the second day members of the team preparing an Action Oriented Policy Paper to assess results and make suggestions for a next phase of activities made presentations on water governance; water resources management; regulation; irrigation improvement; and meeting demand for water supply, followed by group and general discussions. Some main points from presentations and discussions are summarized below, and are discussed in more detail in the conference documents and the report from the AOPP Team.

*Governance*. Governance accomplishments include establishing the Basin Committee, involving local councils in water management, and setting up water user associations. While the basin committee has been active, meeting 46 times, WUAs and civil society are not yet included and local councilors do not always attend. There is not yet an agreed basin plan and the committee lacks authority to allocate finances and enforce decisions. It was recommended that local

councils be empowered and given training and technical support to act as the intermediate level in local water resources management, for dispute resolution, discussion, and regulating illegal well drilling (in partnership with the security forces). WUA capacity and prospects vary considerably, some helping prevent illegal drilling and others being more passive, set up largely to get project benefits. Women, who make up half of society, should be more involved. Farmers should work together to manage water sustainably, acting to help stop unlicensed drilling, install modern equipment and use irrigation water more efficiently. WUAs and district councils should be supported by partnership with the Sana'a Branch of NWRA for information and joint development of sustainable management plans for sub basins, empowerment for monitoring and self-regulation, capacity building and investment funding.

*Water Resources Management.* A comprehensive water resources assessment study has been completed, with a monitoring network set up and some data being collected and analyzed. A revised groundwater model was used to assess water balances separately for 22 sub-basins. While there is debate about some aspects of the study, it does provide a framework and starting point for further monitoring and analysis. A basin master plan needs to be adopted, and translated into a five-year plan and annual programs for financing and implementation. This should focus on sharpened objectives of ensuring affordable safe water for domestic and industrial use, sustainable farm incomes, and win-win transfers between uses, supported by a small but effective planning function in NWRA-SB.

A process for licensing wells has been developed, but only 106 wells were licensed from 2005 to 2009, while at least 614 illegal wells were recorded. Drilling firms are registered by NWRA headquarters, but control is not effective. Water bylaws have been prepared but not approved. Conclusions from the last five years are that regulation will only work if farmers and WUA cooperate as front line water managers, local councils work with them to control drilling rigs and illegal drilling, they are supported by the Basin Committee and by the highest level of government, and drillers cooperate as professional businesses. Simple bottom up processes could be tried to for license applications and controlling illegal drilling. WUAs could comment on license applications, with the local council ensuring due process, and the Basin Committee making final decisions. WUAs would report illegal drilling to the local councils, which would halt drilling, and NWRA and the local security departments would investigate. Violators' wells would be concreted and offending drillers and rigs blacklisted. At the same time, NWRA regulation should work to professionalize drillers, concentrating on the few rigs capable of drilling into the deeper sandstone aquifer.

*Irrigation and Recharge.* Piped conveyance systems have raised irrigation efficiency up to 60%, and localized on-farm delivery by bubblers, sprinklers and drip up to 80-90%, enabling farmers to pump 40% less water while increasing income by 10%, yielding water savings equal to 17 million cubic meters per year from 4,135 hectares. If all 18,953 ha were modernized irrigation water use might drop from 221 MCM to 133MCM and some sub basins might return to living within the annual recharge. Project experience indicates that cascades of check dams and spate breakers provided a cost effective way to increase storage capacity and recharge. Integrated pest management for grapes and qat helped

limit overuse of pesticides. Irrigation improvement needs to be economically justified and linked to sustainable water management, integrating water resources planning and management, support to WUAs, agricultural extension, and irrigation improvement, even if done through different agencies. Questions concern whether irrigation improvement should only be subsidized if the WUA signs up to a sustainable management plan for their area, and how qat, which covers more than half the irrigated area, should be handled.

*Water Supply.* Sana's is the third fastest growing city in the world, the local corporation supplies only half the city's water needs, and the network is expanding only slowly. In total, public and private supply equal 50-60 MCM, equivalent to annual recharge for the basin. The Local Corporation has 6 wells go dry each year, and drills ten new ones, at rising costs. Farm wells supply urban fringe areas and the tanker trade. In the long term, water supply in the Sana'a Basin has to come from the good quality water in the deep sandstone aquifer, which must be protected. Public private partnerships should be developed, encouraging private suppliers to form an association, with light (self) regulation; public support for private network supply, and licensing WUAs to become water suppliers.

*Institutional Capacity.* Phase II implementation will require greatly enhanced institutional capacity, above all in the Sana'a Basin Branch of NWRA, including planning and programming; water resources assessment; capacity building and empowerment support to the Basin Committee, local councils, and WUAs; public awareness; and regulation. This will require careful definition and regularization of functions; a management audit; increased operating budget; recruitment of experienced, highly qualified staff; improved work environment; clearly defined partnerships with stakeholders; and raising staff commitment and effectiveness through performance-based incentives, thorough training, and conversion from contract to staff status.

*Discussion*. There was substantial discussion, after presentations and in the discussion groups. Much of this added depth to the topics discussed, and asked for clarification on various points. Participants said that more of the presentations and materials should have been available in Arabic. Several participants said they had hoped for a format that took a more balanced approach to examining both achievements and problems of the project. In general, participants recommended that the activities piloted by SBWMP should be continued in the next phase, a emphasized that shifting to implementation through permanent national agencies poses challenges, and that agencies must integrate implementation for the program to be successful.

Approaches recommended during the conference included:

- Expanding the role of district councils and WUAs (including both irrigation and water supply) in sub-basin water governance.
- Simplifying procedures for licensing wells and handling violations, involving WUAs, district councils, and the Basin Committee.
- Tightening regulatory control over drilling rigs and professionalizing drillers, concentrating on the rigs capable of drilling into the deeper sandstone aquifer.

- Greatly strengthening the institutional capacity of the Sana'a Branch of NWRA
- Increasing public-private partnerships for improving water supply

Some points on which there was significant debate included:

- Whether to subsidize irrigation modernization for qat
- How much to expect from WUA and district councils, in controlling illegal drilling and how much should be done by security forces and NWRA
- The role of dams in future water resources development
- Whether the Basin Committee should be given authority over financial allocation and licensing wells

**ANNEX 3**

REPUBLIC OF YEMEN
MINISTRY OF WATER & ENVIRONMENT
SANA'A BASIN WATER MANAGEMENT PROJECT (SBWMP)

**TERMS OF REFERENCE FOR**
**PREPARATION OF THE ACTION ORIENTED POLICY PAPER**
**by**
**A Team of an International Consultant and National Consultants**
(Third draft)

## Background

1. Sana'a Basin is situated in Sana'a plain which is a part of Sana'a Governorate about 2,200 m amsl. The Capital City, Sana'a is occupying the central part of the plain. The Basin has an area of some 3,200 $km^2$ and forms the upper part of the catchment of Wadi al Kharid, a sub-catchment of the Wadi al Jawf. It is one of the most populated and water-intensive basins of the central Yemen Highlands. In 2006 the population of the Capital was estimated at about 1,947,139. The population relies largely on groundwater for irrigation, and urban and rural water supplies. Historically water supplies were obtained from dug wells and ghayls (springs) tapping groundwater from the unconsolidated Quaternary deposits in the plain. However, borehole construction and introduction of pumps began in the 1960's and increased rapidly from the mid-1970's onwards, which has tapped water from the consolidated deep aquifers in the basin. The groundwater development has been largely uncontrolled that, by time, causes severe depletion to deeper aquifers which are mined through about 14,000 dug and drilled wells in the basin. Consequently, the groundwater levels in the Sana'a Plain had shown a steady decline, from less than 30 m below ground surface in the early 1970's to more than 150 m below ground surface in 1995 that jeopardizes not only the development of agriculture and industry but also the basic water supply and sanitation.

Since 1972, many studies and investigations were carried out by different agencies, organizations and institutions to cover geology, hydrology, and irrigation and supply-demand management issues and options including expectations of future water-related socio-economic development in the basin. In this context, the Sana'a Basin Water Management Project (SBWMP) has included a component (sub-component 3d) for increasing the understanding of the basin water resources and improving its management through a set of studies and investigations. Under this component, major studies and investigations were carried out by the Hydrosult. Its final documents will be the major source of the Action Oriented Policy Paper (AOPP) to be prepared by this consultancy. Other relevant studies include the JICA study that came out with a proposed action plan for SB , GAF satellite imagery study for cropping pattern distribution and evapotranspiration estimates, and social, institutional

and legal interventions carried out under the SBWMP. These studies would provide important information for the basin water resources management and should also be considered in this policy paper.

Since reorganization processes of water sector commenced in mid-1990s, Yemen has achieved pronounced steps toward integrated water regulations, institutional structure, organizational network and sector strategies e.g. promulgation of the Water Law, establishment of NWRA and its regional branches including Sana'a branch and preparation and implementation of the National Water Sector Strategy and Investment Program (NWSSIP) that are gaining considerable government's and donors' support. However, these steps are still weak in both efficient use of inputs and effectiveness of outputs, resulting in continuous lowering of the Basin's Groundwater levels and lack of progress in water saving-oriented actions. In this context, the SBWMP had been designed with 3 phases over 15 years to bridge some of the gaps and enhance the integrated water resources management in the Sana'a basin. During the first phase, the project was to develop a specific hydro-geological and water resources monitoring and investigation studies and capabilities for the NWRA-Sana'a Branch and Irrigation Sector of the Ministry of Agriculture and Irrigation that particularly improve the qualitative and quantitative management of the basin's surface and groundwater water resources, and obtaining realistic estimations of the supply-demand for the current and the future projections.

**Scope of work**

This consultancy shall be implemented by a team of an international and national consultants (hereinafter called "the consultant team") in the fields of water resources, irrigation, and social development, and the GTZ expert, Eng. Nasir Al Yazidi, in the IWRM institutional part of the assignment. . The work will specifically focus on the water resources management issues and solutions of the Sana'a water basin. The consultant shall work under supervision of the Project Coordination Unit (PCU) of the SBWMP in coordination with the staff of the SBWMP, NWRA headquarter and NWRA-Sana'a branch as well as the relevant stakeholders. The International consultant is responsible for managing the agreed implementation schedule, assigning tasks to the local consultants, supervision of their activities, fulfilling the contractual obligations, and finalizing required reports during the defined period of this consultancy. The consultant team must review Hydrosult's studies (Assessment of Water Resources Potential in Sana'a Basin: Strategic Options for Sustainable Development and Management of Basin's Water Resources 2010). In addition, the consultant team shall carefully review all available references, in particular the recent studies and reports including the Water Resources Management Action Plan for Sana'a Basin prepared by JICA in 2007.

The consultant team shall also conduct meetings with the relevant experts and stakeholders to obtain background information on institutional, organizational, planning, community participation approaches established under the SBWMP, and on human resources development, the management style, bi-lateral and multi-lateral coordination and relationship with donor community. It is clear that numerous reports and recommendations have been depicted to tackle similar management issues;

therefore, new initiatives are appreciated provided that a total number of the pages of the final report should not be more than 100 pages and should not reiterate or repeat any previous work. The consultant team may separately attach some abstracted briefs of important reminders of the previously recommended policies if required.

**Objective**

The main objective of the SBWMP which of course will be the objective of this study is to reduce the over-exploitation through a number of management interventions to reduce water demands and to enhance recharge. New ideas and initiatives are approached and directed to improve the current situation of the Sana'a water basin management through specific actions that help to step up forward on an efficient and proactive ways.

**Expected outcome**

The consultant is expected to compile a policy paper, after assessing, analyzing, and evaluating the strengths and weaknesses of current situation, recommending urgent actions and measures required for the continued economic activities in Sana'a basin as the Capital of Yemen. The recommended measures and actions should be reasonably applicable and can directly contribute to the current planning, implementation and monitoring process and improvement of de-facto sector regulations, strategies and projects of NWRA, its Sana'a Branch, Sana'a City Administration, the Sana'a Basin Committee, and the Government, taking into account their institutional (technical, HR and financial) capacities.

**Tasks to be implemented:**

In light of the Water Law, Water Law-bylaw, and the mandates and plans of the Sana'a Water Basin Committee, NWRA and relevant authorities , the consultant team shall implement the following tasks.

1- Carefully reviewing of the Hydrosult's study recommendations, the consultant team shall discuss pending issues of the current situation concerning the policymaking –oriented and decision support system. Especially, attention shall be directed to the followings:

a- identification of the bottlenecks for saving aquifers in Sana'a basin and discuss approach of actions that lead to implementation of the Hydrosult study recommendations

b- check availability and authenticity of the basic data about surface water, rainfall, groundwater, the irrigation water and water-related environmental monitoring networks found in the basin to propose/recommend complementary management actions/measures / mechanisms that assure adequate areal density coverage of:

- Groundwater observation wells for both water levels and water quality monitoring.
- run-off and rainfall gauging stations

- Monitoring/ control management of liquid and solid wastes e.g. Wastewater treatment plants, treated water reuse and disposals' dumping or recycling etc.

c- Discuss the current status of run-off reservoirs/recharging structures and agricultural terraces as an efficient tool for water harvesting studying the potentiality of their development for irrigation and groundwater recharge including feasibility of redesign of house roofs for direct rainwater harvesting in the urban areas, protection zones to propose thereto efficient and adequately coordinated management.

d- Discuss specific and applicable demand-management options for groundwater abstraction control including :

- Economic incentives considering the limited opportunity for irrigated areas expansion in the currently most intensive abstraction areas (e.g. Bani Hushish area), water allocation, fees and taxation policy especially with regard to Qat plantation, well-metering devices, etc.

- Involvement of local communities e.g. the role of local councils, water user associations, water policy etc .. considering the progress achieved by SBWMP in this regard.

- Enhancement of decentralized management in terms of delegable authorities to Sana'a NWRA branch, the Sana'a Water Basin Committee and coordination with or among related authorities.

- Multi-stakeholder actions including multi-donor coordinated interventions and processes that help national stakeholders having integrated management approaches with regard to groundwater abstraction control.

e- Review the potential of waste water reuse as a resource

f- Assess the evolution of urban water demand and likely sources

2- Review the current status of the licensing and permitting system of well drilling and drilling firms' registration being applied in NWRA Sana'a Branch to propose/ suggest required improving measures/ mechanism in the light of the consultant experience and other NWRA branches procedures and practices such as Taiz Branch. Review the current status and criteria of water rights registration and water allocation and propose adequate improvements or mechanism that follows the water law articles and WRMP of the Basin.

3- Review the water law and its bylaw with regard to guiding principles of water resources planning and suggest applicable internal and external coordination and follow up processes.

4- Propose the contents of an efficient decision support system for NWRA branch e.g. areal coverage, accuracy of data collection and analysis, information exchange etc to analyze and verify potential use of the data base for efficient and timely decision-making processes.

5- Asses the progress and achievement of water resources participatory management approach under the Sana'a Water Basin Management Project e.g. efficiency and effectiveness of the Sana'a Water Basin Management Committee and established WUAs. Especial attention should be paid to their financial sustainability and its development to Sana'a Basin Agency controlling all issues with regards to water management of course in the light of water law, it's by law, and any other legal documents.

6- Compare development alternatives /options of water resources management being theoretically found under the current regulations, strategies, plans and projects with realistic capacities and achievements, hence, verify and suggest applicable actions and/ or integrated/coordinated measures for improved effectiveness as such.

7- Conduct impact assessment of investment and efficient use of different inputs directed to water and irrigation sector's institutional development in view of strengths and weaknesses of developing water resources management in general and NWRA and Sana'a Branch in particular e.g.

   a. Actual water saving due to current SBWMP interventions and its impacts to socio-economic of the basin's stakeholders and to minimizing the GW depletion considering the possibility of interventions expansion to cover the whole irrigated areas in the basins.

   b. Responsive institutional structure, system, management style, transparency and coalition etc.

   c. proactive coordination of planning and implementation processes among sub-water sector, irrigation and environmental authorities and local councils

   d. effectiveness of applied measures with regard to attenuation of groundwater depletion, decease of random well drilling, drilling rigs control,

   e. efficient use of data and information exchange for planning and supportive decision-making purposes,

   f. improved qualification and performance of staff,

   g. raising decision-makers and public mass awareness,

8- Review and brief the management approach and targeted outcomes of the NWSSIP to conduct one week period on-job training for the relevant staff of NWRA Sana'a Branch about indicator-based (result-based) planning and management.

9- Evaluate methodology of training, employment and recruitment policy of staff, achieved results and impacts of the Human Resources Development and recommend the necessary improvement.

10- Organize meetings with the Branch and relevant-related staff (individually or per-group) to touch their daily issues, capacities and work environment including hard and software requirement, staff motivation and incentives etc.

11- Analyze the strength and weakness of NWRA headquarter and Sana'a Branch to suggest enhancing and improving policy actions/measures.

12- Conduct required meetings with relevant bodies and hold at least two workshops to present findings, exchange ideas and to discuss required improving policy actions and measures.

**Annex 4**

# Detailed information on sources for Sana'a water supply

## Well development over the last five years

In the last five years the LC worked in three directions:

- Drilling replacements wells in the eastern and western well fields. Those wells are instead of dried wells or wells can't be maintained due to technical problems.

- New wells in the same eastern and western well fields to follow up the sharp increase in water supply demand.

- Drilling new deep wells in the southern part of Sana'a basin. These wells reach the deep sandstone aquifer and in some locations fully penetrate it. The maximum depth of the wells reached to 1,060 m below surface in Al Wahdah area south of the basin. The LC has started to experience a sharp increase in production costs.

At present between 12 and 15 (in an average) new wells are drilled. In additional to 10 wells either deepened or rehabilitated in each year.

## Current investigations

The current investigations focus in four different areas:

1. Continued development of the southern deep sandstone aquifer. The expected depth of the wells is between 900 and 1100 m.

2. In Al Hafe, a new water supply well-field is proposed at the western foots of Nukum mountain. The depth of the wells will range between 600 and 700m.

3. At Asser, in the south western part of Sana'a basin, a new well field is proposed. The depth of the wells may range between 600 and 700m.

4. The deepest water supply well reached to a depth of 1060 m in Al Wehdah area near to the southern boundary of Sana'a basin. The well fully penetrated the deep sandstone aquifer. A continuous study states pumping test with 30 l/s discharge continue for 72 hours. The static water level is 320 m and the dynamic water levels due to the effect of the pumping test stabled at 348 m after 24 hours of continuous pumping.

The drilling cost of water supply well with a depth reached 600 m is around Rls 50 million ($250,000), with a depth of 900 m cost Rls 100 million ($500,000), and Rls 120 million ($600,000) for a well reaching 1000 m. The well started by 20 inch diameter at the surface and end with 12 inch diameter at the bottom.

**Future program**

The Local Corporation does not have enough information about the aquifers at Bani Al Harith in the northern part of the city and in Subahah at the south western part of the basin. Another area requiring further investigation is the southern end of the basin as well as at the south eastern part of the basin.

- At Bani Al Harith the LC is facing the quantity and quality problem. At present LC is carrying out a geophysical investigation at Bani Al Harith in order to have more detail information.

- At Subahah, the top part of the deep sandstone was reached at a depth of 600 and 700 m by SBWMP. The drilling was at the east and south of the area. This area is the next promising area for the LC. More investigation is required in order to build good lithological cross sections for the deep aquifers. The geological and hydro geological cross-sections required detail geophysical investigation and exploratory drilling. This can be done by detail geological and deep geophysical survey. A total of 3000 m of exploratory drilling is needed to build a general picture of the deep sandstone aquifer at Subahah. The present cost of the deep drilling is 120,000 Yr/m. This required a total cost of 360 M YR. Also deep drilling will be required at the south end of the basin (two wells) and to the south east of the basin (two wells).

**Water needs for the next 5-20 years:**

The estimated present water demand (2010) that is being met by the LC is 32 MCM in 2010. In addition, the recent WEC survey of private water supply estimated that the 189 wells recorded by the NWRA-SB 2007 survey as serving the Sana'a urban market are supplying 27 MCM a year. These figures suggest that already current water supply to the capital is in the range 50-60 MCM, near or exceeding the natural recharge of the basin.

The new master plan for Sana'a city is not available until now. The extension of Sana'a city is expected to be in the northern and southern directions. At present the larger extension is to the south. It was expected that the extension to the north will be larger but the opposite is found.

**Annex 5**

## Theoretical background for recoverable storage calculation:

Definition of 'Recoverable groundwater storage':

**S = saturated thickness of the aquifer * effective porosity**

Only a proportion of stored groundwater is recoverable. The concept of groundwater storage is usually used in connection with limits on the allowable abstraction or depletion of the aquifers. The total storage of an aquifer is generally not available for abstraction because of strategic or other reasons, e.g. because groundwater needs to be reserved for periods of low recharge. Furthermore, it is technically difficult to empty an aquifer because this would require a large number of wells (Hydr,ch9:3).

Maps can be prepared showing groundwater availability under different management conditions. A groundwater storage map therefore is prepared under conditions of a maximum drilling depth. Several storage maps could be prepared using different drilling depths. These maps will indicate groundwater availability for different water management conditions. This will apply especially to the exploitation of the sandstone aquifer (Hydr,9:3).

The effective porosity of the aquifer stores the volume of groundwater that can be drained by gravity. Effective porosity is more or less equal to the specific yield, which is the volume of groundwater released from the aquifer by pumping. Specific yield applies to unconfined conditions (Alluvium, volcanic, and outcropping sandstone aquifers in Sana'a basin). The storage coefficient applies to confined conditions (deep sandstone aquifer in Sana'a basin) (Hydr, 9:3).

Estimation of recoverable groundwater storage should specify minimum and maximum expected values, and always base findings on minimum values. Calibration of the transient groundwater model provides an estimate representing the observed changes in groundwater levels. This estimate can be considered appropriate for a regional approach. Still, differences in estimates of a factor of 2 or 3 should be expected. Therefore, calculations of groundwater storage should present a range of results using a minimum and maximum value of the specific yield. Water use planning should always remain on the safe side by using the minimum values (Hydr, 9:3).

At present, Hydrosult data and the related model represent an input to a planning process that has to complete data collection and confirm model calibration.

Preferably, recoverable groundwater storage is to be presented in raster maps. The storage is calculated separately for each raster cell. The estimate of the specific yield may be verified from a water balance of each raster cell, although it should be realized that there are also inaccuracies in the estimates of the water balance components of recharge and discharge. Cells with large deviations in estimates may indicate areas with lower reliability of the groundwater storage estimate (Hydr, 9:3).

Hydrosult used the raster maps and the following parameters for each aquifer to calculate the recoverable groundwater storage:

- Elevation of the groundwater table.
- Bottom level of the aquifer.
- Average specific yield.

For the volcanic aquifers both quaternary and tertiary volcanic aquifers are treated as one aquifer, and for the sandstone aquifer corrected for borehole penetration (Hydr, 9:3).

Hydrosult modelled specific yield and specific storage:

Results of the transient state calibration of the Naaman Model (2004) [15], showed that the estimated value of specific yield for the alluvium and Tertiary volcanic aquifers (value of 0.2), is lower than the specific yield of the sandstone aquifer (value of 0.005). However, the sandstone aquifer is known to be the main aquifer in Sana'a Basin, and the Quaternary volcanic is characterized by fissures and fractures. The value of Storage Coefficient for the volcanic aquifer was estimated at $3.74^{E-7}$ and for the sandstone aquifer at $0.908^{E-04}$ (Hyde,9:45).

Required data to calculate recoverable storage:

- Elevation of the groundwater table for the unconfined aquifer (saturated thickness) or saturated thickness of the confined aquifer.
- Bottom level of the aquifer.
- Average specific yield for the unconfined aquifer and storage coefficient for the confined aquifer.

Basis of the Hydrosult calculations:

- Using the maximum thickness of the volcanic (500 m), outcropping sandstone (450 m), and deep sandstone (450 m).
- The saturated thickness of the volcanic aquifer used in the calculation is 380 m, in the outcropping sandstone 450m, and for the deep sandstone 380 m.
- The average specific yields used for the volcanic aquifer ranges between 0.019 and 0.28.
- The average specific yield used for the outcropping sandstone ranges between 0.025 and 0.185.
- The average storage coefficient used for the deep sandstone aquifer ranges between 0.053 and 0.195.
- The total surface area used for the alluvium is 505 $km^2$, for the volcanic ranges between 1428 1nd 1751 $km^2$, for the outcropping sandstone ranges between 4.6 and 671 $km^2$, and for the deep sandstone ranges between 600 and 1210 $km^2$.

In general Hydrosult used

- The maximum values to calculate the recoverable storage. It used the maximum thickness of the aquifer and in some cases it exceeds the maximum (450 in the deep sandstone).
- The thickness of the modeled quaternary volcanic ranges between 60 and 260 m with an average thickness 110m, for the tertiary volcanic ranges between 60 and 610 m with an average thickness of 370m, for the

outcropping sandstone the thickness ranges between 10 and 250m and for the deep sandstone the thickness ranges between 70 and 350 m.

- The mean value of the specific yield for the unconfined aquifers (volcanic and outcropping sandstone) varies between 0.1 and 0.005. The maximum Sy for the volcanic is 0.2.
- For the deep aquifer the transient storage coefficient used to calibrate the model is 0.000908.
- The horizontal extend of the volcanic aquifer, outcropping sandstone and deep sandstone is not isotropic and homogenous. The outcropping and deep sandstone are small isolated aquifer highly effected by geological structural activities (step faults in the deep sandstone) , while the volcanic aquifer is fractured aquifer with some cavities.

New findings:

- The local corporation fully penetrates the volcanic aquifer. The volcanic aquifer has low yields ranges between 3 and 4 l/s. At present this is low yield for the local corporation.
- Deep sandstone aquifer fully penetrated in many locations in the southern part of Sana'a. The thickness of the sandstone ranges between 250 and 350m. The newest well (2010) in Al Wihdah area near to the southern boundary of the basin reached to total depth of 1060m. The sandstone started to appears from 790 m to 1060m. The well is fully penetrated the deep sandstone.
- The water levels in the deep sandstone drops by 110 m between the period of 2000 and 2010. The depth was 210 m below the surface at present it reached to 330 m.
- In general deep sandstone with different thicknesses and at different depths is found within the southern boundary of Sana'a basin. It is vertically subdivided into isolated blocks by step faults from the eastern part at Nokom mountain into the western part at Subahah area. The deepest part of the sandstone is located at the center of the plain in Al Sabeen area.
- The northern part of the western LC well field is dry. The dryness of the aquifer started from the northern part of the well fields towards the south.

<u>Recoverable storage of Alluvium aquifer:</u>

In 1973, pre development time, it was noticed that the total mean recoverable groundwater storage approached a depth of 7.8 m, which supposes 1.9 BCM (Hydr, 9:4). The groundwater storage calculated from assumed average saturated thickness of the alluvium aquifer of 79 m and specific yield of 0.08 (Hydr, 3:13). The total recoverable storage of 1.9 is calculated from the groundwater storage and the surface area of the alluvium aquifer (505 $km^2$)(hydre, table 4-3).
The 1.9 BCM is very high due to the following reasons:

- The thickness of the alluvium aquifer is ranged between 20 m at the edge to a maximum thickness of 78 m in most of the area of the aquifer and 158

in the northern part of Bani Al Hareth. This will comes to an average thickness of 70 m.

- Also the average thickness can't be assumed as a fully saturated thickness all over the aquifer. This means that the average saturated thickness should be less than this number.
- The maximum estimated specific yield is used (0.078). For planning purpose the minimum estimated specific yield should be used.
- The total surface area of the alluvium aquifer (505 $km^2$) is used to calculate the recoverable storage. At least part of the surface area at the aquifer boundaries should be ignored (10 – 20% of the surface area).