Palestinian National Authority

Palestinian Water Authority

The Gaza Emergency Technical Assistance Programme (GETAP) on Water Supply to the Gaza Strip

Component 1 – The Comparative Study of Options for an Additional Supply of Water for the Gaza Strip (CSO-G)

The Updated Final Report

[Report 7 of the CSO-G], **31 July 2011**

Phillips Robinson & Associates
Windhoek, Namibia

The CSO-G: Report 7 – The Updated Final Report

TABLE OF CONTENTS

List of Abbreviations

BOO	Build-Own-Operate
BOT	Build-Operate-Transfer
CAB	Coastal Aquifer Basin
CBT	Covered By Tariffs
CMWU	Coastal Municipalities Water Utility
CSO-G	Comparative Study of Options – Gaza
EAB	Eastern Aquifer Basin
ESIA	Environmental & Social Impact Assessment
FS	Feasibility Study
GDP	Gross Domestic Product
GETAP	Gaza Emergency Technical Assistance Programme
GoI	Government of Israel
GPCU	Gaza Programme Coordination Unit
IPCRI	Israeli/Palestinian Center for Research & Information
IWA	Israeli Water Authority
JR	Jordan River
m^3	Cubic metres
MCM	Million Cubic Metres
NEAB	North-Eastern Aquifer Basin
NGEST	North Gaza Emergency Sewage Treatment
NIS	New Israeli Shekels
NSC	North-South Carrier
NSU	Negotiations Support Unit
OQR	Office of the Quartet Representative
PENRA	Palestinian Energy and Natural Resources Authority
PHG	Palestinian Hydrology Group
PLO	Palestine Liberation Organization

PNA	Palestinian National Authority
PWA	Palestinian Water Authority
STLV	Short-Term Low-Volume [desalination]
TECC	Technical Engineering and Consulting Company
TPAT	Technical, Planning and Advisory Team
UfW	Unaccounted for Water
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
US AID	United States Agency for International Development
US EPA	United States Environment Protection Agency
USA	United States of America
US$	United States Dollars
WAB	Western Aquifer Basin
WDM	Water Demand Management
WHO	World Health Organization

Acknowledgements

The project team wishes to acknowledge inputs from a number of individuals and organisations. First and foremost, we thank our counterparts and friends in Gaza for their help and support.... Rebhi Al-Sheikh, Ahmad Yakubi, Sadi Ali, Monther Shoblak, and many others. Our colleagues in TECC in Gaza – Samir Manneh and Marwan Bardawil – must also be cited here, for their exceptionally strong and timely technical assistance. Many others in Gaza helped the project team, and we are grateful for all of your input—and indeed, your perseverance in highly difficult circumstances.

In the West Bank, we pay tribute to Dr. Shaddad Attili, who is in the process of transforming the water sector in Palestine. Michael Talhami, who assisted Dr. Attili on a day-to-day basis during the project period, was of exceptional importance to this project.

We also wish to acknowledge the finance provided by the Government of Norway for this study – and for other important interventions in the water sector in Palestine.

We believe that the problems in Gaza are not intractable. We trust that this report contributes to their solution.

The water sector in Palestine – and especially in Gaza – is no place for the faint-hearted. However, the following is noted:

"You never know what results come from your action. But if you do nothing, there will be no result." [Mahatma Gandi]

"Do not follow where the path may lead. Go instead, where there is no path.... and leave a trail." [Author unrecorded]

The CSO-G project team seeks to 'take action', and leave a trail. We hope and trust that others will follow the trail, should it be sufficiently well-beaten.

Dr. Dave Phillips, Team Leader, CSO-G

Executive Summary

This report addresses the water sector in Gaza, Palestine, with a primary focus on issues at the strategic level pertaining to water supply. This represents the first component of the Gaza Emergency Technical Assistance Programme (GETAP), and is known as the Comparative Study of Options for an Additional Supply of Water for the Gaza Strip, or the CSO-G in acronym. This Updated Final Report for the CSO-G has been produced very rapidly by virtue of a heavily fast-tracked programme of work, and was released on 31 July 2011, less than six months after the project was initially triggered. The pace of the project as a whole reflects the perceived urgency for interventions in Gaza. The CSO-G project is supported by financing from the Government of Norway, and the Palestinian Water Authority (PWA) is the primary counterpart.

The CSO-G project team has met with most or all of the key players of relevance to the water sector in Gaza, and has reached a range of conclusions as to the required future interventions in the sector, which are reported here. The first conclusion pertains to the existing situation in relation to water supply in Gaza, and the project team has altogether rejected the continuation of the *status quo* as an acceptable option. This reflects the fact that the groundwater – the main source of fresh water in Gaza at the present time – is being massively over-pumped currently and the aquifer is showing clear signs of imminent failure or collapse, with rapidly advancing saline intrusion. Severe contamination (mainly from wastewaters) is also evident, and almost none of the groundwater meets internationally accepted guidelines for use as a domestic supply. The population of approximately 1.6 million Palestinians in Gaza is therefore exposed to very high levels of risk, and the treatment of the water is too expensive for many of the inhabitants. Even where the groundwater is treated, the resulting water is often contaminated, and high levels of water-borne disease continue to be prevalent amongst the Gaza population.

Having rejected the maintenance of the *status quo* as an acceptable scenario, the CSO-G project team considered a range of potential options for the supply of water to Gaza in the future. The options listed in the Terms of Reference (see *Annex 1*) were expanded, and nuance was added by separating certain of the options into sub-options. The resulting possibilities for future water supply (for various uses) were then screened against four criteria, these being political; technical; social; and economic. A number of the options and sub-options failed against one or more of these four criteria, and the reasons for this are enumerated in the present report. The options that failed on one or more of the criteria were 'side-lined' for use in the near-term, but were addressed once again at a later stage of the procedure (see below).

The options and sub-options that survived the screening procedure were addressed by the CSO-G project team in detail, and were sorted into a set of interventions that can be introduced in the current scenario in Gaza. A rolling schedule of interventions was then produced, this involving nine projects that are inter-linked and in combination form a coherent programme to address the critical issues in the water sector in Gaza. The nine interventions are summarized as follows:

- The establishment of a Gaza Programme Coordination Unit (GPCU), this being required to drive and coordinate the proposed CSO-G interventions as a whole.

- The introduction of an integrated water and health monitoring project, this to ensure that comprehensive and fully reliable data are available to act as a driver for the desired future changes in the sector, and also to monitor the success of the entire programme of interventions.

- The accelerated upgrading and/or reprovision of the domestic water distribution and supply network in Gaza, this being the subject of specific parallel work that was undertaken by the Technical Engineering and Consulting Company (TECC) in Gaza, linked back to and closely coordinated with the CSO-G effort.

- Enhanced levels of water imports from Israel to Gaza, in relatively small volume. This matter is currently the subject of ongoing negotiations between Palestine and Israel, being facilitated by representatives of the Norwegian and American Governments.

- The introduction of short-term low-volume (STLV) desalination of sea water in Gaza, to provide relatively minor volumes of water of acceptable quality for domestic use in the early years of the CSO-G programme, and to ensure that public health may be protected. The use of brackish water as a possible feedstock for the STLV desalination facilities was considered, but was concluded not to be preferred, due to the urgent need to reduce the abstraction of groundwater and attempt to protect the aquifer.

- The phasing-in of higher levels of sea water desalination through the construction of two regional facilities, in as short a time as possible. These regional desalination facilities act as one of two key drivers of the initiative to reduce the present levels of over-abstraction of the groundwater in Gaza, and are therefore critical to the CSO-G programme as a whole (as well as to the long-term protection of human health in Gaza).

- The introduction and/or extension of pilot schemes for the reuse of treated wastewaters in Gaza, with the reused flows replacing pumped groundwater, as soon as possible.

- The accelerated completion of the major wastewater treatment plants in Gaza, with large-volume reuse being introduced as rapidly as possible and becoming the predominant source of water used in the agricultural sector in Gaza.

- The completion of a high-quality review of the use of water in the agricultural sector in Gaza, this being focused on reducing the overall demand for water; the introduction of large-scale wastewater reuse; and the optimisation of the economic returns from the sector.

The present report describes each of these nine interventions; how they relate to each other; and how each would contribute to the overall programme targeted at the primary goals of the CSO-G strategy. The costs of each programme component are estimated in approximate terms, these mainly being spread over the first six years of the rolling schedule of interventions (2011 to 2016). It is cautioned that more precise cost estimates will need to be developed during later detailed work on each of the nine interventions, individually.

The options that were side-lined during the screening process (see above) are then picked up once more, to clarify their potential use in the future, if circumstances were to change. The CSO-G project team emphasizes that the transfer of high volumes of water from Israel to Palestine is in fact the preferred primary option to address the problems in Gaza, but this does not appear to be available in the current geopolitical environment. Nevertheless, the equitable and reasonable allocation of the fresh water resources that are shared between Palestine and Israel would comply with the principles of customary international water law. The Positive-Sum Outcome developed previously by the Palestinian side – and available not just for Palestine and Israel, but also for the other three riparians of the Jordan River basin – represents the preferred course of action, but is not available at the present time, for various political reasons. The transfer of high volumes of fresh water by pipeline from Turkey to Gaza is considered by the CSO-G project team to also be of significant interest and to merit additional study, but this option would not resolve the urgent problems in Gaza in the near-term. The possibility that a desalination facility could be shared between Gaza and Egypt is also noted, and is suggested to be worthy of further consideration by the Palestinian authorities.

Four additional issues are also discussed in this report. The first of these relates to practical difficulties affecting the interventions as proposed, and the CSO-G strategy as a whole. One of the most important of these involves the blockade of Gaza, and the ongoing problems in the importation of materials and equipment. It is noted that the blockade must be dealt with if the CSO-G interventions are to be successful, and also that political issues should not be permitted to negatively affect the water sector or the need for humanitarian programmes of assistance in particular. Legal issues of relevance are also discussed, and it is emphasized that Israel has failed to honour its commitments as laid down in the Oslo II Agreement of 28 September 1995. Thirdly, the affordability of fresh water in Gaza is addressed, and a view is provided as to the willingness of the population to pay for water supplies. This suggests that some form of cross-subsidy may be needed, if the Gaza economy does not improve substantially in the near term. Finally, comments are provided in relation to the supply of electrical energy for Gaza, and its relationship to the proposed interventions in the CSO-G programme.

1. Introduction

The Palestinian Water Authority (PWA) has long been concerned about the water sector in Gaza, particularly in relation to water supply. The need for the Gaza Emergency Technical Assistance Programme (GETAP) was envisaged initially in a report prepared in late 2008 for the Palestinian Water Authority, this commonly being known as the 'PWA Audit'.[1] The Government of Norway provided the financing for both the PWA Audit and the initial component of the GETAP addressed here – the Comparative Study of Options for Additional Water Supply to the Gaza Strip, known in acronym as the CSO-G. The PWA represents the key project counterpart, but a considerable number of authorities in Palestine[2] are involved (and will need to continue to be involved) in debating and overseeing various components of the eventual programme of works that are required to address the current problems.

Many studies have been completed previously, on the water sector in Gaza. Certain of the early reports produced in the late 1990s and soon thereafter remain a mainstay of the conceptual approach to the sector, amongst the professional water management community. The CSO-G differs from all previous studies, however, in both its timing and its overall approach. As described more fully in Section 2 of this report, the CSO-G represents the first component of an envisaged **emergency response** to the problems in the water sector in Gaza, and provides proposals for an overall strategy to address – and hopefully resolve – the current problems.

The CSO-G was triggered on 01 February 2011 and was run on a heavily fast-tracked basis, with a planned completion date of 30 June 2011. The Consultants were led by *Phillips Robinson and Associates* of Windhoek [Namibia] and a multi-disciplinary team of experts was involved, with exceptionally strong experience of the water sector in Palestine.[3] It is important to emphasize here that the CSO-G is a study at the **strategic** level, designed to identify a preferred broad mix of interventions that will address the existing problems in the water sector in Gaza; the timing of their preferred introduction; and their inter-relationships. The CSO-G revisits an outline analysis completed recently by the CMWU (2010), providing significant additional detail.

This document represents the Updated Final Report for the CSO-G, and has been released on 31 July 2011. It contains the consolidated findings and opinions of the project team, and is provided to the PWA to act as the basis for the remaining consensus-building process, as envisaged in Section 2.5 of the Terms of Reference for the work (which are appended hereto at *Annex 1*).

During the course of the work, the Consultants met with most or all of the key players in the water sector in Palestine, and listened to a wide range of views on potential options that could generate improvements in Gaza. The Consultants also worked very closely with their primary counterparts at the PWA and the Coastal Municipalities Water Utility (CMWU) in Gaza. In addition, many meetings were held with key donors and other organisations who are not direct counterparts to the CSO-G, but are likely to be involved in later interventions that the CSO-G study suggests will be required. The process of consensus building is thus well underway, not simply internally amongst the entities within the Palestinian National Authority (PNA), but with a wide range of other players also. It is intended that the consensus building process will continue and will be led by the PWA, based on the contents of this report. Thereafter, an agreed programme should be fed into the Palestinian Reform and Development Plan (PNA, undated [1]).

---

[1] *An Audit of the Operations and Projects in the Water Sector in Palestine: The Strategic Refocusing of Water Sector Infrastructure in Palestine.* The Palestinian Water Authority, November 2008.

[2] In this report, 'Palestine' denotes the areas within the 1967 borders of the West Bank and Gaza.

[3] The term 'water sector' is used in this report to cover all matters relating to water supply and wastewater treatment, reuse and/or disposal. The focus of the CSO-G is on water supply in Gaza as stated in this introductory section, but wastewater is of importance as a potential resource for reuse, and is hence included in the CSO-G as one of several non-conventional water resources.

The sections of this Final Report that are presented subsequent to this introduction are laid out in the following fashion:

- Section 2 summarizes the information that is currently available on the water sector in Gaza, and explains the rationale for the CSO-G.

- The options included in the Terms of Reference for the CSO-G are discussed in Section 3, and are subjected to a screening process that serves to define the options that are presently available to resolve the problems in the water sector in Gaza.

- Section 4 takes the options that remain after the screening process – and are thus potentially available for use at this time – and proposes a rolling programme of interventions in the water sector in Gaza, using the options in specific admixtures and in a particular chronology.

- The options that were initially 'side-lined' due to their non-availability at the current time are picked up once again in Section 5 of the report, and brief comments are provided on how these might be activated if circumstances were to alter in the future.

- Section 6 provides comments on four additional matters of relevance to the CSO-G.

- Conclusions and recommendations arising from the CSO-G are presented in Section 7.

- References cited in the text of the report are listed in Section 8.

Comments on this report should be sent by E-mail to the CSO-G Team Leader (Dr. David Phillips; E-mail address dphillips@iway.na).

2. The Water Sector in Gaza

This section provides a summary of the major problems pertaining to the water sector in Gaza, in the *status quo* and the future. It is notable that the continuation of the *status quo* is one of the options listed in the Terms of Reference for the CSO-G (see Section 2.4.1 at *Annex 1*), and the project team provides a view here on this matter.

2.1 The Current Problems

2.1.1 A Guiding Metaphor

The current situation relating to the water sector in Gaza is of grave concern. To assist in conceptualisation for those with limited technical knowledge of the water sector in general[4], the CSO-G project team offers a metaphor that reflects the complexity of the situation, yet describes the process in a simplified form. This involves an individual with a disease that is progressing inexorably over time, threatening the life of the patient. To address the problem, the first task is to identify the disease accurately, so that a short-term treatment pattern and schedule can be closely tailored to the problem. The next step is to immediately apply the selected emergency measures that will stop the steady progression of the disease and the decline in health of the patient. The emergency measures should also be consistent with the subsequent set of interventions that, once the physical decline is stopped, will help the patient rebuild the foundation for health. As the patient returns to health, the final step is to review his/her initial lifestyle and environmental situation which led to the debilitating disease, and to make the changes to establish a new lifestyle/environment that will support a healthy life in the long term. The steps taken to diagnose and treat such a patient provide a helpful strategic pattern through which to address the current situation in the Gaza water sector.

2.1.2 Technical Matters

As noted by the CMWU (2010), the supply of fresh water to the population of approximately 1.6 million in Gaza at the present time relies almost totally on the underlying groundwater (the aquifer).[5] Minor volumes of fresh water (4.7 million cubic metres/year, recently) are imported from Israel, and it has not been possible to date to increase those flows. Further very small volumes arise from several scattered desalination facilities in Gaza (Hilles and Al-Najar, 2011), but these are currently insignificant at the strategic level.[6]

The annual sustainable yield of the aquifer within the geographical boundary of Gaza is widely quoted as 55 million cubic metres (MCM). Recent rates of pumping from the aquifer are estimated at 170 MCM/year (this estimate, for 2010).[7] The abstraction rates have increased markedly over the last three decades, due to a combination of inadequate available water imports to Gaza; the expanding

---

[4] This metaphor was employed initially in Report 3 from the CSO-G that was prepared for the *Ad Hoc* Liaison Committee meeting held in Brussels on 13 April 2011. It is retained here in the Updated Final Report, as it is acknowledged that some readers may not be especially familiar with the technical issues that are of relevance to the Gaza water sector, at the present time.

[5] The aquifer in Gaza is in fact simply a geographically defined portion of the much larger groundwater body known as the Coastal Aquifer basin. That basin stretches along the coast from northern Israel, through Gaza, to Sinai in Egypt.

[6] Data amassed and summarised by the PWA in Gaza show that the total volume of desalinated water produced at the present time in Gaza is about 0.4 million cubic metres/year, this varying over time according to a number of circumstances at the facilities involved.

[7] The pumping rates at wells providing domestic water supplies are known with some precision. By contrast, the abstraction rates at wells used to provide agricultural supplies of water are less well characterised, implying that the total volume of groundwater pumped *per* unit time is somewhat uncertain.

population; and the drilling and use of unlicensed wells (especially to provide irrigation for agricultural activities). The over-abstraction has caused saline intrusion (i.e. the entry of sea water to the aquifer from the Mediterranean Sea to the west, and also from deep groundwater in Israel to the south-east of Gaza). This is becoming rapidly worse over time, and modelling data suggest that the deterioration will continue (Figure 1). Several manuscripts have been published on the saline intrusion from the south-east (e.g. see Vengosh *et al.*, 2005; Wienthal *et al.*, 2005; Messerschmid, 2011), and this appears to reflect a hydrological connection between the shallow Gaza groundwater and the Avedat aquifer in Israel. The over-abstraction in southern Gaza in particular is creating a major zone of depression in that area, which is exacerbating this trend (see Figure 2).

A second problem also exists, this being driven primarily by contamination of the shallow groundwater from activities at the surface or near-surface of the land in Gaza. It has been established by Shomar *et al.* (2008) that this contamination arises mainly from wastewater (almost all of which is generated within Gaza, by the indigenous population). The wastewater-driven problems are usually characterised by high levels of nitrates in the groundwater (see Figure 3), which are problematic in themselves, especially in relation to toxicity to infants and children (e.g. see Almasri, 2008; Unicef, 2011). It is notable that the groundwaters have not been especially well characterised for trace contaminants, but the available literature suggests that many pollutants are involved, and at least some of these have important adverse effects on human health (e.g. see Shomar, 2010).

The third problem faced in Gaza relates to the regular military incursions and other forms of hostility by Israel. UNEP (2009) assessed the environmental damage in Gaza following 'Operation Cast Lead' in late 2008 and early 2009, leaving little doubt as to the severity of the damage. Other authors have noted the damage to water sector infrastructure, in the specific (e.g. see Unicef-PHG, 2010; Messerschmid, 2011).

The result of these problems in combination is that: [a] the water **quantity** available to the population in Gaza is inadequate; and [b] the water **quality** falls well short of accepted international guidelines for potable resources (i.e. for use as drinking water, or more broadly for domestic use).[8] Of these two results, the problems with water **quality** are the more urgent. Most of the population in Gaza cannot afford to treat the water themselves, before use. Even those that can afford to post-treat the groundwater – or to purchase treated supplies from commercial vendors – are often exposed to contamination, for a range of reasons (see Text Box 1). The overall effect of this is a very high incidence of water-related disease amongst the population as a whole (Unicef-PHG, 2010; Unicef, 2011). This has been characterised by many commentators as a humanitarian crisis.

In addition, the groundwater quality is so poor in some areas of Gaza that agricultural yields suffer (NSU, 2010; Messerschmid, 2011). This is largely due to the saline intrusion, as chlorides retard plant growth (nitrate and other sewage-derived nutrients are in fact beneficial to plant growth, within limits).

Several parties have stated (usually on the basis of modelling future water quality) that the Gaza groundwater will soon become so contaminated that its entire volume will cease to be available for use. This is commonly known as 'aquifer failure' or 'aquifer collapse'. Figure 4 shows in a diagrammatic fashion how short-term and long-term interventions can potentially stop this from eventuating, and could render the groundwater quality fit for use in the medium and longer terms. Table 1 characterises the two distinct phases relating to the changes shown in Figure 4.

2.1.3 Goals for the Interventions

The above problems define the general goals of the CSO-G, which are to identify the projects and interventions in Gaza that will:

[8] The population of Gaza utilizes about 90 litres *per capita*/day of fresh water on average, currently. This drives the over-abstraction of the groundwater, but the volume used nevertheless remains well below the preferred minimum international guideline of 150 litres/person/day. Over 90% of the total water volume available fails to meet the World Health Organisation guidelines from 2004 (with later addenda in 2006 and 2008), which are widely accepted internationally as being appropriate for domestic water quality.

Figure 1. Levels of chloride (denoting salinity) in the groundwater within the borders of Gaza, for the years 2000 and 2010, plus predicted data for 2020. (Data from the Palestinian Water Authority, Gaza). The internationally accepted guideline for chlorides in drinking water is 250 mg/litre.

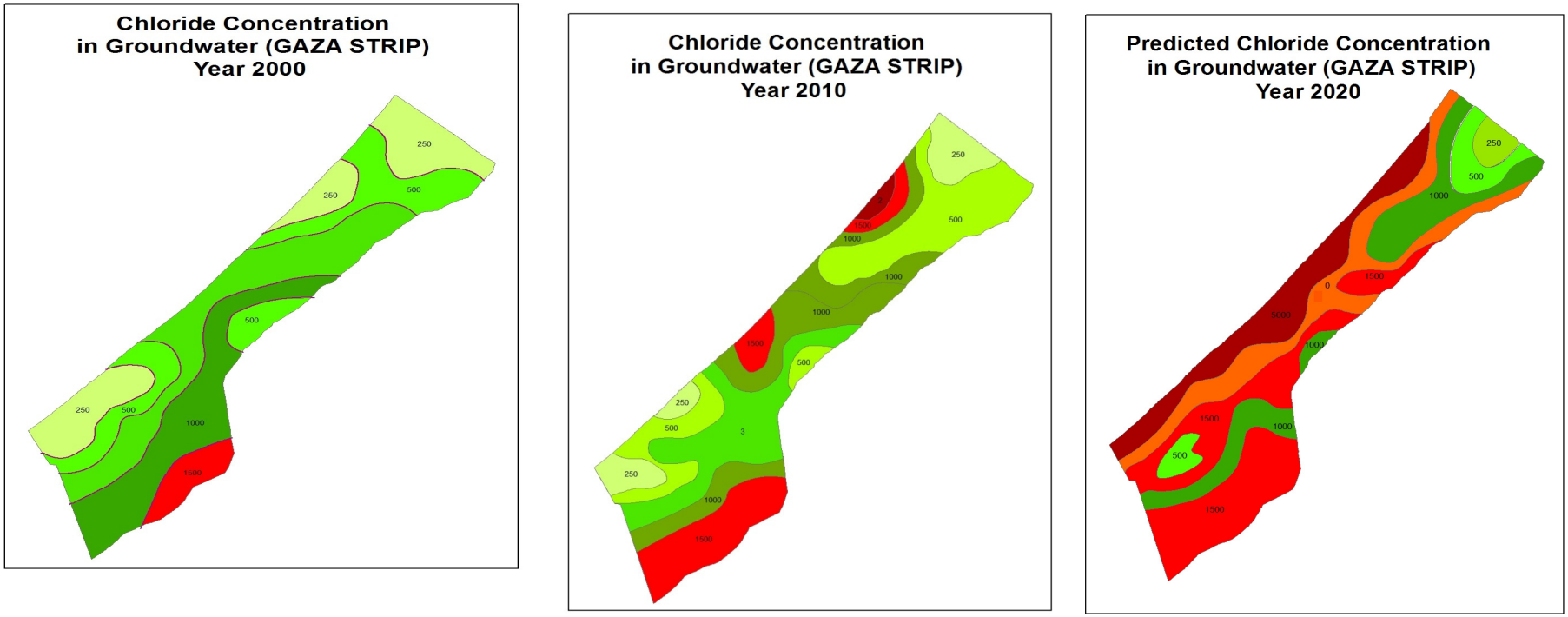


Figure 2. The depth to the groundwater table within the borders of Gaza, for the years 2000 and 2010, plus predicted data for 2020. (Data from the Palestinian Water Authority, Gaza).

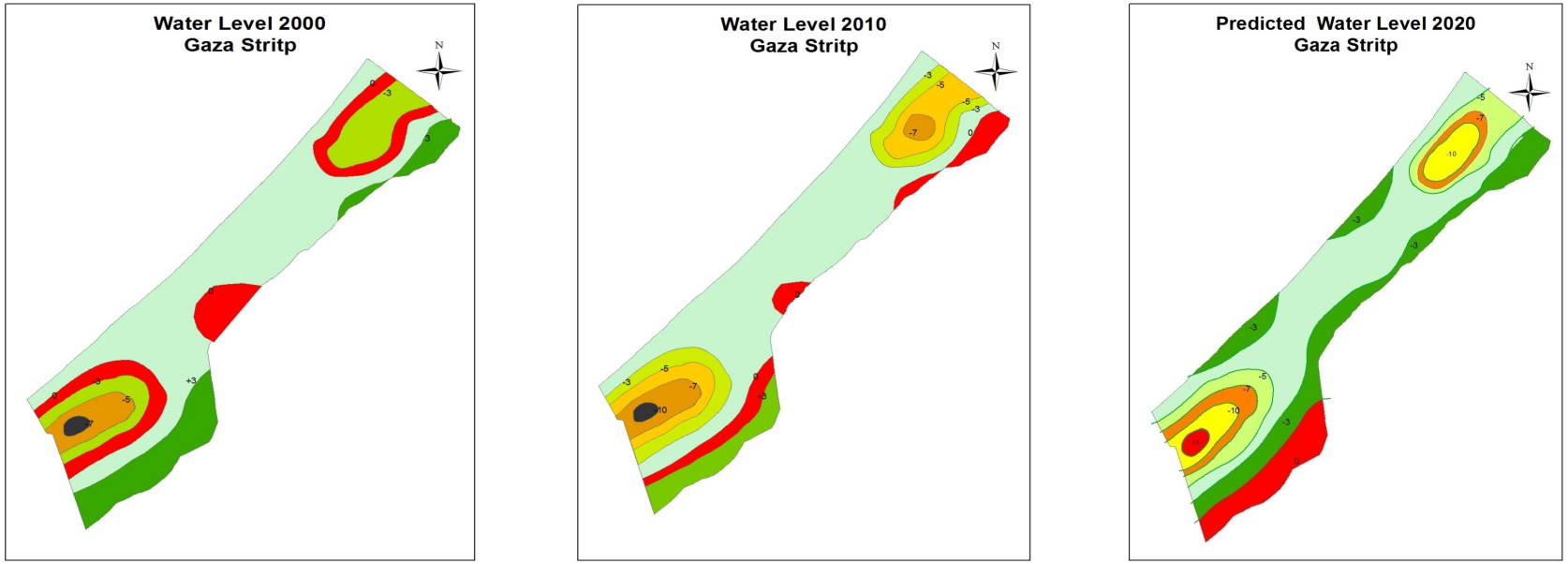
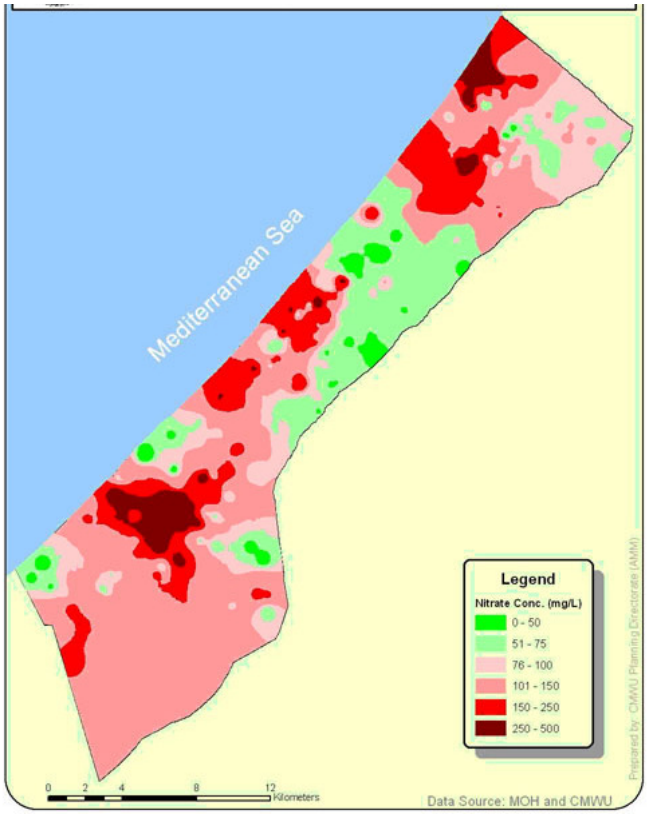


Figure 3. Concentrations of nitrate in the groundwater within the borders of Gaza, for the year 2009. (Data from the Palestinian Water Authority, Gaza). The internationally accepted guideline for nitrate in drinking water is 50 mg/litre.

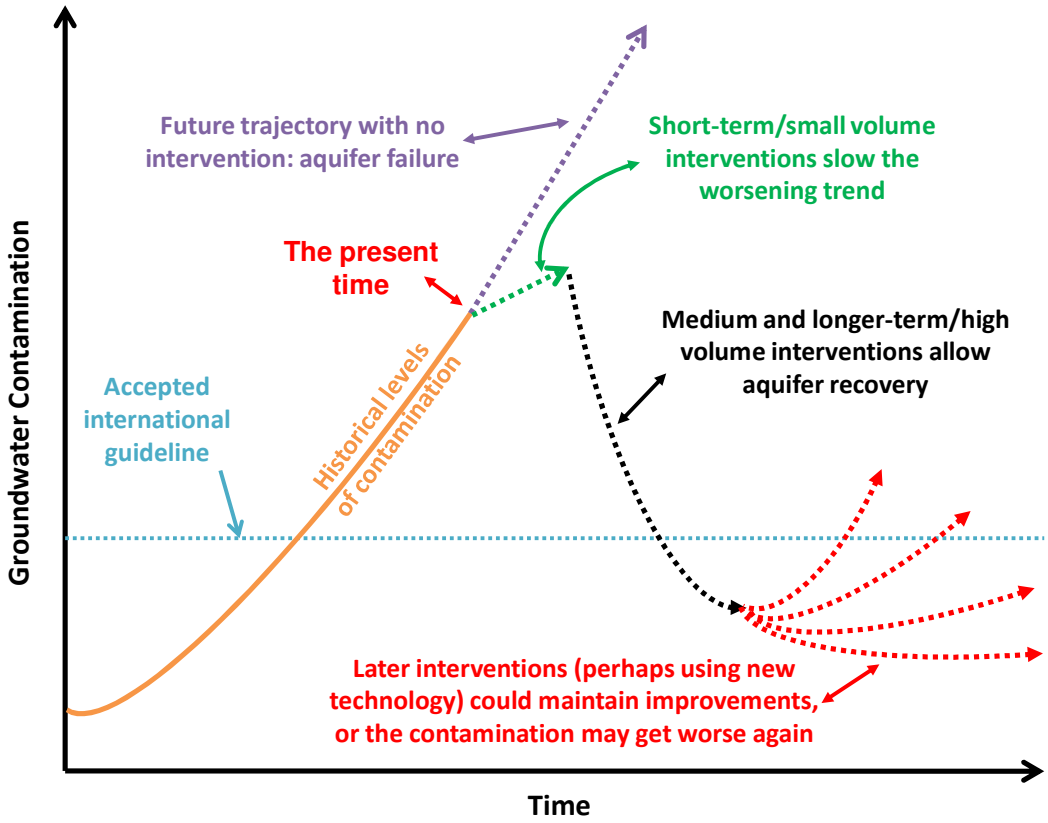


Text Box 1: The Existing Problems with Post-treated Groundwater Supplies

"While households in Beit Lahiya and Tal el Hawa use water filters to purify water, 86.9 per cent of the households surveyed buy their drinking water from unregulated private vendors selling desalinated water for an average cost of NIS 35/m3 – rates unaffordable for poor households.
Eight-six per cent of respondents rely on the [municipal] *network for water for domestic purposes such as cooking or washing. Although more than 47 per cent of the respondents say they are reluctant to use water from the network for cooking, many are forced to do so because of the high cost of privately-supplied water. Cooking heightens the concentration of nitrates and other salts even further."*
Source: Unicef/PHG, 2010

"Each point of the water contamination cycle – from source through distribution by trucks, handling and storage in shop filling tanks, handling for household transport and storage in household tanks and jerry cans – is a point of contamination of desalinated water, transforming water that might have started the cycle free of bacteria into a threat to child health at the point of consumption….
Water-associated diseases account for approximately 26 per cent of disease in Gaza, and are the primary cause of child morbidity; dairrhoea – preventable and easily treated – was the cause of 12 per cent of infant and young child deaths in Gaza in 2009."
Source: Unicef, 2011

Figure 4. A historical profile showing the derivation of problems relating to the groundwater in Gaza, with diagrammatic indications of the effects of short-term, medium-term and longer-term interventions.



The History: Over-abstraction and an inability to address the problems create saline intrusion and contamination of the groundwater. *[The patient gets sick, and fails to receive assistance/treatment to halt the decline in health].*	**Selected Future Interventions:** Short-term interventions reduce the rate at which the situation worsens. Only medium-term and longer-term interventions can generate improvement, allowing the aquifer to recover. *[The patient is treated in phases; the disease process is arrested and reversed; lifestyle and environmental changes ensure continued health].*

Table 1. Key characteristics of the phases shown in Figure 3, with comments in italic font relating to the 'guiding metaphor' discussed above.

- alleviate the current humanitarian and public health crisis in Gaza by improving the quality and increasing the quantity of the water available for domestic use;
- enhance the efficiency and fairness in the water sector by reconfiguring the supply and distribution system;
- benefit the agricultural sector, which is of great importance for the present economy of Gaza;
- rehabilitate the aquifer within the boundaries of Gaza by eliminating the over-abstraction of water, as soon as this may be possible; and
- in the longer term, contribute to the coherent joint management of the Coastal Aquifer as a whole, by both Israel and Palestine.

The strategy devised by the CSO-G project team is focused specifically on all five of these goals, in combination. However, only certain of the options in the CSO-G are of utility in the current geopolitical environment, and the screening process used by the project team has taken this into account, as discussed in Section 3 below.

2.2 THE *STATUS QUO* AS AN OPTION

Section 2.4.1 of the Terms of Reference for the CSO-G (see *Annex 1* to this report) suggests that the continuation of the *status quo* might constitute a viable option for Gaza. The project team rejects this, on three main grounds:

- Over 90% of the groundwater in Gaza does not meet internationally accepted guidelines in relation to appropriate quality for domestic use, and the 1.6 million inhabitants of Gaza are thus exposed to unacceptably high levels of health risk.

- The quantity of water available for domestic purposes for the residents of Gaza is below minimum human consumption levels as determined by internationally accepted standards, and at present rates the population will double in less than twenty years.

- The situation is becoming gradually worse, as the groundwater salinises further over time. Examples of this trend are shown in Figure 5, these being taken from the monitoring of groundwater quality in wells in Gaza. While different wells show distinct trends in groundwater quality, those close to the coast are especially severely exposed to saline intrusion, as are the wells located in the south-eastern portion of Gaza.

It is concluded that interventions must be made in Gaza, if the humanitarian aspects of the problem as a whole are to be addressed, and if the aquifer is to be protected from total failure.

2.3 GAZA IN THE FUTURE

The CMWU has estimated that aquifer failure is likely to eventuate in Gaza in 2016, and while such predictions cannot be fully verified at present, the time course of the changes shown in Figure 5 suggests that intractable problems will occur very soon. In the worst case, the groundwater will become totally salinised, and all potable water will need to be provided from another source. This implies the loss of about 55 MCM/year of otherwise usable flows, and the capital costs for reproviding such a volume will amount to approximately US$300 million, with ongoing costs of at least US$0.55/$m^3$ for fresh water produced through desalination.

The spectre of climate change also needs to be mentioned here. The present predictions on global climate changes reveal that the Mediterranean Sea region will be particularly severely affected (Figure 6), with very significant increases in temperature, coupled to lower and more irregular rainfall. While such predictions also cannot be fully verified at this time, recent studies on Palestine and its capacity to adapt to such impacts have suggested that major additional problems would arise (Al-Dadah, 2009; UNDP, 2009).

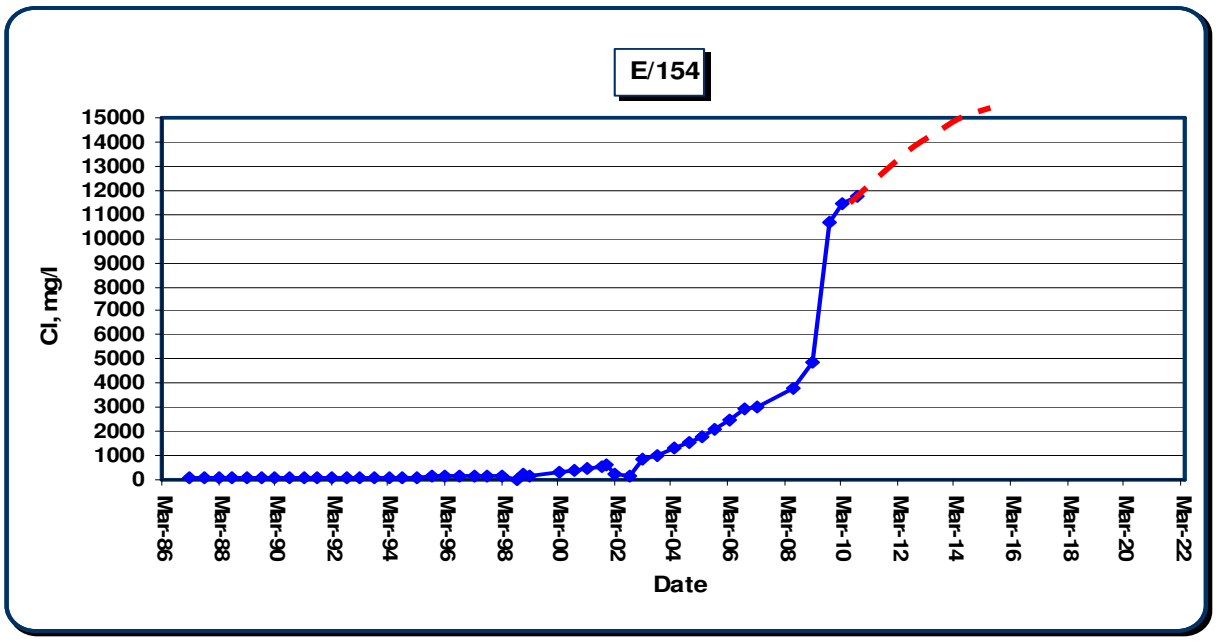
If this does indeed eventuate, a range of changes may be anticipated :

- The recharge of the groundwater in Gaza will be likely to be reduced, driving down the sustainable yield (currently estimated at 55 MCM/year, on average).

- The demand for fresh water will rise, both in the domestic sector and (especially) in the agricultural sector (Al-Dadah, 2009). The latter change will be driven by increases in the rate of evapotranspiration, primarily.

- The preferred crop types in the agricultural sector may also change over time, and the economic performance of the agricultural sector will be eroded – hence reducing yet further the economic capacity of the population of Gaza.

Figure 5. Monitoring data for chloride concentrations (shown in blue) and predicted levels of chloride (red dashed lines) in two of the wells in Gaza. Data from the CMWU.



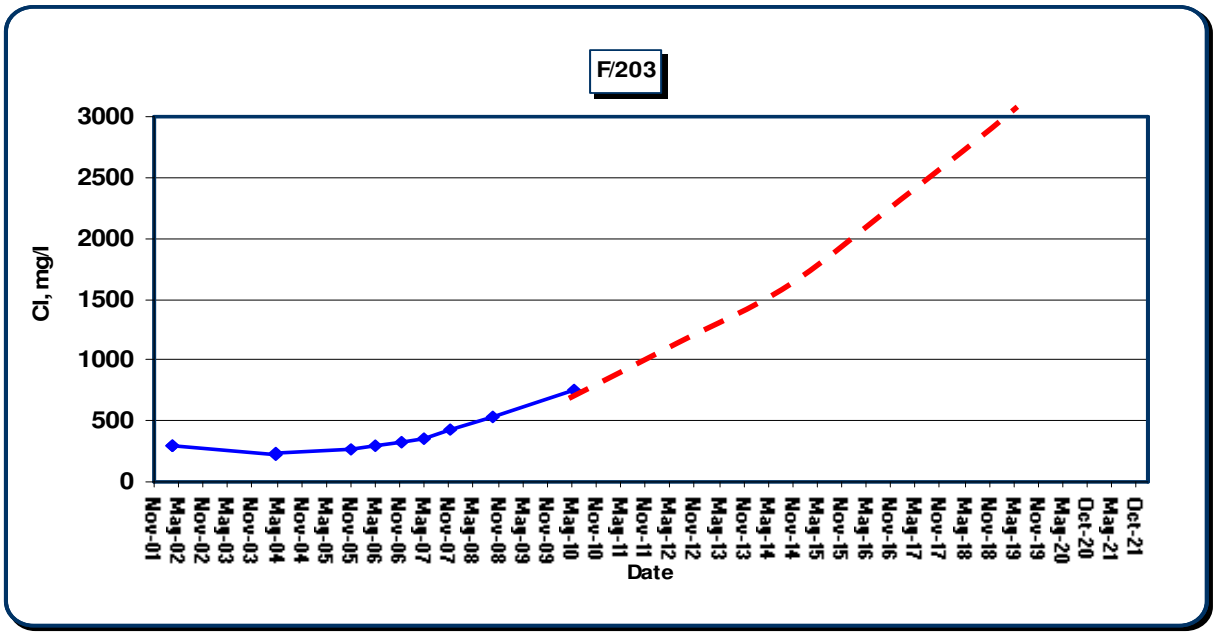
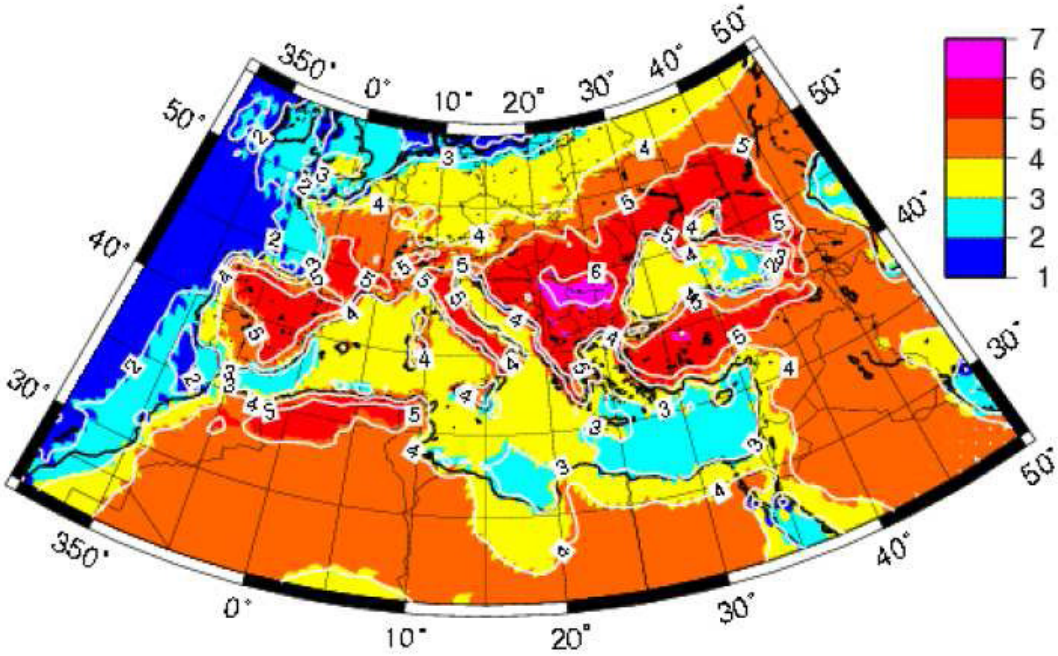


Figure 6. The predicted annual mean increase in air temperatures during summer, as degrees Centigrade (2070-2099 *versus* 1961-1990) for Europe, parts of the Middle East, and north Africa. After Somot *et al.* (2008), as cited by UNDP (2009).



All such impacts are likely to be negative for Gaza, and under the present circumstances at least, adapative capacity is low in the region as a whole (at least outside Israel), and especially in Gaza (UNDP, 2009). It may be concluded that the *status quo* in Gaza is already intolerable, and all signs are that conditions will become worse over time. The effective lack of emigration coupled to the very high birth rate (about 3.3% *per annum* currently, implying a doubling in population in less than twenty years) place ever greater stress on the fresh water resources, and it is clear that severe competition will emerge between domestic and agricultural uses of water – the first sustaining life, and the second representing one of very few sources of employment and a major pillar of the Gaza economy. Gaza is therefore caught presently, 'between a rock and a hard place'. The appreciation of this dilemma represents the key rationale for the CSO-G.

Many parties – indeed, possibly all parties – could be expected to share interests in addressing this scenario, without delay. Such interests would presumably include the following:

- improving the stability of regional relationships;
- reducing the opportunity for radical or extremist groups to incite violence;
- improving the health and protection of groundwater (aquifer) systems in the region;
- providing joint action to alleviate suffering from a severe humanitarian crisis; and
- providing a plan that allows Israel to loosen its blockade, while maintaining desired security standards.

3. Developing and Screening the Options

This section of the present report develops the options listed in the Terms of Reference for the CSO-G to create a more comprehensive and inclusive list, and then screens the larger group of options against a set of four criteria. The performance of each of the options in the screening process is then discussed.

3.1 Developing the Options

The list of options as shown in the Terms of Reference was considered by the project team at the commencement of the study, leading to two types of changes. The first of these involved the addition of two particular options that are not included in the Terms of Reference, these pertaining to the transfer of fresh water to Gaza from Egypt and from Jordan. The second change related to the addition of nuance, with certain of the options being separated into sub-options. Sub-options were created for the following:

- transfers of water from Israel, separating these into high volume and low volume;
- transfers of water from Turkey, separated into techniques using bags, tankers and a pipeline; and
- desalination, separated into short-term low-volume (STLV) desalination in Gaza; regional long-term desalination in Gaza at high volume; and regional long-term desalination in Egypt.

3.2 Screening the Options

The Initial screening process utilized four relatively simple criteria, as follows:

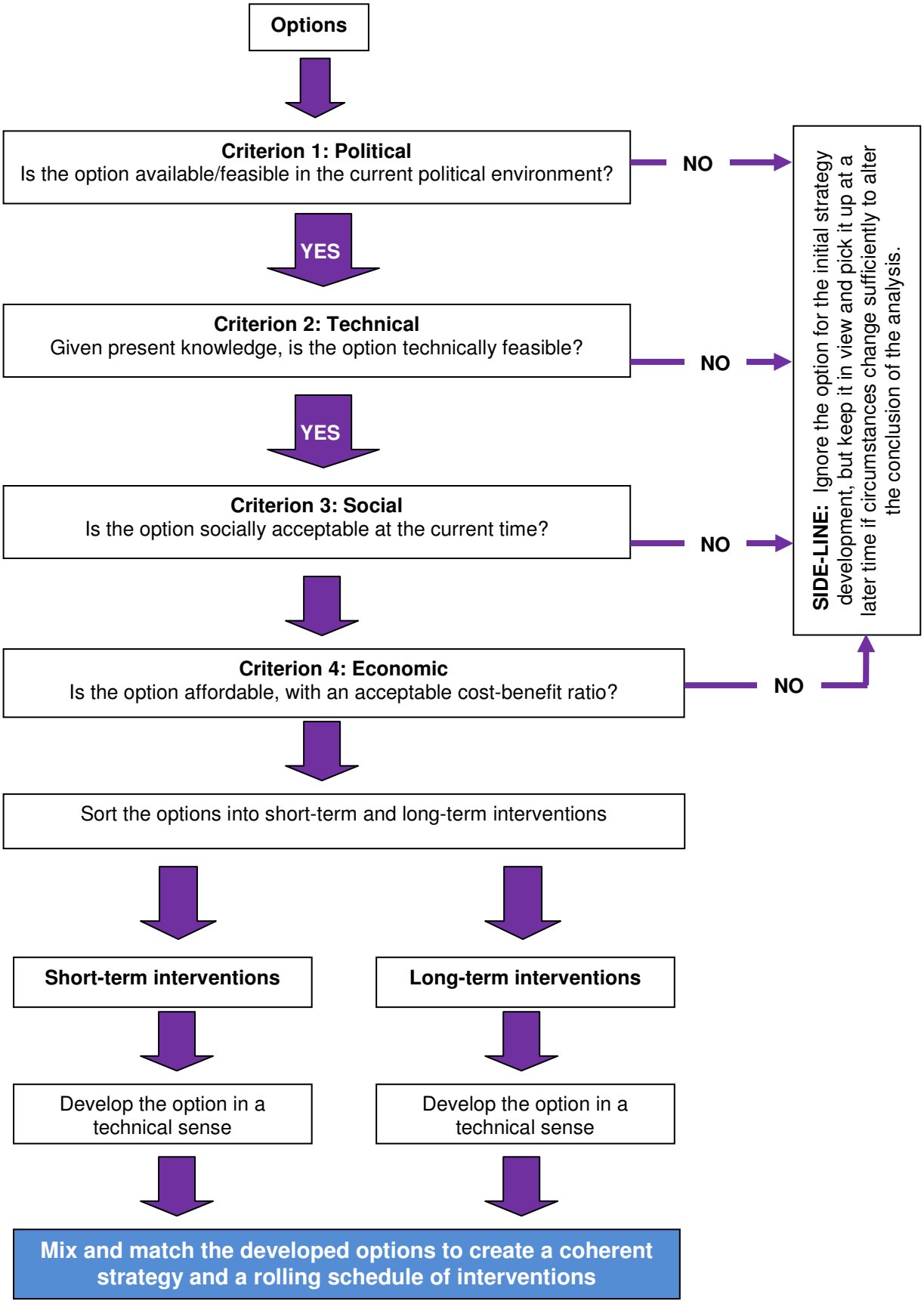
- ***Political:*** Is the option politically acceptable in the current context?
- ***Technical:*** Is the option technically feasible?
- ***Social:*** Is the option socially acceptable?
- ***Economic:*** Is the option affordable, with an acceptable cost-benefit ratio?

The expanded group of options/sub-options generated as described in Section 3.1 above was then screened against the four criteria in a sequential fashion, as shown in Figure 7. This process took account of the *status quo* in all instances.

In most cases, the performance of the option/sub-option against the four criteria was clear, and did not require lengthy deliberation or any consideration of the differential weighting of criteria (see Text Box 2). In certain instances, however, options or sub-options were 'flagged' against particular criteria, and additional thought was needed to form a defensible conclusion as to whether the option would pass or would fail (under the current conditions). This process gave rise to the results as shown in Table 2, and the following sub-sections provide explanations of the screening process for each of the options and sub-options.

Options/sub-options that were considered to fail against any of the criteria were laid aside for use in the current CSO-G strategy. It is noted that some of these options/sub-options could nevertheless be of utility in the longer term if conditions change significantly, and Section 5 of this report returns to this possibility.

Figure 7. The use of screening criteria in the development of the CSO-G strategy.



Option	Sub-Option	Criteria			
		1: Political	***2: Technical***	***3: Social***	***4: Economic***
Water Demand Management	None	Pass	Pass	Pass	Pass
Wastewater reuse	None	Pass	Pass	Flag/Pass	Pass
Within-Palestine transfer	None	Flag/**Fail**	**Fail**	Pass	**Fail**
Transfer from Israel	High volume	**Fail**	Pass	Pass	Pass
	Low volume	Flag/Pass	Pass	Pass	Flag/Pass
Transfer from Turkey	Bags	Flag/Pass	**Fail**	Pass	**Fail**
	Tankers	Flag/Pass	Pass	Pass	**Fail**
	Pipeline	Flag/Pass	Pass	Pass	Flag/Pass?
Transfer from Egypt	None	**Fail**	Pass	Flag/Pass	Pass
Transfer from Jordan	None	**Fail**	Pass	Flag/Pass	**Fail**
Desalination	STLV desalination in Gaza	Flag/Pass	Pass	Pass	Pass
	Regional long-term in Gaza	Flag/Pass	Pass	Pass	Pass
	Regional long-term in Egypt	**Fail?**	Pass	Flag/Pass	Pass

Table 2. The performance of the various options and sub-options during the initial screening process. STLV: Short-term low-volume.

Text Box 2: Weighting the Criteria

The CSO-G project team considered the possible need to weight the criteria used in the analysis described here. After discussion, the project team concluded that the use of differential weighting for any of the criteria would not materially improve the analysis. In certain instances, this is because the criterion is of a 'pass/fail' nature – thus, for example, particular options are either politically acceptable in the *status quo*, or are unavailable. [The provision of additional large volumes of fresh water from Israel to Palestine represents one such instance, and this is addressed further at Section 3.6 below].

Clearly, certain of the conclusions shown in Table 2 above represent reasoned judgements by the CSO-G project team. However, even in these instances, the conclusions as shown here are based on long experience of the scenario in the water sector in Palestine. Some of the conclusions would of course alter if the political circumstances were to change materially in the future. The analysis as shown in Section 4 of the present report deals with the *status quo* and relies on the options that are available as emergency interventions, hence ignoring all of the options that are not believed to be currently available. The possibility that certain options might become available at a future time is revisited in Section 5 of the present report.

3.3 WATER DEMAND MANAGEMENT

Water Demand Management (WDM) is commonly cited by engineers and water managers as a necessary response to drought, or to more general water scarcity. WDM may extend to a wide range of interventions (e.g. see Herbetson and Tate, 2001; PRI, 2005; Butler and Memon, 2006), including the following:

- Regulating demand at the domestic consumer, through the use of diverse economic instruments and water-saving measures.
- Controlling demand in the agricultural sector by a variety of means, which may include the metering of the agricultural use of water; the judicious use of tariffs for fresh water used in the agricultural sector; alterations to irrigation techniques; changes to cropping patterns, and other types of interventions.
- Reusing treated wastewater in the agricultural sector, hence reducing the sectoral demand for higher-quality fresh water resources.
- Improving the capture and/or storage of rainfall or run-off, e.g. through water harvesting techniques.
- Reducing system losses, such as those occurring through leakage in water distribution networks or other forms of Unaccounted for Water (UfW).

These types of interventions vary in their relevance to the scenario in Gaza at the present time. In the first instance, it is important to note that the possibilities for reducing water use in the domestic sector in Gaza are limited (Yaqubi, 2008; PWA, 2010a). The current *per capita* water production rates in Gaza vary from just over 200 litres/day in northern Gaza, to marginally over 100 litres/day in Rafah in the south. Water consumption rates are considerably lower than these values, due to system inefficiencies of various types (leakage, illegal connections, etc.), which approach or may even exceed 40% in certain areas. Hence, many of the Gaza population presently consume less than the recommended minimum volume of fresh water as laid down by the World Health Organization, this being either 100 or 150 litres *per capita*/day, depending on which of the two published benchmarks is preferred. While leakage and inefficiencies can be addressed and create some improvements, the domestic consumers cannot be expected to reduce their water consumption by a significant margin under such circumstances. The use of higher tariffs to attempt to reduce water consumption would also be of little or no benefit, especially at the current levels of poverty in Gaza.[9]

The inequitable access to fresh water within different portions of the Gaza population as a whole has been noted as a concern of both the PWA and the CMWU (Yaquibi, 2008; PWA, 2010a). To address this, the distribution system needs to be 'reconfigured', and this requirement has been subsumed into the strategic planning and the associated work completed within the CSO-G study, as detailed elsewhere in the current report.

The interventions available in the agricultural sector pertaining to WDM offer greater scope. While there is some doubt as to the precise pumpage figures due to the paucity of metering and the high number of unlicensed wells, almost 50% of the abstracted groundwater in Gaza is believed to be allocated to agricultural use presently (PWA, 2010a). This considerable volume is not being used efficiently, for a wide range of reasons connected to the maturity of the agricultural sector in Gaza and the very low investment capacity. There can be no doubt that the introduction of wide-scale wastewater reuse – as envisaged initially in the *Integrated Aquifer Management Plan* produced in the

[9] Further comments on the ability/willingness of the Gaza population to pay for fresh water supplies are provided at Section 6.3 of this report.

year 2000 – would materially benefit the sector.[10] However, a number of problems remain in this regard, and these are addressed in greater detail in Section 3.4 below.

All of the WDM measures that are of utility in the CSO-G have been subsumed into the options discussed in Section 4 of this report.

3.4 Wastewater Reuse

Wastewater reuse is envisaged primarily as a means to support the agricultural sector in Gaza (NSU, 2010). Until relatively recently, it was reported that farmers in Gaza were opposed to the reuse of wastewaters. As shown in Table 2 above, the reuse of wastewater was flagged against the Social criterion, due to the previous controversy amongst farmers in Palestine relating to the social acceptability of this practice. However, recent experience in Jordan and elsewhere in the Middle East (particularly in certain of the Gulf countries) has shown that wastewater reuse is an acceptable technique in the agricultural sector, and the option was therefore deemed to pass the Social criterion (Uleimat, 2007; Nazzal *et al.*, 2000; Sheikh, 2001; McCornick *et al.*, 2004; Grabow *et al.*, 2006; Ammary, 2007; US AID, on-line). Support for this derives from a number of recent studies, all of which have suggested that the farmers in Gaza are willing to utilize treated wastewaters for irrigation, if flows of the relevant volume are made available (e.g. see Almadina-Enfra-DHV, undated).

A recent review of the potential for wastewater reuse in Palestine is relied upon here, in relation to the requirements for introducing this technique in Gaza on a broad scale (NSU, 2010). The review is comprehensive, and points to a wide range of policy-level decisions that should be addressed by the PWA and others in Palestine, for large-scale wastewater reuse to become a reality. In the Gaza context, pilot wastewater reuse schemes have existed for some years, and there are plans for these to be augmented shortly. The key requirement, however, is for the completion of the four major wastewater treatment plants scattered throughout Gaza, as reuse cannot be introduced at any significant scale in the absence of high-quality wastewater treatment.

Section 4.2.9 of this report provides further information on the wastewater reuse components of the CSO-G strategy.

3.5 The Transfer of Water within Palestine

The within-Palestine transfer of water was flagged against the Political criterion (due to potential difficulties in transit through Israel), and also failed on both Technical and Economic grounds. A comprehensive study of a potential West Bank-Gaza transfer of fresh water was undertaken previously (NSU, 2005a). This revealed that there is essentially no potential for transferring significant amounts of fresh water from the West Bank to Gaza (i.e. sufficient volumes to make a material difference in Gaza). There are a number of reasons for this:

- The availability of fresh water in the West Bank – especially the southern areas – is generally poor, and the *per capita* availability of water in those areas is in fact less than that in Gaza, currently (although this admittedly takes account of the over-abstraction of the groundwater in Gaza, somewhat skewing the figures).

[10] See the *Integrated Aquifer Management Plan* developed under USAID funds and released in May 2000. This remains a key planning document in use by the water management authorities in Gaza.

- The capacity to increase fresh water availability in the southern parts of the West Bank is low, and the costs are very high. The only volumes available are effectively those from the Eastern and Western Aquifer Basins[11], and the second of these is highly contested between Palestine and Israel, with no significant enhancement of abstraction by Palestine in the Western Aquifer Basin since the Oslo II Agreement of 28 September 1995. Attempts by Palestine to increase abstraction from the Eastern Aquifer Basin have also been fraught with problems, including difficulties within the Joint Water Committee and addressing the approval process of the Israeli Civil Administration.

- The high costs for accessing additional water quantities in the southern West Bank and supplying these to Gaza relate to well construction and pumping costs to access the deep groundwater and then to attain the hydraulic crest, allowing gravity flow thereafter to Gaza. This represents the rationale for the failure of the option on Economic grounds, as shown in Table 2.

- There is no certainty in relation to the creation of the territorial link between the West Bank and Gaza, which is hostage to the Permanent Status negotiations between Palestine and Israel. The recent experience of the Annapolis Round of negotiations suggests that a breakthrough in this respect is unlikely, and the Palestinian side has been unable to secure preconditions for resuming negotiations (pertaining to the continuing expansion of Israeli settlements in the West Bank). This is the reason for the failure of the West Bank-Gaza transfer on Political grounds, as shown in Table 2.

In any event, any additional volumes of fresh water that could be accessed in either of the two aquifer basins of relevance in the West Bank would almost certainly be allocated to use within the West Bank itself, to address the low *per capita* availability of water in the southern parts of the West Bank in particular (see Messerschmid, 2011). This option was therefore side-lined in the initial screening process, and is addressed again briefly in Section 5 of the present report.

The surface waters of Wadi Gaza should also be mentioned here, in passing. These have been estimated to approximate 30 MCM/year on average, although the flows are highly variable annually. Wadi Gaza has been blocked and its waters completely utilized in Israel, over recent years. It was included as a component of the six major shared watercourses in the work in Palestine on Permanent Status, but no progress has been made in that regard in the political arena (see Sections 3.6 and 5 of this report). The current analysis does not therefore include Wadi Gaza as a resource of significance to Gaza – although the degree to which such flows might have contributed historically to the recharge of the Gaza groundwater system may be contemplated. It is noted that even if Wadi Gaza were to flow on downstream into Gaza in the future, only limited quantities of such flows could be captured and utilized, and these would be available during the wet season, when the demand is lower in any event.

3.6 Transfers of Water from Israel

The transfer of water in high volume to Gaza from Israel failed on the Political criterion (Table 2), reflecting the inability of Palestine and Israel to agree on an equitable and reasonable allocation of their shared fresh water resources, through the Permanent Status negotiations. Section 5 of this report revisits this matter, as a more equitable division of the shared resources would align with the principles of customary international water law. **In fact, this option represents the strong preference of the project team, amongst all of the options considered in the CSO-G** (see Text

[11] The North-Eastern Aquifer Basin is too distant from any potential connection to Gaza, and may therefore be ignored in the context of additional water supplies to Gaza.

Box 3). This dynamic in particular highlights the restricted range of options available in the current geopolitical environment to augment the water supplies in Gaza, which is a predominant theme to the CSO-G.

Text Box 3: The Water Rights of Palestine

Several of the CSO-G project team members assisted the Palestine Liberation Organization (PLO) in preparations for the Permanent Status negotiations on water, extending from the period running up to the Camp David meetings in mid-2000, through to the relatively recent Annapolis Round of negotiations. The work on the bilateral scenario (involving Palestine and Israel) also extended to consideration of the water rights of the other three riparians of the Jordan River basin, as any bilateral agreement would need to align with a possible multilateral agreement which could be produced separately at some point in time.

While some of the preparations for the Permanent Status negotiations remain confidential in nature, certain of the data and conclusions have been published in the open literature (see Phillips *et al.*, 2007, 2009; also Phillips, in press). These show clearly that Palestine as a whole has significant rights to water in the region, extending to all of the six watercourses shared with Israel (four aquifers including the Coastal Aquifer Basin; and the surface waters of both Wadi Gaza and the Jordan River). The sources that might be available to Gaza are determined essentially by practical issues, and the most obvious sources of additional natural waters for Gaza are those of the Coastal Aquifer Basin externally to Gaza itself, and flows from Lake Tiberias which could be delivered to Gaza through the Israeli National Water Carrier.

The principles of customary international water law – which binds all States, whether or not they have signed specific conventions – support a case that the Gaza population should receive a much higher volume of fresh water from the resources shared with Israel. Unfortunately, however, no progress has been made in the negotiation arena on this matter, to date.

As shown in Table 2, the transfer of water in low volume to Gaza from Israel was flagged on both the Political and Economic criteria. However, recent events suggest that this could be attainable politically, and that the resulting flows could be affordable economically (see PWA, 2010b).[12] Three points exist at which flows from Israel could reach Gaza, and the details of this are presented in Section 4.2.4 of the present report. Ongoing negotiations facilitated by the Government of Norway are addressing this possibility, and the current report attempts to faithfully represent the dynamic as at 31 July 2011. It should be noted that even though the additional transfers from Israel that are presently under negotiation are of relatively low volume, they are an important component of the CSO-G strategy that is laid out in Section 4 of this report.

3.7 Transfers of Water from Turkey

The transfer of water from Turkey to Gaza was considered questionable on political grounds, but was eventually deemed to pass this criterion (see Table 2). It is noted in this respect that Turkey has negotiated for some time with Israel and other countries for possible exports of fresh water, and while certain parties in Turkey consider this to be short-sighted, the possibility of such transfers still exists at

[12]The affordability to the Gaza population of fresh water from any source has been a subject of much debate in the past, with commentators disagreeing on many aspects. This issue is addressed in the specific in Section 6.3 of the present report.

the current time (see, for example, IPCRI, 2010). However, the use of bags towed in sea water for such transfers does not represent proven technology currently, and both this and the tanker transport sub-option were in any event deemed to fail on the Economic criterion (see also Gurer and Űlger, 2004; Rende, 2004). Previous efforts involving such transfers between Turkey, Israel and Cyprus were utilized in part as the basis for this analysis.

By contrast to the scenarios above involving bags and tankers, the Mini-Peace Pipeline has been considered by some authors to be an option worthy of consideration in the long term (Al-Jayyousi and Shatanawi, 1996; Becker *et al.*, 1996; Gruen, 2004; Phillips *et al.*, 2007, 2009; Phillips, in press; Wachtel, undated). The original route proposed for the Mini-Peace Pipeline was over land, but a sub-sea route has also been discussed, this being likely to be dependent on oil and electricity transport also (Erdemir, 2009; Foley, 2010). This matter is addressed further in Section 5 of the present report.

3.8 Transfers of Natural Waters from Elsewhere

Transfers of natural waters to Gaza from either Egypt or Jordan were considered to fail against one or more of the four criteria. Such a transfer from Egypt is certainly technically possible, as surface water flows derived from the Nile River estuary are potentially available to Gaza from a possible extension of the Salaam Canal, which flows into the Sinai. However, the ongoing debate between the eleven riparians of the Nile[13] reflects the tensions over allocations of those flows, and the provision of water to Gaza from Egypt is considered most unlikely to be politically attainable. A portent of the scale of protest in such scenarios was provided both during and after the visit of former Egyptian President Anwar Sadat to Israel in November 1977, where debate was triggered as to the possibility of providing Israel with 1% of the flow from the Nile (Phillips *et al.* 2006).

Transfers of fresh water of any significant volume from Jordan to Palestine are also deemed likely to be politically unacceptable[14], and hydrological considerations dictate that any such flows would be very expensive after delivery to Gaza, due to high pumping costs. Jordan is in any event facing its own water shortage, and this has created no little controversy in the region in recent years, notwithstanding the fact that its *per capita* availability of fresh water is more than twice that in Palestine (Phillips *et al.*, 2009; Phillips, in press). It remains possible that desalinated flows arising in Jordan – either from the Red Sea-Dead Sea Conduit or from a (more likely) option involving a desalination facility in Aqaba – could be partially available to Palestine. The degree to which Palestine would wish to use such flows has occasioned considerable debate in the past, with no particularly strong conclusions emerging. However, any such flows would be most likely to be utilized in the western Jordan Valley. There is a remote possibility that the three countries involved in the Red Sea-Dead Sea Conduit studies could agree on a 'wheeling' arrangement where flows available at one point could be forgone, and replaced by flows elsewhere. This might result in a possibility for additional flows to Gaza in the future (from Israel), but the current uncertainties do not permit conclusions to be reached on such matters. Any such volumes have therefore been ignored in the current CSO-G analysis, although the comments in Section 5 of this report concerning the Israeli-Palestinian share of water remain of relevance.

Other [even more remote] possibilities such as the towing of icebergs from the Antarctic to provide fresh water to Gaza (Victor, 1986) do not merit serious consideration here – although this question was raised at one point during a meeting with the project team.

[13]The very recent division of Sudan into North and South Sudan has increased the numbers of riparians of the Nile River to eleven.

[14]The availability of fresh water in Jordan is not as low as that in Palestine, but Jordan faces severe water stress in any event and has a restricted range of options for alleviating this in the future.

3.9 DESALINATION

The sub-options relating to desalination in Gaza are of particular importance in the CSO-G. Both STLV desalination and long-term regional desalination in Gaza were flagged against the Political criterion (see Table 2). This reflects two matters: the problems relating to the blockade of Gaza and the importation of materials and equipment[15]; and the historical reticence of the Palestinian authorities to introduce desalination in Gaza.

Issues pertaining to the blockade are of course of relevance to all of the options addressed in the CSO-G, and this topic is covered elsewhere in the present report (see Section 6.1). Most of the historical reticence to introduce desalination reflects concerns that Palestine's Permanent Status position could be eroded by such a move.[16] However, this attitude has softened in recent times, for three reasons: [a] Permanent Status negotiations have made no progress and appear unlikely to do so in the foreseeable future; [b] the humanitarian crisis in Gaza in relation to drinking water is getting inexorably worse and must be addressed, whatever effects may eventuate; and [c] any erosion of the Permanent Status position is certainly also being experienced by Israel, which has an aggressive and expanding programme for desalination. For these reasons, desalination in Gaza was passed against the Political criterion.

The sub-option involving desalination in Egypt but with a supply to Gaza was raised initially in the 'PWA Audit', as shown in Table 3. As noted in that study, this option is attractive from certain viewpoints, although it remains highly controversial. It is notable that the fresh water supply to El-Arish and other parts of the Sinai in Egypt is very poor, with highly saline groundwater being present in many areas (see, for example, Geriesh *et al*, 2004; Ghodeif and Geriesh, undated). This would suggest that the Egyptian authorities may be amenable to a trans-boundary project pertaining to desalination, with shared benefits.

The project team has debated this matter with a wide range of individuals and entities in Palestine, during the course of the CSO-G. Reactions to such a proposal vary greatly, with emotional statements tending to be more common than views based on logic. The matter is raised once again in Section 5 of the present report, as it is considered that the CSO-G will not solve this problem, which must be addressed by the Palestinian authorities in the longer term.

The question also arises as to how large a regional desalination facility is required in Gaza. The studies leading up to 2003 (financed by US AID; see Ismail, 2003) suggested that a regional desalination plant in Gaza should have a maximum capacity of 55 MCM/year, and a facility involving five 11 MCM/year units was envisaged. In the initial stage, it was proposed that two of these units should be constructed, providing 22 MCM/year of desalinated supplies to Gaza. However, strategic analyses since that time (NSU, 2005b) concluded that this was an under-estimate, and that the near-term demand in Gaza for desalinated supplies is considerably greater than 55 MCM/year. An extract from the study of the NSU (2005b) is shown in Figure 8, this indicating that at 2025 (well within the time horizon of the CSO-G), at least 100 MCM/year of desalinated flows will be required in Gaza.[17] In the face of potential climate change (see Section 2.3 and Figure 6 above), this conclusion appears to be inescapable.

---

[15] The term 'blockade' is preferred for use here, rather than certain other terms that have also been employed, such as 'siege'. The blockade refers to the restricted ability of Palestine to import materials into Gaza across its borders, and this has been problematic for most of the period since disengagement of the Israeli settlements in Gaza in August-September 2005. Further comments on the blockade are provided at Section 6.1 of this report.

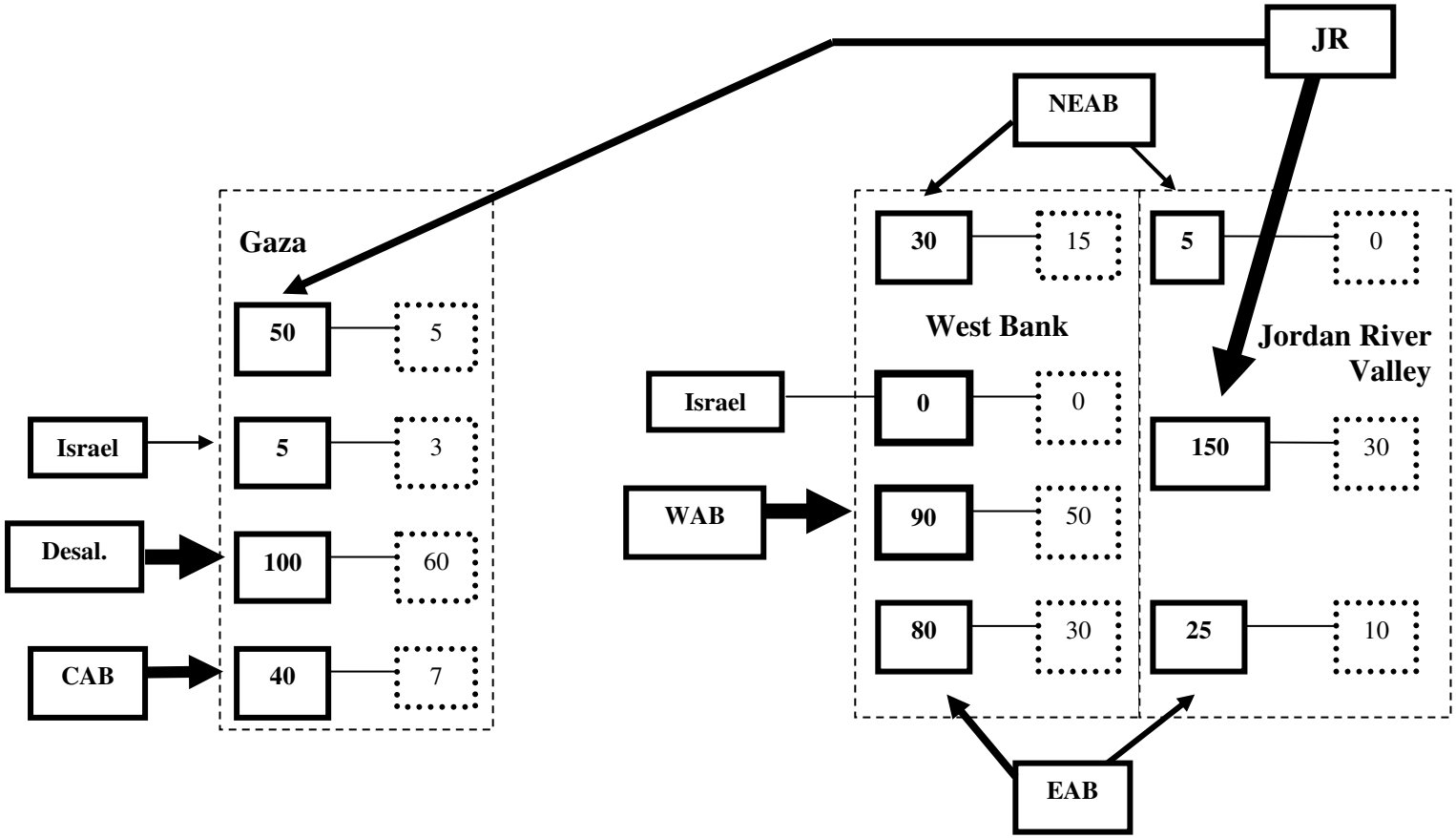
[16] Some parties have been reluctant to introduce desalination in Gaza because of a perception that such supplies are not affordable. This matter is addressed elsewhere in the present report (see Section 6.3).

[17] See later sections of this report, in relation to more recent estimates of the future demand for desalinated supplies in Gaza, which rely on different assumptions relating to the future availability of other water sources, to those used by the study of the NSU (2005b).

Parameter	Option A: Desalination Plant Located in Gaza	Option B: Desalination Plant Located in Sinai, Egypt	Option C: Desalinated Supplies Purchased from Ashkelon [Israel]
Comparative costs	Would be likely to be reduced by grant provision, as a component of humanitarian assistance to Palestine.	Could be reduced by grant provision, assuming the desalinated flows go mainly to Palestine.	High; determined by a Palestinian-Israeli contract.
Likelihood of external capital financing assistance	High (seen as humanitarian assistance).	Moderate to high, depending on packaging of the project.	Low, at least over time (possible assistance initially).
Likelihood of external financing assistance, operation/ maintenance	Low in the longer term.	Low in the longer term.	Low in the medium and longer term (financing benefits the Israeli BOT company).
Contract type	Likely to be a BOT scheme, adding some margin to costs. Otherwise for Palestine to decide.	Likely to be a BOT scheme, adding some margin to costs. Palestine and Egypt to decide.	Contract between Palestine and Israel/BOT; Palestine would have little control over content.
Anticipated elapsed time to water availability	Moderate (decision, updated design and construction time all would be involved).	Could be higher than Option A (international negotiation would be involved).	Probably significantly lower than Option A (but negotiation with Israel would be involved).
Physical security of supply (desalinator)	Challenged (under Palestinian control, but Israeli incursions could create significant damage).	Good, although the pipeline would need armouring and protecting as far as possible.	Challenged (under Israeli control; competing uses in Israel could emerge and be given priority)
Physical security of supply (pipelines)	Challenged (under Palestinian control, but Israeli incursions could create significant damage).	Challenged (Israeli incursions could affect the parts of the system inside Gaza).	Challenged (Israeli incursions could affect the parts of the system inside Gaza).
Political security of supply (desalinator and pipelines)	Good (under Palestinian control; infighting would need control).	Good (protected under agreement between Palestine and Egypt).	Poor (Israel could decide to prefer to allocate flows elsewhere).
Overall security of investment	Challenged (effects of Israeli incursions; possibly also effects from Palestinian infighting).	Good (desalinator unlikely to be damaged; pipelines could be armoured and replaced quickly).	Moderate to good, depending on the contract entered into between the parties.

Table 3. A preliminary comparison of three options for supplying desalinated water to Gaza. After the 'PWA Audit' (see footnote [1] in this report).

Figure 8. A diagrammatic representation of a scenario for 2025, in relation to water supply in the West Bank and Gaza. JR, Jordan River; NEAB, North-eastern Aquifer Basin; WAB, Western Aquifer Basin; EAB, Eastern Aquifer Basin; CAB, Coastal Aquifer Basin (including the 'Gaza Aquifer'); Desal., Desalination. All data are shown as million cubic metres/year, with supply from the primary resource being shown in continuous boxes and re-use being shown in dashed boxes. After NSU (2005b).



The project team and the CSO-G counterparts have debated the preferred approach to desalination, at great length. Two basic possibilities exist, each of these being potentially relevant to both STLV and regional desalination:

- the desalination of the brackish groundwater in Gaza, and its utilization as domestic supplies, with wastewater reuse thereafter; and/or
- the desalination of sea water.

There are advantages and disadvantages to both of these approaches. The desalination of brackish groundwater would be considerably cheaper than that of sea water, and would require less energy. However, a focus on groundwater desalination would imply the need for continued over-pumping of the aquifer, and this would eventually lead to aquifer failure. By contrast, the desalination of sea water adds 'new water' to the equation in Gaza, and this is highly desirable.

If the decision faced at the current time had been taken ten years ago, it is very likely that the STLV desalination would have employed brackish groundwater as a feedstock (as the over-pumping was not so severe, at that time). However, in the current context, the water managers in Gaza feel strongly that the groundwater abstraction rates must be reduced as a first priority (see Yaqubi, 2008). The project team has concurred with this view (after much debate), and both the STLV and regional desalination components of the CSO-G strategy rely on sea water desalination, as a result. This component of the strategy in fact has an advantage, in that the STLV desalination can be utilized as the first stage of the regional desalination. Thus, the techniques to be used for the STLV desalination and the regional desalination are effectively identical, and this allows the regional desalination to be 'bolted onto' the earlier STLV desalination, with obvious and important cost savings (see Sections 4.2.6 and 4.2.7 below).

The overall result of the screening procedure in relation to desalination was the passing of two discrete forms of the process: STLV desalination to address short-term problems; and regional desalination as a longer-term intervention. Section 4 of this report integrates these sub-options into an overall strategy for the CSO-G.

4. The Rolling Programme of Interventions

This section outlines the CSO-G strategy as a whole, integrating the options that are available at the current time into a coherent programme of rolling interventions. The individual components of the programme are delineated and discussed, and these are then integrated into a rolling schedule designed to address the key problems in the water sector in Gaza, responding to Section 2.4.8 of the Terms of Reference for the CSO-G. Initial estimates of the approximate costs for the programme components are provided in the final sub-section.

4.1 The Available Options in the *Status Quo*

The options that are available for use in the CSO-G strategy as this relates to the *status quo* were defined in Section 3 above, and the current sub-section simply provides a consolidated set of interventions that are available at the present time, taking account of the constraints discussed in Section 3.2 above. Figure 9 shows how the various sub-options are derived from the main options listed in the Terms of Reference for the CSO-G, and the manner in which these are grouped together in particular admixtures.

The first issue to note from Figure 9 is how few options/sub-options are in fact available to Gaza (and more broadly, to Palestine), in the *status quo* – as compared, for example, to the expanded list of options created as discussed in Section 3.1 of this report. This is reminiscent in some ways of the situation in Jordan, but Palestine faces even more intractable problems than Jordan, and also has a much lower starting point in terms of its *per capita* availability of fresh water.[18]

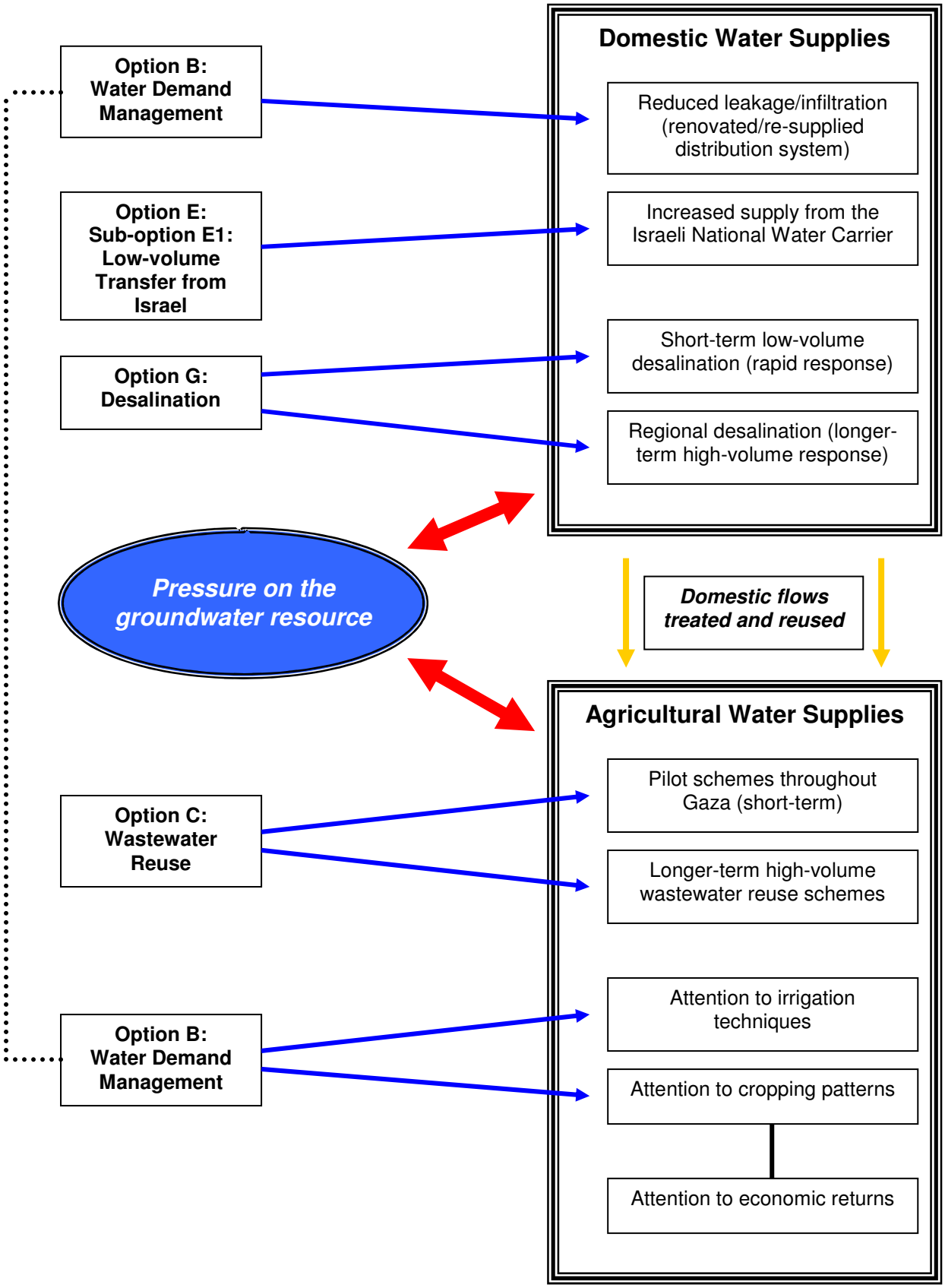
Secondly, it is important to emphasize that all of the options that are considered in Figure 9 to be available to Gaza in the *status quo* in fact depend on certain prior events. Thus, for example:

- It will only be possible to significantly reduce leakage/infiltration rates in the domestic water distribution system (in a reasonable time period) if the ongoing capital works programme in this regard is expanded and accelerated. This will require a considerable injection of additional finance (and the pipe work must of course be adequately maintained, thereafter). This component of the CSO-G programme – that was not listed overtly in the Terms of Reference for the project – is in fact of key importance. This is because the supply to consumers of high-quality (and relatively expensive) water arising from either Israel or desalination [or both] will only be successful if the current leakage/infiltration rates are minimised.

- The additional low-volume transfer of water from Israel (shown as sub-option E1 in Figure 9) is the subject of ongoing negotiations facilitated by the Norwegian Government, and involving the Americans, Israelis and Palestinians. While these negotiations appear to be showing some promise, there is no guarantee that they will be completed successfully in the near term.

[18] The average *per capita* availabilities currently are about 160 cubic metres/year in Jordan, and 70 cubic metres/year in Palestine. If the over-abstraction in Gaza is taken into account, the *per capita* availability of fresh water in Palestine as a whole drops to about 40 cubic metres/year. This equates to about 110 litres/day, for **all** uses, not simply for domestic use. The WHO preferred minimum benchmark for domestic use is 150 litres *per capita*/day, but this ignores the much larger water volume required to produce food.

Figure 9. The available options in the *status quo*, and their grouping in related types of interventions.



- The two sub-options for desalination are capital-intensive; require significant supplies of electrical energy (see Section 6.4 of this report); and also carry relatively high ongoing costs for the provision of desalinated supplies to the Gaza population.

- As noted in Section 3.4 above, wastewater reuse schemes will only be successful if the construction of the key wastewater treatment plants can be completed, and the facilities can be operated effectively.

Even the changes that are believed to be essential in the agricultural sector in terms of improvements in economic water productivity cannot be guaranteed. Most of the farmers in Gaza (and many of those elsewhere in the world) are conservative in their views, and often prefer to use traditional agricultural methods even in situations where these are known to be deeply inefficient.

The task faced in improving the water sector in Gaza is thus of significant scale and difficulty. No 'magic bullets' exist – at least in the absence of an equitable and reasonable reallocation of shared fresh water between Israel and Palestine (see Sections 3.6 and 5.1) – and there will be a need for a major overhaul of the sector as a whole in Gaza. This is required **urgently** if the present over-abstraction of the groundwater is to be eliminated; aquifer failure is to be avoided; and the current health and humanitarian crises are to be alleviated.

It is also most important to note here that the elimination of any of the available options as shown in Figure 9 threatens the overall strategy as a whole, for the CSO-G. Thus:

- If the domestic water distribution system in Gaza is not adequately upgraded and maintained, most consumers will experience little change in the water quality (or quantity) available to them, even where high-quality water is produced 'upstream'.

- If the increased flows from Israel are not made available, the scale of STLV desalination required to address the drinking water problems in the short term becomes untenable. In this event, no sensible short-term measure can be taken to enhance the quality of domestic supplies (at least for the population as a whole), and most or all of the inhabitants of Gaza will need to wait for the regional desalination facilities to be constructed and commissioned. This is estimated to be likely to take a minimum of six years from the present, as is discussed in Section 4.2.7 below.

- If the wastewater treatment facilities cannot be completed in a short period of time, there will be no significant volumes of treated wastewater appropriate for reuse, and the farmers will simply continue to over-pump the groundwater. This will undoubtedly lead to aquifer failure before long, with the consequence that a further deficit of 55 MCM/year of fresh water will be added to the 'balance sheet' for Gaza.

- If the improvements in the agricultural sector are not realized, the use of water in that sector in Gaza will continue to be inefficient, and the economic returns will continue to be sub-optimal. In addition, further degradation of the groundwater – as is obviously already occurring from the examples shown in Figures 1 and 3 above – will continue to erode agricultural productivities.

It is thus evident that the CSO-G strategy – which utilizes all the options/sub-options that are available currently – is in fact a coherent programme of interventions that are linked closely together and require a specific approach to their introduction, rather than representing a set of individual projects. The programme is of some complexity, and the introduction of specific interventions covers at least six years from the present. One conclusion from this aspect of the analysis is that there will be a need for a Gaza Programme Coordination Unit, as the current institutions are not deemed to have sufficient

capacity to coordinate the CSO-G Programme as envisaged here, while addressing their current mandates at the same time.[19]

4.2 Integrating the Options into a Coherent Programme

4.2.1 General Comments

This sub-section integrates the options and sub-options that are presently available for use in Gaza into a coherent programme of rolling interventions. As noted above, this responds to Section 2.4.8 of the Terms of Reference for the CSO-G (see *Annex 1* to this report).

Before presenting the rolling schedule of interventions, it is important to emphasize that the overall programme devised for the CSO-G extends beyond the water sector in Gaza, for a number of reasons. Key sectors other than water that must be included in any coherent strategy for the future include agriculture; health; and energy. In addition and as noted above, programme coordination will be critical. Experience shows very clearly that the rolling schedule of interventions as described here **will fail** if a high-quality coordination mechanism for the programme as a whole is not included. One of the most crucial components of the rolling schedule of interventions is therefore a dedicated coordination unit, and this must be in place very soon, if the strategy is to be realised in an appropriate timeframe.

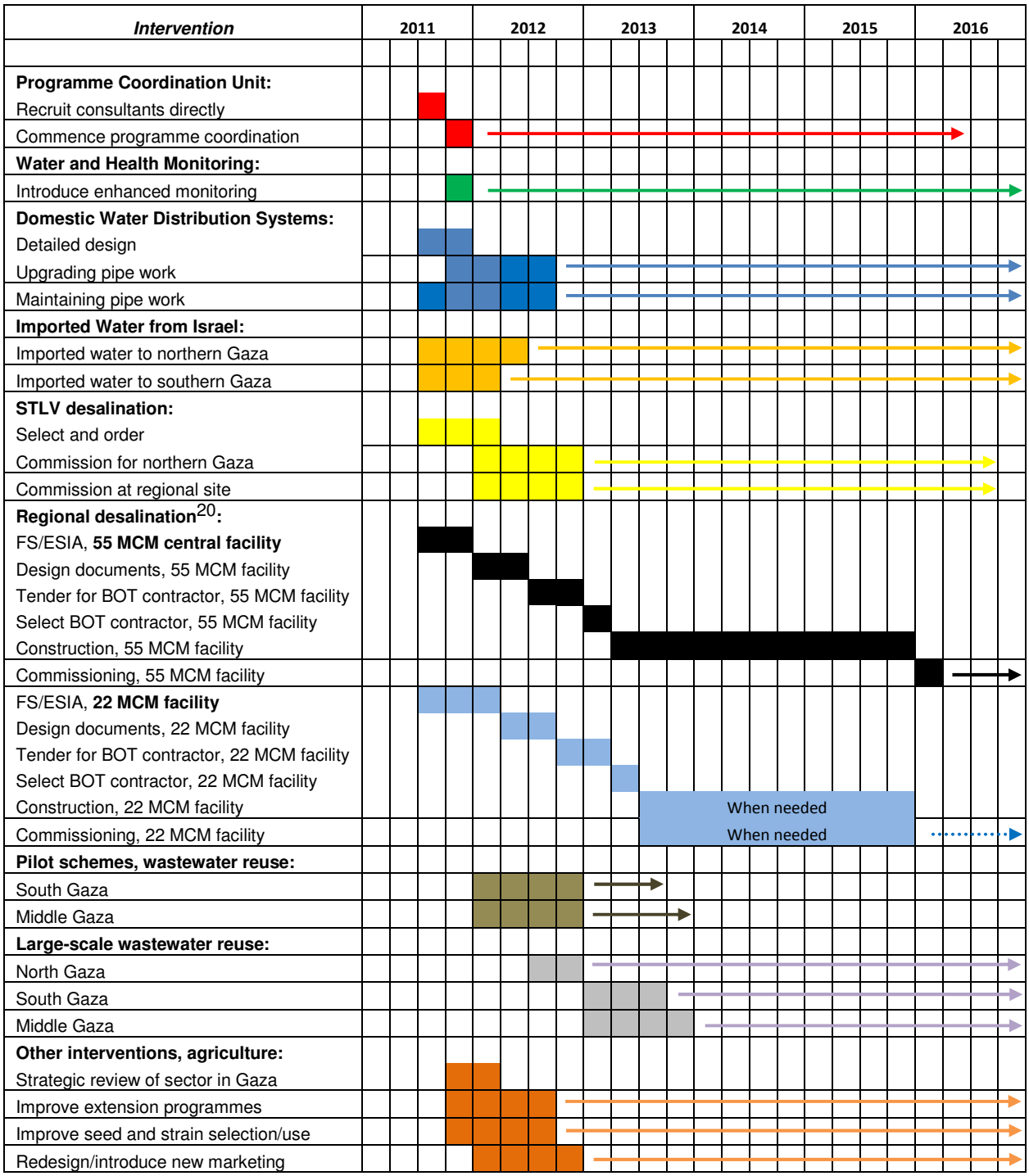
Figure 10 shows the programme of activities recommended by the Consultants for the CSO-G, at a level of broad detail. The activities as presented may be seen by some as individual projects, but it is critical to understand that each fits seamlessly into the overall strategy, and many of the activities either rely on or interact with some other strategy component. This means that an attempt to 'cherry pick' from the activities in Figure 10 will have the potential to damage the strategy as a whole. Put simply, all of the activities shown in Figure 10 are needed, if the current crisis in Gaza is to be alleviated, and if failure of the aquifer (which appears imminent, currently) is to be avoided. The individual activities are described in the following sub-sections.

4.2.2 The Gaza Programme Coordination Unit

As noted previously in this report, the Gaza Programme Coordination Unit (GPCU) is a vital component of the CSO-G strategy as a whole. This reflects the limited capacity of the Palestinian bodies addressing water management at the present time, and also the complexity and intensity of the overall programme that is outlined here and is required to address the current problems in Gaza. The CSO-G consultants recommend the **immediate** recruitment of a small high-quality team of three individuals who would be available full-time for at least five years, and would coordinate the programme shown in Figure 10. The three individuals should have core skill sets in water supply; wastewater treatment and reuse; and information transfer/communications. They should be based in Gaza, on a full-time basis.

[19]This report does not address institutional aspects of relevance to the water sector in Palestine, in any detail. The primary reason for this is that an Institutional Water Sector Review is underway in Palestine at the present time, and it is not considered desirable for the CSO-G to produce cross-cutting proposals in such a circumstance. However, it is abundantly clear that Palestine – in keeping with many other developing countries – faces substantial institutional capacity problems in its water sector, and these are exacerbated by the continual difficulties faced bilaterally, and with the Israeli occupation in general. The CSO-G project team has restricted its comments on institutional matters mainly to those matters of specific relevance to the rolling schedule of interventions as proposed here, and in particular to the GPCU and the Steering Group discussed at Section 4.2.2.

Figure 10. A summary of the first six years of the overall programme of works devised for the CSO-G.



[20]The earliest date that the first regional desalination facility can be commissioned is 2016 (see the text). It is likely that commissioning would actually be later than this for various reasons, and the TECC analysis suggests that demand for 55 MCM/year will not be reached until about 2021 or 2022. An option exists to scale-up the first facility over time, but it is noted that the estimates of demand for desalinated supplies rely on several assumptions, some of which cannot be tested at the present time (see the text).

The GPCU is similar in some fashions to the Technical, Policy and Advisory Team (TPAT) that is presently being established to assist the PWA in the West Bank, essentially in response to a recommendation arising from the 'PWA Audit' dating from late 2008 (see footnote [1] of this report). In point of fact, the PWA Audit also included a recommendation for the establishment of the type of unit in Gaza that is envisaged here. The CSO-G project team has discussed a range of possibilities, in relation to how the GPCU might best be established for the Gaza programme of works. The team has concluded that the recruitment of a high-quality consultancy company is the preferred option, as this would be a relatively rapid process, and would result in the full-time availability of well qualified personnel who are essentially independent from the ongoing political and technical dynamics.

It is envisaged that the GPCU would assume a coordinating role for the CSO-G programme as a whole (i.e. for all of the individual projects shown in Figure 10, and their inter-relationships). It is obvious that the GPCU would need to work on a day-to-day basis with both the PWA and the CMWU in Gaza, but additional interfaces will also be needed. These will include the various Governorates in Gaza, as well as entities external to the classical water sector (in agriculture, health and energy in particular, as stated in Section 4.2.1 above). It is recommended that a Steering Group should be established for the CSO-G programme, with the GPCU effectively acting as its secretariat. The Steering Group should include all entities of relevance to the programme as a whole[21], and should be responsible for driving the CSO-G programme on behalf of Palestine.

4.2.3 The Water and Health Monitoring Project

Both water quantity/quality and public health are monitored in Gaza at the present time, but the CSO-G project team considers that the various monitoring efforts existing currently are fragmented, and are not sufficiently inter-related. With regard to water quantity/quality, the ongoing monitoring of domestic supplies is quite strong, although certain of the trace contaminants do not receive sufficient attention at the present time. Public health monitoring is largely being undertaken by the NGO community, and several of the organisations in Gaza are active in this regard, although a true 'umbrella project' is lacking.

The CSO-G project team recommends the introduction of a more cohesive and integrated programme of monitoring of water quantity/quality and its relationship to public health, in Gaza. There are two main reasons for this:

- Improvements are needed in the monitoring of certain trace contaminants in domestic water supplies, and also in water use and water quality in the agricultural arena. The latter extend to the monitoring of abstraction rates from as many of the agricultural wells as possible, and also to the quality of treated wastewaters to be reused.

- The health monitoring programmes should be better integrated back to the water quality issues, and the existing programmes should be expanded. The protection of infants and children in Gaza has received particular attention recently (e.g. see Unicef, 2011), and this is certainly warranted, given the high susceptibility of younger persons to methemoglobinemia and many other problems connected to trace contaminants in water.[22] However, the population of Gaza as a whole should be covered by a comprehensive health monitoring programme, which will presumably be developed through the long-term study of specific cross-sections of the population.

[21]The minimum membership of the Steering Committee is envisaged by the CSO-G project team to include the PWA; the CMWU; the various Governorates in Gaza; the Ministries of Agriculture, Health, Planning, Public Works, Local Government, National Economy, and Finance; and the Palestinian Energy and Natural Resources Authority.

[22]Methemoglobinemia is also known popularly as 'blue baby syndrome' (see Majumdar, 2003). Other problems connected to poor-quality water supplies and documented in Gaza at high incidence include diarrhoea; parasite infections; and liver and kidney diseases.

It is envisaged here that the results from the expanded water and health monitoring project will be employed in part as an educational tool to drive a specific portion of one of the key goals of the CSO-G strategy, this being the need to reduce the pumping pressure on the aquifer. This is of relevance to both of the sectors where groundwater use is high: domestic users must be educated in the appropriate use of different types of water; and agricultural users must be encouraged to reduce their rates of groundwater abstraction and to commence the utilization of treated wastewaters. It is noted in this regard that the Gaza community is relatively tight-knit, and educational efforts should have considerable reach, if they are well designed and executed.

In relation to institutional responsibilities, the PWA, CMWU, Ministry of Health, and Ministry of Agriculture have specific interests in this component of the CSO-G programme, and all should be closely involved in its design and implementation.

4.2.4 Domestic Water Distribution Systems

If high-quality flows are distributed to consumers in the existing reticulation system in Gaza, there will be little or no improvement to drinking water quality for many consumers. This is because of the poor quality of (some of) the current pipe work, and the significant rate of infiltration. Put simply, certain of the pipes are in such a poor state that the high-quality water would not only leak significantly, but also become contaminated before it reaches most of the consumers.

A rolling programme to distribute high-quality water in a renovated/new reticulation system is therefore a critical requirement, and this must eventually cover all of Gaza. Later stages of this component of the programme will include the North-South Carrier for Gaza that has been envisaged as a requirement since the original strategic studies that were released in the year 2000.

This component of the CSO-G programme was not overtly included in the Terms of Reference for the study, but has been identified by the project team as being of high importance. It has been addressed by a sub-study of the CSO-G that was triggered in mid-March 2011, undertaken by the Technical Engineering Consulting Company (TECC) in Gaza. Two reports have been contributed to the overall CSO-G study by TECC: the first was released on 04 April 2011 and relates to short-term interventions of relevance to 2011 and 2012; and the second was released in final form in July 2011 and pertains to the longer-term interventions.[23]

A number of facets in the approach taken by TECC – which was approved by the CSO-G team leader – are of relevance here, as follows:

- For short-term interventions, it was necessary to lay down specific benchmarks to be attained for domestic water quality at the consumer, this being the focus of the initial work by TECC. It was recognised that adherence to the WHO guidelines for domestic water quality would be preferred, but if these were to be used in the early period of the CSO-G programme, the volume of STLV desalination required would have been too great, and the costs too high. As a result, a benchmark of 400 mg/litre of chloride was assumed as the target for domestic supplies of water at the consumer, this being below the human threshold of 'salty taste'. Blend ratios between desalinated water and groundwater were calculated to allow this benchmark to be realised. It is recognised that such an approach is not ideal, but the CSO-G strategy amounts to 'the art of the possible' in the early stages of the programme. It is also notable that the benchmark chloride concentration of 400 mg/litre is well inside that included in the Israeli standards (see Table 4).

[23]The rationale for this approach involved the request by the PWA for the CSO-G consultants to contribute a document to the *Ad Hoc* Liaison Committee meeting of 13 April 2011. The documents of relevance were released by *Phillips Robinson and Associates* on 07 April 2011, which was the date that had been agreed by the PWA and the representatives of the Government of Norway.

Parameter	Maximum Allowable Concentration (mg/litre, except microbial indicators and pH, as shown)		
	Israeli Legislation	***WHO Guidelines***	***Palestinian Guidelines***[24]
Antimony	No limit stated	0.02	0.005
Arsenic	0.05	0.01[c]	0.01
Barium	1.0	0.7	No limit stated
Boron	No limit stated	0.5[c]	No limit stated
Cadmium	0.01	0.003	0.003
Calcium	80[a]	No limit stated	100-200
Chloride	600	250	600
Chromium	0.05	0.05[c]	0.05
Copper	1.4	2.0	1.0
Cyanide	0.05	0.07	0.05
Faecal coliforms	<1/100ml	No limit stated	No limit stated
Fluoride	1.4-1.7[b]	1.5	1.5
Hardness	200[a]	No limit stated	600
Iron	1.0	No limit stated	0.5
Lead	0.05	0.01	0.01
Magnesium	150	No limit stated	150
Mercury	0.001	0.006	0.001
Mineral oil	0.3	No limit stated	No limit stated
Molybdenum	No limit stated	0.07	No limit stated
Nickel	No limit stated	0.07	0.05
Nitrate	90	50 (acute)	70
Nitrite	No limit stated	3.0 (acute)/0.2[c] (chronic)	0.1
Range in pH	6.5-9.5	No limit stated	No limit stated
Selenium	0.01	0.01	0.01
Surfactants	1.0	No limit stated	No limit stated
Total coliforms	<3/100 ml	No limit stated	No limit stated
Total dissolved solids	1,500	No limit stated	1,500
Trihalomethanes	0.1	<1 total	No limit stated
Uranium	No limit stated	0.015[c]	No limit stated
Zinc	15	No limit stated	5.0

[a] No maximum allowable concentration exists for either calcium or hardness. The values shown for these parameters are maximum desirable concentrations.
[b] Maximum allowable concentrations for fluoride vary with the region concerned.
[c] Provisional values only. The lower value for copper relates to staining of laundry; the upper value is health-related and is provisional.

Table 4. A comparison of the quality standards (selected parameters only) for drinking water under Israeli law (IWA, on-line), the World Health Organization guidelines (WHO, 2004), and in Palestine.

[24] The Palestinian guidelines have been agreed by the water management entities, but have not as yet been passed by the legislature.

- In a few areas, it was noted that not all of the existing contamination problems would be resolved by such an approach. This is especially relevant to northern Gaza, where chlorides are not a major problem as yet, but nitrate contamination is significant in particular areas (see Figure 3 in this report). Certain of the PWA representatives in Gaza have suggested that there is a case for the denitrification of domestic water supplies in northern Gaza, to attempt to attain nitrate levels below 50 mg/litre (equating to the WHO guideline; see Table 4). As noted above, a primary concern in this regard involves the toxic effects of nitrates on infants and young children. There are a number of methods available for the denitrification of drinking water, most involving membrane bioreactors of distinct types (e.g. see Pekdemir *et al.*, 1998; Fonseca *et al.*, 2000; Ergas and Rheinheimer, 2004; Buttiglieri *et al.*, 2005; Zhao *et al.*, 2009; Silverstein, 2010). Whilst a case could be made for this approach in northern Gaza in the specific, the CSO-G project team felt that the expenditure involved would be difficult to justify, simply for a short-term intervention (i.e. before the regional desalination facilities come on-line, this being estimated to occur at about 2016). As a result, denitrification at the northern Gaza water supply facilities has **not** been included in the CSO-G strategy.

- The TECC analysis also took account of the inequalities in domestic water distribution in Gaza, noted in Sections 2.1.3 and 3.3 of this report as being a justifiable concern amongst the current water managers in Gaza. In this regard, the TECC work included a requirement to reconfigure the domestic water distribution system over time, while taking account of the need to deliver high-quality supplies for domestic use to as many of the Gaza population as possible, as quickly as possible. The data arising from this effort are included in Table 5 of this report, and show that a benchmark of 120-150 litres *per capita*/day was taken for fresh water production, for the whole of Gaza towards the end of the short-term intervention period. This period is defined as the earliest time that the regional desalination facilities could be on-line, i.e. at around 2016. It was recognised that such a **production** figure does not equate to water **consumption** by the Gaza population, due to system inefficiencies (leakage, illegal connections, etc.), and that this therefore implies that the population would not reach the preferred WHO minimum water consumption figures. However, any attempt to raise the production figures also created unacceptable costs for the short-term interventions.

These assumptions used in the TECC studies were distinct from those employed in either the planning work for the regional desalination facility leading up to 2003, or the strategic analysis of the NSU (2005b).[25] This resulted in different estimates for the precise demand for desalinated water supplies in Gaza at specific benchmark dates, as shown in Table 5. The estimates by TECC as shown in Table 5 were taken into the CSO-G strategy as the most likely updated demand figures for Gaza, although comments are provided below on the need to review these figures over time, in the future.

A particularly important point arises from the data shown in Table 5. Thus, the volumes of desalinated flows required at the benchmark dates were estimated in the TECC study to rise from 10.57 MCM/year at the end of 2012; to 13.00 MCM/year at the end of 2015; and then to 49.13 MCM/year at the end of 2020. This major change in 2015-2020 occurs because of the predicted salinisation of the existing groundwater in Gaza, and the strategy to take wells out of domestic water production at a benchmark value of 1,000 mg/litre of chloride. The key message from this analysis confirms the data shown at Figure 5 of this report: the aquifer is experiencing the intermediate stages of failure currently, and it is not reasonable to assume that groundwater quality will even remain as it is at present, in the future. The profiles shown in Figures 1 and 2 of this report drive this point home in a particularly strong manner.

[25] The key differences between the various studies related to the volumes *per capita* to be produced or consumed by the population in Gaza; and the number and volumes of alternative sources of fresh water.

			Production by Source			Water Production	
Governorate	Target Year	Population Thousands	Wells m^3/year	Mekoroth m^3/year	Desalination m^3/year	Total m^3/year	Litres *per capita*/day
North	2010	299,627	22,030,009			22,030,009	201
Gaza		536,474	32,113,958			32,113,958	164
Middle		222,758	10,224,944	1,900,000		12,524,944	154
Khan Younis		214,190	8,598,468			8,598,468	110
Eastern villages		72,431	2,162,673	2,800,000		4,962,673	150
Rafah		173,328	6,840,752			6,840,752	108
Totals		**1,518,808**	**81,970,804**	**4,700,000**	**0**	**87,070,804**	**148**
North	2012	320,968	22,030,009		0	22,030,009	188
Gaza		586,113	24,440,400	5,000,000	3,714,154	33,154,554	155
Middle		238,624	8,580,420	2,800,000	1,959,500	12,839,920	147
Khan Younis		214,190	5,781,600	0	3,599,922	9,381,522	120
Eastern Villages		77,591	2,162,673	2,900,000	0	3,962,673	140
Rafah		205,911	6,840,752		1,291,725	8,132,477	120
Totals		**1,643,397**	**69,835,854**	**10,700,000**	**10,565,302**	**89,501,156**	**145**
North	2015	355862	23,140,252			23,140,252	178
Gaza		637163	22,181,963	8,988,562	3,714,154	34,884,678	150
Middle		270650	7,264,778	2,630,207	1,959,500	11,854,485	120
Khan Younis		237476	5,781,600	1,019,926	3,599,922	10,401,448	120
Eastern Villages		86026	2,162,673	2,900,000		3,767,931	120
Rafah		228298	6,272,102		3,727,343	9,999,444	120
Totals		**1,815,475**	**66,803,366**	**15,538,695**	**13,000,919**	**94,048,238**	**135**
North	2020	422,653	19,693,296		3,446,956	23,140,252	150
Gaza		771,799	15,406,650	10,000,000	16,849,345	42,255,995	150
Middle		314,222	3,317,850	4,500,000	9,385,805	17,203,655	150
Khan Younis		282,047	5,781,600	1,019,926	8,640,548	15,442,073	150
Eastern Villages		102,172	2,162,673	2,900,000	531,244	5,593,917	150
Rafah		271,145	4,566,150		10,279,039	14,845,189	150
Totals		**2,164,038**	**50,928,219**	**18,419,926**	**49,132,936**	**118,481,081**	**150**
North	2025	501,979	19,003,905		8,479,455	27,483,360	150
Gaza		916,655	14,051,588	12,000,000	24,135,279	50,186,867	150
Middle		373,197	2,528,465	4,500,000	13,404,080	20,432,545	150
Khan Younis		334,983	5,781,600	1,600,000	10,958,739	18,340,339	150
Eastern Villages		121,348	2,162,673	2,900,000	1,581,146	6,643,819	150
Rafah		322,035	4,224,960		13,406,468	17,631,427	150
Totals		**2,570,198**	**47,753,190**	**21,000,000**	**71,965,167**	**140,718,357**	**150**
North	2035	708,091	19,003,905		19,764,089	38,767,994	150
Gaza		1,293,033	14,051,588	12,000,000	44,741,945	70,793,532	150
Middle		526,431	2,528,465	4,500,000	21,793,658	28,822,122	150
Khanyounis		472,527	5,781,600	1,600,000	18,489,259	25,870,859	150
Eastern Villages		171,174	2,162,673	2,900,000	4,309,089	9,371,762	150
Rafah		454,262	4,224,960		20,645,910	24,870,870	150
Totals		**3,625,519**	**47,753,190**	**21,000,000**	**129,743,950**	**198,497,140**	**150**

Table 5. Data arising from the TECC analysis of the demand for desalinated flows and the capital works required for the domestic water distribution system. After TECC, as submitted to the Government of Norway on 04 April 2011 and 28 May 2011; and the updated version of July 2011.

The work by TECC has dovetailed the coastal STLV desalination facilities to all of the other facilities needed to supply high-quality water to domestic consumers in Gaza. This involves a range of pipe work, blending and storage tanks, and booster stations. It is notable that some of the existing pipe work contains [blue] asbestos, this having been laid mostly in the 1970s and 1980s by Mekoroth. The CSO-G strategy assumes that all of the asbestos-containing pipe work will be replaced (and it is emphasized here that care will be needed in the disposal of the existing pipes, which should be double-bagged and buried at clearly designated sites in landfills).

The CSO-G analysis places great emphasis on the regional desalination component of the CSO-G programme, as it is this element of the strategy that actually begins to reverse the trend towards aquifer failure (see the black dotted line in Figure 4 of this report). The STLV desalination (coupled to the upgrading of the distribution networks) assists in slowing the trend towards deterioration of the aquifer, and provides high-quality water to consumers. However, the regional high-volume desalination, coupled to wastewater reuse in the agricultural sector, are the interventions that reduce the groundwater abstraction rates and hence allow the aquifer to begin to recover. It is notable in this regard that the agricultural pumpage alone is considerably greater than the estimated sustainable yield of the aquifer, and this serves to emphasize the importance of the wastewater reuse component of the CSO-G strategy (see Section 4.2.9 below).

The later stages of the provision of the domestic water supply system were addressed in detail by TECC in the second stage of their input. As noted above, new data were generated for the domestic demand for fresh water, as compared to those estimated in the Coastal Aquifer Management Project about a decade previously, or the study of the NSU (2005b). The new data took account of a number of circumstances in Gaza that have emerged in the intervening years. The analysis by TECC was linked back to the CSO-G work, and informed the overall scale and estimated cost of certain of the CSO-G interventions, as proposed here. A review was also completed by TECC of the designs produced in the years 2000 and 2006 for the North-South Carrier (NSC) in Gaza. This review addressed the route and size of the NSC, and the associated water-related facilities.

The water demand data generated by TECC confirmed the CSO-G conclusion, that the earlier plans for a regional desalination facility would need to be significantly expanded in scale (see Section 4.2.7 below).

4.2.5 Imported Water from Israel

As noted in Section 3.6 of this report, negotiations are ongoing at the present time in a 'political track' concerning the enhanced transfer of water from Israel to Gaza. It is envisaged that this would occur at three distinct locations as shown in Table 6, and additional relatively minor engineering works are needed to realise the programme:

- At Nahal Oz in the northern half of Gaza, no flows are received currently. A section of pipe work some 130 metres in length is required at the 1967 border between Gaza and Israel, to fully connect the networks. A volume of 1-2 MCM/year could then be transferred at this point, rising possibly to 5 MCM/year in 2012 after additional engineering works are completed (these involving a booster station on the Israeli side, which could then be accompanied by additional pipe work at a later stage). The hydrological capacity of the system after such additional works would be approximately 12 MCM/year as shown in Table 6, and it is not inconceivable that additional volumes could be negotiated for later transfer.

- At Bani Suhaiula further south, Mekoroth has supplied about 2.8 MCM/year to Gaza, in recent years. This could be increased to 4.5 MCM/year, to assist in enhancing the domestic supplies available to Gaza communities.

Connection	Served Municipalities	Current Population Served	Storage Capacity (m^3)	Physical Status	Average Annual Mekoroth Supply (MCM/year)	Average Annual Local Well supply (MCM/year)	Annual Billed Water (MCM/year)
Bani Suhaiula Reservoir	Big Abasan, New Abasan, Ikhza'a, Bani Suhaila	72,500	1,000	No maintenance needed	2.8	4	2.72
Ben Said Reservoir	Bureij, Nuseirat, Maghazi, Zawaida	153,000	1,000	No maintenance needed. Rented land	1.9	7.7	4.66
Gaza Nahal Oz (proposed)	Gaza City	100,000 (target area), 550,000 total	5,000	No maintenance needed	-	33.7	21.8

Connection	Supply (litres *per capita*/day)	Supply Pipe (inches)	Maximum Possible Quantity (MCM/year)	Comments
Bani Suhaiula Reservoir	102	14	4.5	The water quality of the local wells is saline. Additional potable water can be used to replace part of the brackish water, in addition to increasing water availability to 120 litres *per capita*/day. More improvements on system efficiency are a priority. A hydraulic assessment is needed to evaluate the relationship among storage capacity/ supply and demand.
Ben Said Reservoir	83	12	4.0	As above. Currently the reservoir is almost empty due to the fact that supplied water is consumed directly from the distribution system.
Gaza Nahal Oz (proposed)	115	24	12	As above. In addition, the main distribution system from the storage tank needs maintenance. It can serve 100,000 inhabitants but this figure can be increased if a reconfiguration of the distribution system is achieved as planned. Very recent damage to the Gaza reservoir due to Israeli shelling in April 2011 must be assessed, and repairs must be expedited.

Table 6. Data on the existing and potential imports of fresh water from Israel to Gaza. After the PWA (Gaza), 12 April 2011.

- At Ben Said, the scenario is similar to that at Bani Suhaiula. The historical flow of 1.9 MCM/year could be increased to 4 MCM/year.

All such flows from Israel derive from their National Water Carrier, which at these points contains a blend of flows from Lake Tiberias and from their desalination facilities between Gaza and Lake Tiberias, located along the Israeli coast. Debate has occurred in the past between the parties, as to the precise quality of this water that could be transferred from Israel to Gaza. Over time, however, the blend ratio has become more heavily dominated by desalinated water, as the various Israeli desalination facilities have come on-line and their capacity has been increased. This process is ongoing; more facilities are at various stages of being commissioned, and the capacities of plants such as Ashkelon are being enhanced.[26]

The effect of this is that Israel will not experience any decrease in available water volumes over time in the future, consequent to the supply of further (relatively minor) volumes to Gaza. This is effectively a component of the so-called 'Positive-Sum Outcome' proposed by the Palestinian side during Permanent Status negotiations with Israel (see Section 5.1 of this report, and Phillips *et al.*, 2007, 2009; Phillips, in press), but the Israeli authorities have refused hitherto to discuss such proposals, either during Permanent Status negotiations or outside these.

In relation to water quality, it is notable here that the Israeli standards for potable water do not match the widely accepted international guidelines laid down by the WHO (2004), or indeed those of Palestine. These disparities are shown in Table 4 above. It is recommended here that the parties should utilise the international guidelines of the WHO (2004) for domestic water quality – with relevant amendments from 2006 and 2008 – as a preferred benchmark for any water volumes that are transferred between them in the future.

In relation to timing, Figure 10 shows the required engineering works being completed for the additional water imports from Israel, within about the next year (i.e. by mid-2012). This is believed to be entirely possible, but is subject to the interference of the blockade (see Section 6.1 of this report), and also to the successful conclusion of the ongoing negotiations. Institutionally, the CMWU and the PWA are the key players on the Palestinian side, in relation to this component of the CSO-G programme.

4.2.6 Short-term Low-volume (STLV) Desalination

As noted in Section 3.9 above, short-term low-volume (STLV) desalination has been selected as a sub-option of relevance to the CSO-G, due to the fact that relatively small volumes of desalinated water can be produced rapidly, at specific locations.

This water source is somewhat expensive compared to larger-scale desalination facilities, but the current problems in Gaza relating to drinking water are sufficiently extreme that the use of STLV desalination is recommended, prior to the completion of the regional desalination facilities (see Section 4.2.7 below). Thus, it is proposed that the additional low-volume supply of water from Israel (see Section 4.2.5 above) should be augmented by STLV desalination, such that high-quality water may be provided to most or all of the Gaza population (for potable use) at the earliest possible time.

[26] It is reported that the capacity at Ashkelon – originally 100 MCM/year, but since then increased to 108 MCM/year – will shortly be increased to 125 MCM/year. Similar increases to the output of other desalination plants in Israel are planned for the near future.

It is noted here that a considerable number of commercial entities have offered services to the Palestinian authorities and/or to the CSO-G project team, during the course of the work addressed by this report. These include international and regional companies, and also several located in Israel. Various options involving containerised facilities (for desalinating brackish water or sea water) have been suggested, in addition to the possible relocation of desalination plants in present use elsewhere, and the potential use of a vessel designed to desalinate sea water and pipe the resulting flows to the shore. The CSO-G project team has not completed an in-depth review of all of the possibilities for STLV desalination, as this should occur at a later stage, once the strategy as outlined here has been agreed. However, our conceptual base has included the use of on-land STLV facilities at two locations, as noted elsewhere in this report, and as discussed below.

The detailed calculations by TECC (see Table 5 above) have revealed that approximately 13.0 MCM/ year of desalinated water is required in the interim period before the regional desalination plants can be commissioned (the latter being estimated at 2016 at the earliest; see Section 4.2.7 below for a discussion of this). These calculations take account of the availability of groundwater of acceptable quality for blending-back to the desalinated flows, providing sufficient volumes of high-quality water for potable use. Whilst the flows produced in the interim period will not precisely meet the World Health Organization guidelines for potable water, their calculated quality (based on the attainment of 400 mg/litre of chloride) is considered to be acceptable, and the water will not taste saline. The WHO guideline values cannot be attained in their entirety in the interim phase of the CSO-G, as this would require an unacceptably high capital cost for the STLV component of the strategy.[27]

The STLV desalination – referred to as 'containerised desalination' by some parties – is envisaged by the TECC studies to best be located at three locations: [a] towards the southern edge of the Northern Governorate, these flows serving western Gaza City; [b] at the existing Deir al Balah desalination site, expanding the capacity of this; and [c] at the proposed site for the first regional desalination facility, somewhat to the south of Deir al Balah. The northern facility would produce about 3.7 MCM/year of desalinated flows, while an additional 2 MCM/year would be produced at the existing Deir al Balah site. The STLV desalination at the regional site would produce the remaining 7.3 MCM/year. The PWA representatives in Gaza have reported to the CSO-G team that sufficient land is available at each of the selected sites to house the required STLV facilities, the precise layout of which would be determined by later more detailed studies.

It is notable that a small-volume desalination facility financed originally by the French Government is located somewhat to the north of the northern site recommended here for future use. This is not a preferred location for the northern STLV facility as envisaged here, as it is close to the border of Gaza and has been commonly subject to Israeli incursions previously. The French-funded facility (which is not used presently) was visited twice in April 2011 by the CSO-G project team, and contains a range of equipment that could be utilised in the STLV plant proposed here. PWA representatives in Gaza are currently pursuing discussions with the contractor who was responsible for the French-funded site, and are attempting to follow the strategy outlined here (which would lead to some cost savings).

[27] The TECC analysis suggests a demand for desalinated supplies of 10.6 MCM/year at the end of 2012, rising to 13 MCM/year at the end of 2015. The CSO-G proposes the provision of 13 MCM/year as soon as possible in 2012, thus somewhat anticipating the slight rise in demand in the period from 2012 to 2015. This reflects a conservative approach in the CSO-G, which is believed to be warranted because of uncertainty surrounding some of the assumptions used by TECC.

In addition, a project proposal is presently being considered by the European Commission, involving desalination to serve southern areas of Gaza. The initial proposal was prepared by Unicef and the CMWU in concert, and involves the phased introduction of desalinated flows (derived from sea water), with an ultimate capacity of 21.9 MCM/year. The CSO-G project team has discussed the proposal at some length with representatives of the European Commission and Unicef, and the parties have indicated that they are committed to collaborating on whatever project outline may be agreed through the consideration of the CSO-G proposals. Representatives of the European Commission have stated to the CSO-G project team that some 10 million Euros could be made available for the desalination project (to be committed by September 2011 and spent within three years), and it appears that this could most usefully part-finance the required STLV facilities at the regional desalination site in Gaza.

If this is agreed as a component of the CSO-G strategy, some relatively minor changes will be needed to the current project proposal of the European Commission. The work of TECC has provided a strong basis for this.

It is also noted here that the CSO-G project team has proposed that the STLV desalination facilities at the site that was originally proposed some ten years ago could become part of the regional facility itself at the same site, at a later time. The full details of such a plan have not been developed at this stage, and additional thought would be needed in relation to contractual matters in particular. However, this possibility appears attractive, especially in that the STLV and regional phases would be 'stitched together' very coherently, and that the costs of the regional desalination plant would be significantly reduced. The work of TECC has been predicated on the fact that the STLV facilities at the main regional site (generating 7.3 MCM/year) would become part of the eventual regional desalination plant at the same site. The other two smaller STLV plants at the southern edge of the northern Governorate and at the existing desalination facility at Deir al Balah could either be run independently, or consolidated to become part of the regional facility, as may be preferred. This is a matter for discussion with the contractors providing the various desalination facilities.

4.2.7 Regional Desalination

The major intervention driving the most important changes in Figure 4 of this report (shown as the black dashed line in Figure 4) involves high-volume regional desalination. If this is not introduced – and on the assumption that other high-volume options remain elusive due to the political environment and/or their technical difficulty (see Section 5) – the groundwater will not be protected adequately and the aquifer will fail totally. The high-volume desalination is therefore altogether critical as a driver of the overall CSO-G strategy, and there is no room for parties to believe that the STLV desalination described in Section 4.2.6 above can solve the existing problems (see also Sanders, 2009; CMWU, 2010).

The CSO-G project team recommends the review and updating of the previous documentation for the so-called 'regional desalination facility' produced under US AID funding in the years from 2000 to 2003, and the use of a fast-tracked approach to prepare for a call for tenders for either a Build-Own-Operate (BOO) or a Build-Operate-Transfer (BOT) facility. This would involve the updating of the previous Feasibility Study and Environmental & Social Impact Assessment (FS/ESIA), which should be achieved rapidly on a fast-tracked programme. This amounts to a 'line of least resistance' in the planning of the first of the high-volume regional desalination facilities. Calculations suggest that a volume of 55 MCM/year for that facility would be appropriate, and this was the planning base taken for the second-stage effort of TECC (see above). The comments above in relation to the possible 'stitching in' of the STLV desalination facilities are notable here, once again.

The updating of the design documents for the first of the regional desalination plants would follow, and this should also be progressed on a fast-tracked schedule (see Figure 10). Thereafter, all documentation will be ready for the production and publication of a Request for Proposals on the provision of the first such facility. The Palestinian authorities will need to decide whether a BOO or a BOT –or possibly even a turnkey – approach is to be preferred, and this will have implications for the training of Palestinian staff (and somewhat, for costs). In any of these instances, the contractual arrangement should reflect the likely difficulties in covering the costs of the desalinated flows in the early period, due to the poor state of the economy in Gaza. Several distinct approaches are available in this regard, all of which essentially involve different forms of cross-subsidies. These issues – and the general willingness of the Gaza population to pay for high-quality supplies of fresh water – are discussed in greater detail at Section 6.3 of the present report.

As noted in Section 3.9 of this report, the CSO-G team recommends the construction of two regional desalination plants: the first of 55 MCM/year at the site originally selected in middle Gaza, as noted above; and the second (initially) of 22 MCM/year in either southern Gaza, or northern Egypt.[28] Calculations by TECC of the demand for desalinated flows (see Table 5 above) suggest that the second facility would be required shortly after the year 2020, although this estimate is based on a range of assumptions. The most important of the assumptions relate to the rate at which the groundwater in Gaza will continue to degrade through saline intrusion in particular, and this is challenging to estimate with accuracy. It is therefore recommended that the work for the second regional desalination facility should proceed in parallel to that for the first such facility, at least to the stage where the FS/ESIA and the design documents have been completed (as shown in Figure 10). Assuming that the southern Gaza option is preferred, the CSO-G team recommends an approach where the second facility is effectively a down-sized version of the first regional plant (two 11 MCM/year modules being constructed initially, as opposed to five such modules). This will assist in the process of completing the FS-ESIA, and the design documents. Once that stage has been reached, a decision can be made as to the preferred timing of a Request for Proposals for the second regional facility. That decision will be driven primarily by: [a] the emerging demand for high-quality water for domestic use in Gaza; and [b] the ongoing results arising from the water and health monitoring project discussed in Section 4.2.3 above.

The CSO-G project team has debated the likely duration of the programme to complete the regional desalination facilities, at some length. A number of assumptions are required in the production of such an estimate, especially concerning the potential effects of the blockade (see Section 6.1 of this report). The completion of the regional desalination facilities is one of the most urgent items in the CSO-G programme as a whole, as this is critical to the supply of potable water in the medium and longer terms, and also to relieving the pressure on the groundwater.[29] Our estimates of the most rapid possible procedure are as follows:

- a period of 6-9 months for the completion of the Feasibility Studies and Environmental & Social Impact Assessments;
- a further 6 months for the production of design documents[30];
- a period of 12 months in total to call for tenders and to select and negotiate with a preferred company for a BOT, BOO or turnkey facility; and

[28] If the second desalination facility is to be shared with Egypt, it is obvious that its scale would need to be increased from that noted here. This would be subject to negotiations with the Egyptian authorities, but the Palestinian side should ensure that unacceptable delays to the construction of such a plant would not occur.

[29] As noted in Section 4.2.4 and as shown in Table 5, STLV desalination cannot keep pace with the demand for potable supplies after the year 2015. This is the primary factor adding urgency to the completion of at least the first of the regional desalination facilities (i.e. the larger plant of 55 MCM/year capacity).

[30] This cannot be parallel-tracked to the FS/ESIA effort, as the latter determine the precise design parameters.

- between two and three years for the construction phase.

On this basis, we estimate that the earliest possible time for the first regional desalination facility to be commissioned would be in early 2016, as shown in Figure 10. It is important to emphasize that this is also the time that the TECC estimates suggest that the STLV desalination will fail to keep pace with the demand for desalinated flows (see Table 5). Any delay in the construction and commissioning of the first regional desalination facility will therefore lead to a rapid reduction in the availability of fresh water of acceptable quality, to the population of Gaza.

It is also notable here that the demand for desalinated water was estimated by TECC to be greater than 100 MCM/year before the year 2035 (see Table 5). This implies that the regional desalination facilities would need to be enlarged over time, or new high-volume plants would be required. However, the estimate is based on many assumptions as to the growth of the Gaza population (and the continued lack of emigration), which appear questionable – and also on the future fate of the groundwater. It is not considered appropriate to plan over such long time horizons in Gaza, and it is clear that the requirement for possible further expansion of the regional desalination plants should simply be kept in view by the Palestinian authorities, as time passes.

4.2.8 Groundwater Supplies to the Agricultural Sector

The problems with leakage and infiltration are much less intractable in Gaza in relation to the agricultural use of groundwater, compared to domestic water supply. There are several reasons for this:

- Pipe runs for agricultural supplies of water tend to be much shorter than those supplying water for domestic use.

- The agricultural use of water occurs mostly within the ambit of the private sector farming community, and many of the wells are unlicensed. Where leakage occurs, the flows generally recycle into the groundwater (rather than being lost to evaporation), and leakage thus simply adds cost to the use of water in the agricultural sector (due to pumping demands).

- Infiltration is of much less importance in the agricultural sector, as there are far less constraints on water quality at the point of use, compared to those in the domestic sector.

The CSO-G strategy does not therefore include a significant component for the reprovision of pipe work in the agricultural sector in Gaza, at least in relation to the use of groundwater. Rather, the strategy is focused upon the accelerated introduction of the reuse of wastewater, which is addressed by the following sub-section.

4.2.9 The Increased Reuse of Treated Wastewater

As noted in Section 3.4 above, the reuse of treated wastewater is a very important component of the CSO-G strategy developed by the Consultants, in part because approximately half of the current fresh water use in Gaza is allocated to the agricultural sector. It is emphasized that whilst the interventions discussed above pertaining to the domestic use of water will serve to reduce the abstraction pressure on the groundwater to some extent (especially when the regional desalination facilities come on-line), the introduction of wastewater reuse will be an exceptionally important component of any reduction in the present over-abstraction of groundwater. This implies that the interventions as noted in the current report should not be seen as discrete projects, but as a coherent single programme, all components of which are needed if the appropriate end results (including the protection of the groundwater) are to be realised.

The reuse of treated wastewaters depends fundamentally on the completion of high quality wastewater treatment facilities, and – as noted in some detail in *Annex 2* to this report – the main plants of that type in Gaza are at distinct stages of construction:

- the North Gaza Emergency Sewage Treatment (NGEST) plant is the most advanced, in a relatively late stage of construction at present;
- the Gaza City treatment facility presently discharges some 22 MCM/year of partially treated wastewater to the Mediterranean Sea, and requires major upgrading;
- the Rafah and Khan Younis treatment facilities are due to be replaced, but the authorities are caught between upgrading the existing plants and pressing forwards with the construction of the new facility.

The CSO-G strategy envisages the fast-tracking of pilot schemes for wastewater reuse, coupled to a transition to major reuse schemes at the earliest possible time. This will require considerable effort at all of the existing treatment facilities (see *Annex 2* for details), and the effects of the blockade will be of particular relevance (see Section 6.1 of this report).

As noted by the comprehensive review of the NSU (2010) on wastewater reuse, certain policy-level issues must also be addressed during this process. These include the following:

- A coherent policy needs to be put into place, concerning wastewater reuse. This could relate simply to Gaza in its initial phase (responding to the particularly urgent issues as addressed here), or might be of relevance throughout Palestine.
- The standards for wastewater reuse promulgated by the Palestinian Standards Institute need to be reviewed and revised, without delay.
- The institutional responsibilities pertaining to wastewater reuse need to be established, in full. This is a potentially challenging area, as a range of institutions should be involved. In relation to Gaza, the Steering Group proposed at Section 4.2.2 above (to oversee the work of the GPCU) would be of utility in addressing issues of relevance to wastewater reuse.
- Comprehensive controls should be devised to protect human health, in terms of both occupational exposures to contaminants and pathogens, and for agricultural products grown using reused wastewater.
- There is also a requirement for the promulgation of coherent legislation on wastewater reuse, including updated standards and monitoring requirements.

Attention to these issues is of some urgency in relation to Gaza, as the CSO-G envisages the short-term introduction of pilot reuse programmes, followed by the wide-scale reuse of wastewaters at the earliest possible time. The costs of the wastewater treatment upgrading programmes are mostly already committed, and are hence not included under the CSO-G (see Section 4.3 below).

4.2.10 Other Interventions in the Agricultural Sector

The agricultural sector represents a key source of income for Gaza, at the present time. However, the sector suffers from inefficiencies, and from the profligate and uncontrolled use of the precious water supplies. There is much scope for a strategic review of the sector, aimed at elevating 'economic water productivity', i.e. the economic return generated per cubic metre of water allocated to the sector in Gaza.

This review should cover a wide range of technical and trade-related issues, as follows:

- An assessment of the extent of irrigation and the methods employed for this in the agricultural sector in Gaza, with a view to improving both the efficiency of water use and the yields of crops. The conjunctive use of Green Water and Blue Water should be a specific focus, in this regard.[31]

- The preparation of proposals for new cropping patterns and strain selection. The farming community in Gaza relies largely on traditional approaches, and is not focused at the present time on optimising the economic returns from the use of water. Given the water scarcity in Gaza, the production of high-value crops for export should be the primary focus, these generating sufficient income to support the importation of staple foods.

- The use of chemicals in the agricultural sector in Gaza, and how this may affect both crop yields and the quality of the groundwater.

The focus in the agricultural sector in Gaza should be on **food security**, not food self-sufficiency. The CSO-G project team recommends that the production of the agricultural sector review should be triggered without delay.

4.3 The Estimated Costs of the Interventions

The costs of the interventions included in the CSO-G strategy have been estimated on the basis of inputs from various parties. It is emphasized that the cost estimates provided here are of an approximate nature only (and also depend on a range of assumptions). The broad estimates shown here should be updated during the course of preparing each of the individual projects in detail.

The present cost estimates are shown in Table 7, and the following notes are of relevance in this regard:

- Where interventions can/should be triggered immediately, the estimated costs in 2011 assume a half-year finance requirement. This implies that the authorities in Palestine will gain a consensus on the CSO-G recommendations in a short period of time, and that finance will be made available rapidly for the particularly fast-tracked interventions.

- The cost for the GPCU is known with some accuracy, this being based in a *pro rata* fashion on the cost for the Technical, Policy and Advisory Team (TPAT) which has recently been formed to assist the PWA in Ramallah.

- The finance requirement shown in Table 7 for the water and health monitoring project represents simply an 'uplift' in funding, designed to enhance the ongoing monitoring programmes. The costs of the ongoing monitoring programmes are not included in this estimate.

[31] Green Water is also known as 'soil water' and is derived directly from rainfall and run-off. The conjunctive use of Green and Blue Water – especially in arid areas – is known to benefit water use efficiency markedly (see, for example, Oweis and Hatchum, 2004).

Component	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***Comments***
1. Gaza Programme Coordination Unit	0.35	0.7	0.7	0.7	0.7	0.35	May lapse after mid-2016
2. Water and Health Monitoring	0.5	1.0	1.0	1.0	1.0	1.0	To continue for at least ten years in total
3. Domestic Water Distribution Systems	8.0	14.0	104 [see *Annex 3*]				Phasing of the costs in 2013-2016 to be considered
4. Water Imports from Israel	Data not yet available, as negotiations are ongoing						To be addressed when negotiations are completed
5. STLV Desalination	18.0	29.0	CBT	CBT	CBT	CBT	Covered by tariffs (CBT) after initial investment
6. Regional Desalination	2.0	2.0	-	-	-	CBT	Covered by tariffs (CBT) once commissioned.
7. The Increased Reuse of Wastewater	2.0	2.0	To be determined by future progress				Treatment works require completion initially
8. Other Interventions, Agriculture	0.2	0.2	-	-	-	-	The review to be completed by mid-2012

Table 7. Estimated costs allocated to Palestine and requiring external funding support (additional to ongoing programmes), for the interventions identified by the CSO-G strategy for triggering between 2011 and 2016 (matching the interventions shown in Figure 10). All costs are shown in US$ millions and are approximate only, to be refined during later more detailed studies of the individual interventions.

- The early costs in 2011 and 2012 for domestic water distribution systems are taken from the initial stage of the work of TECC, which suggested a capital investment of US$22 million to upgrade the network in 2011-2012 and provide the basis for the supply of the additional water volumes from Israel and the STLV desalinated flows. This US$22 million is additional to the ongoing capital investment of the CMWU on the domestic water supply network. The costs shown in Table 7 for 2013 onwards involve longer-term interventions, including the construction of the North-South Carrier (NSC) in Gaza. The NSC was envisaged in the initial strategic studies on the water sector in Gaza, but its design has been reviewed by TECC alongside the work reported here. Certain changes were made to the earlier design to reflect the capacity of STLV-related facilities needed (at an earlier stage) in the south of Gaza, and this has generated a cost saving to the NSC as originally envisaged.

- The costs for the additional water imports from Israel can only be assessed with any accuracy once the negotiations between Palestine and Israel reach a later stage.

- The capital cost for STLV desalination has been allocated to 2011 and 2012 only, and includes two components: approximately US$40 million for the equipment needed to produce some 13 MCM/year of desalinated flows (see Table 5 above); and a further US$7 million to provide inducements/subsidies to reduce the initial price of the water – hence encouraging its use by the population. It is assumed that standby electricity generating facilities will be made available as needed (see Section 6.4 of this report). Ongoing costs for the desalinated flows are assumed to be covered by tariffs, after the initial subsidies cease (see Section 6.3 of this report).

- The costs in 2011 and 2012 for regional desalination refer (only) to the completion of the Feasibility Studies and embedded Environmental & Social Impact Assessments, plus the production of design and tender documents for the two facilities. This matches the general timelines shown in Figure 10 of this report. It is assumed thereafter that the finance for the regional desalination facilities will be provided by the tendering parties, with the Palestinian authorities contracted to pay for a guaranteed minimum flow at a specific cost/cubic metre.[32] The latter costs should be covered by tariffs, with cross-subsidies included as may be agreed by the authorities in Palestine (see Section 6.3 of this report).

- The estimated costs for wastewater reuse in 2011 and 2012 refer to pilot reuse programmes only, and again represent an 'uplift' in currently committed funding (which is significant at several of the wastewater treatment facilities). It is not possible at this stage to accurately identify the costs and their phasing connected to the reuse of wastewaters, as these will depend on progress in the construction of the upgraded wastewater treatment facilities, which cannot be precisely predicted at this time. However, it is noted that the PWA has estimated a requirement (not covered by present commitments) of US$75 million for the upgrading of the treatment facilities.

- The review of water use in the agricultural sector is assumed to be completed over eight months spanning the end of 2011 and the beginning of 2012. The estimated cost is minor, but this assessment will be important in reducing the agricultural demand for water in the longer term in Gaza (and hence, in relieving the abstraction pressure on the groundwater).

In general terms, it is notable that the CSO-G team has assumed that the costs after 2016 for the supply of water of adequate quality in Gaza will be covered by tariffs. This aligns in broad terms with

[32]The capital costs for constructing the regional desalination facilities are estimated in approximate terms at between US$200 million and US$350 million. Importantly, it appears very likely that a tendering party will require a guarantee of its investment. This matter is beyond the scope of the present report, but should be considered with some urgency by the authorities in Palestine.

the analysis shown at Section 6.3 of the present report, although certain assumptions are made in terms of cross-subsidization. Various assumptions are also necessary as to the state of the economy in Gaza over the medium to longer terms – and these are hostage to regional peace, at least to some extent.

5. The Side-lined Options

This section returns to the options that were 'side-lined' in the screening procedure discussed in Section 3.2 of the present report, and provides proposals as to how each of these should be addressed in the future. The various options involved are discussed in turn, below.

5.1 High-Volume Transfers from Israel

As noted in Section 3.6 of this report, **the transfer of high water volumes from Israel to Palestine is considered by the project team to be the preferred option for Gaza of all potential possibilities in the CSO-G**. Its failure as an available option at the present time lies in the current uncooperative political relationship that has developed from the interaction during past Permanent Status negotiations between Palestine and Israel. The analysis that arrives at this conclusion deserves a detailed explanation, given the overwhelming preference of the CSO-G project team for this option.

Over the last 12 years of on-and-off negotiations, the Palestinian side has been clear that a Two-State Solution would only be viable if there were a coherent and fair outcome in relation to water supply to Palestine, in particular. The sanitation sub-sector received relatively little attention in the early stages, but has climbed significantly in importance since then.

The Palestinian negotiators relied upon established principles of customary international water law, most recently codified in 1997 by the United Nations Convention on the Law of the Non-navigational Uses of International Watercourses. Of the three principles central to international water law, the most significant is the need for the *equitable and reasonable use* of shared watercourses. (The other two principles require parties to *avoid causing significant harm* to other parties, and to provide *prior notification* of projects that may materially affect shared water resources; neither of these should be contested by Palestine or Israel).

The principle of *equitable and reasonable use* would require Israel and Palestine to allocate their shared water resources (the four aquifers and two surface waters of significance) in ways that would provide Palestine with substantially more water than they are allowed to receive, under the current occupation. Palestinian negotiators offered a transition period during which Israel could provide 'new water' through desalination or other means, so that Israel would never actually face a decrease in available water for its consumers. In this regard, the Palestinian side developed a Positive-Sum Outcome (PSO) that allows all five riparians of the Jordan River basin to access and utilize higher water volumes, concurrently (see Figures 11 and 12).

Israel has steadfastly refused to consider the possibility of reallocation of the water resources it shares with Palestine, based on the principle of equitable and reasonable use. Indeed, Israeli negotiators have repeatedly told Palestinians that "*there is no more water; you must go to the sea.*" At the Camp David negotiations, this approach was supported by a member of the US delegation, who told the Palestinian negotiators that discussion of water for agricultural use was irrelevant, and that the answer was "US=$", which she wrote in big letters on a white board.

Figure 11. A diagrammatic representation of possible changes over time in the availability/allocation of water resources to the co-riparians of the Jordan River basin. After Phillips *et al.* (2009).

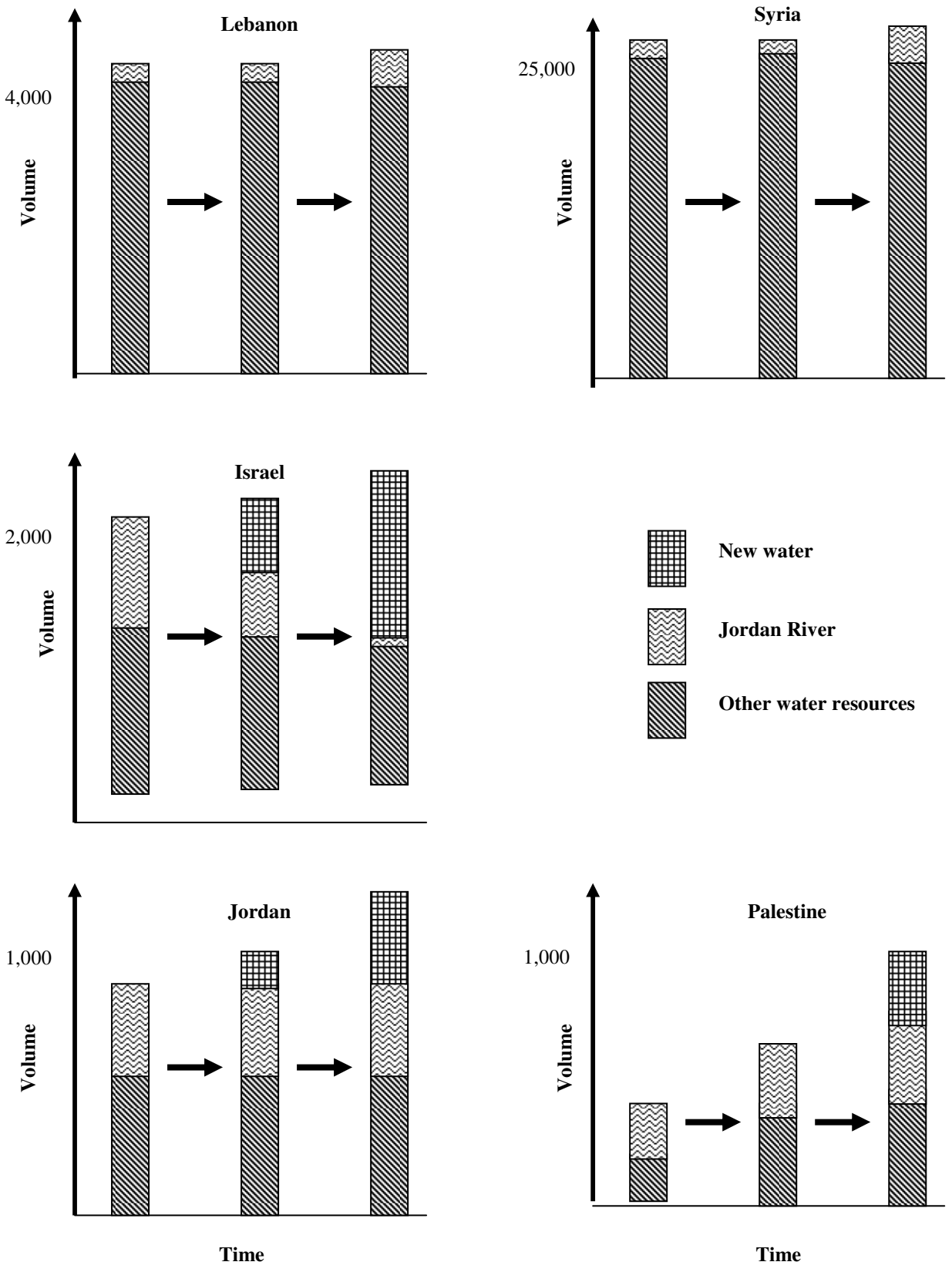
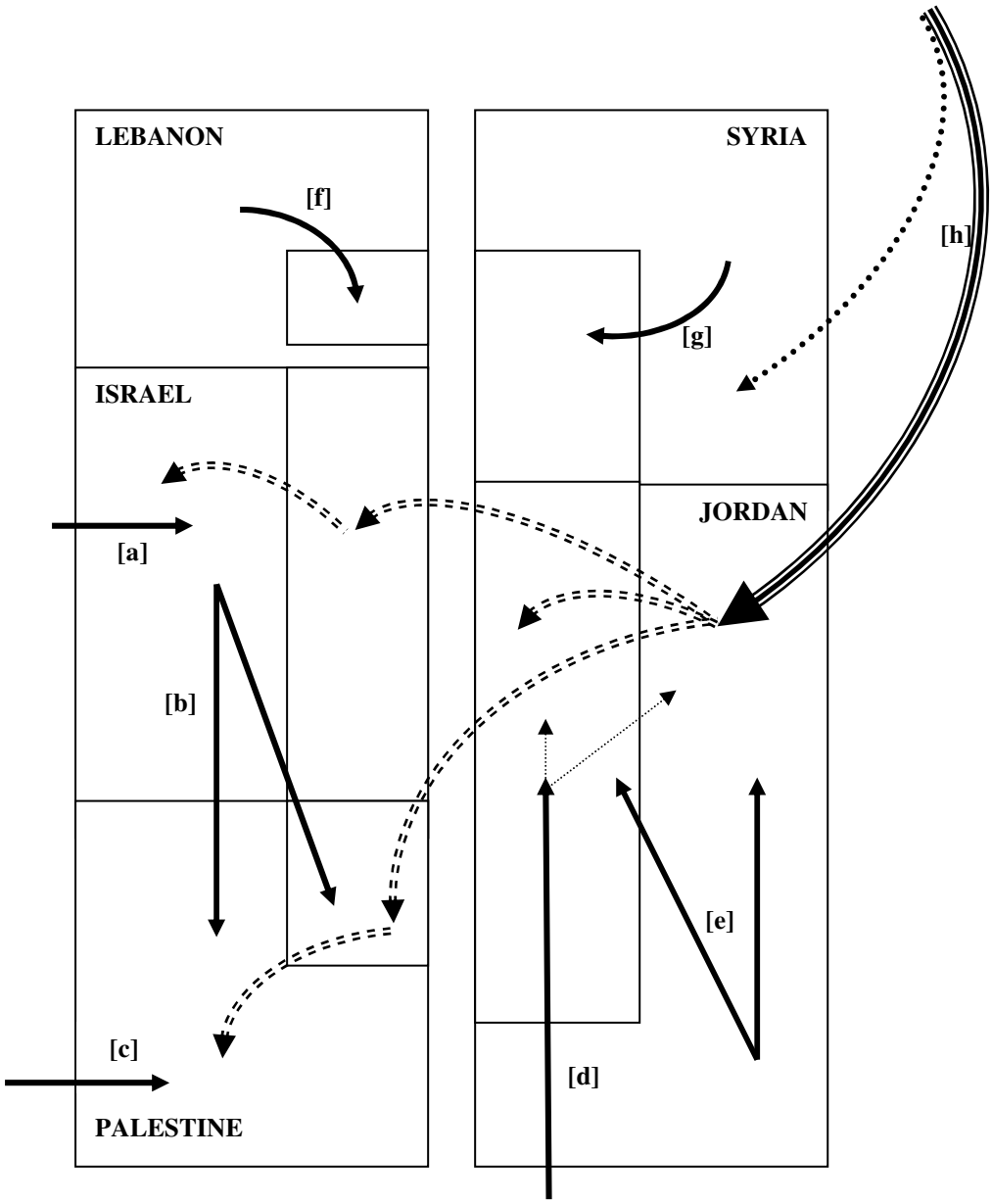


Figure 12. A diagrammatic representation of the preferred major options for addressing present inequities and for developing new water in the future in the Jordan River basin. The basin is denoted by the middle rectangle. The options involve: [a] Desalination by Israel. [b] A reallocation of water supplies between Israel and Palestine. [c] Desalination by Palestine, at Gaza. [d] The Red Sea-Dead Sea conduit. [e] Desalination at Aqaba, and/or further abstraction from the Disi Aquifer. [f] An inter-basin transfer from the Litani River to southern Lebanon. [g] An inter-basin transfer from the Tigris River to south-western Syria. [h] A Mini-Peace Pipeline or similar scheme from Turkey, supplying all riparians other than Lebanon. All options involving new water would be accompanied by wastewater reuse. After Phillips *et al.* (2009).



In such circumstances, the CSO-G project team has been forced to side-line the option of the equitable and reasonable use of the waters shared between Palestine and Israel, despite the strong conviction of the team members that this represents the best of all of the options available to the parties. If the bilateral negotiation dynamic were to change in the future, an equitable and reasonable allocation of fresh water between the parties should be sought with all vigour, and consideration should be given to extending this to the other riparians of the Jordan River basin. Specific mechanisms for such an approach have been developed for the Palestinian negotiators, but these are confidential and are therefore not discussed here.

If such a negotiating approach were to succeed at any time in the future, the water balance in Gaza would change dramatically. Palestine would presumably seek to realise its surface water rights through transfers of flows from Lake Tiberias to both the West Bank and Gaza, the latter involving a transfer through the Israeli National Water Carrier (and the former involving the construction of the West Ghor Canal proposed during the Johnston missions in the mid-1950s). There is an obvious relationship between this type of arrangement and the additional low-volume imports of water from Israel to Gaza (see Sections 3.6 and 4.2.5 of this report), although it is emphasized that the minor water volumes discussed at Section 4.2.5 above do not in any fashion equate to the water rights of the Palestinian population in Gaza.

5.2 High-Volume Transfers from Turkey

As noted in Section 3.7 of this report, the transfer of significant volumes of fresh water from Turkey to Gaza using bags or tankers is considered not to be feasible and/or economically affordable.

By contrast, historical proposals for a so-called 'Mini-Peace Pipeline' are believed to merit further consideration. Phillips *et al.* (2007, 2009) suggested that a major inter-basin transfer of this type could have substantial merit, at least by comparison with the results of the ongoing studies of the Red Sea-Dead Sea Conduit. It is obvious that such a major engineering programme could only be realised in the medium to longer terms, and this is largely the reason for the side-lining of this option in the CSO-G. Nevertheless, the restricted range of options for realising 'new water' that are available to Palestine and Jordan in particular, suggest that this option should be reconsidered (see Phillips *et al.*, 2009). It would appear likely that there is a restricted political window of opportunity to realise such a major inter-basin transfer from Turkey (see Rende, 2004). The completion of a full-scale Feasibility Study would be the preferred first step.

The Mini-Peace Pipeline is a potential long-term intervention for the region. While it could theoretically be of relevance within the 30-year time horizon of the CSO-G, the project team cannot provide further concrete advice at this time, in advance of the completion of a Feasibility Study of the option. It is emphasized that this would be in the clear interests of both Palestine and Jordan (Phillips *et al.*, 2007, 2009).

5.3 Desalination Shared with Egypt

The possibility that a second (or even a third) regional desalination facility serving Gaza could be constructed in Egypt (rather than in Gaza itself) was cited in Section 3.9 above. The CSO-G project team considers that the key distinction between these alternatives relates to project risk, rather than any other factor. Certain of the Palestinian water managers have argued that the construction of two desalination plants in Gaza would reduce the project risk created by possible Israeli military bombardment, but there is little evidence to support such an argument.

It is clear, however, that an attempt to construct a shared desalination facility located in Egypt but supplying flows to Gaza would be likely to be a somewhat protracted affair. It appears highly doubtful that such an initiative could be realised within the time frame shown in Figure 10 of this report, although the comments in Section 4.2.7 may modify the preferred timeline for the second desalination facility, in any event.

Certain international parties have expressed interest in the concept of a shared desalination facility involving both Egypt and Palestine, and it appears that financial assistance could be made available in this regard. The project team recommends that this possibility should be kept in close view by the authorities in Palestine, particularly as the ongoing changes occur in the Governmental apparatus in Egypt.

5.4 Other Options and Sub-options

The other options/sub-options that were side-lined in the analysis discussed at Section 3.2 of this report are not believed to be of significant utility to Gaza in the future. To recap, the reasons for this are as follows:

- The within-Palestine transfer of fresh water from the West Bank to Gaza fails to provide a workable solution, because there is insufficient water available in the West Bank to make a significant difference to the situation in Gaza (see NSU, 2005a; Messerschmid, 2011). The costs of such a transfer are also problematic, as is the fact that there is no guarantee that a territorial link will exist between the two land areas (which is hostage to the Permanent Status negotiations).

- The use of 'medusa bags' or the like to tow fresh water by sea from Turkey to Gaza does not represent proven technology, and the costs of such a venture are estimated to be unacceptably high. Previous studies by Israel have concluded that the use of tankers to deliver fresh water from Turkey (probably from the Manavgat River; see Gurer and Űlger, 2004; Rende, 2004) would also be prohibitively expensive.

- The allocation to Gaza of surface waters derived from the Nile River is believed to be politically unattainable.

- The allocation of significant volumes of fresh water from Jordan to Gaza appears most unlikely, and Jordan faces its own water-related problems.

6. Additional Matters of Relevance

This section covers additional issues that do not fit well into the previous logic flow, but are nevertheless of importance to the CSO-G, and to the future of the water sector in Gaza. Four broad topics are addressed here, these involving practical difficulties; legal issues; the affordability of fresh water supplies to the population of Gaza; and the availability of electrical energy.

6.1 Practical Difficulties

Two broad sets of practical issues constitute major threats to the realisation of the CSO-G strategy as outlined in this report. The first of these relates to the blockade of Gaza, which heavily restricts the importation of construction materials and equipment through its borders with Israel and Egypt. The blockade has been in place since 2007, and represents a major factor restricting capital works within Gaza (despite Israeli rhetoric to the contrary; see Messerschmid, 2011).[33] The water managers in Gaza confirmed recently that this remains the case, and reports from certain of the NGOs operating in Gaza during the first half of 2011 have noted that the blockade heavily hinders their efforts at providing humanitarian assistance to the population (e.g. see WASH NAF CAP, 2011).

A recent statement promulgated by the Quartet Envoy and Israeli Prime Minister Netanyahu (OQR, 2011) might suggest that improvements in the blockade could eventuate in the future. While this statement erroneously referred to the Joint Water Committee as having a responsibility for decisions on Gaza[34], it did contain a commitment by the Government of Israel relating to *"two sets of mobile desalination plants"*, and also cited 'in principle' agreement to the establishment of larger desalination plants (see Text Box 4).

Text Box 4: Extract from OQR (2011) on 'Water'

- *"On Gazan water supply, the GoI has agreed to facilitate proposals agreed in the Israeli-Palestinian Joint Water Committee, which are supported by the USA and Norway: to facilitate the establishment of two sets of mobile desalination plants within a few days of receiving applications; and, in principle, to the establishment of larger desalination plants.*
- *The GoI has approved the German-supported Sheikh Ajleen water treatment plant, in addition to UNDP's Khan Yunis project, for which funds are still required. The GoI has committed to facilitating the entry of construction materials to enable these projects and the NGEST project to be completed on schedule."*

[33]The Rafah checkpoint between Gaza and Egypt was opened in late May 2011, and this offers hope that the blockade of Gaza will be eased in general in the forthcoming months.

[34]The Oslo II Agreement states very clearly that the Joint Water Committee has no jurisdiction whatever over water sector-related issues in Gaza.

The citation in the statement shown in Text Box 4 to 'agreement in principle' to the establishment of larger desalination plants is reminiscent of recent events in the Joint Water Committee, pertaining to water sector infrastructure in the West Bank. The Palestinian side has noted that this in fact represents simply a new hurdle created by the Israeli authorities, rather than offering true support for realizing infrastructure requirements.

Despite this – and the long experience of the strength of the Gaza blockade, in the face of rhetoric from Israeli authorities – the statement released by the OQR (2011) may provide some support for at least certain of the interventions proposed as part of the CSO-G strategy, and the very recent opening of the Rafah checkpoint between Egypt and Gaza is also a positive sign.

The second practical issue concerns a broader connected topic that was addressed in the 'PWA Audit' (see footnote [1] to this report), and pertains to the need to 'keep water out of politics'. The case was made in the PWA Audit that the Israeli and Palestinian authorities had not adhered to a previous agreement to this effect, and that political issues therefore remained a major hurdle to the development of coherent water sector infrastructure in Palestine. The CSO-G project team notes here that this situation has continued to date, and has arguably been exacerbated at times by tensions within Gaza, amongst distinct Palestinian factions. It is emphasized here that humanitarian programmes relating to water sector infrastructure should not be hostage to political concerns of any fashion.

6.2 Legal Issues

6.2.1 The Oslo II Agreement and Gaza

The analysis in this section is based on the proposition that the Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip of 28 September 1995[35] (the Interim Agreement or Oslo II Agreement) is legally binding, a conclusion that was reached in a separate study (McCaffrey, 2010).[36] Article 40 entitled 'Water and Sewage' is contained in Appendix 1 (Powers and Responsibilities for Civil Affairs) to Annex III (the Protocol Concerning Civil Affairs) of the Oslo II Agreement. Article 40 contains several provisions of relevance to Gaza, most notably paragraph 25, entitled 'The Gaza Strip'. Also relevant to Palestinian water rights in Gaza is international humanitarian law. Each of these sources of law, and their application to Gaza, is examined here briefly.

6.2.2 Article 40

Paragraph 1 of Article 40 is set forth under the heading entitled 'Principles'. The paragraph states as follows: *"Israel recognizes the Palestinian water rights in the West Bank. These will be negotiated in the permanent status negotiations and settled in the Permanent Status Agreement relating to the various water resources."* Apart from the fact that this formulation is problematic (McCaffrey, 2010), according to its terms it does not cover Gaza.

As indicated above, Gaza is the subject of paragraph 25 of Article 40. However, it is also dealt with in paragraph 7, which falls under the heading, "Additional Water". The relevant provisions under that heading read as follows:

---

[35] Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip, Israel-PLO, 28 Sept. 1995, 36 I.L.M. 551 (1997).

[36] However, if the plan announced on August 25, 2009 by Prime Minister Salam Fayyad *"to establish a de facto state apparatus within the next two years"* is successful, this could be regarded as bringing to an end the 'interim' period. The status of all agreements pertaining to that period, first and foremost the Oslo II Agreement, could then be called into question.

*"**Additional Water***

6. *Both sides have agreed that the future needs of the Palestinians in the West Bank are estimated to be between 70 - 80 mcm/year.*
7. *In this framework, and in order to meet the immediate needs of the Palestinians in fresh water for domestic use, both sides recognize the necessity to make available to the Palestinians during the interim period a total quantity of 28.6 mcm/year, as detailed below:*
    a. *Israeli Commitment:*

        . . .

        6. Additional supply to the Gaza Strip - 5 mcm/year.

    b. *Palestinian Responsibility:*

        . . .

        3. A new pipeline to convey the 5 mcm/year from the existing Israeli water system to the Gaza Strip. In the future, this quantity will come from desalination in Israel.

8. *The provisions of paragraphs 6-7 above shall not prejudice the provisions of paragraph 1 to this Article.*
9. *Israel shall assist the Council in the implementation of the provisions of paragraph 7 above, including the following:*
    a. *Making available all relevant data. . . . ."*

These provisions raise several issues with regard to Gaza. First, Israel has not complied with its commitment to provide Gaza with the 5 MCM/year from the Israeli water system, despite the fact that Palestine is in substantial compliance with its responsibility (under paragraph 7.b[3]) to construct the new pipeline (McCaffrey, 2010; section 3.2). Second, it should also be noted with respect to paragraph 7.b[3] that the meaning of the second sentence (beginning "In the future . . .") is entirely unclear. In the first place, there is no indication of what is meant by "the future" – i.e., whether this is intended to be a time frame within the interim period or beyond (presumably the former, since paragraph 1 prevails over paragraphs 6 and 7). And in the second place, there is no explanation why it should be necessary to specify the source of the 5 MCM/year, whether desalination or natural sources (Jordan River water delivered *via* Israel's National Water Carrier). The reason for this might relate to Israel's plan to meet its obligations to Palestine with desalinated water, for which it would levy charges, rather than with natural flows. On the other hand, it could be argued that this provision gives Palestine a right to desalinated water from the Ashkelon plant and/or the recently commissioned desalination facility at Hadera. Third, in any event, the text of paragraph 7.b.[3] appears to assume that the desalinated water would be kept separate from naturally-occurring fresh water. If Israel continues to feed desalinated water into the National Water Carrier, as it has been doing, this intermixing of desalinated and naturally-occurring water would seem to undercut any case Israel may make for charging Palestine for desalinated water. The provisions of Article 40 on Water Purchases, and the question whether Israel may charge Palestine for the water it "provides" through its system, are discussed below. Finally, Israel has almost certainly not fulfilled its obligation under paragraph 9 to make available all relevant data, including that concerning Gaza, a point also discussed below.

Paragraphs 18 and 19 of Article 40 appear under the heading, "Water Purchases". Paragraph 18 provides as follows: *"Both sides have agreed that in the case of purchase of water by one side from*

the other, the purchaser shall pay the full real cost incurred by the supplier, including the cost of production at the source and the conveyance all the way to the point of delivery. Relevant provisions will be included in the Protocol referred to in paragraph 19 below."

Paragraph 19 provides that the Joint Water Committee (JWC) is to *"develop a Protocol relating to all aspects of the supply of water from one side to the other . . . ."* On 20 December 1998, the parties signed the Protocol Relating to Water Supply (Selby, 2009), but the concept of water purchases is potentially problematic. At the most fundamental level, a party cannot be made to pay for water to which it is entitled, because that water is already owned by the party. Therefore, unless water is supplied from one party's share to the other party, or one party requests water from the other to avoid having to develop its own resources, there should be no cost to the party receiving the water. The latter party should be permitted to extract the water to which it is entitled. When it does not have access to the source of the water, that access should be provided by the other party. The fact that Israel is effectively occupying the Gaza Strip should not alter these well-settled principles. As discussed in section 6.2.3 below, Israel is only entitled to enough water from the share to which the occupied territory is entitled as is necessary to sustain reasonable numbers of its civil administration and occupying armed forces. But if any payment made or promised by the Palestinians covers not the water itself but only the "full real cost incurred by the supplier", as provided in paragraph 18, such payment would not affect rights in the water itself.

Paragraph 25 is the sole paragraph under the heading, "The Gaza Strip". It provides that *"existing agreements and arrangements . . . concerning water resources and water and sewage systems in the Gaza Strip shall remain unchanged, as detailed in Schedule 11."* The detail is provided in the nine paragraphs of Schedule 11, and the following points are notable.

- Schedule 11 is now dated, in view of the Israeli disengagement from the Gaza Strip in August-September 2005. Many of its provisions are designed to protect, or at least focus upon, water for Israeli settlements in the Gaza Strip. However, violations by Israel occurred during the occupation. For example, Schedule 11, paragraph 3, second sub-paragraph, requires Israel to *"provide the Council with all data concerning the number of wells in the Settlements and the quantities and quality of the water pumped from each well, on a monthly basis."* No such data were ever provided by Israel.

- Water purchases. The issue of payment for water supplied by Israel arises again here. Specifically, paragraph 5 of Schedule 11 provides: *"The Council shall pay Mekoroth for the cost of water supplied from Israel and for the real expenses incurred in supplying water to the Council."* This again raises the question of whether Palestine is being charged for water to which it is entitled, or whether the charges cover only *"the real expenses incurred in supplying water"* to the Palestinians. In view of the construction of the sentence – specifically, the use of the conjunctive "and" between "the cost of water supplied from Israel" and "for the real expenses incurred . . ." – the natural interpretation would be that Palestinians are being charged for the water itself, not only for the cost of delivering it. If this water is part or all of the 5 MCM/year that Israel committed to supply to Gaza, there should be no charge for it as indicated above, only for the expense (pumping, etc.) of delivering it.

- Subcommittee. Schedule 11 provides in its paragraph 8 for the establishment by the two sides of a subcommittee *"to deal with all issues of mutual interest including the exchange of all relevant data to the management and operation of the water resources and systems and mutual prevention of harm to water resources."* There is nothing in this paragraph that restricts the terms of reference of the subcommittee to the situation prior to the Israeli disengagement. It is not known to the authors (a) whether this subcommittee was ever established, (b) whether it

continues to function, or (c) if so, whether Israel provides the indicated data to Palestine (there is no indication that it has).

Israel's record of compliance with its obligations in respect to Gaza under Article 40 has not been good (McCaffrey, 2010). While both sides have breached obligations relating to water under the agreement, virtually all third-party observers agree that the character of the breaches by the two sides is dramatically different. Israel's complete control over water and indeed over all aspects of Palestinian life in the West Bank, and effectively also in Gaza (Amnesty International, 2009; World Bank, 2009) means that except in the most unusual circumstances Israel can (and does), figuratively speaking, 'turn the Palestinian tap on or off at will'. Israel's failures to meet its obligations relating to water under the Oslo II Agreement (as well as its breaches of international humanitarian law, considered below) therefore take on an aspect of deliberateness. Israel's breaches appear to be intentional, rather than unwitting, negligent, or caused by a lack of capacity or resources. Any breaches by Palestine, on the other hand, must be seen through the prism of a lack of control by Palestinian authorities over water resources and some other important aspects of civil affairs in the Occupied Territories. In addition, in large part due to Israeli incursions, blockades, restrictions on access and movement, as well as other restrictions, the relevant Palestinian authorities may not always have the capacity (including the financial capacity) or the capability to fulfil the obligations for which they are responsible. Thus any breaches by Palestine would seem, for the most part, to be attributable to conditions caused by Israel's conduct, rather than any deliberateness on the part of Palestine.

In particular, Israel has not supplied the full 5 MCM/year it committed itself to provide to Gaza from the Israeli water system. Israel has sold some water (quantities have ranged from 3.5-4.8 MCM/year) from Mekoroth through pipelines used to supply Israeli settlements in Gaza prior to the Israeli disengagement in August-September 2005. Israel has also offered to sell to Gaza 5 MCM/year (or more) from its desalination plant at Ashkelon.[37] Palestine has rejected the latter offer on the ground that it is entitled to naturally-occurring water without charge (for the water itself) and is not required to pay for desalinated water. With regard to its obligation under paragraph 9 to assist the Council in implementing paragraph 7, Israel has provided some assistance, but in respect of Gaza, in particular, Israel has actively hindered the implementation of 7.a.[6] and 7.b.[3]. In addition, as indicated above it is doubtful that Israel has "[made] available all relevant data" as required by paragraph 9.a.

For its part, Palestine fulfilled its responsibility (under paragraph 7.b.[3]) to construct the new pipeline referred to above (Selby, 2009). After Israel installed a pipeline from its National Water Carrier to the border with Gaza in 2005, US AID in that year installed a pipeline from the border to the Gaza City reservoir. There remains only a short (130 metre) section straddling the border where there is no pipeline in place.

6.2.3 International Humanitarian Law

Under international humanitarian law generally, the occupying power stands in the shoes of the legitimate power, and must administer the territory and its population as the legitimate power would have, except where absolutely necessary. The occupying power is responsible for the welfare of the population of the occupied territory. Thus, for example, article 43 of the 1907 Hague Regulations provides as follows: *"The authority of the legitimate power having in fact passed into the hands of the occupant, the latter shall take all the measures in his power to restore, and ensure, as far as possible, public order and safety, while respecting, unless absolutely prevented, the laws in force in the country."*

[37] In fact, Israel has offered up to 15 MCM/year from the Ashkelon plant at different times, this volume being additional to the 5 CM/year provided for in the Oslo II agreement.

Similarly, Article 47 of the Fourth Geneva Convention of 1949 provides: *"Protected persons*[38] *who are in occupied territory shall not be deprived, in any case or in any manner whatsoever, of the benefits of the present Convention by any change introduced, as the result of the occupation of a territory, into the institutions or government of the said territory, nor by any agreement concluded between the authorities of the occupied territories and the Occupying Power, nor by any annexation by the latter of the whole or part of the occupied territory."*

The intent of this provision is clear: to afford the general humanitarian protections of the Convention to those living in occupied territories, despite any changes that may be made by the occupying power due to military necessity. This extends to those living in occupied territory that is annexed by the occupying power.

International humanitarian law in general, and the law of belligerent occupation in particular, place responsibility for the health and well-being of the population of an occupied territory on the occupier. Thus Israel, as the occupier, has an obligation to provide additional water to Palestinian residents of Gaza (and the West Bank), over and above the quantities it has agreed in the Oslo II agreement to provide, if such additional quantities are necessary to ensure the health and well-being of those populations.

Israel's policy of control of the water sector in the Occupied Territories for the benefit of its citizens living both in its territory and in settlements in the West Bank (and formerly in Gaza), violates the fundamental principle underlying the law of belligerent occupation, i.e. that the Occupying Power is responsible for the welfare of those living in the occupied territory. There are many and varied concrete manifestations of this general violation. The policy violates the obligation of the Occupying Power to act only as a usufructuary under Article 55 of the Hague Regulations. Israel has also violated Article 55 of the Fourth Geneva Convention by failing to ensure, *"to the fullest extent of the means available to it, . . . the food and medical supplies of the population"* and failing to *"bring in the necessary foodstuffs . . . and other articles if the resources of the occupied territory are inadequate."* International practice considers "food" and "foodstuffs" to include water. These violations apply not only to the West Bank, but also – and in an aggravated form – to Gaza.

Israel's attacks on water and wastewater facilities in Gaza during its military operations there in December 2008-January 2009 (Goldstone Report, 2009), are blatant violations of Article 54 of Additional Protocol 1 to the 1949 Geneva Conventions. There is no doubt that these facilities constitute *"objects indispensable to the survival of the civilian population, such as . . . drinking water installations and supplies . . . ."*. The highly disproportionate nature of the attacks, as compared with the missiles fired into Israeli territory from Gaza by Hamas, rules out their legitimacy as counter-measures or measures of self defence. These actions also violate Article 53 of the Fourth Geneva Convention, prohibiting the destruction of real or personal property. The same actions, together with Israel's refusal to permit materials for the repair of water facilities to be transported into Gaza, also violate international human rights law, including both the human right to water and the principle of non-discrimination.

Israel's restrictions on ingress and egress in respect of Gaza, and in particular on the provision of supplies needed for humanitarian purposes including for water and wastewater services, violate Article 56 of the Fourth Geneva Convention, which requires the Occupying Power to ensure public health and hygiene in the occupied territory. The same can be said of the effect of Israeli delays and refusals on what the Fourth Geneva Convention refers to as *"relief schemes"* in Article 59. Article 59 requires the Occupying Power to permit and facilitate relief schemes if *"the whole or part of the*

[38] *"Protected persons"* are defined by Article 4 of the Convention as *"those who, at a given moment and in any manner whatsoever, find themselves, in case of a conflict or occupation, in the hands of a Party to the conflict or Occupying Power of which they are not nationals."*

population of an occupied territory is inadequately supplied". This is especially true in Gaza, particularly after Israel's attacks there during 'Operation Cast Lead' in December 2008 - January 2009, in respect of water supply and wastewater facilities, as well as materials to construct and maintain those facilities. Israeli delays and refusals to permit humanitarian assistance – most dramatically that sought to be provided to Gaza by the humanitarian flotilla attacked by Israel in international waters off Gaza on May 31, 2010 – discourage, *inter alia*, donors who are prepared to fund water supply projects and wastewater treatment plants but whose intentions are thwarted by Israeli obstructions. Such conduct clearly and blatantly violates Article 59.

In summary, Israel is bound by both the law of belligerent occupation and international human rights law in respect of the Occupied Palestinian Territories, including Gaza. Israel has acted in violation of the law of belligerent occupation in respect of Gaza since it occupied that Palestinian territory in 1967. Israel's violations have increased in frequency and severity over time. The most conspicuous evidence of this in Gaza is Israel's blockade, resulting – especially due to the Israeli military campaign against the Gaza population, its infrastructure (including that relating to water and wastewater) and civilian and government structures in December 2008-January 2009, in widespread suffering, deprivations and severe health effects, many from conditions relating to water and wastewater.

6.3 THE AFFORDABILITY AND WILLINGNESS TO PAY FOR WATER IN GAZA

6.3.1 Previous Studies

Section 2.4.9 of the Terms of Reference (see *Annex 1* to this report) requires the CSO-G team to *"[p]rovide an indication of the affordability and willingness to pay for water by the Palestinian population in the Gaza Strip based on previous studies"*. Several previous studies were sourced and reviewed in this regard, and the analyses have been updated using recent economic data of relevance to the Gaza population. Payment for water supply only was addressed, with no attention being given to any separate payment for wastewater treatment and disposal. An affordability threshold of 4% of household income was employed, this aligning in general terms to the 5% threshold that is commonly employed for both water supply and wastewater treatment/disposal.

Tiltnes (1998) published a lengthy report on affordability and willingness to pay for water and sewage services in both Nablus and Gaza City, based on studies of residents inside and outside refugee camps in both locations. He reported an average expenditure at that time ranging between 1.1 and 2.9% of household income, and suggested that there was some scope for an increase in tariffs. However, the poorer sections of the populations were clearly unable to pay for any increased costs of water supply, and some of the residents without connections to the municipal supply did not wish to be connected, because they could not pay for the service.

Ismail (2003) also suggested that there could be scope for an increase in water tariffs in Gaza, but noted that cross-subsidies would be required to protect the poorer sectors of the population.

In a later study based on interviews completed in 2004, Al-Ghuraiz and Enshassi (2005) reported an average level of willingness to pay in Gaza of NIS3.06/m^3 (ranging from NIS2.82/m^3 in refugee camps to NIS3.4/m^3 in villages), provided that the quality of water would meet the WHO guidelines and that service levels would be improved. They suggested that tariffs would have to rise from the (then current) level of NIS1.08/m^3 to at least NIS2.54/m^3 to finance the capital investment necessary to meet the required improvements to quality and levels of service. At that time, the average household size in Gaza was 7.2 individuals, and the average *per capita* income ranged between NIS151 and NIS293/month, depending on the Governorate involved. For those on the lower end of the income scale, the authors recommended the introduction of cross subsidies through rising block tariffs. It was

concluded that at a tariff of NIS3.00/m^3, the average consumer would be able to afford 100 litres per day, which equates to the lower minimum of the World Health Organization for *per capita* water availability.

Al-Ghuraiz and Enshassi (2006) extended their findings to a survey of the level of satisfaction of customers in Gaza with the water supply service. They concluded that water quality was the principal area of complaint for the residents (in particular, relating to salinity), followed by poor levels of service (which were perceived to be due to poor maintenance of the network). The availability of fresh water was considered to be the most pressing concern to be addressed by the authorities.

Several of the NGOs have commented on the affordability of water supply in Palestine as a whole, and in Gaza in the specific. PHG-WASH MP (2006) stated the following: *"The financial crisis which has struck all of the OPT.... has made the provision of services literally impossible.... Water prices are highly variable and inconsistent from one community to the next.... The price of water is so high in some communities that individuals and families can no longer afford to meet even their minimum water needs."* Unicef (2011) stated that 82.7% of households in Gaza purchase desalinated water supplies, but up to a third of the household income is used to pay for water, and the high price of desalinated supplies is unaffordable for many. As noted previously in this report (see Text Box 1), the desalinated water from commercial vendors in Gaza costs an average of NIS35/m^3, which is approximately 10-fold greater than the estimated cost of desalinated flows from a regional facility.

6.3.2 Gaza at the Present Time

At the current time, the utilities in Gaza are performing badly financially, largely through poor revenue collection efficiency. This is likely to be at least partly attributable to falling income levels (and hence to affordability constraints), although resistance to payment through dissatisfaction with the levels of service is also believed by the PWA officials in Gaza to be an important factor. Before the second *intifada* [uprising] in late 2000, revenue collection efficiency in Gaza was approximately 80%, and most of the water managers in Gaza state that the population would pay 'reasonable costs' for water if the service were to be improved (especially in relation to the quality of the water supplied).

As has been widely documented, the average income in Gaza fell significantly during the last decade, due to the political situation. The conclusions from earlier studies should therefore be considered with significant care. Data from 2009 are shown in Table 8.

Parameter	***Unit***	***Result***
Access to public water supply network	%	96
Water quality	Assessment	7% good; 29% challenged; and 64% bad
Access to sewerage network	%	84
Population supplied	Thousands	1,440
Domestic water supply	Million m^3	91
Agricultural	Million m^3	80
Per capita availability (assuming losses of 40%)	Litres per day	98
Revenue collection	% of billing	19–48% (but fell considerably from 70-80% in 2000)
Working ratios (OpEx divided by revenues)	%	140–257%
Domestic tariffs	NIS/m^3	0 – 5 m^3: 0.3 – 1.0 5 – 10 m^3: 0.5 – 1.0 10 – 20 m^3: 0.5 – 1.0 20 – 40 m^3: 0.8 – 1.5 40 + m^3: 0.8 – 2.0

Table 8. Data from 2009 of relevance to water supply and tariffs in Gaza.

In the current analysis, the following assumptions have been used:

- income levels are assumed to have changed in accordance with the average GDP *per capita* growth rates for Gaza;
- costs have risen in accordance with the inflation statistics for Gaza; and
- there have been no material changes to the other factors cited in earlier reports concerning household sizes, consumption patterns, and the like.

Data from the Palestinian Central Bureau of Statistics over the period 2004-2010 reveal that real GDP growth in Gaza has been negative, with real GDP *per capita* falling by 23.7%.[39] The accumulated inflation for Gaza over the same period was 33.6%. Consequently, the nominal growth in incomes (including inflationary effects) is calculated as approximately 10% over this period. By extrapolation, the findings of Ghuraiz and Enshassi (2005) can be adjusted upwards in nominal terms by 10%, i.e. the average willingness to pay threshold would rise from NIS3.06/m^3 to NIS3.37/m^3 (equivalent to US$0.99/$m^3$ at the present rates of exchange).

The fall in real incomes in Gaza helps to explain the collapse in revenue collection performance over the last ten years (see Table 8), which may be assumed to reflect a response to the much-reduced household income pushing more and more families into 'water and energy poverty' through this period.

On the basis of the costs for water supply in locations where desalinated supplies predominate, the CSO-G project team estimates that full cost recovery would be possible if tariffs for water supply were to be increased to between US$1.00/$m^3$ and US$1.20/$m^3$. At the current exchange rate of US$1.00 = NIS3.40, the lower end of this predicted tariff range is on the threshold of affordability for the population in Gaza, on average. An increase in tariffs from the bottom of this range will in all probability result in a greater unwillingness to pay, and will therefore worsen an already poor situation with respect to revenue collection. Furthermore, this prediction of willingness to pay is predicated on the premise that levels of service will improve, as also noted by Ghuraiz and Enshassi (2005, 2006).

Although income growth in Gaza has largely been negative in the last decade, the current trend is positive, with real annual GDP *per capita* growth of 3 to 5%. Barring any social, security and economic shocks, a continuation of this upward movement will ease affordability and willingness to pay constraints, over time. If this growth rate were to continue, it is estimated that real above-inflation tariff increases of some 3% per year could be tolerated.

This analysis addresses 'average' incomes, consumption and tariffs; however, it is recognised that wealth distribution can distort the results. Statistical information on wealth distribution (as GINI coefficients) in Gaza is not readily available, but Ghuraiz and Enshassi (2005) suggest that some 50% of the population falls below the average household income level, and almost 20% of the population have incomes that are less than two-thirds of the average. On the basis that the daily level of fresh water consumption is restricted to less than 100 litres *per capita* there may be very little opportunity for income elasticity of demand. This implies that it is unlikely that demand by poorer families will be reduced significantly, in order to remain within tight family budgets. Consequently, it appears likely that almost 50% of the families in Gaza would face difficulties in meeting their water bills.

[39] Over the period 2004 – 2008 real GDP *per capita* for Gaza fell from US$1,103 to US$774 (at 1997 base year), equating to a real growth rate (excluding inflation) of -29.8%. From 2008 to 2010 real GDP *per capita* grew from US$806.5 to US$876.7 (at 2004 base year) equating to a real growth rate (excluding inflation) of 8.7%. Combined, the overall effect from 2004 to 2010 is a real term fall in GDP *per capita* of -23.7%.

Attempts to alleviate affordability constraints through rising block tariff structures should be treated with caution. The degree to which prices for consumption above basic levels (taken as 100 litres *per capita*/day) will need to be increased in order to maintain affordability to the poor will probably be quite significant. It is considered that if subsidies are to be provided, these should be provided through alternative sources or mechanisms.

6.3.3 Conclusions

The conclusion of Al-Ghuraiz and Enshassi (2005) concerning the possibility for an increase in tariffs for fresh water in Gaza no longer appears to be supportable, due to erosion created by inflationary effects coupled to falling real income levels. The predicted requirement to increase tariffs to NIS3.4/m^3 is on the threshold of average affordability, even assuming that the levels of service improve. Such an increase in tariffs would probably result in increased resistance to payment, worsening an already critical situation relating to revenue collection (see Table 8). Furthermore, as tariffs approach this threshold, sudden price shocks will have ever greater impact. It is therefore considered necessary to temper price increases through subsidy mechanisms where possible, even if only for a limited period of time.

Cross-subsidies from commercial to domestic customers are already being applied, and a further widening of this gap could be seen as a step backwards. Similarly, the further widening of the rising block structure should also be discouraged where possible (as noted above).

It may therefore not be possible for the proposed investment plan for Gaza to be financially viable on the basis of the predicted tariff levels – at least in the short term, until the economy improves to a level that can sustain such prices for fresh water supplies. This implies that there will probably be a need for short-term subsidies to be introduced. These could take several forms:

- **The funding of capital projects:**
  - Donor funding through grants: The use of grants for investment (not only for system improvements but for major capital maintenance in the network) will ease cash flow in the short term. This may still result in financial losses on the basis that depreciation provisions are not provided for, but this is a perfectly acceptable accounting and regulatory practice[40].
  - Donor funding through soft loans and generous repayment terms: Soft loans reduce interest charges and generous grace and repayment periods significantly ease cash flow difficulties.

- **Direct subsidies to operating companies from Government:**
  - Government to utilities: The PNA could choose to support the utilities financially by providing them with direct subsidies. However, this relies on sound Government finances that can afford such subsidies and can assure them for a significant period of time. Furthermore, such subsidies are not necessarily targeted towards the poorer customers.
  - Government to customers: The Government could introduce a social safety net for the poor, by supporting the payment of their bills. However, this would require extensive social security infrastructure (means testing, screening, payment systems, etc.) that may not be practicable, especially in the short term when the assistance is needed most.

[40] Accounting conventions amortise grants over the life of the asset it finances, effectively treating it as deferred income. Consequently, depreciation is offset by this process. Regulatory conventions disregard assets financed by grants, and do not qualify as assets that can earn a return on capital.

- **Wealth redistribution from the West Bank to Gaza:**
  - Given the higher income levels and affordability in the West Bank, a national cross-subsidy from the West Bank to Gaza represents one possibility. Thus, consideration could be given to a premium on water tariffs in the West Bank, this to be passed on to the utilities in Gaza. Although this is likely to be resisted by West Bank residents, it may be considered acceptable as a means of national wealth redistribution. If such a mechanism were to be considered, further detailed analysis would be necessary.

6.4 Requirements for Electrical Energy

All of the interventions noted in this report will require enhanced electrical energy supplies, and the energy available in Gaza at the present time does not meet the demand. While distinct forms of desalination vary considerably in their demand for electrical energy, the international literature suggests that the desalination of sea water at significant scale by reverse osmosis requires approximately 3.0-5.5 kWh/m^3 of electrical energy.[41] This equates to a considerable power demand for all of the desalination facilities envisaged in the present report, and certain forms of STLV facilities may in fact use greater amounts of energy electrical energy than that cited here.

To address this requirement, the CSO-G project team has attempted to align the CSO-G strategy with the pre-existing strategy of the Palestinian Energy and Natural Resources Authority (PENRA). In relation to Gaza, the PENRA intends to develop further electrical supplies through a range of short-term and medium-term interventions, certain of these involving several of Palestine's neighbouring States (PNA, undated [2]). One such intervention relates to the offshore gas field in the Mediterranean Sea, and this was also referred to in the recent statement released by the Quartet Envoy (OQR, 2011), as shown in Text Box 5.

Text Box 5: Extract from OQR (2011) on 'Energy'

- *"To address long-term Gazan energy needs, the Government of Israel (GoI) has agreed to begin discussions immediately with the Palestinian Authority (PA) on the development of the "Gaza Marine" offshore gas field, with a commitment to conclude preliminary discussions in three months.*
- *Subject to development of the "Gaza Marine" gas field, the GoI has agreed in principle to the use of gas from Gaza Marine by the existing and any future power plant in Gaza. Additionally, it has approved the upgrading of the Gaza power station and the construction of a second power station, subject to submission of specific PA plans.*
- *On electricity supply to Gaza, the GoI has agreed to review requests to provide electricity to Gaza from Israeli sources within three months of application."*

[41] This estimate approximates the electrical energy requirement for the recent facilities constructed by Israel, Spain, and by parties in the Gulf. Changes are continuing rapidly over time in relation to the costs for desalinating sea water, these being largely driven by technologies focused on conserving energy. Such changes are likely to continue in the future, but the present report takes a somewhat conservative approach to the preferred technologies and their electrical energy requirements.

The electrical supplies that are needed to support the desalination initiatives in Gaza can be calculated in approximate terms by multiplying the energy needs noted above, by the desalination volumes shown in Table 5 to be required at specific benchmark dates. In this connection, it is most important that the existing plans of PENRA are realised, especially as the desalination facilities envisaged here require the guaranteed and non-interrupted availability of electrical energy.

The CSO-G team recommends that the STLV desalination as described in Section 4.2.6 of this report should be accompanied by stand-by generator equipment, as it appears unlikely at present that sufficient electrical power will exist in Gaza to operate the STLV desalination equipment, within the near future. The precise facilities to be supplied should be negotiated with the contractors providing the STLV equipment. It is clear also that the importation of diesel fuel to Gaza will in any event need to be guaranteed, if such an approach is taken – and the blockade discussed at Section 6.1 above is again of obvious relevance.

The later regional desalination programme would presumably be supported by electrical supplies that will be available in the future in Gaza, according to the current plans of PENRA. The electrical demand is significant, being calculated at approximately 30MW for the initial regional desalination facility of 55 MCM/year. Clearly, the improvement over time in electrical energy supplies to Gaza (as overseen by PENRA) must be coordinated with the plans discussed at Section 4.2.7 of the present report, such that sufficient power is available to serve the regional desalination facilities as they are completed.

7. Conclusions and Recommendations

The conclusions and recommendations arising from the CSO-G are enumerated here.

The first conclusion – and one of the most important – from the CSO-G project is that the continuation of the *status quo* in the water sector in Gaza is not acceptable. There are three main reasons for this: [a] the population has effectively no access to a reliable supply of fresh water for domestic use; [b] the agricultural sector over-utilizes water and yields are beginning to suffer due to deteriorating water quality; and [c] the groundwater is massively over-abstracted, is salinising rapidly over time, and is heavily contaminated by wastewaters. The latest monitoring data suggest that the aquifer is currently in the process of failing, and this will remove a further 55 MCM/year of water from the Gaza 'balance sheet'.

Given the need for rapid interventions to attempt to retrieve the situation in the water sector in Gaza, the CSO-G project team has addressed the options listed in the Terms of Reference, and has expanded these and added nuance to the potential types of interventions. However, the use of a screening process involving four types of criteria (political, technical, social and economic) has severely limited the options available for either short-term or medium-term interventions that may be used to attempt to solve the current problems. Much of the reason for this involves the political constraints faced by Palestine, in particular in its relationship with Israel. The option favoured most heavily by the CSO-G project team – the equitable and reasonable reallocation of the existing fresh water resources shared between Palestine and Israel – unfortunately failed to survive the screening process (even though it is supported in full by the principles of customary international water law).

Only four of the various options/sub-options considered in the CSO-G survived the screening procedure. One of these – Water Demand Management – has been integrated into the schedule of interventions in two sub-sectors: through the upgrading of pipe work to reduce leakage/infiltration and deliver high-quality water for domestic use by consumers; and also by developing wastewater reuse and higher water use efficiencies in the agricultural sector. Additional low-volume water imports from Israel are also envisaged, and these are being addressed by a parallel process in the 'political track', which should be pursued with all vigour. Desalination is also a favoured option, both in the short-term (to create relatively low water volumes for blending back to limited quantities of groundwater, for domestic use by residents of Gaza), and in the much longer term to assure a consistent supply of high-quality water for the expanding population. While desalination has been resisted – at least at any significant volume – in the past in Gaza, it is concluded that this is an inescapable component of the Gaza Emergency Technical Assistance Project as a whole, and of its first component addressed here (the CSO-G). It is noted that whilst the introduction of desalination could affect Palestine's position in relation to Permanent Status negotiations (should these resume at any stage), Israel's position is being even more impacted in this regard.

The mix of currently available options and sub-options has been characterised at the strategic level and through the addition of certain technical detail, and a rolling schedule of interventions has been developed. This includes nine components in total, all of which are inter-linked and some of which are mutually inter-dependent. It is concluded that:

- A Gaza Programme Coordination Unit should be established (effectively immediately) to oversee and coordinate the CSO-G programme of interventions as a whole.

- A Water and Health Monitoring Project should be commenced, integrating the various ongoing efforts of this type into a more coherent package and ensuring that reliable data are available to drive the interventions, and to monitor their success.

- The domestic water distribution system should be upgraded/reprovided on an accelerated schedule, such that high-quality flows intended for domestic use reach the consumers without being lost or contaminated to any significant degree.

- Increased (relatively low) volumes of fresh water should be imported from Israel, entering Gaza at three selected points on the domestic distribution network.

- Short-term low-volume (STLV) desalination should be introduced without delay, creating new fresh water from sea water. The desalinated flows should be blended-back into limited volumes of groundwater, to act as domestic water supplies for the Gaza population in the near future, for a period of approximately six years.

- Regional desalination should be introduced at high volume, at the earliest possible time. This requires an immediate start on the preparatory works, as the high-volume facilities will need to replace the STLV desalination effort in 2016, if at all possible. Two regional facilities are preferred, at specific sites in Gaza – although it is recommended that the Palestinian authorities keep in view the possibility that one such plant could be located in Egypt.

- The reuse of treated wastewater should be introduced immediately on a pilot scale, with the intention to prove the value of this to the farming community (using the results of the Water and Health Monitoring Project noted above).

- The pilot reuse projects should be followed as soon as possible by the large-volume reuse of treated wastewaters. This intervention is especially important in reducing groundwater abstraction (voluntarily, by the farmers) and hence in protecting the aquifer in the long term, but this is altogether reliant on the accelerated completion of the wastewater treatment facilities.

- A comprehensive review should be completed of the use of water – and the economic returns from water – in the agricultural sector in Gaza. This should seek to minimize water use and maximise the economic returns.

The estimated costs of these nine forms of interventions are enumerated, although the costs as quoted here rely on various assumptions and should be revisited when more detailed plans are being developed for each of the projects.

It is concluded also that three of the options that were 'side-lined' in the initial screening process may have merit in the medium or longer terms, if future events permit this. The first of these is the equitable and reasonable reallocation of the water resources shared by Palestine and Israel – the favourite option by far of the CSO-G project team (but politically unavailable, currently). Secondly, it is recommended that the possibility of a Mini-Peace Pipeline from Turkey to Palestine (and probably also serving Jordan) should be considered through the completion of a full-scale Feasibility Study. The third option involves a longer-term approach to shared desalination with Egypt, which was also mentioned above.

Four additional matters of relevance to the CSO-G are addressed. The first of these relates to practical difficulties, and in particular, to the blockade of Gaza that has existed since 2007. This must be resolved, if the CSO-G initiatives are to be successful – and all parties should strive to 'keep water out of politics' in the future.

Legal issues are also covered in the present report, and the case is made once again that Israel has failed to meet its commitments under the Oslo II Agreement of 1995 (and that the 5 MCM/year noted in that Agreement should be provided to Palestine free of charge). The affordability of fresh water to the Gaza population is also addressed, and a case is made that cross-subsidies of one form or another may be needed, especially to protect the poorer residents. Finally, the requirements for electrical energy (especially for desalination) are reviewed briefly, and the need is emphasized to realise the strategy of the Palestinian Energy and Natural Resources Authority.

Comments on this report should be sent by E-mail to the CSO-G team leader, Dr. David Phillips (dphillips@iway.na).

8. References

Al-Dadah, J. (2009). Re-estimation of water requirements by using CROPWAT model under vulnerable climatic changes conditions in Gaza Strip. Climate Change Mitigation & Adaptation 2009, Advanced International Training Programme in Norrköping, Sweden, October 26 to November 20, 2009.

Al-Ghuraiz, Y. and A. Enshassi (2005). Ability and willingness to pay for water supply service in the Gaza Strip. *Building and Environment*, 40, 1093-1102.

Al-Ghuraiz, Y. and A. Enshassi (2006). Customers' satisfaction with water supply service in the Gaza Strip. *Building and Environment*, 41, 1243-1250.

Al-Jayyousi, O.R. and M.R. Shatanawi (1996). An analysis of future water policies in Jordan using decision support systems. *International Journal of Water Resources Development*, Vol. 11 (3), pp. 315-330.

Almadina-Enfra-DHV (undated). *Non-conventional Water Resources: Reuse of Treated Water in the Gaza Strip.* Almadina-Enfra-DHV Consultants, Gaza, Palestine.

Almasry, M.N. (2008). Assessment of intrinsic vulnerability to contamination for Gaza coastal aquifer, Palestine. *Journal of Environmental Management*, 88, 577-593.

Ammary, B.Y. (2007). Wastewater reuse in Jordan: Present status and future plans. *Desalination*, 211 (1-3), 164-176.

Amnesty International (2009). *Troubled Waters – Palestinians Denied Fair Access to Water*. Amnesty International, Geneva.

Becker, N., N. Zeitani and M. Shechter (1996). Reallocating water resources in the Middle East through market mechanisms. *International Journal of Water Resources Development*, Vol. 12 (1), pp. 17-32.

Butler, D.A. and F.A. Memon (2006). *Water Demand Management.* IWA Publishing, London.

Buttiglieri, G., F. Malpei, E. Daverio, M. Melchiori, H. Nieman and J. Lighart (2205). Denitrification of drinking water sources by advanced biological treatment using a membrane bioreactor. *Desalination*, 178 (3), 211-218.

CMWU (2010). *New Water Resource Development Plan for Gaza Strip. Planned Period from Year 2010 till Year 2035.* Coastal Municipalities Water Utility, Gaza, Palestine.

Erdemir, H. (2009). The policies around the BTC pipeline. *Turkish Journal of International Relations*, 8 (4), 20-44.

Ergas, S.J. and D.E. Rheinheimer (2004). Drinking water denitrification using a membrane bioreactor. *Water Research*, 38 (14-15), 3225-3232.

Foley, S. (2010). Turkey and the Gulf States in the twenty-first century. *Middle East Review of International Affairs*, 14 (3), 29-37.

Fonseca, A.D., J.G. Crespo, J.S. Almeida and M.A. Reis (2000). Drinking water denitrification using a novel ion-exchange membrane bioreactor. *Environmental Science and Technology*, 34 (8), 1557–1562.

Geriesh, M.H., A.E. El-Reyes and K. Ghodeif (2004). Potential sources of groundwater contamination in Rafah environs, North Sinai, Egypt. *Proceedings of the 7th Conference on the Geology of Sinai for Development of Ismailia*, pp.41-52.

Ghodeif, K. and M.H. Geriesh (undated). Contamination of domestic groundwater supply of El-Arish city, North Sinai, Egypt. Unpublished manuscript.

Goldstone Report (2009). *Report of the United Nations Fact Finding Mission on the Gaza Conflict*, U.N. Doc. A/HRC/12/48, 15 Sept. 2009, Chapter XIII, "Attacks on the Foundations of Civilian Life in Gaza: Destruction of Industrial Infrastructure, Food Production, Water Installations, Sewage Treatment Plants and Housing".

Grabow, G.L., J. Pasch, A.M. Abu-Awwad and G. Panzani (2006). Re-use of treated municipal wastewater with drip irrigation in Jordan. American Society of Agricultural and Biological Engineers, Annual Meeting 2006.

Gruen, G.E. (2004). Turkish water exports: A model for regional cooperation in the development of water resources. 2nd Israeli-Palestinian International Conference on Water for Life in the Middle East, Antalya, Turkey, 10-14 October 2004. Israel/Palestine Center for Research and Information, Jerusalem.

Gurer, Í and Űlger, M. (2004). Manavgat River water as a limited but alternative water resource for domestic use in Middle East. 2nd Israeli-Palestinian International Conference on Water for Life in the Middle East, Antalya, Turkey, 10-14 October 2004. Israel/Palestine Center for Research and Information, Jerusalem.

Herbetson, P.W. and E.L. Tate (2001). *Tools for Water Use and Demand Management in South Africa.* Technical Reports in Hydrology and Water Resources No. 73, World Meteorological Organization, Geneva.

Hilles, A.H. and H. Al-Najar (2011). Brackish water desalination is the merely potable water potential in the Gaza Strip: Prospects and limitations. *Journal of Environmental Science and Technology*, 4 (2), 158-171.

IPCRI (2010). *IPCRI Fact Sheet #2: Water Imports – An Alternative Solution to Water Scarcity in Israel, Palestine, and Jordan?* Israel/Palestine Center for Research and Information, January 2010.

Ismail, M. (2003). *Prospects of Water Desalination in the Gaza Strip*. Master of Science thesis, Department of Land and Water Resources Engineering, Royal Institute of Technology, Stockholm, Sweden.

IWA (on-line). Standards for drinking water quality. See http://www1.huji.ac.il/www_teva_law/law_english.html

Majumdar, D. (2003). The blue baby syndrome: Nitrate poisoning in humans. *Resonance*, 8 (10), 20-30.

McCaffrey, S. (2010). *Legal Analysis of Issues Relating to the Oslo II Agreement, Particularly with Respect to Water, and the Status Quo Between the Parties.* Report for the Negotiations Support Unit, March 2010.

McCornick, P.G., A. Hijazi and B. Sheikh (2004). From wastewater reuse to water reclamation: Progression of water reuse standards in Jordan. In *Wastewater Use in Irrigated Agriculture: Confronting the Livelihood and Environmental Realities*, Eds. C. Scott, N.I. Faruqui and L. Raschid, pp. 153-162. CAB International, Wallingford, England.

Messerschmid, C. (2011). *Water in Gaza: Problems and Prospects*. Available at http://ssrn.com/abstract=1764252

Nazzal, Y.K., M. Mansour, M. Al Najjar and P. McCornick (2000). *Wastewater Reuse Law and Standards in the Kingdom of Jordan.* Report of the Ministry of Water and Irrigation, Amman, Jordan.

NSU (2005a). *West Bank-Gaza Water Link.* The Negotiations Support Unit, Ramallah, January 2005.

NSU (2005b). *A Preliminary Analysis of Strategic Water Supply in Palestine.* The Negotiations Support Unit, Ramallah, Palestine.

NSU (2010). *A Strategic Plan for the Introduction of Wastewater Reuse in Palestine*. The Negotiations Support Unit, Ramallah, Palestine.

OQR (2011). *Package of Measures Agreed between the Government of Israel and the Quartet Representative on 4 February 2011*. Office of the Quartet Representative, Jerusalem.

Oweis, T.Y. and Hatchum, A.Y. (2004). Improving water productivity in the dry areas of West Asia and North Africa. In *Water Productivity in Agriculture: Limits and Opportunities for Improvement*, Eds. Kijne, J.W., Barker, R. and Molden, D. CABI, Colombo, Sri Lanka.

Pekdemir, T., E.K. Kaçmazoglu, B. Keslinker and Ö. F. Algur (1998). Drinking water denitrification in a fixed bed packed biofilm reactor. *Turkish Journal of Engineering and Environmental Sciences*, 22, 39-45.

PHG-WASH MP (2006). *Water for Life.* Palestinian Hydrology Group, Ramallah.

Phillips, D.J.H., M. Daoudy, J. Öjendal, A. Turton and S. McCaffrey (2006). *Trans-boundary Water Cooperation as a Tool for Conflict Prevention and for Broader Benefit-sharing.* Ministry for Foreign Affairs, Stockholm, Sweden.

Phillips, D.J.H., S. Attili, S. McCaffrey and J.S. Murray (2007). The Jordan River Basin: 2. Potential future allocations to the co-riparians. *Water International*, 32 (1), 39-62.

Phillips, D.J.H., A. Jägerskog and A. Turton (2009). The Jordan River Basin: 3. Options for satisfying the current and future water demand of the five riparians. *Water International*, 34 (2), 170-188.

Phillips, D.J.H. (in press). The Jordan River Basin: At the crossroads between conflict and cooperation. *International Journal of Sustainable Society*, in press.

PNA (undated [1]). *Palestinian National Authority: Palestinian Reform and Development Plan, 2008-2010.* Palestinian National Authority.

PNA (undated [2]). *Palestinian National Authority: Energy Sector Strategy 2011-2013*. Palestinian National Authority.

PRI (2005). Economic Instruments for Water Demand Management in an Integrated Water Resources Management Framework : Synthesis Report. Policy Research Initiative, Canada.

PWA (2010a). *Agricultural and Municipal Water Demand in Gaza Governorates for 2009.* Strategic Planning Directorate, Palestinian Water Authority, June 2010.

PWA (2010b). *PWA Project Briefing Memo: Project: Water Supply from Israel to the Gaza Strip*. Palestinian Water Authority, October 2010.

Rende, M. (2004). Water transfer from Turkey to water-stressed countries in the Middle East. 2nd Israeli-Palestinian International Conference on Water for Life in the Middle East, Antalya, Turkey, 10-14 October 2004. Israel/Palestine Center for Research and Information, Jerusalem.

Sanders, R. (2009). Water desalting and the Middle East peace process. *Technology in Society*, 31, 94-99.

Selby, J. (2009). *The Status Quo and Future of the Joint Water Committee/Israeli Licensing Procedure.* Report for the Negotiations Support Unit, 01 October 2009.

Sheikh, B. (2001). *Standards, Regulations and Legislation for Water Reuse in Jordan.* Water Reuse Component, Water Policy Support Project, Ministry of Water and Irrigation, Amman, Jordan.

Shomar (2010). Groundwater contaminations and health perspectives in developing world case study: Gaza Strip. *Environmental Geochemistry and Health*, DOI 10.1007/s10653-010-9332-8.

Shomar, B., K. Osenbrück and A. Yahya (2008). Elevated nitrate levels in the groundwater of the Gaza Strip: Distribution and sources. *Science of the Total Environment,* 398, 164-174.

Silverstein, J. (2010). Anaerobic biological treatment for removal of inorganic contaminants from drinking water. Workshop on Biological Drinking Water Treatment, IWA Leading Edge Technology Conference, University of Colorado, Boulder. Available at http://civil.colorado.edu/~silverst/IWA%202010%20silverstein,.pdf

Somot, S. F. Sevault, M. Déqué and M. Crépon (2008). 21st century climate scenario for the Mediterranean using a coupled atmosphere-ocean regional climate model. *Global and Climate Change*, 63 (1-2), 112-126.

Tiltnes, Å.A. (1998). *Ability and Willingness to Pay for Water and Sewage Services in Two Palestinian Cities. Results from a Household Survey in Nablus and Gaza City.* Fafo Paper 17, Norway.

Uleimat (2007). Quality aspects of reclaimed domestic wastewater in Jordan. Presentation to the Regional Workshop on Integrated Water Resources Management, 07-09 March 2007, the Royal Scientific Society, Amman, Jordan.

UNDP (2009). *Climate Change Adaptation Strategy for the Occupied Palestinian Territory.* Report of consultants to the UNDP/PAPP initiative: Climate change adaptation strategy and programme of

action for the Palestinian National Authority. July 2009, United Nations Development Programme, Geneva.

UNEP (2009). *Environmental Assessment of the Gaza Strip following the Escalation of Hostilities in December 2008-January 2009.* United Nations Environment Programme, Geneva.

Unicef (2011). *Protecting Children from Unsafe Water in Gaza: Strategy, Action Plan and Project Resources.* March 2011, Unicef, Occupied Palestinian Territory.

Unicef-PHG (2010). *Water, Sanitation and Hygiene Household Survey, Gaza*. Unicef and the Palestinian Hydrology Group, April 2010.

US AID (on-line). Wastewater reuse in Jordan: A US AID initiative. Available on-line at http://www.jordan,usaid.gov/

US EPA (on-line). See http://www.epa.gov/safewater/mcl.html#mcls

Vengosh, A., W. Kloppmann, A. Marei, Y. Livshitz, A. Gutierrez, M. Banna, C. Guerrot, I. Pankratov and H. Rannan (2005). Sources of salinity and boron in the Gaza Strip: Natural contaminant flow in the southern Mediterranean Coastal Aquifer. Water Resources Research, 41, W01013, doi:10.1029/2004WR003344.

Victor, P.-E. (1986). Will deserts drink icebergs? *UNESCO Courier*, May-June 1986. Available at http://findarticles.com/p/articles/mi_m1310/is_1986_May-June/ai_4375017/

Wachtel, B. (undated). The Peace Canal plan – Peace plan/water import project from Turkey to the Middle East. Unpublished manuscript.

WASH NAF CAP (2011). *Consolidated Appeal 2011: Needs Assessment Framework NAF for Water, Sanitation and Hygiene in the Occupied Palestinian Territory.*

WHO (2004). *Guidelines for Drinking-water Quality*. Third Edition Incorporating the First and Second Addenda: World Health Organisation, Geneva.

Wienthal, E, A. Vengosh, A. Marei, A, Gutierrez and W. Kloppmann (2005). The water crisis in the Gaza Strip: Prospects for resolution. *Ground Water*, 43 (5), 653-660.

World Bank (2009). *Assessment of Restrictions on Palestinian Water Sector Development.* The World Bank, Washington D.C.

Yaqubi, A. (2008). *Towards Domestic Groundwater Supply Management in the Gaza Strip Governorates (Gaza Strip-Palestine).* Report of the Palestinian Water Authority, Gaza.

Zhao, X., X. Meng and J. Wang (2009). Biological denitrification of drinking water using biodegradable polymer. *International Journal of Environment and Pollution*, 38 (3), 328-338.

dpt9303

ANNEX 1 – Terms of Reference

TERMS of REFERENCE

for a

Gaza Emergency Technical Assistance Programme (GETAP) on Water Supply to the Gaza Strip

Component 1 – Comparative Study of Options for an Additional Supply of Water for the Gaza Strip (CSO-G)

FINAL

1.0 Background

A number of recent reports have highlighted the fragile state of the Water Sector[42] in Palestine. In November 2008, a Norwegian-funded infrastructure audit of the Water Sector in Palestine[43] stated that *"In Gaza in particular, urgent humanitarian concerns are of primary importance, but the current operations and projects do not reflect this adequately, and no consensual focus has been generated as yet on humanitarian projects in the water sector"* and in specific relation to water supply the report states that although "*A genuine humanitarian crisis is now present in Gaza, no consensus exists on how best to halt or to reverse this*". The crisis in the Gaza Strip and the prolonged occupation of Palestine have both created political obstacles which weigh heavily on the Water Sector. These exogenous obstacles are exacerbated by the inherent inefficiencies and problems in funding and delivering basic services to the people of Palestine. The current population of Gaza is approximately 1.6 million, with an annual growth rate of 3.3%. This is one of the highest such growth rates in the world, implying a doubling of the population every two decades. The Palestinians in Gaza live in an area of only 365km^2, in exceptionally challenging circumstances. Major incursions and military attacks by Israel have been commonplace in recent years, the last of these ('Operation Cast Lead') in 2008-2009 severely damaged the infrastructure.

The fresh water supply to Gaza relies almost exclusively on the so-called Gaza Aquifer, which is in reality a portion of the much larger Coastal Aquifer Basin extending from northern Israel, through Gaza, to north-eastern Egypt. The portion of the Coastal Aquifer underlying Gaza has a sustainable yield estimated at 55 million cubic metres (MCM) annually, this varying with climatic conditions. Predictions of future climate change in the region suggest that this is a hot-spot for adverse effects, with a major increase in average temperatures and a significant reduction in precipitation. If the Gaza residents were to simply pump the sustainable yield from the underlying aquifer, the fresh water availability *per capita* would amount to about 37m^3/year – one of the lowest fresh water availabilities in the world. There are no other volumetrically significant sources of fresh water available to Gaza at the present time.[44] To obtain barely sufficient supplies, the inhabitants of Gaza pump about 170 MCM/year from the underlying aquifer at the current time, using thousands of unlicensed wells. This leads to major saline intrusion in the aquifer, which is becoming worse over time.

The quality of the great majority of the groundwater available to the population of Gaza does not meet the internationally accepted guidelines for domestic supplies as promulgated by the World Health Organisation, with highly elevated levels of salinity, nitrates, and other trace contaminants derived from various types of wastewaters. This creates significant public health issues, with exceptionally high rates of liver and kidney disease, in addition to methaemoglobinemia ('blue baby syndrome', due to the high nitrate levels) and intestinal problems from faecal contamination. The medical services in Gaza remain unequipped to deal with the magnitude of the problem, and medical supplies often fail to enter the Gaza Strip.

Strategic studies completed by the PWA and assessments by both the World Bank and UNEP have all shown that the water supply situation in Gaza is of extreme concern at present, and will become much worse over time, in the absence of major interventions. It has been accepted on the basis of these and other studies that one or more major desalination facilities must be constructed without delay, to

---

[42] In this document, the "Water Sector" is a term used to refer to all activities associated with water resources management and the provision of water and wastewater-related services.

[43] *An Audit of the Operations and Projects in the Water Sector in Palestine: The Strategic Refocusing of Water Sector Infrastructure in Palestine.* Audit Environmental, Final Report, 18 November 2008.

[44] A few very small brackish water desalination facilities exist in Gaza currently, but the USAID-funded programme to construct a major regional desalination plant was halted in 2003 due to an incident involving the deaths of three personnel. To date, Israel has consistently refused to provide additional fresh water to Gaza from outside sources, with the exception of possible supplies from the desalination plant located at Ashkelon.

provide water of an acceptable quality for potable use in Gaza. However, controversy has arisen as to whether desalinated supplies should be made available from a facility sited in Gaza itself, off the coast of Gaza, or in north-eastern Egypt. This concern reflects the security risk of further incursions, which could damage or destroy large-scale infrastructure investments within the Gaza Strip.

Several other possibilities also exist, to supply Gaza with additional sources of fresh water. These include supply from surface water, groundwater, and desalination sources externally (within Israel or the West Bank); and broader options involving inter-basin transfers from further afield. In addition to such options, any strategic plan for the availability and use of fresh water in Gaza must address the potential for demand-side management and for wastewater reuse, as well as institutional issues. Experience since 2006 has shown that addressing the fragmentation between the PWA in the West Bank and PWA in Gaza (as well as duplication of water authorities within Gaza itself) is crucial for the implementation and maintenance of any water infrastructure in Gaza.

The Palestinian National Authority (PNA) has recognized the urgency for developing a consensual strategic plan for water supply to Gaza. The need for this is critical, at the present time. The project proposed here would give rise to such a strategic plan, and would then develop all of the required project-related documents for specific preferred interventions, as a subsequent stage. This would create a package that would provide external donors with all the requirements to commence on-the-ground interventions.

2.0 The Gaza Emergency Technical Assistance Programme

2.1 General

The Gaza Emergency Technical Assistance Programme (GETAP) is envisaged to involve two broad phases, as follows:

- The completion of a Comparative Study of Options (CSO-G), which would consider all possible sources of additional fresh water for Gaza, and would derive a proposed scheme for introducing such sources on a rolling programme extending over 30 years from 2010 to 2040. This effort shall include the discussion of the conclusions of the CSO-G with all interested parties within Palestine, to attain a national consensus as to the preferred rolling schedule for interventions.

- The drafting and finalisation of all supporting and contract-related documents for the interventions selected for the first five years of the rolling programme.

The projects proposed here are of an emergency nature, designed to specifically address water supply problems in Gaza, and closely connected issues.

2.2 Objectives and Scope of Work

The purpose of the CSO-G on water supply for the Gaza Strip is to provide informed input to a PWA led process aimed at deriving a consensus within the Water Sector in Palestine on the feasibility of various options for the supply of water to the Gaza Strip, after taking into account the political, security, technical, and economic considerations for each option.

The objectives of the work to be carried out are to:

1. assess the available / proposed options for the supply of water for the Gaza Strip with the aim of further identifying the feasibility of various interventions; and

2. to conduct a comparative analysis between various options and then devise a rolling programme of interventions.

The Comparative Study of Options will estimate the demand for fresh water in Gaza at the present time, and the change in such demand extending through the entire time horizon of the project (to the year 2040), with a range of scenarios being addressed by the demand forecasting. The CSO-G will then address the following possibilities relating to the supply of additional fresh water for Gaza:

- the continuation of the *status quo*, or a 'do nothing option';
- demand management to reduce/minimise the requirement for fresh water in Gaza;
- the reuse of wastewaters to enhance the availability of water in Gaza;
- the transfer of water from the West Bank to Gaza;
- the transfer of distinct types of water from various sources in Israel to Gaza;
- the transfer of water to Gaza from sources further afield, using various technologies; and
- the introduction of desalination for Gaza.

The CSO-G will devise a rolling programme of interventions which will be designed to meet a reasonable water demand in Gaza at the earliest possible time, sustaining the supply and matching the future anticipated growth in reasonable fresh water demand throughout the time horizon as stated above.[45] The interventions will be focused on addressing humanitarian needs in particular, reflecting the focus of customary international water law on 'water for vital human needs'.

As part of the first phase of the work, the proposed rolling programme of interventions will be discussed with all interested parties in Palestine, led by the Minister of the PWA with support as needed from the study team. All of the relevant Ministries and authorities in Palestine will be consulted in the process of deriving an internal consensus on the preferred interventions. The involvement of the parties of relevance outside Palestine will vary according to the interventions included in the rolling programme, as developed by the study team.

Consulting services will be provided for a duration of 5 months by a team conducting the CSO-G (for a duration of 3 months) and then aiding in the consensus building process (for a duration of 2 months).

[45] The term 'reasonable demand' is utilized here. This reflects the fact that the present use of fresh water in Gaza is altogether unsustainable, and changes are considered to be needed to the allocation of fresh water to distinct end uses. In particular, the over-abstraction of groundwater through unlicensed wells for use in the agricultural sector will require critical review.

2.3 Background Research

The consultancy team will be responsible for reviewing all relevant studies and soliciting comment from interested parties, as part of the review. The documentation available and for the most part listed here is extensive and provides a strong basis for the assessment of the various options listed in Section 2.4.

2.3.1 Relevant Studies

A review shall be conducted of all key documents to date on the water sector in Palestine. The relevant studies include, but are not limited to:

Supporting Documentation:

- "*An Audit of the Operations and Projects in the Water Sector in Palestine: The Strategic Refocusing of Water Sector Infrastructure in Palestine*", PWA (2008).
- "*The Coastal Aquifer Management Program*", USAid/Metcalf & Eddy with Camp Dresser & McKee (1994 – 2004).
- "*National Water Plan*", PWA (2000).
- "*Water Sector Strategic Planning Study*" Carl Bro (2000).
- "*Gaza Sea Water Desalination Plant Feasibility Study*", Aqua Resources International, LLC. February (2003).
- "*Gaza Sea Water Desalination Plant*", RFP (2003).
- "*Feasibility Study for the proposed New Wastewater Treatment Plant for Gaza Agglomeration Phase 3 Final Report*", OTUI/ Home Engineering (1998).
- "*Feasibility Study of the Reuse of Wastewater for the Entire Gaza Agglomeration Phase 2 Report*", OTUI/ Home Engineering (1998).
- "*Wastewater Treatment and Reuse for Gaza and the West Bank*", PECDAR (1994).
- "*Environmental Assessment, North Gaza Emergency Sewage Treatment Plant project*", Final Report, Palestinian Water Authority (2006).
- "*Final Environmental Impact Assessment Study Report Khan Younis Wastewater Treatment Plant*", UNDP, December (2010).
- "*Environmental Assessment of the Gaza Strip following the escalation of hostilities in December 2008 – January 2009*", UNEP (2009).
- "*New Water Resource Development Plan for Gaza Strip Planned Period From Year 2010 till Year 2035*", CMWU (2010).

- "*PWA Project Briefing Memo Project: Water Supply from Israel to the Gaza Strip*", PWA (2010).

- "*IPCRI Fact Sheet #2 Water Imports – An Alternative Solution to Water Scarcity in Israel, Palestine, and Jordan?*", IPCRI (2010).

- "*Study of Alternatives*" (DRAFT REPORT), Red Sea – Dead Sea Water Conveyance Study Programme (2010).

- "*Palestinian Reform and Development Plan*", PNA (2008).

- "*The Palestinian National Early Recovery and Reconstruction Plan for Gaza 2009-2010*", PNA (2009).

- "*A Water System from Turkey to Countries around Mediterranean Sea*", Scan Water A/S (1998).

- "Executive Overview: Desalination Facility based on a Ship", Global Water Solutions, Inc. (2010)

Relevant Joint Water Committee Documentation:

- "*Protocol Relating to Water Supply*", Israeli – Palestinian Joint Water Committee, JWC (1998).

- "*Additional Supply of 5 MCM to the Gaza Strip*", The Ministry of National Infrastructures Water Commission, State of Israel (2006).

- "*Draft Memorandum of Understanding on the Supply of Additional Water to the Gaza Strip*" Israeli – Palestinian Joint Water Committee, JWC (2005).

- "*Water Infrastructure in the Gaza Strip*" as part of the Government of Israel 'Disengagement' Plan from the Gaza Strip, Coordinator of Government Activities in the Territories, State of Israel Ministry of Defense (2005).

- "*Desalinated Water to Gaza from Ashkelon Plant*", VID Desalination Company (2004).

In addition, the consultants shall review the following country-specific reports on the situation faced in the water sector in Palestine, with a particular focus on the Gaza Strip:

- "Assessment of Restrictions on Water Sector Development", World Bank (2009).

- "Troubled Waters – Palestinians Denied Fair Access to Water", Amnesty International (2009).

2.3.2 Soliciting Comments from Interested Parties

In recognition of the need for a broad consensus, the consulting team shall consult fully with all interested parties in the Water Sector in Palestine. The methodology to be used shall be described in a consultation work plan to be developed by the consultancy team immediately after the contract is issued, for submission to the Minister of the PWA for approval.

The parties to be consulted have initially been sub-divided into three main categories and have been tentatively identified as:

Governmental Policy and Coordinating Institutions:
Palestinian Water Authority (PWA)
Ministry of Planning and Development (MOPAD)
Ministry of Finance (MoF)
Ministry of Local Government (MoLG)
Environmental Quality Authority (EQA)
Ministry of Agriculture (MoA)
Ministry of Justice (MoJ)
Ministry of Health (MoH)
Municipalities (Beladiya)

International Organisations:
International Organisations (World Bank, ICRC)
Bilateral Donors (AfD, EC, GTZ, KFW, Norway, Sweden, USAID, etc)
UN Organisations (UNRWA, UNICEF, UNDP, UNEP)

Public/Private Sector Organisations:
Coastal Municipal Water Utility (CMWU)

2.4 Tasks to be Completed

The CSO-G shall primarily be based on a review of, but not limited to, an extensive list of documentation, included here within (Section 2.3.1), and stakeholder consultation to allow for the completion of the tasks identified in Section 2.4. After each of the options has been assessed a comparative analysis shall be conducted with the aim of identifying a select set of options which are deemed feasible over the short, medium and long term. The review phase is anticipated to take three-months and be followed by a one-month PWA led consensus building process that shall inform the design of a rolling programme of interventions, to be delivered in the Final Report by the end of the fifth-month of the project.

The following options are to be assessed as part of the CSO-G.

2.4.1 Option A: Continuation of the Status Quo

The *status quo* in terms of the general water, wastewater, and environmental situation in the Gaza Strip has been extensively documented over the past fifteen years. The consultants shall be expected to conduct a thorough literature review and interviews with relevant water sector institutions as part of

an effort to identify the consequences of the 'do nothing option'. Additional tasks to be completed as part of the Option A study are provided below:

- Assess the effect that variations in the rate of abstraction could have on water availability over the specified 30 year duration while taking into consideration bringing on-line other water supply interventions.
- Assess other technical issues as well as political, security, and economic considerations, if any, and as needed in association with deriving the feasibility of this option.

2.4.2 Option B: Water Demand Management

A range of Water Demand Management (WDM) strategies shall be considered with the aim of reducing/minimizing the requirement for fresh water in the Gaza Strip in the domestic, industrial and agricultural sectors separately. The tasks to be completed as part of the WDM assessment are provided below:

- Review the scope for market-based measures to be deployed using adaptable water prices, tariffs and water subsidies as an incentive for achieving conservation, efficiency, equity, cost recovery and sustainability.
- Review the potential for metering to enable a form of lifeline pricing to be adopted with the aim of providing water for basic domestic and subsistence needs for the most marginalized households.
- Review the potential for service providers to install consumption monitoring or water conservation equipment, reducing leakage, adjusting pressure, and providing sewerage.
- Assess other technical and economic issues as well as political, and security considerations, if any, and as needed in association with deriving the feasibility of this option.

2.4.3 Option C: Potential for Wastewater Reuse

There are three large-scale Wastewater Treatment Plants (WWTP) planned for construction/further development in the Gaza Strip (North Gaza, Middle Area, and South Gaza). The development plan for these facilities is to construct them in stages, starting with primary treatment plus short sea outfalls, with the intention to develop tertiary treatment plus reuse in order to safeguard the shared risks associated with the release of untreated wastewater into the environment. In the long term these WWTP could provide additional quantities of water (re-use) in agriculture and potentially for artificial recharge. The general technical details for each of the WWTP are available, including the design capacity and the treatment standards for the potential reuse of wastewater. The tasks to be completed as part of assessing the potential for using wastewater as a non-conventional water resource are provided below:

- Compare the quantity of treated wastewater to be generated from the three proposed WWTP with the agricultural water demand.
- Assess the potential for the conservation of fresh water for high value uses as a result of the introduction of wastewater reuse for agriculture.
- Assess the potential of treatment beyond tertiary to rehabilitate portions of the Coastal Aquifer that underlie the Gaza Strip for storage and to reduce/eliminate seawater intrusion.
- Assess the economic contribution of reusing wastewater as a function of unit cost.

- Assess the degree to which the environmental impact of preventing wastewater from being directly released to the environment could affect the availability of fresh water over the specified 30-year study duration.
- Assess other technical and economic issues as well as political, and security considerations, if any, and as needed in association with deriving the feasibility of this option.

2.4.4 Option D: National (Within Palestine) Transfer of Water

The national transfer of water from the West Bank to the Gaza Strip via various alternate configurations has been studied in the past. However, the feasibility of the West Bank – Gaza Link is not only a matter of technical and economic considerations but primarily a function of whether a Permanent Status agreement is reached between the Palestine Liberation Organisation (PLO) and the Government of Israel (GOI). Regardless, the potential for an agreement to be reached still exists, and therefore creates the need for this option to be considered as a potential intervention in deriving a rolling programme of interventions over the specified 30 year period. The tasks to be completed as part of assessing the potential for the West Bank – Gaza Link to augment the water supply to the Gaza Strip are provided below:

- Assess the potential quantities available to be transferred to the Gaza Strip from the West Bank in the *status quo* and as a result of an agreement being reached between the PLO and GOI based on customary international water law and specifically the principle of equitable and reasonable utilization of the trans-boundary water resources.
- Assess as a result of additional quantities being made available from the West Bank to the Gaza Strip the degree to which this could reduce pressure on the over-extracted Coastal Aquifer within the Gaza Strip.
- Assess the overall costs associated with transferring the quantities of water identified as part of this study from the West Bank to the Gaza Strip.
- Assess other technical and economic issues as well as political, and security considerations, if any, and as needed in association with deriving the feasibility of this option.

2.4.5 Option E: Transfer of Water from Israel

The transfer of distinct types of water from various sources in Israel to the Gaza Strip has in the past been a routine matter of discussion between the Palestinian National Authority (PNA) and the GOI. The range of distinct types of water include: desalinated flows from the Ashkelon desalination plant in Israel via a direct pipeline to the northern border of the Gaza Strip; an admixture of fresh water and desalinated water via the Israeli National Water Carrier (NWC) provided to the Gaza Strip through the Nahel Oz crossing; and the existing infrastructure that currently delivers water from the Israeli NWC to the Gaza Strip through the two main connections, at or nearby, Bani Suheila and Bani Said, which are located in the Middle Area. The tasks to be completed as part of assessing the potential for the transfer of water from Israel to the Gaza Strip are provided below:

- Document the quantity, quality and costs associated with desalinated flows historically offered by the GOI from: the Ashkelon desalination plant; the Israeli NWC; and as part of previous agreements between the PLO and GOI.
- Review the technical, economic, political and security related issues previously identified in association with these options and assess other issues, if any, and as needed in association with deriving the feasibility of these options.

2.4.6 Option F:Transfer of Water to the Gaza Strip from Turkey

The transfer of water to the Gaza Strip from sources further afield using various technologies has been an issue that has been raised for several decades. Most recently these options have been included as part of the Red Sea – Dead Sea Water Conveyance Study Programme led by the World Bank as part of the Study of Alternatives. It is expected that the work carried out by the Alternative Study team thus far will provide the basis for the consultant to carry out this portion of the study outlined here within. The tasks associated with each of the individual types of technologies that have been proposed in the past are provided below:

- Assess the feasibility of bringing water from the Manavgat facility in Turkey by the use of Spragg Bags, Medusa Bags, and or Nordic Bags.
- Assess the feasibility of bringing water from the Manavgat facility in Turkey by the use of tankers.
- Assess the feasibility of bringing water from the Ceyhan and Seyhan Rivers in Turkey via overland pipeline (i.e. the mini peace pipeline).
- Assess the feasibility of bringing water from the Ceyhan and Seyhan Rivers in Turkey via an underwater pipeline (i.e. through the Mediterranean Sea).
- Assess other technical, economic, and political issues as well as and security considerations, if any, and as needed in association with the feasibility of these options.

2.4.7 Option G: The Introduction of Desalination

The various options for the introduction of desalinated water to the Gaza Strip were identified in the report entitled "An Audit of the Operations and Projects in the Water Sector in Palestine: The Strategic Refocusing of Water Sector Infrastructure in Palestine" (commonly referred to as the PWA Audit) as a preliminary comparison of three locations for the construction of a seawater desalination plant. In addition, other documentation that is relevant includes the CMWU Report (2010), CAMP Report (2003), and the Global Water Solutions proposal (2010) (Refer to Section 2.3.1). It is expected that the documentation mentioned above will provide the basis for the consultant to carry out this portion of the study outlined here within. The tasks associated with the introduction of desalination to the Gaza Strip are provided below:

- Further assess the technical and economic factors (including energy-related issues), as well as the political and security-related issues connected to the various options identified below, as needed in association with deriving the feasibility of this option:

    1. Desalinated flows from a single and/or multiple desalination facilities located in the Gaza Strip, including conventional construction, module assembly, and containerized assembly, and mobile facilities to meet short-term needs.
    2. Desalinated flows from a desalination facility located in the Egyptian area of Sinai near Al-Arish and/or Rafah (Egyptian side).
    3. Desalinated flows from a desalination facility located in Israel.
    4. Desalinated flows from a desalination facility located on a vessel stationed off the coast of the Gaza Strip, within Palestinian maritime waters.

2.4.8 CSO-G Draft Report – Comparative Analysis

The draft report shall be based on the previous sub-studies (2.4.1 through 2.4.7) and shall provide a comparative analysis between the various options for augmenting the supply of water to the Gaza Strip as part of an effort to derive a proposed rolling programme of interventions designed to meet a reasonable water demand in the Gaza Strip at the earliest time. The comparative analysis between the options identified here shall be assessed based on political, security, technical, and economic considerations as stated in this section. The outputs of the draft report shall act as the basis for a one-

month PWA led consensus building stage. The consultant will also be expected to prepare a presentation based on the CSO-G Draft Report to be presented to the PWA and other interested parties, as identified by the Minister of the PWA and conveyed to the consultants, no later than one week after the submission of the Draft Report. This shall form the basis for comments to be submitted to the consultants based on the consensus building process, and will feed into the drafting of the CSO-G Final Report.

2.4.9 CSO-G Final Report

The consultants shall be expected to incorporate all relevant comments by the stakeholders involved in the consensus building process, as identified by the PWA and conveyed to the consultants within one-month of the submission the Draft Report. During this period the consultants will be expected to:

- Further detail the rolling programme of interventions by including a thorough description of each of the proposed interventions according to the previous assessments (2.4.1 through 2.4.7).
- As part of the rolling programme and in relation to the distribution system assess the potential for the phased implementation of a north-south water carrier, and in general discuss the necessary reconfiguration of the existing distribution system in parts of the Gaza Strip and the expansion of the system in other parts, as necessary.
- Provide a rolling estimate for the alleviation of the overall abstraction from the Coastal Aquifer as a function of the various interventions being brought on-line.
- Identify relevant construction-related issues and propose a timeline for the construction period for each intervention, as well as a timeline for each of the interventions to come on-line.
- Provide an indication of the affordability and willingness to pay for water by the Palestinian population in the Gaza Strip based on previous studies.
- Provide an approximate estimate in terms of cost for the overall budget of the rolling programme of interventions.

In addition, the CSO-G Final Report shall include a clear and unambiguous set of recommendations relating to a rolling series of interventions over the specified time frame (covering the short, medium, and long terms), on the following:

- The most effective institutional arrangement required to manage the preferred sequence of options[46].
- A discussion of potential financing arrangements which have been deemed to hold merit in relation to the rolling programme of interventions.

2.5 Expected Outputs

It is estimated that up to three months shall be required for the review process (section 2.4.1 through 2.4.7) to end with the delivery of a Draft Report (section 2.4.8) and an additional one-month for PWA to lead the consensus-building process, which shall be taken into consideration by the consultants in drafting the Final Report (section 2.4.9) to be completed by the end of the fifth-month.

The main output from the CSO-G is as follows:

[46] As part of a broad Water Sector Reform initiative led by the PWA and approved by the PNA Cabinet of Ministers, a team of consultants are conducting an Institutional Water Sector Review (IWSR), which is anticipated to be completed by the end of March 2011. The IWSR shall provide the basis for carrying out this task.

2.5.1 CSO-G Final Report

The Final Report shall be based on the Draft Report (2.4.8) and shall include a preferred rolling programme of interventions designed to meet a reasonable water demand in the Gaza Strip at the earliest time.

The outputs of the CSO-G Final Report shall inform:

- The official decision to be taken by the PWA and PNA in relation to water supply interventions for the Gaza Strip.
- The Palestinian Reform and Development Plan (PRDP) for the development of water and wastewater related projects.
- Donor financing on the preferred sequence of interventions.
- The later drafting and finalisation of all supporting and contract-related documents for the interventions selected over the course of the rolling programme.

3.0 Human Resources to be Provided by the Consultant

It is anticipated that the experts engaged in conducting the CSO-G shall be required over a total duration of five months. The consulting team will need the following certain core competencies and areas of expertise:

Water and Environmental Issues: Expertise in trans-boundary water resource management, water policy, hydrogeology, hydrology, and environmental science.

Water Resource Management, Water Supply, and Wastewater Issues: Expertise in water resource management, water supply and wastewater engineering, water reuse for agriculture, and aquifer storage and recovery.

Desalination Issues: Expertise in desalination, including a variety of seawater and brackish water desalination

Strategic Issues: Expertise in strategic design, planning and policy formation in relation to the management of natural resources in a complex conflict situation.

Legal Issues: Expertise in customary international water law.

Economic and Financial Issues: Expertise in financial and economic aspects relating to the water resource management, water supply and wastewater sub-sectors.

The broad technical expertise of the consultancy team shall cover trans-boundary water resource management, water resource management, hydrogeology, hydrology, environmental science, energy, water supply, wastewater treatment and reuse, seawater and brackish water desalination, international water law, and economic and financial analysis.

The Consultant will provide qualified experts to carry out the work outlined in these ToR. The specific consultant positions, expected qualifications and the input (PD – person days) to be included as part of the consultancy team are given in Table 3.1 below.

The specified distribution of the individual person days as estimated below may be subject to negotiation between the Client and the Consultant prior to the signing of the contract.

Table 3.1 Human Resources Requirement and Inputs

Position	Expected Qualifications	Input PD
Specialists		
Senior Trans-boundaryWater Resource Management and Environmental Expert (Team Leader)	- University degree in relevant discipline (Environmental Science, Water Policy and Water Resources Management, or similar). - Minimum of 20 years working experience including 10 years in the field of trans-boundary water resource management. - 10 years experience in water and environmental issues in Palestine. - Proven team leadership experience. - Fluency in English. - Excellent oral and written communication skills. - Broad international experience.	45
Senior Water Supply and Wastewater Specialist	- University degree in a relevant discipline (Water and Wastewater Engineering). - Minimum 15 years work experience including experience in water resources management strategies; water supply and wastewater planning and policy development; hydrology; hydrogeology; water reuse for agriculture; aquifer and storage recovery; and/or water quality protection and assessment. - 10 years experience in water supply and wastewater issues in Palestine. - Project experience that includes an understanding of current water management approaches, policy and regulation. - Understanding of the broad implications of climate change and adaptation on the Middle East and climate adaptation options and approaches for water resource management. - Advanced research skills. - Fluent in English. - Excellent oral and written communication skills. - Broad international experience.	16

Senior Desalination Specialist	- University degree in a relevant discipline (Water Engineering). - Minimum 15 years work experience including experience in seawater desalination and brackish water desalination; desalination re-use technologies; and the design, construction, operation and management of desalination facilities. - Work experience in Palestine in the Water and Wastewater Sector is preferable. - Advanced research skills. - Fluent in English. - Excellent oral and written communication skills. - Broad international experience.	10
Senior Strategic Specialist	- University degree in a relevant discipline (Diplomacy and Conflict Resolution). - Minimum 20 years work experience in strategic analysis of political conflicts and negotiations over natural resources. - Work experience in Palestine in the Water Sector is preferable. - Advanced research skills. - Fluent in English. - Excellent oral and written communication skills. - Broad international experience.	15
Senior Legal Specialist	- University degree in a relevant discipline (Environmental Law, Water Law and/or other relevant Legal degree). - Minimum 20 years work experience including experience in international water law. - Advanced research skills. - Fluent in English. - Excellent oral and written communication skills. - Broad international experience. - Work experience in Palestine preferable.	5
Senior Water Economist and Financial Expert	- University degree in a relevant discipline (Environmental Economist, Water Economist and/or other relevant economic degree). - Minimum 15 years work experience in the water and wastewater sector with specific experience in	10

	economic evaluations, pricing policies and regulation, market-based instruments, and cost recovery and economic efficiency mechanisms. - Advanced research skills. - Fluent in English. - Excellent oral and written communication skills. - Broad international experience. - Work experience in Palestine preferable.	
Total PD		**101**

4.0 Facilities and Services to be Provided

The consultancy team selected to carry out the CSO-G shall be expected to spend time in the West Bank and Gaza Strip as needed to carry out the tasks as detailed in these TOR. The consultant shall provide a team of technical experts as well as independent administrative support. The team shall be based in the offices of the PWA in Ramallah and the Project Management Unit Office (PMU) in the Gaza Strip, and shall report to the Minister of the PWA.

4.1 By the Client (Palestinian Water Authority)

The PWA shall be responsible for assigning a focal point for the consulting team to help facilitate the work plan and provide assistance with any other matters related to the tasks stated in this TOR. The consulting team shall be provided with adequate work space at the PWA office located in Ramallah, and in the Project Management Unit office located in Gaza City, on an as-needed basis. The PWA shall cover all charges associated with the consulting team's use of the office space (e.g. cleaning, electricity, heating, and water), as well as other standard expenses associated with the use of the work space. In addition, the PWA will provide advice and guidance on local accommodation and logistics to the consulting team during the five-month implementation period.

4.2 By the Consultant

The consulting team shall set up an office in accordance with Section 5 and will formally report to the Minister of the PWA. The consultants will participate in coordination and progress meetings as agreed upon with the PWA after the work commences. Logistical arrangements to be considered include:

- all invoices shall be sent to the PWA for confirmation and payment;
- any amendments to the invoicing procedures shall be negotiated between the Head of the PWA and the consultants directly; and
- the consulting team shall be responsible for all costs associated with local accommodation, local transportation, and in-country insurance.

5.0 Implementation Arrangements

The PWA views it as important that the services be contracted through a legally established company rather than individuals, based on a sole-source contract. The rational for sole sourcing is that many of

the options to be assessed have a linkage to Permanent Status and in order to fulfil the sheer number of tasks identified in the ToR, in a relatively short period of time, not only is a multidisciplinary team of expertise required but extensive experience with Permanent Status related issues in Palestine pertaining to water is an absolute necessity.

Reporting to the donor shall be based on the deliverable schedule and the submission of the consolidated work plan and inception report with a single reporting mechanism through the Minister of the PWA. The advantages of this system are that there will be little or no donor bias or agendas built into the process; there will be neutral technical advice; and management and reporting will be streamlined.

In order to function in a clear, transparent and accountable manner, the consulting company completing the CSO-G shall operate under a clear set of rules. These are as follows:

- the consulting team shall have a single contract for five months;
- when in-country, the consulting team shall be located in the Palestinian Water Authority Office in Ramallah and the Project Management Unit Office in the Gaza Strip on an as-needed basis;
- the consulting team shall have one agreed work plan, finalised after their submission of an Inception Report three weeks following the commencement of the contract;
- the head of the consulting team shall report on progress (both in writing and verbally) on a monthly basis at the minimum, to the Minister of the PWA; and
- the consulting team shall have core staff as noted above, and shall be able to draw on additional short-term expertise as needs dictate.

6.0 Implementation Schedule

The implementation of the components outlined in these ToR shall commence as soon as possible after the signing of the contract and shall be carried out over the five month period as outlined in Table 6.1. The consulting team is permitted to submit revisions to the implementation schedule as required to successfully carry out the work as detailed in these TOR to the Minister of the PWA. The submittal shall be reviewed and may be approved by the Minister of the PWA.

TABLE 6.1. Project Implementation Schedule

		Month 1				Month 2				Month 3				Month 4				Month 5			
#	Deliverable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Work Plan																				
2	Inception Report																				
3	CSO-G Draft Report																				
4	CSO-G Draft Report Presentation																				
5	CSO-G Final Report																				

7.0 Reporting Requirements

The Consulting team shall be responsible for producing and submitting the following reports and documents in accordance with the reporting requirements outlined in Table 7.1 to the Minister of the PWA.

TABLE 7.1 REPORTING REQUIREMENTS

Deliverable No.	Report	Due	Copies
1	The **Work Plan (WP)** shall outline the proposed methodology to be used for soliciting the comments of interested parties. The WP will be subject to the approval of the Minister of the PWA.	After 1Week	3 (draft) 5 (final)
2	The **Inception Report (IR)** shall provide an update to the TOR in specific relation to the planned tasks, outputs, schedule, general organization of the project, reporting and monitoring procedures, and an update on the financial and manpower resources. The IR will be subject to the approval of the Minister of the PWA.	After 3 Weeks	3 (draft) 5 (final)
3	The **CSO-G Draft Report: A Discussion of Options and Recommendations**	At the end of 3 months	3 (draft) 5 (final)
4	The **CSO-G Draft Report Presentation**	To be presented no more than 1 week after the submission of the CSO-G Draft Report	3 (draft) 5 (final)
5	The **CSO-G Final Report**	At the end of 5 months	10 (final)

Additional materials produced during the duration of the review (e.g. electronic presentations, working papers, etc...) shall be provided by the consulting team to the Minister of the PWA.

[END OF MAIN TERMS OF REFERENCE]

ANNEX 2 to the CSO-G:
Wastewater Treatment and Wastewater Reuse in Gaza

This document synthesises and summarises other reports, notably PWA (2011), PWA (2010), AIMADINA-ENFRA-DHV (2011) which were based on CMWU reports 2008 and 2009.

The status and future plans of the wastewater sector in Gaza are well documented, and readers of this CSO-G report are referred to the work done in CMWU 2008, 2009; PWA (2011), PWA (2010); AIMADINA-ENFRA-DHV (2011).

Existing WW Treatment

As shown in Figure 1, four WWTPs exist in Gaza (though that of Khan Younis is more of a collection pond, currently). Collectively, these provide coverage of about 84% of the population (Table 1). The general characteristics of each WWTP are detailed in Table 2. The quality of treated effluent from all of these WWTPs is far below PWA guidelines (Table 3), and remains a serious hazard to groundwater quality and public health. The summary status of proposed WWTP in Gaza is detailed in Table 4.

Table 1. Wastewater Network Coverage, Gaza Strip, 2009

Region	Population	Coverage %
North Gaza	286,246	80
Gaza City	519,027	90
Middle Area	215,808	65
Khan Younis	283,286	40
Rafah	182,449	65
Total (Gaza Strip)	1,486,816	84

(Adapted from the Austrian Development Agency funded report entitled "Assessment of Wastewater Treatment and Reuse Practices" April 2011 – Table 3.1 "The coverage of wastewater network in 2009" (Original Reference CMWU 2009))

Table 2: General Characteristics of WWTPs in the Gaza Strip

	Municipalities WWTP	Type of Treatment	Construction date	Effluent Quantity m^3/d	Effluent Disposal Method
Gaza Strip	Beit Lahia	Stabilization ponds and aerated lagoons	1976	25,000	100% Infiltration basins East & North of Gaza Strip
	Gaza	Anaerobic ponds followed with bio-towers	1977	60,000	100% to sea (50,000 partially; 10,000 Raw)
	Middle Area	Without treatment	1998	More than 10,000	100% Wadi Gaza and to the Sea 10,000 Raw
	Khan Younis	Anaerobic lagoon followed by aerobic lagoon	2007	8,000	100% to sea (partially treated)

	Rafah	Anaerobic ponds followed with bio-towers	1983	More than 10,000	100% to sea 10.000 partially
	Total effluent of Gaza (MCM/year)	41 MCM (38 MCM discharged to the Sea)			

(Adapted from Austrian Development Agency "Assessment of Wastewater Treatment and Reuse Practices" April 2011 – Table 3.2 "General Characteristics of Municipal Wastewater Treatment Plants, 2009" (Original Reference CMWU 2009))

Table 3. Gaza Wastewater Influent and Effluent Quality, 2009

WWTP	BOD_5			COD			TSS		
	Influent (mg/l)	Effluent mg/l	% removal	Influent	Effluent	% removal	Influent	Effluent	% removal
Gaza WWTP	442.05	138.78	68.02	904.20	297.64	66.61	392.00	104.30	72.68
Rafah WWTP	435.00	123.25	71.71	877.50	285.00	67.44	472.50	123.75	73.82
Khan Yonis WWTP	425.00	105.00	75.26	838.75	223.75	73.42	473.75	130.75	72.30

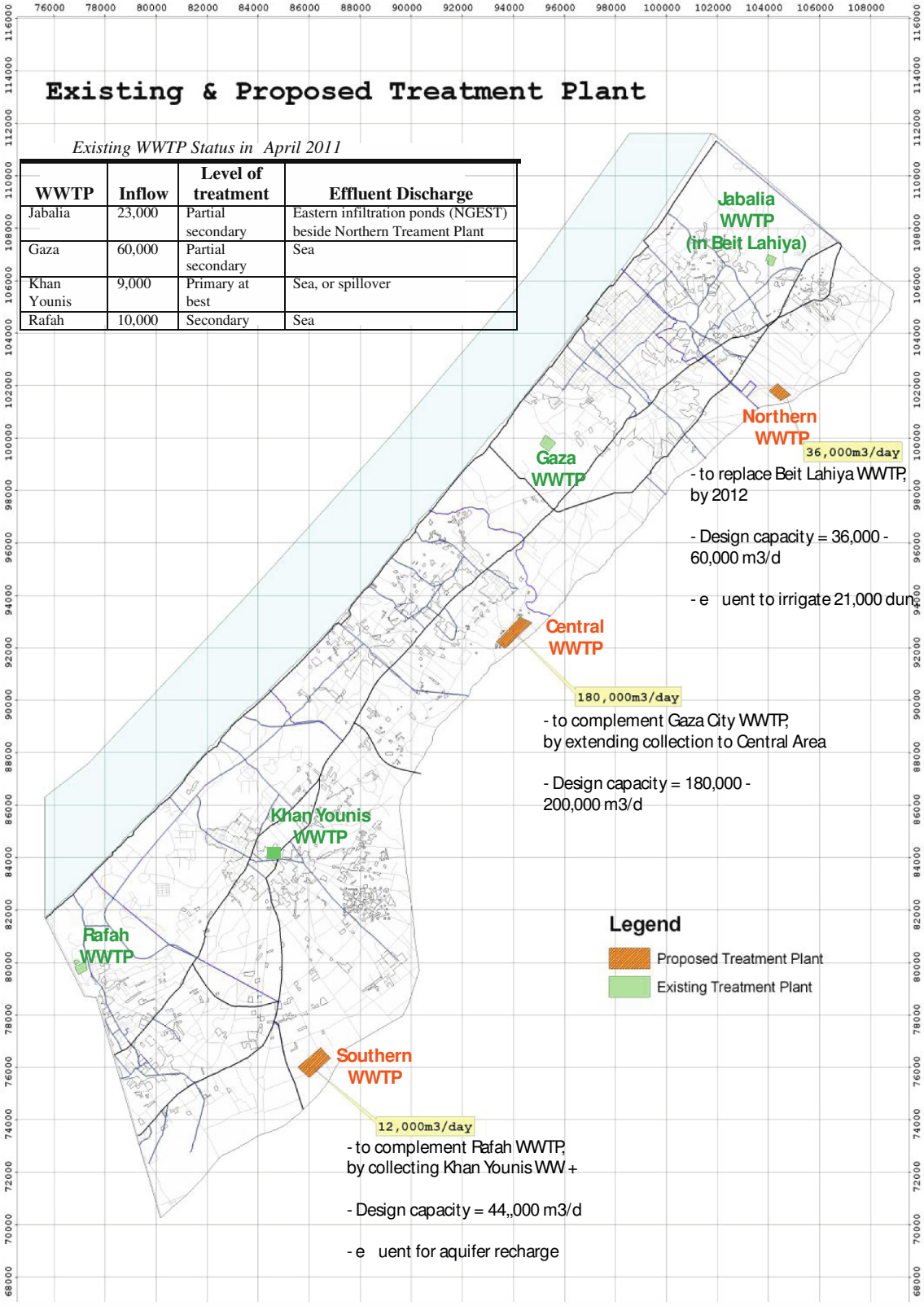
(Adapted from Austrian Development Agency "Assessment of Wastewater Treatment and Reuse Practices" April 2011 – Table 3.3 "Selected chemical characteristics of partial treated wastewater in Gaza, 2009" (Original Reference CMWU 2009))

Table 4: Summary Status of Proposed WWTPs in Gaza

Name of T.P	Status	Population* 1000 served (year)	Capacity (MCM/yr)	Funding Agency	Estimated cost for construction (million US$)	Technology
Northern Gaza	Under construction	(2015) (2025)	12.8 (Phase1) 22 (phase2)	World Bank, Sweden, France, EIB, Belgium	50 (Phase 1)	Plug flow/ Complete mixing
Central Gaza	Detailed Design	(2025)	72.7	Germany (KfW)	70 (Phase 1)	Oxidation ditch
Southern Gaza	Detailed Design	(2025)	16.0 (phase1)	Japan	35 (Phase 1)	Oxidation ditch
Total (GS)		2900	111		155	

(Adapted from Austrian Development Agency "Assessment of Wastewater Treatment and Reuse Practices" April 2011 – Table 3.4: "Summarizes the status of available information on the planned WWTPs" (Modified from CMWU 2009))

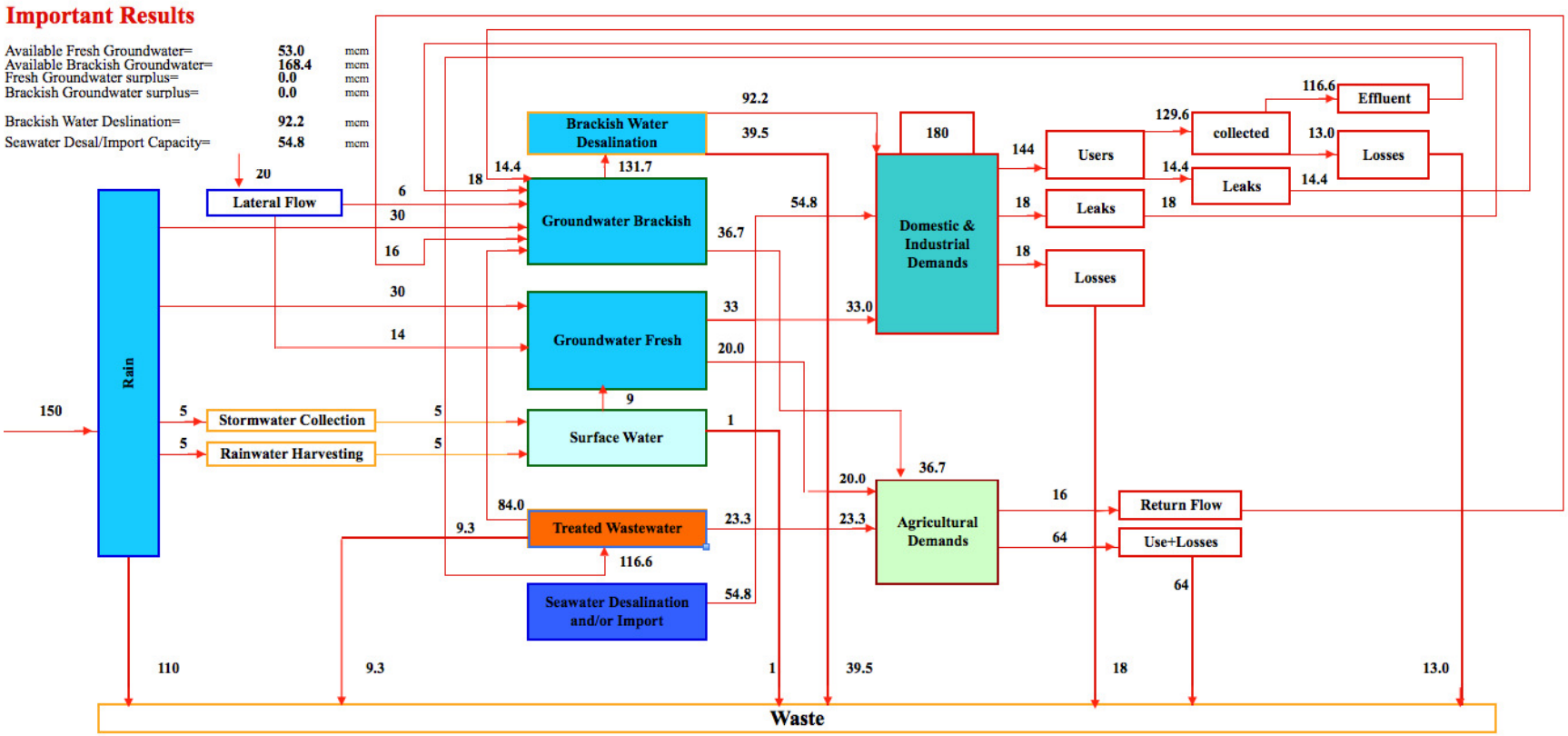
Figure 1. Existing and Planned WWTPs in Gaza, 2011 . (Adapted from PWA 2010: Figure 2).



WWTP	Inflow	Level of treatment	Effluent Discharge
Jabalia	23,000	Partial secondary	Eastern infiltration ponds (NGEST) beside Northern Treament Plant
Gaza	60,000	Partial secondary	Sea
Khan Younis	9,000	Primary at best	Sea, or spillover
Rafah	10,000	Secondary	Sea

Adapted from PWA (2010). Technical Assistance on Reuse of Wastewater and Storm Water Harvesting in the Gaza Strip. ADA/PWA Gaza QCBS 01 09, ALMADINA - Enfra Consultants, in cooperation with DHV BV - Netherlands

Figure 2. Water Balance for Gaza, based on average 150mm rain. Estimated effluent is shown as 116 MCM/y, and wastewater under this scenario can provide up to 23 MCM/y for irrigation, and 84 MCM/y for aquifer recharge. *Source: Khairy al Jamal.*



Resource Data

1	Rain Fall =	150	mcm
2	Rain Infiltration efficiency =	40%	
3	Stormwater =	5	mcm
4	Rainwater Harvesting =	5	mcm
5	Surface Infiltration Efficiency =	90%	
6	Lateral Inflow Balance =	20	mcm
7	Brackish as Groundwater from Rain =	50%	
8	Brackish Water Recovery =	70%	
9	Lateral Inflow Fresh =	70%	

Wastewater Data

Collection Efficiency =	90%
Treatment Efficiency =	90%
Infiltration Efficiency =	90%
Surface Treated Effluent Losses =	10%
Surface Treated Effluent Use =	20%

Demand Data

Domestic & Industrial Demand =	180	mcm
Return Flows from leak =	10%	
Losses outside the Water Balance=	10%	
Agricultural Demand Fresh =	20	mcm
Agricultural Demand Brackish =	60	mcm
Agricultural return Flow % =	20%	

Planned WWTPs

There are plans to treat all Gaza wastewater through the construction of three regional WWTPs – the location and capacity of which are shown in Figure 1.

Studies

Numerous studies related to wastewater treatment and reuse have been conducted. These vary from guidelines to preferred technology and social acceptability reports, as listed in the following documents and summarized in Appendix A. It may be considered that Gaza has long ago passed the 'trial' stage and is ready for much larger-scale wastewater reuse than currently exists.

- *Technical Assistance on Reuse of Wastewater and Storm Water Harvesting in the Gaza Strip: Assessment of Wastewater Treatment and Reuse Practices*. ADC/PWA Gaza 2011)
- *Sludge and Effluent Reuse Study of Gaza Central Area (KfW, 2005)*
- *Policy Guidelines for Sustainable Wastewater Management in Gaza Strip (ONEP, 2002)*
- *Development of Tools and Guidelines for the Promotion of Sustainable Urban Wastewater Treatment and Reuse in the Agricultural Production in Mediterranean Countries (Medaware, 2005)*
- *Effluent Reuse Study for Khan Younis Governorate*
- *Coastal Aquifer Management Plan (CAMP)*
- *Feasibility Study for Wastewater Treatment Plant for Northern Gaza*
- *Master-plan for Sewerage and Storm-water Drainage (Sogreah, 1999)*

9.1.1.1 Pilot Projects

A number of wastewater reuse demonstration or pilot projects have been established in Gaza, as shown in Table 3 and summarised in Appendix B. Note there are also wastewater reuse projects associated with Birzeit University, and al Bireh and Hebron WWTPs that can be drawn upon.

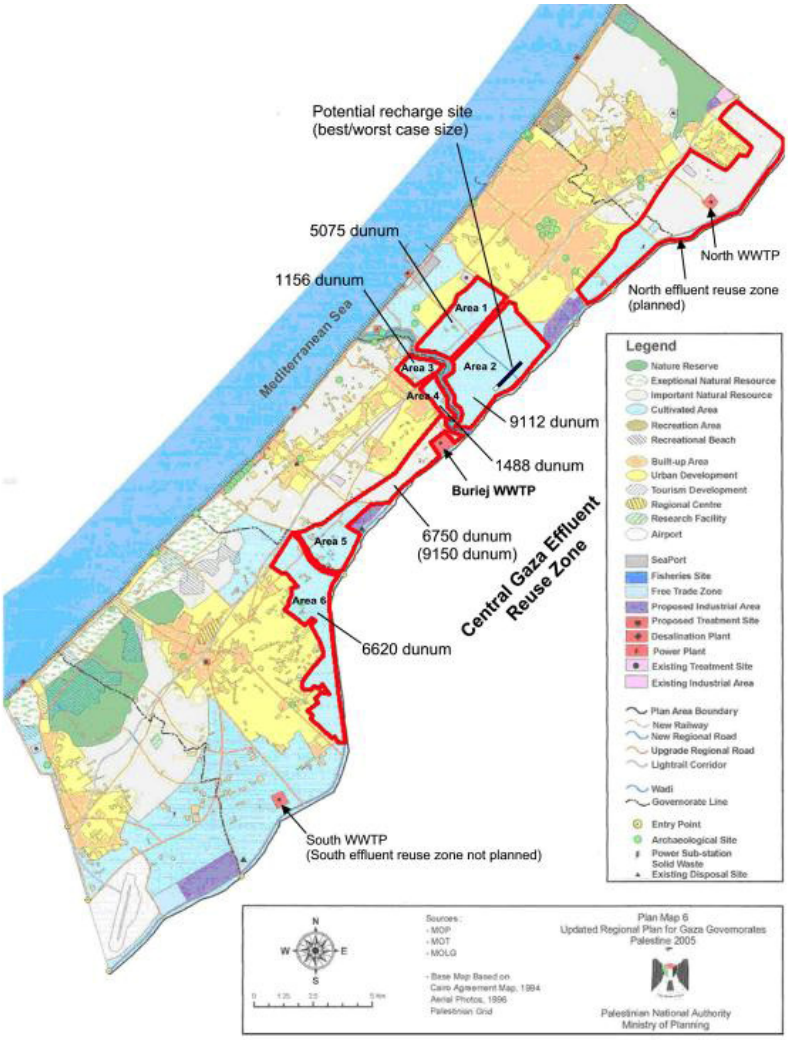
Table 3. Current and planned wastewater or stormwater reuse projects in Gaza.

Project Name	Location	Involved	Description
UNDERWAY			
Water Management and Water Savings Strategies in the Middle East.	Beit Lahia (Um Al-Nasser), Gaza City (Shiekh Ejleen)	PHG, France	2 separate pilot projects testing yields, methods and sustainability.
Pilot Project at Um Al-Nasser	Beit Lahia	PHG, ECHO, Italy	Irrigating 45 dunums alfalfa, olives + farmers' awareness programme.
Reuse Project at Tal-Assultan	Rafah	PHG, ECHO	*Planned* – to irrigation 40 dunums next to Rafah WWTP.
Pilot Waste Water Reuse Scheme	Gaza City	PHG, France	Irrigating 100 dunums of citrus and olives, from Gaza City WWTP.
European Hospital WWTP	Khan Younis	MoA, PWA, EC	Irrigating 9 ha of olives.
PLANNED			
SAT Project at Al-Mawasi	Khan Younis	CMWU,	*Planned* – to irrigate 90 dunums with recovery wells, through soil-aquifer treatment.
Effluent Recovery and Irrigation Scheme of North Gaza	North	PWA,	*Planned* – to irrigate from ww and recovery wells – from 5 up to 13 MCM/y, from the Northern WWTP.

Emergency Sewage Treatment			
ICARDA Project	Gaza City	PWA, ICARDA	*Planned* - to irrigate 5 dunums with grey water, from Gaza City WWTP
Sheikh Radwan Reservoir	Gaza City	Municipality of Gaza	Reservoir being used for fish ponds may be used for infitration.

A regional development plan for wastewater re-use has also been developed, as shown in Figure 3.

Figure 3. Regional Development Plan for Wastewater Reuse. MoP, from PWA (PWA 2010: Figure 6).



APPENDIX A
Status Update of WWTPs in Gaza

Taken directly from PWA (2011: Section 3.2).

In the following a summary description of most existing WWTPs in operation:

Beit Lahia WWTP

Beit Lahia wastewater treatment plant (BLWWTP) was built in 1976 and designed to serve a population of 50,000 with a load capacity to treat 5,000 cubic meters per day (CM/day) of wastewater to secondary treatment level. However the plant currently receives more than 23,000 CM/d to the design capacity. The sewage is delivered from the main manholes and is processed though a number of lagoons shown in the schematic diagram of Beit Lahia wastewater treatment plant below. The treatment consists of: Primary sedimentation lagoons (1 and 2) with area of 7,660 and 8000m^2; Aerobic lagoons with surface aerators (3 and 4) with areas 7,514 and 7915m^2; Facultative Lagoons (5 and 6) with areas of 15,584 and 15,604m^2. Finally the wastewater flows to a maturation pond (7) and is disposed by siphoning to the newly constructed Emergency lagoon. Finally the treated wastewater is conveyed through two pump station to the Eastern infiltration basins (NGEST) and to the temporary infiltration basins at the Northerner boarder. Due to the huge overload on the system, the wastewater is only partially treated, and the effluent is considered a low quality.

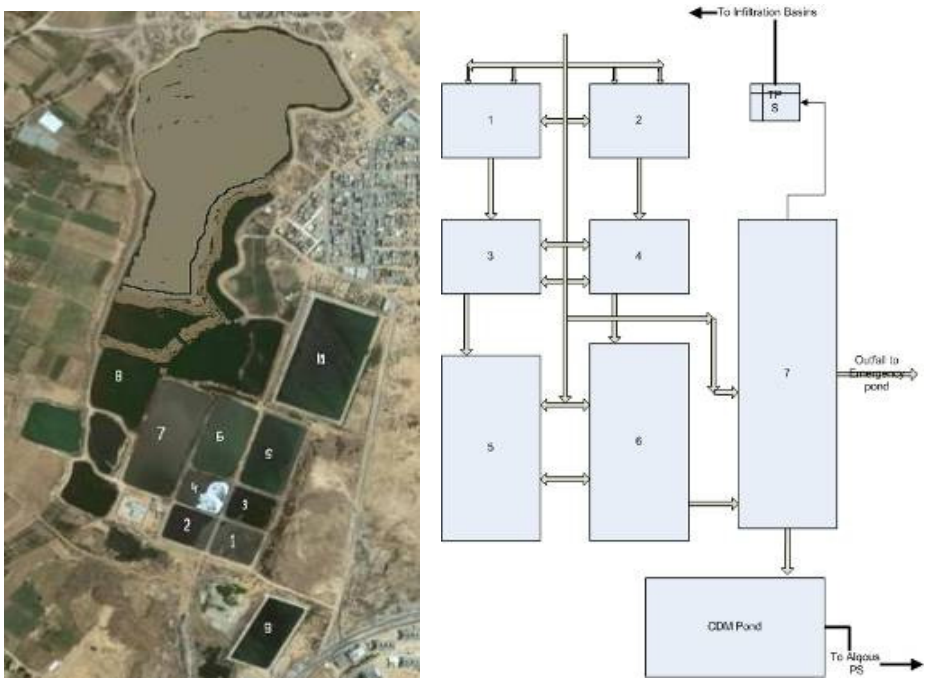


Figure 3.1: Beit Lahia WWTP & its Process Schematic Diagram

Gaza WWTP

The Gaza Wastewater Treatment Plant (GWWTP) serves the municipality of Gaza and part of the North Gaza Governorate, although the latter area is expected eventually to be diverted to the Northern WWTP. The GWWTP plant is located on an elevated position to the south of the city (in the area of Sheikh Ejleen). The plant covers an area of 130,000 m2. Originally the plant was constructed in 1977 as a two-pond treatment system. It was expanded in 1986 by UNDP when two additional ponds were constructed. Part of this expansion included reuse facilities, consisting of three large recharge basins, a booster pumping stations, a 5,000 m^3 storage tank, a distribution piping system and an overflow pipeline to the Wadi Gaza. Modifications were made in 1996 and funded by USAID, including the addition of two "bio-tower" trickling filters. In 2006, the Gaza Municipality commenced construction of an additional fourth anaerobic pond. Currently, CMWU and the Municipality of Gaza are upgrading the plant for improving the effluent quality on the medium term.

Khan Younis WWTP

This facility is a temporary partial wastewater treatment plant with anaerobic, aerobic, and settling ponds. The plant was constructed in 2007 as a temporary solution. The current flow rate is about 7000 m^3/day, and it is currently discharging to the sea.

The existing treatment process is designed to treat the influent to be suitable for disposal to the sea. The influent BOD, COD, Total suspended solids (TSS) and TKN are 380, 820, 400 and 71 mg/l respectively. The BOD removal efficiency accounts for less than 70%. It is noticeable that the effluent is not fulfilling the criteria for sea disposal or even reuse in irrigation purposes according to the Palestinian standards.

Rafah WWTP

The RWWTP plant serves a population of 112,500 in Rafah. In 2007 the total volume of water production was 5.6 MCM with average daily flow 8000-8500 m^3/d. The raw sewage has a high pollutant concentration. The raw wastewater characteristics are BOD = 740 mg/l, COD = 1200 mg/l and TSS = 635 mg/l.

This plant consists of two anaerobic ponds, with grit removal and inlet structures. Another old lagoon still exists and will be used as polishing pond in the future. Currently, development is ongoing at Rafah wastewater treatment plant to add the following facilities:

- Two bio-filters, piping, BTFPS, and distribution chamber.
- Polishing Pond.
- Pumping assembly.
- Drying beds.
- A constructed wetland of reeds for additional filtering and nutrient (nitrogen) removal
- Infiltration basin.

Taken directly from PWA (2011: Section 3.4).

The status of the planned WWTPs in Gaza is further detailed below:

Northern Wastewater Treatment Plant (NWWTP)

The Northern Wastewater Treatment Plant is designed to replace Beit Lahia WWTP. It will serve the whole of the Northern Governorate to a design horizon of 2025. At that year the NWWTP will be operating with full capacity of 60,000 m^3/d. Processes will include primary sedimentation followed by an oxidation ditch, sand filtration and UV disinfection. Wastewater is planned to be treated to the following quality standards: BOD 10 mg/L, TSS 15 mg/l; total N 10 mg/l; Faecal coliforms <1,000 MPN/100 ml; and helminths <1/l. The effluent is planned to be reused in agriculture. It is proposed to cover a command area of 21,000 dunum, from the Green Line to the east and Salah El Din Street to the west, and from the northern border to the El Montar crossing to the south. Excess wastewater will be recharged into the groundwater through infiltration basins located near the WWTP.

The main objective of the current project is to design recovery wells, water storage tanks, a pump station and irrigation networks which should account for possible infiltrated wastewater, recovery

scheme, and the demand for crops up to year 2025 or 2030 (based on a consultant prediction) which could reach the identified capacities of treated wastewater (69,000 m^3/day). Two phases based on generated wastewater quantities (35,600 m^3/d and 69,000 m^3/d) at specific target years (around 2012 and 2025) will be considered. The detailed design of the recovery scheme is for 35,600 m^3/day as infiltrated treated wastewater. A future extension of infiltration basins and recovery scheme to accommodate 69,000 m^3/day of treated wastewater will be suggested.

The total project area is around 16,500 dunums located at the north-east of the Gaza Strip adjacent to the eastern border with Israel. The agricultural area is about 13,700 dunums whereas the industrial and residential area account for 546 dunums. The proposed area is divided into two zones (A and B) according to its relationship to infiltration basins. Zone A is the part located north of infiltration basins with 9,400 dunums whereas, Zone B is located south of proposed WWTP with about 5,000 dunums.

Central Wastewater Treatment Plant (CWWTP)

This treatment plant is planned to serve Gaza City as well as those communities in the Middle Governorate that are not served currently with wastewater drainage systems. The plant will occupy 250 dunums. It was planned to be in operation in 2008. However, the construction works has not yet started. In accordance with PWA's effluent quality criteria, in the first phase the effluent quality of the CWWTP should not exceed BOD 20 mg/l; TSS 30 mg/l; TN 25 mg/l. In the second phase, the effluent should meet BOD 10-20 mg/l; TSS 15-20 mg/l; TN 10-15 mg/l; fecal coli form <1,000 MPN/100 ml; and helminths (KFW, 2004).

Khan-Younis Wastewater Treatment Plant (KYWWTP)

A plan exists to establish Khan Younis Wastewater Treatment Plant (KY WWTP) in the eastern part of the governorate within Al Fukhary area, which will treat the wastewater generated from the households of the town. The proposed KY WWTP will achieve a secondary level treatment. After that, the effluents will be discharged into infiltration basins for aquifer recharge, and to the sea in case of emergency. KY WWTP will have a capacity of treating up to 44,000m^3 of raw sewage every day, generated by the residents of the governorate in year 2025.

APPENDIX B
Studies on Wastewater Treatment and Reuse in Gaza

Technical Assistance on Reuse of Wastewater and Storm Water Harvesting in the Gaza Strip: Assessment of Wastewater Treatment and Reuse Practices (ADC/PWA Gaza, 2011)
This study provides an insight into the situation of the wastewater sectors in Palestine; it will be one of the baseline documents within the Project for all further activities, like the development and construction of pilot project, the formulation of wastewater treatment and reuse guidelines and the implementation of different training programmes. (Pg. 7).

Taken directly from PWA (2010: Section 4.4).

Sludge and Effluent Reuse Study of Gaza Central Area (KfW, 2005)
The study investigated different issues related to wastewater reuse of the Shiekh Ejleen WWTP. The significance of this study to this project comes from the three options for institutional setup for regulating, managing, and operating all reuse activities, including technical and financial activities. These options serve as a bench mark for the Consultant to build upon during conceptualization phase.

Policy Guidelines for Sustainable Wastewater Management in Gaza Strip (ONEP, 2002)
This study was prepared in 2002 by ONEP and Islamic University of Gaza. This study covered legal, institutional, and technical issues related to WW reuse. On the institutional reforms, it proposes specified competent authorities and responsibility areas. Accordingly, responsibilities of involved institutions, at different levels, were also specified. This took a form of integrated institutional setup for regulating, managing, operating and monitoring reuse of TWW.

Development of Tools and Guidelines for the Promotion of Sustainable Urban Wastewater Treatment and Reuse in the Agricultural Production in Mediterranean Countries (Medaware, 2005)
The MEDAWARE project is a project funded by the Euro-Mediterranean partnership. The project aims at addressing significant issues of wastewater treatment and reuse in agriculture. Several countries from Middle East and North Africa participated in the project. These countries included: Palestine, Jordan, Morocco, Lebanon, Turkey, Spain, and Greece. The study has identified the profile of each country in regards to existing population, water demand and WW production, treatment facilities, and effluent qualities and quantities, and institutional and legal frameworks.

Effluent Reuse Study for Khan Younis Governorate
This study evaluated the feasibility of reuse of effluent from New Khan Younis WWTP. This study has highly recommended Al Foukary and Sofa for TWW reuse. A major contribution of this study is that it established a survey to specify the acceptance of farmers to use of TWW. It has shown that, in principle, the vast majority of farmers accept the use of reclaimed WW. It also specified the type and form of training and public awareness necessary before decision to start using TWW is taken.

Coastal Aquifer Management Plan (CAMP)
This study provides a significant source for data on groundwater model, physical surveys, study and design of water resources related infrastructure.

Feasibility Study for Wastewater Treatment Plant for Northern Gaza
This study provides the effluent reuse strategy for agricultural irrigation and aquifer recharge of effluent at the New Northern Wastewater Treatment Plant. Also, it serves as a source for extensive data on hydrological, urban and natural systems in the zone surrounding location of NWWTP.

Master Plan for Sewerage and Storm-water Drainage (Sogreah, 1999)
In 1999, Sogreah prepared the Master Plan for Sewerage and Stormwater Drainage in the Gaza Governorates. This study served as a bench mark for successive studies. This master plan will be used as a guide for evaluation of alternatives for development of Shiekh Radwan Lagoon as well as selection of proper sites for stormwater pilot projects.

APPENDIX C
Studies on Wastewater Treatment and Reuse in Gaza

Taken directly from PWA (2010: Section 4.5).

Project 1: Water Management and Water Savings Strategies in the Middle East. Palestinian Territories Component – Gaza Strip Activities.
This project has been established in 2003 under the fund of the French Government. Two separate pilot projects have been conducted to testify the feasibility of TWW reuse in terms of yield, methods, and sustainability. Also, this project has defined technical orientation of the future and training for farmers and technicians. The NGO Palestinian Hydrology Group (PHG) has been chosen to execute the local coordination of the actions and to manage the necessary local funds. The program has been coordinated by a Steering Committee PWA, French Consulate, MREA that chaired by a MoA, and each pilot project has been managed by a technical committee (MoA, PWA, PHG, French Consulate, MREA).

Project 2: Pilot Project at Um Al-Nasser, Beit Lahia.
This project is funded by ECHO and implemented by CRIC and PHG. It exists at the north of the Bedouin village near the northern borders with a total area of 130-140 dunums. These areas are planted with alfalfa that is surrounded by olive trees. This project includes an awareness and training program for farmers involved.

Project 3: Reuse Project at Tal-Assultan, Rafah.
This project did not yet start although it has been approved to be funded by ECHO and to be implemented by CRIC and PHG. The total area that will be irrigated is about 40 dunums in the nearby of Rafah WWTP which will be the source of TWW.

Project 4: Pilot Waste Water Reuse Scheme in Gaza City
In 2004, the Palestinian Hydrology Group has proposed a project to use treated wastewater from Shiekh Ejleen WWTP for irrigating 100,000 m^2 of citrus and olive trees. The project has been established under French funding and the supervision of PWA and the Municipality of Gaza with coordination with MoH and MoA. This project was successful, thereafter, extension has made till the last Israeli invasion in 2008-2009 that led to the destruction of some of infrastructure of the project. However, rehabilitation is currently being done under MREA and APY funding. This project is expected to be operated again on November 2010. This rehabilitation included construction of 6 small storage tanks for farmers.

Project 5: SAT Project at Al-Mawasi, Khan-Yunis
CMWU has signed an agreement with a local association called 'Charity Association of Astal's Sons' to supply water from recovery wells as a part of a SAT system. This agreement limits irrigated crops to trees and fodder crops. These recovery wells were dug by the Job Creation Program in cooperation with PWA for research purposes. According to the agreement, farmers will consume 4000 m^3/yr to irrigate up to 90 dunums. This agreement was signed in 15 Nov 2010 and it will be valid for one year from that date with opportunity to be extended. The BOD in the irrigation water was found to be 20-25 mg/l.

Project 6: Effluent Recovery and Irrigation Scheme of North Gaza Emergency Sewage Treatment (NGEST)
This project is still currently at the stage of design revision. The preliminary design of the project comprises of two parts: the recovery wells and irrigation reuse infrastructure. The recovery part includes recovery wells, connection pipes from tanks and monitoring wells. The reuse part consists of two 4000 m^3 water tanks, a booster pumping station, and the distribution network. The design is still evaluating three scenarios for reuse. These scenarios recover 15,000, 21,000, and 35,600 m^3/d respectively. These scenarios differ from each other in terms of state of infiltration run (steady or transient) and accordingly, the number of recovery wells.

Project 7: ICARDA Project
This is a research project funded by International Center for Agricultural Research in the Dry Areas with the implementation of Agricultural Development Organization and a steering committee from PWA, PHG, Azhar University and Ministry of Agriculture. This project aims at establishment of

research and applications on TWW reuse in areas near the Shiekh Ejleen WWTP. This research covers a land of 5 dunums. It is concerned with treatment and reuse of grey water. This project includes an awareness and training programme as well as a monitoring system. This project will study socio-economic aspects and conditions related to the project.

Project 8: Sheikh Radwan Reservoir

The consultant met difficulties in gathering data and information about the Sheikh Radwan Reservoir, since substantial information is missing. The following information is provided by the Municipality of Gaza. The storage volume of the reservoir is 560,000 m^3 in addition to 20,000 m^3 in the main culvert. Water collected in the reservoir infiltrates laterally into the sandy sides of the reservoir through rock filled gabion baskets. Local residents in the neighbourhood claim that the reservoir is currently a source for mosquitoes. The draining pumping station is of 500 m^3/hr capacity that discharges to the sea via a 14" diameter force main. Under the Gaza Wastewater Project (GWWP) a hydraulic model has been developed by Metcalf & Eddy for the operation of the Reservoir to allow the Municipality of Gaza to determine when the reservoir should be pumped out. Through the use of this model, it may be possible to modify operational practice to allow some of this flow to be retained and infiltrated to the aquifer. However, no retaining on infiltration purposes is done currently.

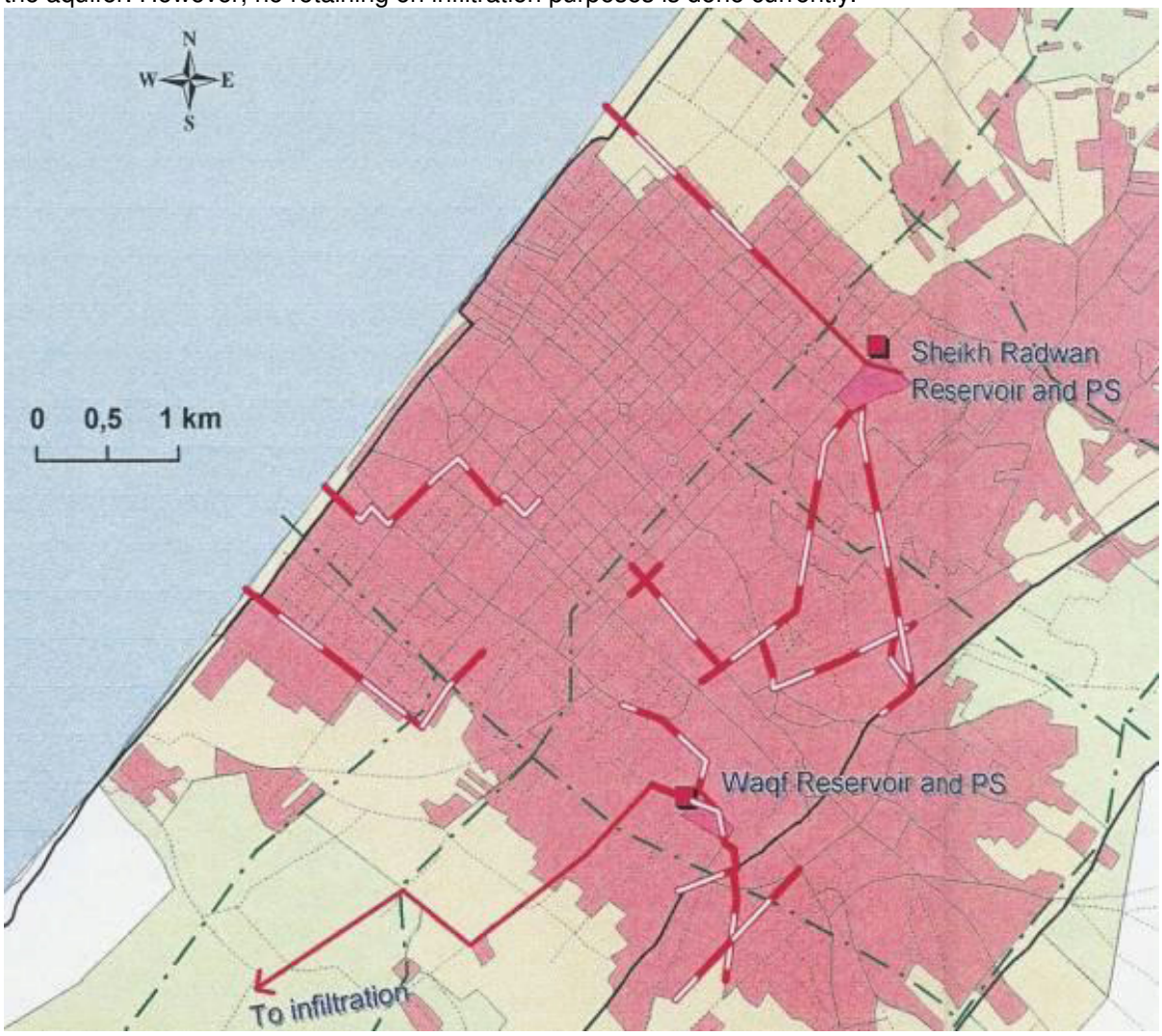


Figure 7: Storm Water Drainage Master Plan for Gaza City (Source: Updated Regional Plan for Gaza Governorates, 2005).

Recently, the Municipality of Gaza has established a project for fish breeding within the reservoir for the purpose of mitigation of mosquitoes' problem. In case this project succeeds, the possibility for retaining water for infiltration becomes possible.

Further information below taken directly from {AlMADINA-ENFRA-DHV, 2011 #1659: 16}:

Beit Lahia Project
The first pilot location in Beit Lahia aims to demonstrate in the area of the Bedouin village that uses water from the artificial lake (constituted by the effluent of the Beit Lahia Lake water treatment). Fodder crops (alfalfa, Sudan grass and ray grass) are irrigated and used for feeding the small animals. The total area cultivated by Alfalfa is extended to 45 dunums extended to 140 dunums in 2010 by an Italian fund. A comprehensive monitoring system is also used to examine and detect hygiene and environmental problems and is extended to cover crop, soil , ground water and the effluent. The other running components of the French funded project include a short training course for the farmers as well the agricultural engineers to qualify the target groups and strengthen the capacity building in PWA, MoA and NGOs beside launching public awareness for the interested farmers and agricultural associations. A field visit for 4 farmers to Jordan has been organized to introduce the Jordanian expertise and pilot projects funded by the French Embassy (MREA) in Jordan.

Sheikh Ejleen Pilot Project
The second proposed pilot farm aimed to demonstrate the reuse of treated wastewater for the irrigation of citrus and olive orchards. Farmers interested in experimenting with this new source of water have been contacted in the area around the Gaza City treatment plant. This area is located around the Salah el Deen road, close to the network conveying the TWW from the Gaza City WWTP to the infiltration basins and wadis. In 2004, the Job Creation Program in cooperation with Palestinian Hydrology Group proposed a project to use treated wastewater from Sheikh Ejleen WWTP for irrigating 100 dunums of citrus and olive trees. The project has been established under French fund and the supervision of PWA and Municipality of Gaza with coordination with MoH and MoA. This project was successful, thereafter, extension has made till the last Israeli invasion that led to the destruction of some of infrastructure of the project. However, rehabilitation is currently done under the French and Spanish funds. This project was operated again on November 2010 covering 186 dunums.

Soil-Aquifer Treatment (SAT)

Soil Aquifer treatment involves the infiltration (or injection) of sewage effluent into the aquifer, and the movement of the effluent within the groundwater acts as a natural filter to treat wastewater, decreasing BOD, TSS, bacteriological presence and metal concentrations. Since the soil and aquifer are used for natural treatment, such a system is called Soil-Aquifer Treatment or SAT system. Soil-aquifer treatment is, essentially, a low-cost, advanced wastewater treatment system. It also has an aesthetic advantage over conventionally treated sewage in that water recovered from a SAT system is not only clear and odour-free but it comes from a well, drain, or via natural drainage, rather than from a sewer treatment plant. Thus, the water has lost its connotation of sewage and the public see the water as comprising groundwater, more than as sewage effluent. This could be an important factor in the public acceptance of sewage reuse schemes. With a fund of the Catalan Government, the JCP in close cooperation with PWA and CMWU, launched a small pilot project started with 60 dunums in 2008 and expanded to 90 dunums in 2010 cultivated with Jawaffa and Palm trees. The BOD results from the recovery wells reach 20-25 mg/l.

European Hospital in Khan Younis
In a project funded by the European Commission, a small-scale wastewater treatment plant was installed in new European Hospital in Khan Younis in 2001. This plant is generating 150 - 200 m^3/day in summer and 300 m^3/day in winter. The effluent from the plant is irrigating (sprinkler) 9 ha of olive, and other trees. The main partners involved are MoA and PWA .

REFERENCES

AlMADINA-ENFRA-DHV (2011). *Non-Conventional Water Resources*. Progress report (March 2011). file name 'Gaza Dr. Samir WW-1 progress report.doc', ALMADINA - Enfra Consultants, in cooperation with DHV BV - Netherlands

PWA (2011). *Technical Assistance on Reuse of Wastewater and Storm Water Harvesting in the Gaza Strip: Assessment of Wastewater Treatment and Reuse Practices*. ADA/PWA Gaza QCBS 01 09, ALMADINA - Enfra Consultants, in cooperation with DHV BV - Netherlands – with funding from Austrian Development Cooperation

PWA (2010). *Technical Assistance on Reuse of Wastewater and Storm Water Harvesting in the Gaza Strip*. ADA/PWA Gaza QCBS 01 09, ALMADINA - Enfra Consultants, in cooperation with DHV BV - Netherlands