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Village Wastewater System Feasibility Report for the West Hebron and South Nablus Clusters Final Report

by

EHP Staff

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VILLAGE WASTEWATER SYSTEM FEASIBILITY REPORT FOR THE WEST HEBRON AND SOUTH NABLUS CLUSTERS

Final Report

11 February 2002

Prepared for the USAID Mission for the West Bank and Gaza
Under Task Order HRN-I-802-99-00011-00

EXECUTIVE SUMMARY

Infrastructure development must include consideration of community participation as integral to technical improvements in water, sanitation and solid waste. The linking of these three elements of infrastructure to environmental health has been well demonstrated in the past decades of public health development work. In an attempt to tackle the need for environmental improvements in 46 West Bank villages (18 in Nablus area and 28 in Hebron area) USAID conceived of a Village Water and Sanitation (VWS) Program. This report is written as one of the deliverables of the VWS program under Task Order HRN-I-802-99-00011-00.

STUDY APPROACH

A review was made of existing documentation including several pre-design and feasibility study reports for other West Bank villages. Field visits, discussions with local professionals, and municipal level questionnaires permitted a description of existing policies and practices. Much of the analysis presented here is based on previous donor studies. One of the distinguishing characteristics of the wastewater field in the West Bank is that there are many studies, but very few implemented programs. Some of the conditions qualifying this study are: short time frame; data collection was qualitative rather than quantitative; cost figures are estimates based on comparisons with similar work rather than on detailed quantities; the study was conducted under occupation conditions that severely limited the ability to conduct field visits or even obtain data from various agencies.

GENERAL CHARACTERISTICS

Mostly agrarian economic base, consisting of olives, grapes, fruits and vegetables; some animal husbandry; little infrastructure and paved roads, some on electrical grids and some diesel generation; hilly topography, rocky and permeable soils, both automobiles and animals used for transportation; some access to primary education and primary health care. The most pervasive characteristic is the severely depressed economic conditions. Related to this, it is important to note that the villages under study were economically stressed and suffering from high unemployment rates because of the *intifada* conditions. This should be kept in consideration when extrapolating the conclusions outlined herein and designing any program to involve community participation

WATER CONDITIONS

Water supply for these villages comes from a combination of piped supply, rainwater harvesting, tanker trucks, wells and springs. Because of the intermittent nature of supply the majority of households have large underground cisterns in which they can store up to several months' water. Affluent households have electrical pumps to pump the cistern water up to roof tanks; poorer households draw cistern water up by the bucket. There is a Ministry of Health program to add chlorine tablets to cisterns to mitigate against water quality deterioration. However, due to the difficult travel conditions, the success of these efforts is sporadic.

WASTEWATER CONDITIONS AND EVALUATION

Because of the lack of water, and the water-frugal habits of the villagers, the wastewater is very concentrated, with BOD and TSS values over 1000mg/L. The primary mode of wastewater disposal is cesspits. These are underground tanks with unlined bottoms that allow liquids to leach into the ground. Cesspits can only work properly where soil conditions are suitable, with low population density and no nearby underground water.

This is not true in the study villages and therefore cesspits are considered an inadequate long-term treatment approach. Current household costs for wastewater disposal, based on cesspit evacuation range from $25-$400/HH/yr depending on cesspit size, soil conditions and household size. Current practices are already suspected to be causing deteriorating groundwater quality (a regional environmental impact) and disease (adverse affects at the household level). **A sanitation intervention is needed.** The pilot programs described herein will attempt to start tackling the wastewater and sanitation questions, however household sanitation problems should be addressed whether or not the pilot programs are implemented.

A better on-site sanitation method than cesspits is the septic tank. While the septic system is a simple and effective disposal method, misapplication of the technology is common. Various NGOs with varying degrees of success have piloted a version of the septic system in some portions of some of the villages. Main problems seem to be with the poor quality of construction and villagers' expectations of the system.

The only method for wastewater treatment and disposal in dense or fast-growing areas is by collection and centralized treatment. The most appropriate collection options for these villages are probably a combination of the small-bore, simplified or conventional sewer system. A cost/benefit analysis including O&M costs must be done during design. There are several options for treatment plant technology, from high-rate ponds to activated sludge plants. Main selection criteria for a village treatment plant in the West Bank are: low cost, ease of maintenance, the ability to treat high-strength waste, public acceptance, and the ability to be built in incremental (modular) units.

WASTEWATER REUSE

Wastewater reuse is, in concept, an excellent long-term strategy for this region. Some villagers are already separating and re-using household gray water for watering gardens and are eager for any new wastewater technology that has a reusable effluent stream. PWA has included reuse as one of its core strategies. Thus, both the grassroots and political climates, and ironically, the *lack* of conventional water and wastewater infrastructure, make conditions in rural Palestine very favorable for reuse. However, because of the water shortage and subsequent highly concentrated and meager wastewater stream, reuse has not yet proved successful at any scale, as evidenced by several pilot wastewater efforts. In spite of this, it is imperative that attempts continue to keep infrastructure and institutional structure for reuse in pace with the changing water supply situation.

PILOT PROGRAMS

This study considers community participation to be integral to all aspects of any sanitation intervention, thus no attempt has been made to detail a design. Rather, the recommendation from this report is that a few carefully considered, community-based pilot programs be implemented in up to four villages. The lessons learned from these efforts may then help in defining a replicable solution for more villages.

The following were the main criteria used in selecting pilot program sites: Population size between 1000 and 5000 to allow feasibility of testing a centralized treatment approach; Topography (reuse potential and availability of land for treatment plant); Willingness to participate of all stakeholders; Economic level of the community (community being able to afford connection fees, construction costs, O&M costs etc.); Political Area A or B (Palestinian controlled); Likely adequate water supply in the near future so there is an adequate wastewater stream for treatment.

Out of a choice of 28 potential sites in West Hebron, seven were pre-selected and three were finally chosen. Preliminary cost estimates for the sites are summarized in the table below:

SUMMARY OF COSTS FOR WEST HEBRON PILOT PROGRAMS			
	Deir Samit	**Nuba**	**El Kum Group**
Population Served 2003	5,304	4,145	2,435
Subtotal Construction costs	$ 2,550,000	$ 2,030,000	$ 1,200,000
TOTAL CAPITAL COSTS:	$ 4,000,000	$ 3,200,000	$ 1,900,000
ANNUAL O&M COSTS 1.5%	$ 60,000	$ 48,000	$ 28,500

The recommended program is for an initial phase of building community awareness, assessment and demand creation for better sanitation. Next, is a community-based technical design, in which the community will be called on to help solve issues such as: which technology would be most publicly acceptable and able to be maintained; land procurement; and strategies for disposal of by-products such as gas, sludge and wastewater effluent.

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ABBREVIATIONS

ARIJ	Applied Research Institute – Jerusalem
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DFID	Department For International Development
EHP	Environmental Health Project
HH	Household
HH	Household
JSC	Joint Service Council
KAP	Knowledge, Attitude, Practice (survey technique)
MEnA	Ministry of Environmental Affairs
NGO	Non Governmental Organization
NIS	New Israeli Shekel
O&M	Operation and Maintenance
PA	Palestinian Authority
PARC	Palestinian Agricultural Relief Committees
PCBS	Palestinian Central Bureau of Statistics
PECDAR	Palestinian Economic Council for Development and Reconstruction
PHG	Palestinian Hydrology Group
PWA	Palestinian Water Authority
SCF	Save Children Federation
SDT	Subsurface Drainage Technique
SWM	Solid Waste Management
TSS	Total Suspended Solids
UASB	Upflow Anaerobic Sludge Blanket
UNRWA	United Nations Relief and Work Agency
USAID	United States Agency for International Development
VWS	USAID Village Water and Sanitation Program
WSSPS	Water Sector Strategic Planning Study
WWTP	Waste Water Treatment Plant

1 INTRODUCTION

1.1 BACKGROUND AND PURPOSE

Infrastructure development of public work should include consideration of community participation as an integral part of technical improvements in water, sanitation and solid waste. The linking of these three elements of infrastructure to environmental health has been well demonstrated in the past decades of public health development work. In an attempt to tackle the need for environmental improvements in 44 West Bank villages (16 in Nablus area and 28 in Hebron area) USAID conceived of a Village Water and Sanitation (VWS) Program. This report is written as one of the deliverables of the VWS program under Task Order HRN-I-802-99-00011-00. The reader is also referred to the *Preliminary Design Report for the West Hebron Service Area Distribution Systems* as well as the *Feasibility Report for Water Systems in the South Nablus Area.* These should be available by December 2001 and the *Environmental Assessment for West Hebron and South Nablus Area Water Network Design Report* and *West Hebron Wastewater Pilot Programs Design Report* expected to be completed by September 2002.

The planned investments being made in water supply will result in an increased quantity of water flowing into the villages. Current practices for dealing with gray and black wastewater will rapidly be overwhelmed. Grey wastewater, or sullage, is considered to be all household wastewater that is not from the toilet. Toilet wastewater is called black wastewater. Current practices are already suspected to be causing deteriorating groundwater quality (a regional environmental impact) and disease (adverse affects at the household level). A sanitation intervention is needed. The purpose of this study is to provide a general overview of the existing situation and attempt to give some direction on feasible wastewater collection and treatment options. Recommendations made herein will be used to guide the next step, which is a pre-design for a pilot rural wastewater program. This project could provide a unique opportunity for taking a pro-active approach to provide both the needed water and wastewater facilities for improving the environmental and public health of the residents in these villages. The pilot programs described herein will attempt to start tackling the wastewater and sanitation questions, however household sanitation problems should be addressed whether or not the pilot programs are implemented. The concurrent institutional program under the VWS will attempt to tackle questions of household health behaviors and provide recommendations for improved household sanitation with respect to cisterns and cesspits.

As a result of prolonged neglect and increasing poverty, the rural areas in the West Bank and Gaza Strip suffer from underdevelopment of their physical, economic and social infrastructures. The region suffers from a lack of safe and adequate water supply, proper sanitation facilities and satisfactory solid waste management practices. In the last 10 years, the issue of providing adequate water supply systems in the West Bank and Gaza Strip has been well investigated. Some improvement has been noticed in this regard in most of the Governorates in West Bank and Gaza Strip. However, the wastewater sector is still undeveloped and suffering from resultant environmental and health consequences. In addition, no comprehensive data (beyond general Palestinian Central Bureau of Statistics reports) on wastewater characteristics and discharge quantities are yet available.

Although the focus of this report is on rural areas, it should be noted that the situation for wastewater collection and treatment is extremely critical in the urban centers. Approximately 65% of the houses in the main cities are connected to a sewage network. However, only in four cities is the collected wastewater conveyed to treatment plants, which are not all functioning as designed. Several of donor-funded initiatives are

attempting to address this issue, with varying degrees of success. Some of the technical alternatives described herein may be appropriate for an urban context, however, as the urban context was not analyzed, no further comment can be made on this point.

In the refugee camps, the houses are either connected to a municipal sewage network or to cesspits. In a number of the refugee camps, the gray wastewater is discharged to open drains that were originally constructed to convey storm water.

Other programs for Nablus and Hebron area associated to this scope of work include, for South Nablus and West Hebron Villages, the Design of Water Supply Systems, Environmental Health Assessment and Activities, Institutional Capacity Building for Joint Service Councils (JSC) whose duties will include oversight of some infrastructure development and utilities. Improvements for solid waste collection and disposal are not part of this study.

1.2 PROJECT AREA

The West Hebron villages are listed in Table 1-1 and indicated in Figure 1-1. The villages in the two South Nablus clusters are listed in Table 1-2 and indicated in Figure 1-2. A brief description of the areas is presented below:

Buildings/Roads: Most of the roads within the villages are unpaved. The larger villages have a greater percentage of paved roads. In general, the less dense, more rural villages have more dirt roads, wider roads, and separate 1-2 story houses with some yards. The larger villages have some 2-3 story multi-family buildings, and narrower roads (minimum 2-3m) and with more paved roads.

Electricity: Most of the villages have electricity either through connection to the main Israeli power grid or from local diesel-driven generators. Those smaller villages with diesel generators generally have electricity for only a few hours a day. All electrical utilities are above ground.

Medical Services: Even smaller villages will have some access to a basic health clinic, however, since the *intifada*, there have been major problems with accessing primary health care because of the travel restrictions.

Education: All children have access to primary level education and there are regional secondary level schools.

Environment: The main differentiating factors between West Hebron and South Nablus villages are: that the Nablus area gets more precipitation, is flatter and is characterized by olive groves. The villages are larger, usually between 2000 – 5000 people. There are more Israeli settlements scattered in and around the Nablus villages (significant because the settlements draw from wells that tap into the same aquifer, and therefore are direct competitors for the water resources). The West Hebron villages are drier, very hilly and the main crop is grapes. While they are closer to the Israeli/Palestinian border, the West Hebron area is forbidden from tapping into the underlying Western Aquifer, and therefore they do not compete for water with the Israelis.

Table 1-1
West Hebron Villages Included in Study

Village English Name	**Village Arabic Name**	**Locality Code**
Al Bira	البيره	503165
Al Burj	البرج	503170
Al Kum	الكوم	502770
Al Majd	المجد	502910
Al Muwarraq	المورق	502795
Al-Jaba'	الجبعة	502355
As Simiya	السيمية	503230
Beit ar Rush al Fauqa	بيت الروش الفوقا	503090
Beit ar Rush at Tahta	بيت الروش التحتا	503010
Beit 'Awwa	بيت عوا	502835
Beit Maqdum	بيت مقدوم	502765
Beit Mirsim and Abu Suhweila	بيت مرسم وأبو سحويله	503075
Beit Ula	بيت أولا	502615
Beit Ummar	بيت أومر	502540
Deir al 'Asal al Fouqa	دير العسل الفوقا	502970
Deir al 'Asal at Tahta	دير العسل التحتا	502925
Deir Samit	دير سامت	502810
Idhna	إذنا	502685
Iskeik	إسكيك	502985
Jala	الجا	502545
Kharas	الخراس	502560
Khirbet Salama	خربة سلامة	502865
Nuba	النبوة	502585
Safa	الصافا	502485
Sikka	السكة	502860
Surif	السريف	502450
Tarqumiya	ترقوميا	502640
Tawas	طواس	502890

Figure 1-1 Location of West Hebron Villages

Table 1-2
South Nablus Villages Included in Study

Village English Name	Village Arabic Name	Locality Code from the PCBS
Burin Cluster	**مجموعة بورين**	
Asira Al Qibliya	عصيرة القبلية	151095
Burin	بورين	151080
Einabus	عينبوس	151195
Madama	مادما	151050
Rujeib	روجيب	151010
Sarra	صرة	150955
Tell	تل	150990
Urif	عوريف	151160
Aqraba Cluster	مجموعة عقربا	
Aqraba	عقربا	151270
Awarta	عورتا	151135
Duma	دوما	151445
Jalud	جالود	151420
Jurish	جوريش	151345
Majdal Bani Fadel	مجدل بني فاضل	151385
Osarin	أوصرين	151265
Qaryut	قريوت	151410
Qusra	قصرة	151365
Talfit	تلفيت	151375

Figure 1-2 Location of South Nablus Villages

1.3 STUDY APPROACH

The planned investments being made in water supply will result in an increased quantity of water flowing into the villages. The present practices for dealing with gray and black wastewater will rapidly be overwhelmed. This project could provide a unique opportunity for taking a pro-active approach to provide both the needed water and wastewater facilities for improving the environmental and public health of the residents in these villages. To accomplish this, it is important that any sanitation intervention be viewed as a two-step process, the first step being working with the community to change attitudes and perceptions about current wastewater and health problems, followed by a community-based technical intervention.

The approach used in this Report included the following key steps:

1. Data collection on existing conditions. A review was made of existing documentation including several pre-design and feasibility study reports for other West Bank villages and towns. Field visits, discussions with local professionals and municipal level questionnaires permitted a description of existing policies and practices.

2. Assessment of alternatives. An assessment was made of appropriate approaches to improving wastewater collection and treatment, based on existing conditions and the estimation of future wastewater production.

3. Based on the above, a broad general approach is outlined herein for improving current and anticipated future wastewater problems within the entire project area (i.e. West Hebron and South Nablus village clusters). This includes an overview of technical options for wastewater collection, treatment and reuse.

4. Pilot project. A pilot program has been outlined for three villages in West Hebron. It is expected that the recommendations of this feasibility study will be developed into a detailed design to be followed by construction. The purpose of the pilot program will be to test the applicability and replicability of a proposed wastewater approach, in order to develop a comprehensive program for future replication in all West Hebron and South Nablus area villages.

1.4 LIMITATIONS OF THIS STUDY

Due to the rapidly changing pace of current events, the scope of work for this project had to be flexible. Much of the analysis presented here is based on previous donor studies. In fact, one of the distinguishing characteristics of the wastewater field in the West Bank is that there are many studies, but very few implemented programs. These previous studies vary in quality from very cursory to those with detailed investment programs. The reader should be aware of some of the conditions qualifying this study:

1. This entire study was compressed from 3 months to a 4-week time frame
2. Data collection was qualitative rather than quantitative
3. Cost figures are gross estimates based on comparisons with similar work rather than on detailed quantities.
4. This study was conducted during an *intifada*. This alone led to restrictions on travel that made data collection difficult. In addition, the most intense work period coincided with a two-week period when Ramallah was under occupation. The curfew situation and ubiquitous roadblocks severely limited the ability to conduct

field visits or even obtain data from any agencies based in other towns or Ramallah. Related to this, it is important to note that the villages under study were economically stressed and suffering from high unemployment rates. This should be kept in consideration when extrapolating the conclusions outlined herein and designing any program to involve community participation.

2 EXISTING CONDITIONS

2.1 GENERAL CHARACTERISTICS

Utilities and infrastructure concerns at the village level are under the jurisdiction of 'Village Councils' or 'Municipalities'. These entities have varying degrees of involvement and effectiveness depending on the village. An appointee of the Governorate generally heads these Councils. The West Hebron villages come under the Hebron Governorate and the South Nablus villages come under the Nablus Governorate. In order to get a better understanding of the existing wastewater conditions in the target villages, a questionnaire was designed and circulated to these Village Councils (municipalities, village councils and development committees). The data from the returned responses to the questionnaires was collected (see Annex 1) and is given a brief analysis below.

2.1.1 West Hebron Villages

In the 28 surveyed communities, the main wastewater disposal system used is cesspits. Only in Deir Samit were septic tanks mentioned as another method of wastewater disposal. Central wastewater collection networks are not available in any of the communities within the project area.

The average size of the cesspits ranges between 10 to 50 cubic meters. In most communities, cesspits are emptied two to five times per year. In some other communities such as Beit Ummar and Kharas, the frequency of cesspit emptying is 12 times per year. However, in other communities such as Al-Kum, Al-Muwarraq, and As-Simya cesspits are rarely emptied. The frequency of cesspit emptying depends on the geologic formation, water consumption and wastewater generation rates and methods of construction of the cesspits. Cesspits are normally constructed with opening in the walls and no concrete bottoms, thereby allowing the liquid septage to seep into the ground at rates depending on soil conditions.

Cesspit emptying is affected by the disposal practices. If gray wastewater is separated from black wastewater, the frequency of cesspit emptying is less. It was clear in the project area that not all the houses separate gray wastewater from black wastewater. Some houses in about half of the communities within the project area have separate disposal systems. Some communities such as Beit Ummar and Idhna do not separate gray wastewater from black and all the wastewater is conveyed to the cesspits. In communities where the gray wastewater is separated from the black wastewater, gray water is used to irrigate house gardens. This was found in Deir Samit and Kharas. In some villages, the gray wastewater is used to irrigate agricultural crops an example for that is Beit ar Rush and Deir Samit. In one community, Nuba, the gray wastewater is disposed in the streets.

Evacuation of the cesspits is performed using vacuum tankers that are owned by the private sector. All the vacuum tankers are owned by people from outside the project area. Neither the local councils nor people from the villages themselves are involved in the cesspit evacuation and disposal of the septage. Usually the septage is disposed in the nearby wadis and agricultural lands, however, in some villages septage is disposed of also at roadsides, an example of this is at Deir al-Asal and Kharas. The average cost ranges between 100 to 300 NIS ($25 to $75) per each 6m^3 tanker load removed. To reduce the cost of cesspit emptying in some communities, the householders empty their

cesspits during the rainy season into the streets. Although all of the villages have agricultural lands, black wastewater is not used for crop irrigation.

In all villages except Deir Samit and Nuba, studies for sanitary and wastewater disposal projects are not available. In Deir Samit, a study was prepared for the construction of a communal stabilization pond to treat the septage received from the cesspits. In Nuba, a study was prepared for wastewater collection and treatment.

Except in four villages which are: Deir Samit, Nuba, Al-Kum and Beit Ula, governmental authorities and NGO's are not involved in the solution of the black wastewater problem. However, in the four mentioned villages, solutions are not comprehensive and mainly include the introduction of the SDT system to a limited number of houses in the villages. In Deir Samit, a British Department for International Development (DFID) sanitation project, involving the collection of the sewage from 40 houses with a sewage collection network of about 1 km that will be conveyed to a collection tank, is under construction at present time. The project is funded by the Save the Children (SCF) and expected to be put in operation by January 2002.

The local authorities believe that sanitary networks are not available in their villages because they do not have prepared studies and because they do not have the needed funds. Some of them believe that, in addition to the above-mentioned reasons, the lack of permits from the Israeli side is another reason. However, the local authorities in three villages have applied for sanitary projects. Applications were issued to PECDAR, Ministry of Local Government and Palestinian Hydrology Group (PHG) requesting funds to solve their sanitary problems.

Most of the local authorities are willing to cooperate with a Joint Service Council (JSC) for the wastewater collection and treatment. Four of the local authorities which are: Tarqumiya, Al-Kum, As-Simya and Beit Ula are not sure about this issue and one (Nuba Village Council) shows no willingness to cooperate with JSC. However, all the local authorities showed willingness to be involved in the process of wastewater projects. Also, they believe that communities themselves have the same willingness to participate in the process.

According to the local authorities, the living standards in the villages within the project area are low to medium. Most of the employed population are workers inside Israel. Less than 20% are working in agricultural activities, while less than 10% are local workers. Less than 10% have their own private enterprises.

A number of the village councils address the health and environmental hazards associated with the absence of a sewage collection and treatment projects. They express their belief that the wastewater is very close to the ground surface. They believe that sanitary projects are badly needed and public awareness programs should be taken into consideration when funding wastewater collection and treatment projects.

2.1.2 South Nablus Villages

In the 19 questionnaire communities, only 13 communities responded and it was clear from their responses that the main wastewater disposal system used is cesspits. Only in 5 communities were septic tanks mentioned as another method of wastewater disposal. Central wastewater collection networks are not available in any of the communities within the project area.

The average size of the cesspits ranges between 5 to 40 cubic meters. In most communities, cesspits are emptied two to five times per year. In some other communities such as Urif and Jurish, the frequency of cesspit emptying is 12 times per year. The frequency of cesspit emptying depends on the geologic formation, water consumption and wastewater generation rates and methods of construction of the cesspits.

Cesspit emptying is affected by the disposal practices. If gray wastewater is separated from black wastewater, the frequency of cesspit emptying is less. This was clear in the project area not all the houses separate gray wastewater from black wastewater. Most of the houses in the communities, within the project area, have separate disposal systems. Some communities such as Tell and Talfit do not separate gray wastewater and all the wastewater is conveyed to the cesspits. In communities where the gray wastewater is separated, it is used to irrigate house gardens. This was found in Sarra and Aqraba. In some villages, the gray wastewater is used to irrigate agricultural crops such as Majdal Bani Fadel. In some communities, such as Burin and Einabus, gray wastewater is discharged to the streets.

Evacuation of the cesspits is performed using vacuum tankers that are owned by the private sector. Most the vacuum tankers are owned by people from outside the project area, while few are owned by people from the villages themselves who are involved in the cesspit evacuation and disposal of the septage. Usually the septage is disposed in the nearby wadis and agricultural lands, however, in some villages septage is disposed also at roadsides, an example for that is Asira Al-Qibliya and Talfit. The average cost of disposal ranges between 40 to 120 NIS ($10 to $30) per $6m^s$ tanker load removed. Costs are lower here than in Hebron area perhaps because septic evacuation is managed by residents of the Askar refugee camp who have a lower overhead and operations cost than the organizations in the Hebron area. *[The detailed cost breakdown to account for this discrepancy could not be obtained in time for printing of this report.]* Although, all of the villages have agricultural lands, black wastewater is not used for crop irrigation.

In all villages except Sarra, studies for sanitary and wastewater disposal projects are not available. In Sarra, a study was prepared by PHG (funding agency not known) for the construction of a low cost system to treat the wastewater received from the 90 households. A project based on the above study has been implemented and put in operation in the last 2 months using a communal septic tank followed by constructed Wetland Technology, however, the system is not functioning properly. PHG along with the community are trying to make some improvements to increase the efficiency of this project. Except in Sarra, governmental authorities and NGO's are not involved in the solutions for the village wastewater problem.

The local authorities believe that sanitary networks are not available in their villages because they do not have prepared studies and because they do not have the needed funds. Some of them believe that in addition to the above mentioned reasons the lack of permits from the Israeli side is another reason.

Most of the local authorities are willing to cooperate with a Joint Service Council (JSC) for the wastewater collection and treatment. Two local authorities which are: Asira Al-Qibiliya and Sarra are not sure about this issue. However, all the local authorities showed willingness to be involved in the process of wastewater projects. Also, they believe that communities themselves have the same willingness to participate in the process.

According to the local authorities, the living standards in the villages within the project area are low to medium. Most of the employed population are workers inside Israel, or in agriculture, while few of them are local workers or self-employed.

A number of the village councils address the health and environmental hazards associated with the absence of a sewage collection and treatment projects. They express their belief that the wastewater is very close to the ground surface. They believe that sanitary projects are badly needed and awareness programs should be taken into consideration when funding wastewater collection and treatment projects.

2.2 REGULATORY POLICIES

According to the *Water Sector Strategic Planning Study* (WSSPS) that was issued by the Palestinian Water Authority (PWA) in 1999, the following PWA policies are most relevant to this study:

- Rehabilitation of all the existing overloaded treatment plants should be a priority, followed by the necessary rehabilitation of all sewage schemes to maximize existing assets.

- Introducing sewage systems to the small communities (having less than 10,000 population) is a third priority according to the WSSPS.

- Appropriate low cost wastewater collection and treatment technologies should be introduced for communities with population less than 5,000, while for larger communities conventional systems should be the proposed solution for the wastewater collection and treatment.

- Reuse possibilities have to be integrated in all future sewage collection and treatment strategies.

2.3 WATER SUPPLY

The water supply situation is detailed in the partner report *Preliminary Design Report for the West Hebron Service Area Distribution System Networks*. Water supplied to the West Hebron villages is from the following sources:

- Piped water from Israel's Mekerot system (mostly in northern villages)
- Mekerot water delivered by tanker trucks
- Rainwater harvesting (more common in south where there is no Mekerot source)
- Springs – very few of these shallow springs exist, and are used mainly for irrigation
- Wells – Palestinians are not allowed, by the Oslo Accords, to tap any wells in the study area although there is an underlying aquifer

Nablus villages, where the water supply situation is even more critical, get their water from the following sources:

- Rainwater harvesting
- Mekerot water delivered by tanker trucks
- Mekerot piped water in Rujeib village
- Springs both for household use and irrigation

The major problem with the water supplies is quantity. However, there is likely also a quality problem especially with spring water and water from cisterns that are not well built or maintained. In many cases cistern walls are porous plaster rather than concrete, increasing potential for sewage infiltration into cracks; infrequent disinfection and cleaning also exacerbates poor quality (cleaning costs may prevent households from more regular maintenance). The Ministry of Health distributes free chlorine tablets to villagers.

However, due to Israeli closures delivery of these is sporadic, and there may be an issue with villagers' disliking the chlorine taste and odor.

2.4 WASTEWATER CHARACTERISTICS

Current wastewater composition is mainly domestic, sanitary waste. Other sources of wastewater are: olive oil processing, wastewater from stonecutting and brick manufacturing, chicken farms and butcheries. In total, this waste stream would not contribute significantly to the total wastewater stream, however a qualitative summary of each is included herein.

Olive oil processing: Olive products (fruit, oil and wood) are a significant agricultural product in most villages, especially in the Nablus area. The olive oil pressing season extends only for two months from mid-October to mid-December. Manual, semi-automatic or fully automated presses are used for the olive pressing. Water is used to clean the raw olives and to facilitate oil extraction. Depending on the equipment, the quantity of the water needed varies. Consequently, the quantity and quality of the wastewater stream (called in Arabic *zeebar)* is site-specific but is rich in complex compounds such as phenol acids that would inhibit any biological wastewater treatment process. At present, the wastewater from the olive mills is discharged to cesspits that are evacuated after the olive oil season and disposed of randomly in the nearby wadis. Several studies have been investigated handling and treatment of the *zeebar*. In addition, the Ministry of Environmental Affairs (MEnA) is currently examining *zeebar* treatment alternatives as part of the Environmental Hot Spots Project.

Liquid waste from chicken farms and village butcheries is another small wastewater flow stream. Chicken coops are cleaned out monthly, and the water disposed of by land application along with the chicken manure. Butcher shops generally have their own cesspit into which slaughterhouse wastewater is discharged.

Liquid waste from stonecutting and brick making is usually in the form of a sludge that is pumped out from on-site sedimentation basins and discharged into a wadi.

Because there is no formal wastewater collection system, the issue of combined sewers does not arise. There are no stormwater drainage systems, rainwater is usually collected by various rainwater harvesting techniques and stored in household underground cisterns. In those cases where this is not done, stormwater flooding is not a problem because the villages have few paved roads and the runoff usually infiltrates into groundwater. However, stormwater does pose a hazard in that it can flood cesspits and carry wastewater into cisterns and up onto streets and wadis increasing the potential for direct human contact. Protection of cesspits and health education should be a component of the concurrent VWS institutional programs.

2.5 TOILETS, COLLECTION AND TREATMENT SYSTEMS

The clusters that are being considered are located in semi-urban to rural areas where no cohesive community wastewater collection and treatment systems exist. The following is a description of the different methods of wastewater disposal practices in the villages within the project area and reflect the general situation of wastewater disposal in the West Bank.

2.5.1 Toilets

The most common type of toilet is the squat-pan pour flush toilet. That is, water in a bucket is used for flushing excreta into a cesspit or other collection system. Some affluent

households will have an additional pedestal-type toilet with a tank-flush mechanism. However, it has been reported that even if a tank flush mechanism exists, people will prefer to use a bucket in order to save water. It is estimated, based on PBCS statistics that 98% of households in West Bank use pour or tank flush toilets. Other deposition methods, such as pit latrines, or open defecation are rare and limited to less than 2% of households (except for when people are out working in the fields). Pit latrines have been used for hundreds of years, especially in urban areas before being replaced by the cesspits and later on by the sewage systems. They were well promoted in the rural areas during the middle of the last century through an environmental health program implemented by the Jordanian Government and UNRWA during the Jordanian rule of the West Bank. As villages developed, the pit latrines were abandoned and replaced by the cesspits. However, some householders are still using the pit latrine because they cannot afford the change to another system, especially in the very small remote rural communities.

2.5.2 Cesspits

Cesspits (or cesspools) are the traditional method for sewage disposal in Palestine. It has been used for centuries in all the communities before they were slowly replaced in the major cities by the sewage collection networks. However, they are still used in the villages and the rural communities.

Cesspits are essentially covered pits that receive raw sewage. They are dug into pervious soils . They are deliberately constructed without bottom and with a permeable side lining to allow the liquid portion of the waste to seep off into the ground. In some case they are sealed from all sides except the bottom. They are fully sealed from the top to prevent the infiltration of the rainwater into the pit.

Cesspits are designed and constructed in different sizes ranging from 5 to 50 cubic meters depending on:

- The number of houses that will be connected to it,
- The availability of land, and
- The affordability to the house owner compared to the cost of construction.

With time, the solids accumulate in the pit and gradually seal the pores in the surrounding soil, which necessitates periodic emptying of the cesspit by vacuum tankers. This service is provided sometimes by the private sector, sometimes by the village councils. The average annual cost of emptying the cesspits in the southern West Bank is reported to be up to $400/HH/yr (where appropriate, household is abbreviated to HH). An average quantity of about 5 cubic meters of the cesspit contents is removed monthly from each cesspit. The evacuated septage is usually improperly disposed of in agricultural lands, nearby wadis or roadsides.

Wastewater flooding from the full cesspits has been observed in a large number of villages in the West Bank. A survey conducted by the Applied Research Institute – Jerusalem (ARIJ) showed that more than 60% of the surveyed villages (which included some West Bank villages) suffer from the flooding of cesspits and open channels. The solutions to this are better construction and maintenance, and increased frequency of evacuation. Although simple, villagers are completely capable of this, these measures are costly, and compete with expenditures on basic necessities.

2.5.3 Septic Tanks

The septic tank consists of a covered watertight settling tank into which raw sewage is drained by the building sewer. The process that takes place inside the septic tank constitutes a primary treatment of the raw sewage. The effluent is usually discharged to a buried, perforated pipe network for infiltration into the under lying soil. Further treatment of the liquid takes place in the soil matrix by anaerobic and aerobic bacteria.

The septic tank is more advanced than the cesspit as it provides a primary treatment and on-site disposal of the settled liquid. However, there still exists the problem of disposal of the sludge that accumulates in the tank. Typically, the effluent from a conventional single-chamber septic tank is of adequate quality to be drained into the subsurface via perforated pipes (the drainage area is called the leach field). Factors that have hampered its widespread application versus cesspits are: it requires a larger land area for the leach field and that it is more costly.

2.5.4 Advanced Septic Systems

An advanced form of the septic system consists of a dual chamber septic tank. The effluent from such a dual (or multi) chamber system is typically good enough to be collected and land applied. However, if the influent is of very high strength (such as concentrated sewage typical in Palestinian village) it may require further detention or be channeled to subsurface drainage. Primary sedimentation occurs in the first chamber and anaerobic decomposition takes place in the second chamber. The septic tank effluent is discharged to an agricultural field for subsurface irrigation through perforated pipes or tile pipes surrounded by a porous media such as coarse sand or gravel. Secondary treatment allowing for further BOD reduction takes place in the porous media (that simulate a filter) through the activity of the aerobic bacteria. Drainage fields require approximately 50-100 m^2 of land with a deep soil cover, dependent on septic tank size.

This system needs efficient primary treatment and clear effluent. Suspended matter carried by the effluent or by excessive slime growth can clog the pores. This system is not recommended where ground water or rocky layer is close to the surface. Experience has shown that tile pipes should not be laid closer than 90 centimeters to the ground water level. Sludge evacuation should not be required more than every one to two years for a well-functioning system.

Save the Children Federation (SCF) has implemented such a system in some of the study villages (including those proposed for pilot programs in this report) under the name of the Subsurface Drainage Technique or SDT.

Discussions with SCF and site visits showed that there have been some problems with SDT implementation. Many householders who were selected by SCF to use the system did not construct the SDT system according to the specifications. They were given materials and instructions with little ongoing oversight. Consequently most of them constructed either the septic tank alone or constructed a cesspit. Even those that were constructed according to the specifications did not work properly because of the low wastewater production rates (actual production rate was much lower than design). By learning from past problems, SCF and other NGOs continue to improve and introduce the SDT system in the villages. In general, the health education campaigns that have accompanied the SDT programs have had good results.

One upgrade to the SDT system is the ‘communal SDT’. This system consists of tying together several households to one large septic tank. Surprisingly, there does not seem to be significant cost savings reported for construction of such a system. From an

engineering standpoint, the communal SDT complicates matters because the increased effluent flow stream requires a correspondingly large drainage field. In at least one of the villages, the system was designed to have the tank effluent discharge directly into a wadi. There are however non-technical reasons why the communal SDT system has been recommended by NGOs. One reason is because a communal system necessitates the involvement of the village council and requires cooperation between neighbors, important intangible benefits. It is important to recognize that despite shortcomings, these systems may be the only feasible on-site sanitation option.

2.5.5 No Treatment

In some of the major cities and refugee camps, a sewer network exists without treatment facilities at the down stream end of the trunk line. The wastewater flows directly to the nearby wadis creating an aesthetic problem and potentially environmental and health hazards. Farmers at the sides of the wadis sometimes use the raw sewage in irrigating their agricultural crops, which are often vegetables that are eaten raw. Water resources close to the flowing raw sewage streams can also become polluted.

2.5.6 Other Technologies

A few innovative systems have been piloted on an experimental basis at a very small scale involving for example a school or some households in a village. These have included combinations of septic systems with collection and treatment. Some of technologies tested include: trickling filters, sequencing batch reactors and facultative ponds. These systems will be described in Section 3. Evaluation reports of these systems indicate that none of the systems piloted in more rural villages have been very successful.

2.6 WASTEWATER REUSE FOR AGRICULTURE

It should be stated from the outset that wastewater reuse is defined as reuse only for non-potable and non-direct human contact purposes. Wastewater could not be sufficiently treated at the household level to produce high quality water and would probably run into acceptability problems.

Currently some households reuse domestic gray water. While it would require a more detailed survey to quantify how many practice reuse, some general observations are included herein. The houses at the outskirts of the village center usually separate the gray wastewater from the black wastewater and reuse the gray water in irrigating their gardens. In village centers where houses are more crowded, this kind of separation of the gray water is not possible because houses are less likely to have gardens. However sometimes gray water from houses at the village center is separated from sewage and discharged to the streets probably to reduce frequency of cesspit evacuation. Some people have reported reusing gray water but have stopped because the soapy water from washing tends to pond rather than infiltrate and attracts insects.

There was an initiative by Palestinian Agricultural Relief Committees (PARC) to provide household filter units to allow gray water to be filtered to a point where it was more suitable for garden irrigation. These systems consisted of three 200L drums in series filled with various gradations of gravel. Due to time constraints, a more detailed description and evaluation of the efficacy of the system could not be conducted.

There were no examples of systems where wastewater was being reused after some type of treatment, i.e. supernatant from a cesspit or SDT. This is thought to be because there is inadequate water, or because the tanks leak due to poor construction and the liquid

portion leaches out. However, in some of the more recent SDT projects, villagers are still expecting that SDT supernatant will eventually start to flow, and have plans for its reuse. This expectation is surprising, considering that tank effluent in a properly constructed SDT system would drain into the subsurface and therefore would never be available as an actual effluent flow stream above ground.

There was some anecdotal evidence that some villagers feel that reusing wastewater goes against Islamic laws. Upon investigation, it turns out that there is no such restriction, however such a habit may have been mis-reported by some early foreign researchers, whose results were then picked up and disseminated by subsequent sanitation programs.

2.7 SOLID WASTE

Several institutions provide solid Waste Management (SWM) services in the West Bank. In the main cities, the municipalities are responsible for the SWM services. In the villages, the village councils are usually responsible for collecting the solid waste. In some villages, private contractors collect and dispose the solid waste. In the refugee camps, United Nations Relief and Work Agency (UNRWA) is responsible for solid waste collection and disposal.

2.8 EVALUATION OF EXISTING PRACTICES

It is difficult to adequately evaluate villagers' water and sanitation practices to determine causal links in such a short-term study. An attempt is made here is to list potentially high-risk behavior and less than optimal living conditions and highlight some of the possible negative impacts. In reviewing the following, it should be kept in mind that these problems will be greatly magnified if/when water supply increases (taking a pro-active sanitation approach). Potential high-risk conditions:

1. Poorly constructed water cisterns in close proximity to cesspits that may leak, flood or overflow
2. Dumping of gray water onto the streets
3. Increasing population size requiring more frequent cesspit evacuation combined with villagers' reduced economic situation due to Israeli closures
4. Faulty SDT construction and application
5. Villagers' misapprehension of SDT function, especially perception that it is supposed to provide them with a useable wastewater stream
6. Water ponding and insects caused by some villagers' graywater reuse practices
7. Untreated wastewater and sludge from cesspits or sewer networks being directly discharged to wadis
8. Untreated wastewater and sludge from cesspits or sewer networks being directly land applied

Because of the above 'causes' the following 'effects' may be occurring:

1. Environmental pollution of groundwater resources, especially shallow springs
2. Health problems from overloaded cesspits and subsurface infiltration of sewage into leaky water cisterns and shallow springs (exacerbated in rainy season)
3. Health problems from consumption of crops irrigated with untreated wastewater sewage
4. Increasing water table levels from wastewater seeping into the subsurface.
5. SDTs acting merely as holding tanks, not primary treatment (measured SDT effluent quality values not available)
6. Failure of SDTs to perform to villagers' expectations, thereby undermining their confidence in external sanitation interventions

7. Exacerbation of already difficult economic conditions due to increasing frequency of cesspit evacuation and consequent increased annual sanitation costs

Some of the positive behaviors observed include:

1. Villagers very open to the idea of wastewater reuse
2. Village councils eager for improved wastewater treatment (i.e. there is a demand)

2.9 CURRENT COSTS

The costs associated with wastewater disposal are difficult to quantify or summarize in general statistics because of the lack of data and also because of the site-specific differences in sanitation (cesspit size, household size, subsurface soil). These limitations render cost numbers very approximate. Recognizing this, municipal surveys indicated that maximum costs are incurred in those households with a large number of people and with poor soil conditions, resulting in costs of about $400/yr/HH (cesspit evacuation every month at $25/evacuation). Minimum costs are approximately $25/yr/HH. There are of course many intangibles such as costs associated with inconveniences, poor health and environmental deterioration due to sanitation conditions.

Finally, a comparison of cost vs. income is even more difficult to quantify as the *intifada* effects have so depressed the village economy. Standard rules of thumb (e.g. water and sanitation costs should be from 2% - 8% or even less of household income) used in gauging the burden of utility tariffs are virtually meaningless. A recent PCBS statistics showed annual HH village income estimate (pre-*intifada*) less than $10,000/yr. Current income would likely be much lower.

3 EVALUATION OF ALTERNATIVES

3.1 EXPECTED FUTURE CONDITIONS

3.1.1 Wastewater Flow Projections

Future wastewater production values were based on the water demand projections as outlined in the *Preliminary Design Report for the West Hebron Service Area Distribution System Networks* and the *Feasibility Report for Water Systems in the South Nablus Area* produced under the same USAID contract as this report. The planning horizon for the water pre-designs was 2023. However, as will be detailed in this section, the current wastewater situation in some of the villages lends itself to on-site treatment options with a closer horizon. This being the case, it is recommended that a 5 or 10-yr planning horizon be considered for those villages. A planning horizon does not have significant impact on the design of an on-site system, i.e., more treatment units can be added as houses are built. Essentially construction is implemented for existing population only.

However, for villages where collection and centralized treatment is more appropriate, a 10-yr horizon can be used for sizing of the collection and treatment plants. As noted in Annex 2, design year 2003 and 2013 projections are shown. Wastewater flow values were derived by taking 60% of the projected water demand (20% removed for system losses between water supply and households, and another 20% removed for water consumption in the household).

3.1.2 Wastewater Characteristics

Wastewater characteristics are not projected to change significantly in the near future. That is, domestic wastewater is expected to be the most significant contributor to the flow stream. There is no projected increase in industrial or commercial wastewater production. As in existing conditions, it is expected wastewater from commercial enterprises will continue to be pre-treated on-site in cesspits, as with stone and brick processing by-products or slaughterhouse wastes, before discharge to the sewer system. It cannot be over-emphasized that those waste streams that could harm a biological wastewater treatment plant, such as olive oil wastes, must be collected and processed in an entirely different system and that significant public education be conducted to ensure that such wastes never enter the sewer system. Olive oil wastes were not considered in this scope of work because there is already a program underway by the Ministry of Environmental Affairs.

Due to the lack of water and extreme frugality with which villagers use water, the current wastewater is characterized as being of ‘high strength’. If improved water supply does materialize in these villages, it is possible that the wastewater could become characterized as ‘medium strength’. However, there will not be significant difference in wastewater treatment methodology for medium or high strength wastewater. Table 3.1 below shows typical domestic black water characteristics based on measured values from similar villages in the West Bank (see Annex 3). Also listed are MEnA Treated Wastewater Effluent Standards for Aquifer Recharge (effectively, this is the standard for discharge from a treatment plant to a wadi).

Table 3.1 Typical Domestic Black Wastewater Strength Characteristics and MEnA Effluent Standards

Parameter	Expected Domestic Wastewater Characteristics [a] (mg/L)	MEnA Treated Wastewater Effluent Standard for 'Aquifer Recharge' (mg/L)
Biochemical Oxygen Demand (BOD)	1,000	40
Chemical Oxygen Demand (COD)	2,000	150
Total Suspended Solids (TSS)	1,200	50

a) See Annex 3 for references. Measured values for other parameters such as nitrogen were not available. BOD was based on 50g/d/capita, 72l/c/d domestic wastewater flow rate (design for worst case). COD was taken at 2:1 ratio.

3.2 TREATMENT SELECTION CRITERIA

The following selection criteria were used to help select systems most appropriate for use in the West Bank villages:

Low Cost: The majority of the rural population in the study area is of a lower income than those in larger, more developed urban centers. This situation has been greatly exacerbated by the severe economic stress caused by the *intifada*. Unemployment is high and the village authorities report that more and more people are unable to pay for basic services such as water. Therefore, low costs heads the list of selection criteria, as follows:

- low capital costs (materials and labor)
- low O&M costs (labor, running costs such as electricity, chemical costs)
- low household connection costs

Ease of Maintenance: By the nature of rural villages, it is difficult to find skilled labor to operate and maintain equipment. Therefore the technology selected should be 'stand-alone':

- Minimize mechanical parts
- Simple to understand and operate
- Include fail-safe mechanisms so that treatment problems manifest quickly and obviously and are not costly or complicated to repair
- Does not require frequent sampling and analysis (in particular, real-time treatment decisions must not depend on such sampling)

Capable of Treating High-Strength Wastewater: As discussed, the treatment influent is expected to be concentrated due to the villagers' water-conservative habits. The treatment technology must therefore be capable of handling high strength domestic wastewater.

Ability to be Built in Modular Units. Two major uncertainties exist: whether increased water supply and subsequent increased wastewater will actually materialize, and projected population increases. A previous project designed anaerobic ponds for an anticipated future 'design' flow rate. When this did not materialize, all the design calculations such as hydraulic retention rates were wrong, resulting in a malfunctioning plant. A modular design, e.g. one with parallel flow trains, will allow the treatment plant flexibility for flow variations.

Reuse of End- and By-products: Because of the water scarce conditions of these villages, it is imperative that the technology treats wastewater to the point that it can be

reused. In addition, it would be ideal if other by-products such as sludge or off-gas were useful. At the very least, by-products must not be toxic or require costly treatment prior to disposal.

Proven Technology: There are a number of studies that have suggested a wide range of treatment options for the West Bank, but relatively few implemented programs. Partly due to the time constraints of this study that did not allow for detailed evaluation of new techniques, technologies that have been tried and tested are greatly preferred to experimental technologies, regardless of how promising they seem.

Maximize Local Materials: Local materials will improve chances of adequate construction and ongoing O&M.

Gravity System: because of cost and operations considerations, systems that minimize or avoid pumping in the sewer network and at the plant site are most desirable.

Publicly Acceptable: The rural population has its own biases and prejudices; therefore it is imperative that publicly acceptable technologies are chosen with the community integrally involved in technology selection and design. The chosen treatment must at minimum not create nuisances such as odors or insects.

Environmentally Acceptable: the chosen technology must not create environmental pollution, especially with regard to groundwater contamination.

3.3 TECHNICAL OPTIONS

In some sites, with low-density villages, on-site options may be more appropriate than centralized collection and treatment. On-site options particularly must be designed with a view to being expandable, or be able to be retrofit into a larger system, as population density increases.

3.3.1 Toilets

Selection criteria for picking a toilet are: public acceptability, ease of use, minimization of health risk, compatibility with collection and treatment system and minimization of water used. Pit latrines do not meet these criteria and are also incompatible with current and future trends towards more sophisticated off-site treatment systems. Based on the available data it appears that the pour flush technique with a squat-pan ('eastern toilet') is the most widely accepted method in rural West Bank. In addition to its major advantage of already being well-accepted household practice, it is compatible with any ancillary collection system for both on and off-site treatment. Perhaps most importantly, it has significant water savings over a tank flush mechanism. Although low-volume tank-flush mechanisms are available, they are not common and would require household retrofits, which will likely not be affordable during this economically stressed time.

3.3.2 On Site Treatment Options

Available on-site options are cesspits, septic tanks, and advanced septic systems. These types of systems are already in use in most of the villages and are described in detail in Section 2.5. Cesspits cannot be considered a bad technology *a priori*. Efficacy of cesspits is a function of HH size, cesspit volume (cesspit volume per person), soil conditions, proximity of an underground water source (cisterns, shallow springs etc) and public acceptance (vs. demand for better sanitation). Given the right conditions, i.e., low population density, large land area, suitable soil (conditions that are difficult to quantify

scientifically) cesspits can be acceptable. However, for these villages with increasing population density, increasing land price, very permeable soils, numerous shallow springs and increasing sanitation demand, cesspits are not considered a feasible long-term solution. Finally, there was a pilot program effort by PHG in the Hebron district to implement dry sanitation (i.e. urine separation) units. This was not considered further because it goes against current household practice.

3.3.3 Off-Site Treatment Options

Centralized collection and treatment is appropriate for those villages with high population density where yard or street space is not available for on-site systems. Because of cost considerations, it is important that all consideration be given to those systems that can be hydraulically configured so as to avoid pumping in the sewer system or at the plant. Off-site systems have three components: collection systems (i.e. sewers), treatment plants and effluent disposal.

Collection Systems

There are three main options for sewage collection: conventional gravity sewers, simplified sewers, and small-bore or settled sewers.

Conventional sewers

In conventional sewers, both gray and black wastewaters are carried away for disposal away from the household. This system must accommodate the water borne transportation of solid particles up to 100 mm size. This has important implications on the siting and size of the sewer system. If, in any part of the sewage system, there should be a low point, heavy particles, which do not remain in suspension, will tend to be deposited and in time build up to form a blockage. Even if the sewer has a constant fall, the solid particles can settle and remain as deposits unless there is enough water with a fall that provides a velocity of flow sufficient to wash those particles away. The velocities should be sufficient to cause turbulent flow where eddies tend to lift all but the heaviest particles into suspension.

In conventional designs, sewers are usually located in public highways, right-of ways or commonly held land. Each property will have an individual connection to the sewer. In addition, sewers normally have a minimum diameter of 150mm to avoid blockage and minimum cover of 900mm in order to ensure protection from imposed traffic loads. It is generally accepted that conventional sewerage is the most expensive system for collecting sewage.

Simplified sewers

In order to overcome the high costs of traditional sewers, other approaches have been implemented. Simplified sewers operate as conventional sewers, but with a number of modifications:

- the minimum diameter and minimum acceptable cover are reduced
- the slope is determined by using the tractive force concept (i.e. vacuum or pumping) or by velocity of resuspension of solids, rather than the minimum velocity of flow
- using tractive force allows small diameter sewers with full flow in the pipe (but pumping or vacuum can increase costs)
- sewers are installed below footpaths where possible and many costly manholes are eliminated or replaced with less expensive structures.

In simplified sewers systems, the division of the network into small elements avoids long trunk sewers, large pump stations and deep excavations and, where feasible, a project area can be defined by individual drainage basins, each with its own collection sewer and treatment facility. Because of the nature of the hydraulic concepts involved, the design of these sewers requires application of different equations and analyses than traditional partial flow sewers.

There can be a savings of 20% - 50% on the conventional system for the same area coverage. These systems are more applicable in city centers or densely populated areas like the refugee camps than in rural villages.

Settled sewers

Settled sewage is a technical combination of an on-site disposal system with an effluent collection system of small pipes that receives and transports sewage from which solids have been settled at on-site locations.

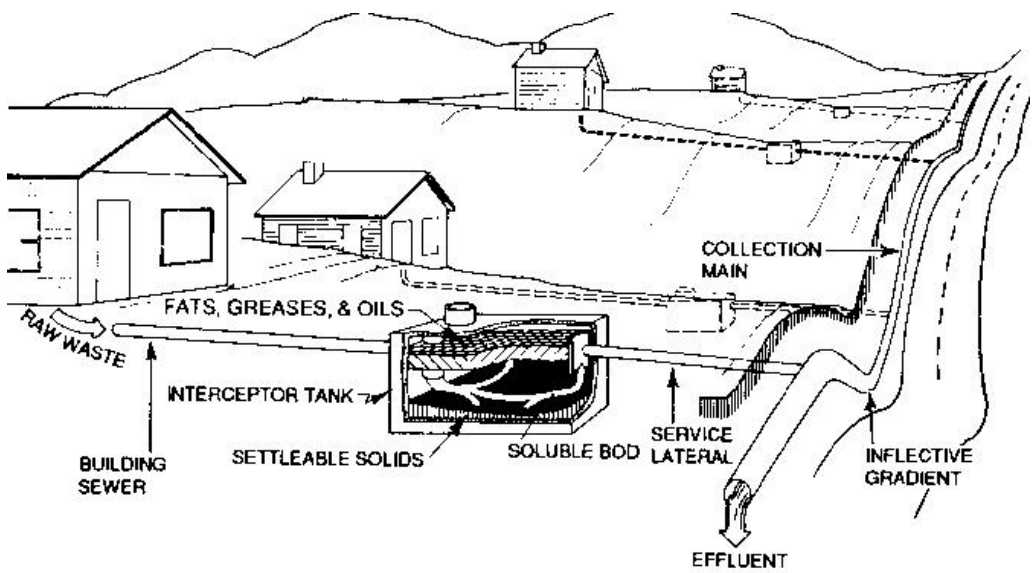


Figure 3-1 Settled Sewage System
From WAWTTAR

In this system, wastewater is collected in an interceptor tank. The interceptor tank acts as a septic tank in which there is sedimentation of the solids from the wastewater, storage of the accumulated solids for a significant amount of time (can be three or more years), anaerobic digestion of the accumulated sludge (reducing the BOD and quantity of sludge), and flow attenuation by reducing peak flows. For the West Bank context, it should be borne in mind that many households have yards behind the houses and additional piping might be required to convey the settled wastewater to street sewers.

The solids-free effluent is discharged into small-diameter, shallow pipes operating by gravity, at full section, without the need for limitations for gradient, velocity or tractive force. The interception tanks must be evacuated on a regular basis. Thus, the importance of community participation in the decision-making process, as, if the tanks are

not emptied on a timely basis, the system can be compromised through solids trying flow down the narrow diameter pipes.

This system also has the advantage of allowing bypass of a primary settling stage at the wastewater treatment plant.

A combination of the above technologies can be used depending on site constraints such as topography, density of housing, road width and use.

Treatment Systems

Central to a wastewater treatment system is a process to stabilize organic matter and remove nutrients in the wastewater. A basic form for this is a waste stabilization pond. Aquatic plants, weeds, algae and microorganisms stabilize the organic matter. Algae give off oxygen that is used by microorganisms to digest the organic matter. The microorganisms give off carbon dioxide, ammonia, and phosphates that the algae use. There are several types of stabilization ponds. Aerobic ponds are shallow ponds (less than 2m) where dissolved oxygen is maintained throughout the entire depth, mainly by action of photosynthesis or through mechanical aeration. Facultative ponds have an anaerobic lower zone, a facultative middle zone and an aerobic upper zone. The upper zone is maintained in aerobic conditions by photosynthesis or by mechanical aeration. Anaerobic ponds are so deep and receive such a high organic loading that anaerobic conditions prevail throughout the entire depth. Many systems include all three pond types with a deeper anaerobic pond followed by a facultative pond and finally an aerobic or maturation pond for final treatment of the effluent.

In addition to waste stabilization, there are ancillary processes such as primary settling which occurs before biological treatment, and tertiary or polishing processes to treat the effluent from the stabilization ponds. Polishing processes can be maturation ponds or filters. Maturation ponds are used for polishing effluent from secondary biological processes, using dissolved oxygen from photosynthesis or mechanical aeration.

While myriads of combinations exist for primary, secondary and tertiary treatment, a pre-selection was made for consideration in the Palestinian context. This list was formed based primarily on low-cost, low-tech treatment methodologies that would work in a rural or semi-urban context, with a bias towards those that have been proposed or tried in the region. From this general list, a few on and off site technologies have been short-listed as being optimal based on more detailed selection criteria as described in Sections 3.3 and 3.4.

<u>Aerobic Processes</u>

These are processes designed around aerobic degradation of wastewater.

1. Aerated Ponds – An aerated pond is a stabilization pond that has mechanical aerators. Such ponds are typically deeper and have shorter detention times than non-aerated ponds. In warm climates and with floating aerators, small areas can support several hundred kilograms of BOD reduction per day.
2. Activated Sludge Processes – this is a technique in which a mixture of wastewater and recycled sludge (water, organic and inorganic solids and treatment chemicals that accumulates in settling tanks) is aerated to produce a highly activate biomass which degrades organic material at a high rate. Typically, activated sludge processes are operations-intensive, requiring pumping, sludge recycle, mechanical mixing and mechanical aeration. Extended aeration processes can be used to

eliminate the pre-settling step and continuous sludge wasting. The Oxidation Ditch is a type of extended aeration system in which the aeration tank is replaced by narrow oval ditch in which wastewater is mechanically aerated.

3. Aerobic (High-Rate) Algal Ponds (facultative algal ponds will be discussed below) - These are aerobic stabilization ponds with or without mechanical aerators, and with or without recycle. The rate of reaction depends on the ancillary processes, with recycle and mechanical aeration, the rates of reaction will increase, and the process can be classified 'high-rate'. Algae grown in the pond can be harvested as animal feed or disposed of with sludge, however this requires a solids separation step. In the West Bank villages this type of system would require an additional public education step as well as more processes for algae separation.
4. Trickling Filters – These are filter beds filled with a rock or plastic media upon which biomass attaches. Wastewater is 'trickled' at a low rate to maintain aerobic conditions over the top of the filter bed. Although quite efficient, trickling filters are relatively costly, require significant O&M, and require a secondary settling step.

Anaerobic Processes

These are processes designed around anaerobic degradation of wastewater. Anaerobic metabolism is higher rate and more efficient than aerobic.

1. Anaerobic Ponds - These are relatively deep and designed to receive such a high organic loading that anaerobic conditions prevail throughout the entire depth. With optimum operation, up to 75% of BOD reduction can be achieved. Advantages are that is it suitable for gravity fed influent, will accept large flow variations and requires minimal sludge handling.
2. Anaerobic Rock Filters – These are deep filter beds filled with a rock media upon which biomass attaches. Wastewater flows upwards through the filter bed. This method is suitable for low strength wastes. However field-tested applications of this technology should be investigated before design.
3. Upflow Anaerobic Sludge Blanket (UASB) Reactors - This technology consists of a tank in which the wastewater is introduced at the bottom. Biogas is produced as an end product of organic digestion, which escapes as bubbles, thus providing the mixing needed and then drawn off from the top of the tank. Major drawbacks of this system are vulnerability to flow variations, making it difficult to maintain a gravity fed system, although this can to some extent be buffered by an upstream buffer tank, interceptor tanks in small-bore sewage (surge inflows can blow the sludge blanket out); frequent sludge draw-off (manual or automatic) and lower efficiency with BOD values less than 1000 mg/L.

Facultative and Combined Processes:

These are processes using facultative bacteria (bacteria that can metabolize both anaerobically or aerobically depending on conditions) or using a combination of aerobic and anaerobic processes in sequence.

1. Facultative Ponds – Facultative ponds have an anaerobic layer at the bottom and an aerobic layer at the top, with a facultative zone (facultative bacteria can metabolize both anaerobically or aerobically) in the middle. Facultative ponds are the most common pond type selected for small communities in the United States. Long retention times and large volumes easily handle large fluctuations in wastewater flow and strength with no significant effect on effluent quality.
2. Anaerobic Facultative Maturation Ponds: This is a combination of the processes already described, i.e. a 3 step process. The maturation pond provides fecal

coliform reduction and final effluent polishing. Without mechanical aeration, facultative and maturation ponds, would occupy 50% more land than aerated ponds. One variation of the facultative pond is the **Facultative (High-Rate) Algal Pond**. In this version, flow enters at the bottom of a deep pond; anaerobic process dominate at the bottom, and aerobic processes dominate at the top. Algae that produce oxygen-rich conditions sustain the top aerobic zone. Facultative bacteria live in the intermediate zone. Again, this concept can be applied with variations that will affect the rate of reaction or such as recycle and mechanical aeration. [The process can also be two-step, with an anaerobic pre-settling tank followed by an aerobic shallow algal pond].

3. Package plants - These are small compact plants that come ready-made from the manufacturer. Typically they are expensive and highly mechanized although they are very efficient and require minimal area. There has been one such plant implemented in the Jordan Valley Zubedat Village where land costs were so high that the package plant was more cost effective.
4. Imhoff Tank- these are a combination tank that allows primary settling at the top with anaerobic treatment zone at the bottom. These tanks require continuous or frequent sludge draw-off from the bottom of the tank, and work best with dilute wastewater.

<u>Ancillary Processes</u>

These are processes that can be used in *addition* to the main waste stabilization process to either improve the efficiency of bacterial processes, allow use of process by-products, or to help meet effluent discharge criteria.

1. Primary Settling – this provides a physical removal process to remove most of the settleable or suspended solids. With domestic wastewater, a 25%-25% reduction in BOD is expected. Primary settling can be done in a settling basin at the plant site, or with interceptor tanks as described in the 'settled sewers' Section 3.2.3 above.
2. Trickling Filter as a polishing step: although too expensive when used in combination with a standard primary settler, this process could be used as a secondary system, e.g. downstream of a UASB reactor. The same organic loading rate can be applied as when treating pre-settled wastewater, but at much higher hydraulic loadings, since the BOD of the influent is quite low already.
3. Constructed Wetland Ponds with crop harvesting. These have been used for disposal of treated waste effluent. Effluent is released to depths of approximately 0.2m. Reeds, grasses (as in a program in Sarah village) or duckweed (as in a pilot program in Jericho) are planted for nutrient uptake and can be harvested and sold.
4. Sand filtration – for small populations, a slow sand filter (or intermittent sand filter) is suitable. It consists of a layer of sand about 2m thick, upon which pre-treated wastewater is applied intermittently (several filters can be operated in parallel with intermittent application of wastewater). When wastewater is not being applied, air goes through the filter, maintaining aerobic conditions. After a certain number of loading and drying cycles, the top layer can be scraped off manually. It is used as a final step to polish the effluent from the main stabilization process. Although the designs are similar to those used in water supply treatment, coarser media is used since the turbidity requirements are less stringent. Another feature of the system has been described in a prior UN report: "poor or lacking maintenance will not directly lead to a deterioration of effluent quality, but to flooding of the filters and subsequently of the treatment site itself, incidents that will not go unnoticed and that will be addressed".

3.4 WASTEWATER EFFLUENT STANDARDS

The Ministry of Environmental Affairs (MEnA) has prepared a comprehensive document on wastewater effluent guidelines. This sets effluent quality standards based on the type of reuse. Effluent that will be reused for crops that grow low to the ground have the most rigorous standards, followed by tree crops; the most lenient standards are for discharge into a dry wadi that could be classified as 'aquifer recharge'. The wadi discharge standards have been included in Table 3.1. The type of reuse and the standard to be met (as well as potentially, negotiations with MEnA on the guidelines) and must guide treatment selection during the pre-design phase of any wastewater treatment project. Close consultation with the community with a view to potential reuse possibilities will be critical. For the pilot programs to be implemented under the VWS, there will also be close coordination with the concurrent institutional programs, which will be investigating wastewater reuse at a national level (also under the VWS program). The MEnA standards have been included in Annex 4.

3.5 MOST FEASIBLE SYSTEMS

There is no simple equation based on population density to determine whether or not an on-site system is suitable. Several factors must be considered such as land price, public acceptance and variations in projected growth rates. Each project has to be evaluated on a case-by-case basis. Based on the criteria outlined above, a qualitative ranking showed a range of systems to be the most appropriate for the Palestinian context.

On-site systems: Individual or communal septic systems such as the SDT appear to be the best choice because they have been widely tested, and a system exists to ensure public acceptance. In the villages where SDTs had been piloted, there seems to be a great demand for them amongst the villagers without systems. In one village, there had been reports of people making illegal connection to the existing communal SDT network under construction. SCF, who pioneered this system in Palestine, has recognized that there were some problems with SDTs in the past, but has been continuously improving the methods and implementation. For example, one of the weaknesses of earlier pilot projects was inadequate construction supervision leading to leaky or faulty SDTs. Improved oversight in construction and O&M has been added to new programs. The fact that this system has been so well field-tested is one of its major advantages.

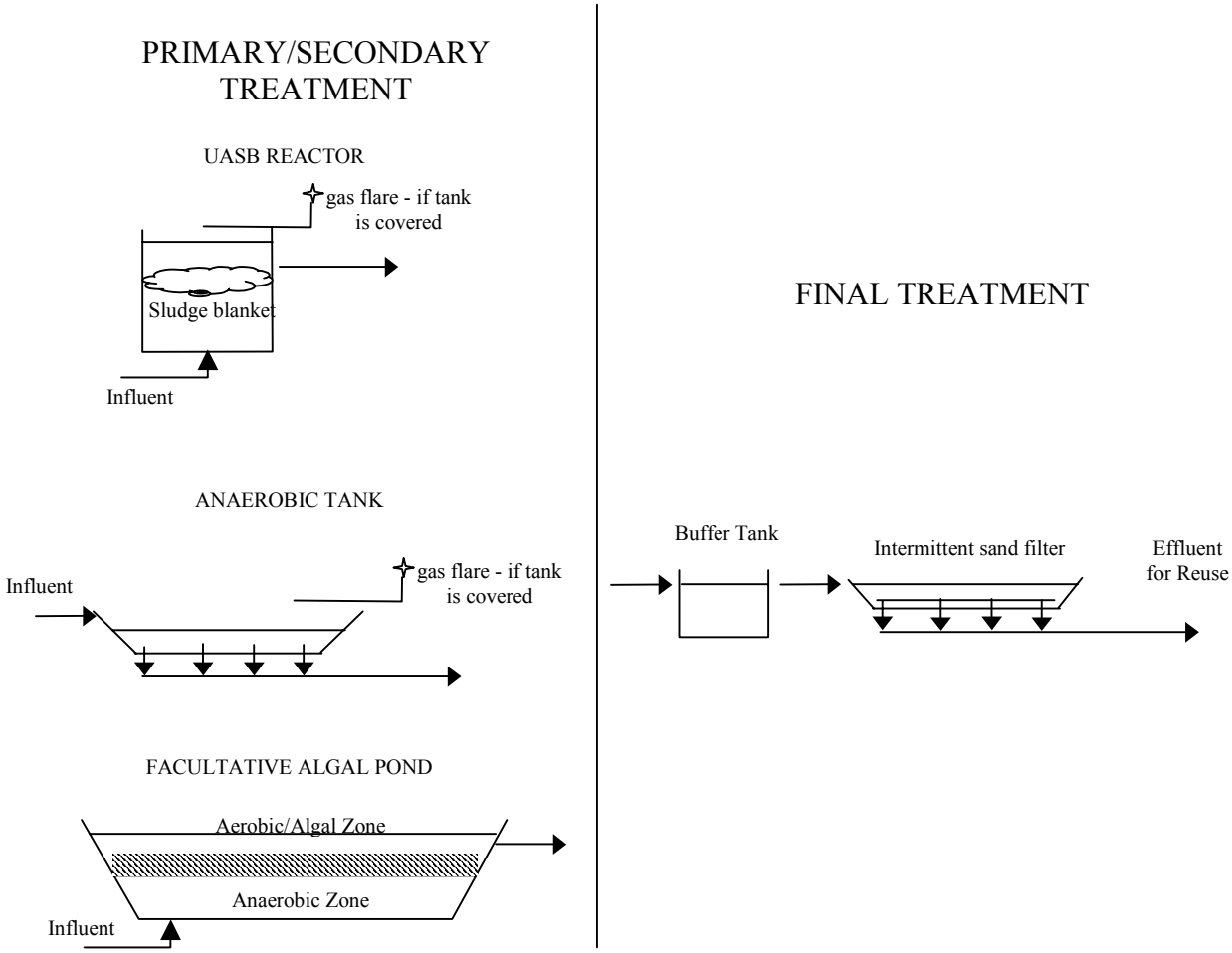
Off-Site systems: An off-site system might be appropriate for village level sanitation in more dense or rapidly growing villages where on-site systems will not work. The following process train meets all the above selection criteria:

1. Interceptor tanks as a pretreatment step with small bore/settled sewers or conventional sewers depending on topography and a cost benefit analysis that includes future O&M costs.
2. Treatment processes: feasible options are:
    - Covered or uncovered anaerobic tanks
    - Upflow anaerobic sludge blanket (UASB) reactor
    - Facultative Algal ponds
3. Buffer tank and intermittent sand filter with effluent reuse
4. Other ancillary processes to be considered include: gas capture (can be dangerous), land application of sludge, algae harvesting.

Issues that need to be resolved in design include: effluent quality criteria (and reuse potential), treatment selection, sludge disposal, off-gas disposal, and land availability.

Schematics of the systems are shown in Figures 3-1. A rigorous cost-benefit analysis for selection of the system and detailed cost estimates must be included in pre-design.

Figure 3-1 Treatment Options



3.6 OPERATIONS AND MAINTENANCE

Ongoing O&M will be a major concern with any system that requires a centralized waste treatment facility. A major O&M component will be the maintenance of the sewers and pumping out of anaerobic tanks. Use of intermittent sand filters will require a person to be onsite to monitor the flow rates. This is another reason why institutional capacity building of the village council will be critical to successful management of both on and off site wastewater system. In addition, there needs to be some kind of ongoing outside support to help troubleshoot institutional and technical problems, perhaps through a 'service contract' with a local NGO and/or the JSC.

3.7 SITE SELECTION CRITERIA

The following criteria must be used to select the plant site:

1. As dictated by hydraulic analysis so as to avoid or minimize pumping
2. Proximity to wadi or fields for reuse or disposal of wastewater effluent. Reuse requires locations where the soil is suitable for irrigation, and the ability to handle flows when irrigation is not required in the rainy season

3. Minimize piping requirements from households
4. At sufficient distance from densely inhabited areas so as to not create a nuisance to villagers
5. Available land for future expansion

3.8 WASTEWATER REUSE AND SLUDGE DISPOSAL

It appears that a certain number of villagers are already either reusing their wastewater, or are eager to do so. Therefore, public acceptability, one of the major hurdles to reuse, has already been surmounted. Other factors influencing reuse are: over-abundant effluent from SDT (if/when water supply increases); distance from treatment plant. Ideally, sludge from the wastewater digestion process should be land applied.

4 RECOMMENDED WEST BANK VILLAGE SANITATION APPROACH

4.1 GENERAL APPROACH

In the past several years, there has been general acceptance on the following basic principles for improving sanitation:

- **Sanitation is about health.** Millions of children die from diarrhea every year. Many of these deaths are preventable by adequate sanitation and related hygiene behavior change. The major aim of a sanitation programs should be to contribute to improving the health and quality of life of the population as a whole – especially the more vulnerable lower income families.

- **Properly designed sanitation helps the environment.** The natural environment – especially surface and underground water resources must be considered in all development activities and appropriate protection applied. The provision of water supply services that have unacceptable impacts on the environment is not sustainable or adequate. Similarly, the provision of sanitation services should also avoid having unacceptable impacts on the environment.

- **The root causes of inadequate sanitation are insufficient recurrent revenues and poor management - not inappropriate technologies.** In the majority of cases where the provision of sanitation services have failed, the root causes were found to be poor management, lack of planning and failure to generate revenue sufficient to operate and maintain systems. Trying to solve the problem by introducing a new and more "appropriate technology" more often than not fails to address the main constraints.

- **Sanitation service provision is a local function.** The nature of sanitation makes it an inherently local function that requires the involvement of local government, the community as a whole, and individual households. Central government does have a role, however, in regulation, standard setting, technical assistance, and financing.

- **Sanitation should be driven by informed household demand.** For sanitation interventions to be sustainable and successful in preventing diseases, households should explicitly demonstrate their demand for sanitation as a priority by expressing a willingness to pay for the recurrent costs involved in operating and maintaining a sanitation system. In many cases, demand may need to be created by providing information about the need and importance of sanitation and information about the options and related costs available. Worldwide experience has repeatedly shown that sanitation systems that are "supplied" inevitably end in failure.

- **Users should pay for all recurrent costs, but sanitation interventions should be affordable by households.** For a sanitation system to be sustainable, the service provider must recover all O&M costs. For this to be feasible, any proposed sanitation system must have operations and maintenance costs that are within the ability of a household to pay. It is important that the recurrent costs for sanitation be recognized as distinct from the recurrent costs for water systems and the related tariff of both together need to be affordable at the household level.

- **Targeted subsidies may be appropriate.** Given the high capital costs involved in the construction of basic infrastructure, governments and external donors may need to

subsidize the initial capital costs for the minimum basic level of service for poorer households and software costs such as hygiene promotion and training. Even these targeted subsidies will need to be prioritized given insufficient amount of subsidized capital funds available for sanitation. Governments and external donors and financial agencies should not subsidize recurrent O&M costs – but cross subsidies between richer and poorer households may be appropriate and required.

- **Water supply, sanitation and hygiene promotion need to be seen as a coherent sector.** Sanitation development is not possible in isolation from other sectors, and special note should be taken of the relationship between water supply, sanitation, hygiene behavior change and their synergistic impact on health. Co-ordination is necessary between different departments and agencies and different levels of government.

4.2 COMMUNITY PREPARATION: DEMAND CREATION

Even though some municipal officials may be aware of a sanitation problem, most people do not perceive that there is a 'wastewater problem', but rather a minor drainage problem. The water consumption habits of the people do not create a vast excess of wastewater. There are poor hygiene and environmental habits that are probably creating a sanitation problem, but the villagers do not necessarily see this connection. At this point, their higher priority problems are poverty and unemployment brought on by the *intifada* more than lack of water or problems of wastewater. Thus, there might be resistance to any sanitation intervention. People will not be inclined to pay for services that they do not think they need. There will have to be a significant work with the community before any sanitation interventions can take place. This can be outlined in the following steps based on the EHP document *Methodology for Improving Sanitation in Small Towns in Latin America*.

Determination of the interest of local officials. The starting point is the interest of local officials in improving sanitation services in their villages. Since the strategy seeks to improve services on a town-wide basis in a financially sustainable manner, the municipality must be a willing partner. Ensuring that the mayor and local council are fully supportive is a critical first step. To make an informed decision whether to participate in the development of a plan, local officials must understand the key issues that must be addressed as well as the process they are about to engage in. This includes a realistic picture of the time it will take, the commitment of time they must make, and an understanding that there are no easy solutions. They must also be committed to addressing the financial issues and accepting the health and environmental goals of improving sanitation services.

Organization of introductory public meeting. Once the local officials have formally agreed to participate in the activity, the next step is to develop and implement a strategy to introduce the project to the municipality. The purpose of this initial step is to inform the public, gain public support for the activity, and send the message that the plan will be developed in a way that takes everyone's perspective into account. The basic principles underlying the activity should be explained with a special focus on the importance of financial sustainability and that residents must be willing to pay for services. It should be made clear to the municipal public that this meeting is the first one and that they will be consulted at other critical points along the way. The strategy should target both a representative group of consumers and institutional stakeholders such as schools, commercial enterprises, hospitals, and government building. The strategy for introducing the activity to consumers should draw heavily on the techniques used for citizen participation in local government strengthening programs. These approaches include the use of public meetings at the village and neighborhood levels and information campaigns. The larger the village the more reliance there will be on information campaigns rather than face-to-face approaches.

4.3 COMMUNITY BASED TECHNICAL DESIGN

This section presents an overview of the steps for developing a plan for improving sanitation services in a village.

Preliminary Data Collection. Many sanitation projects fail because the project designers often take shortcuts and apply standard approaches and technologies without first taking into consideration that specific conditions of a given village and household preferences. It is not uncommon for engineers to decide what kind of technology is to be used in a project even before visiting the site. Designing an effective and sustainable sanitation project for a village requires a good understanding of the village's existing water supply systems as well as sanitation practices and systems and a preliminary determination of the demand for sanitation services. Information to be collected includes current sanitation systems as well as technical, financial, health, social, and environmental conditions. This will provide project designers, the municipality, the community members and other stakeholders with insights to guide the initial thinking and decision making process regarding the range of sanitation technologies and approaches that would be appropriate and sustainable for the specific village. This step should include a focused effort to consult a representative sample of households about the current technologies in use, what they like or do not like about their current sanitary solutions, ideas for improving their sanitation solutions, receptivity to on-site solutions, understanding of the connection between sanitation and health, hygiene practices such as whether children use the toilet, and how much they are currently paying for sanitation services.

This step could use some introductory questionnaires at the municipal and household levels as well as with farmers and other potential water users. It would probably be useful at the time to carry out a KAP (Knowledge, Attitude, and Practice) baseline survey to permit useful post project evaluation. The Environmental Health and Water Reuse Assessment, that are part of Task 2, will address this step specifically.

*Identification and costing of the range of feasible technical options***.** This step builds directly on the information collected in the previous step. The purpose of this step is to identify a range of sanitation related technologies that may be feasible and acceptable in order to present them to stakeholders in the next step. Each option should include a description of the benefits and drawbacks, an estimate of the capital and recurrent costs as well as the possible sources of financing and how that translates into tariffs. Conditions can vary greatly. In some villages, for example, on-site sanitation may not be feasible because of the density of population. If household connections for water supply are provided, then collection and disposition of wastewater must be addressed. The assessment of options should include household centered-approaches and more conventional wastewater collection and treatment and, if feasible, reuse of the treated wastewater. The examination of these options should be at the pre-feasibility level, which implies a preliminary analysis that will provide enough information to narrow the range of options for more detailed consideration. This step is critical in designing a sanitation project in that it will provide information to the stakeholders so that they can participate in an informed manner in expressing their sanitation needs and priorities. Options to be presented to stakeholders should be confined to those that are likely to be cost effective in reaching the maximum number of households in the village, provide the type and level of benefits that households expressed interest in, and are financially sustainable. Particular attention should also be paid to an appropriate estimation of population for a target year (i.e. design should be for some time in the future) and of the quality and quantity of wastewater to be treated, as well as effluent standards depending on what the expected reuse is going to be.

This report is a first definition in this process based on general conditions. This will have to be refined with more solid data obtained from the previous step.

Discussion of feasible technical options with municipal stakeholders and households. The purpose of this step is to present the full range of feasible technical options developed in the previous step to the municipality. These options should be shared with stakeholders so an informed decision can be made before proceeding with the development of detailed plans. This presentation should include the technical options, level of service, benefits, cost implications (particularly recurrent O&M costs), location of facilities, and health and environmental issues. As in a previous step, stakeholders consulted should include both institutional stakeholders such as schools, businesses, and clinics as well as households. The strategy for presenting the options should be adapted to the size of the village and the number of stakeholders to be consulted. The result of this step should be the selection of one or two options that would then be developed in much greater detail by the consultant team. The selection should be based not only on the most appropriate technology, but also on broad equity terms in reaching the highest number of households, financial capacity, willingness to pay, and health and environment concerns.

Detailed analysis of selected technical option(s). In this step the consultant team, in conjunction with the municipality, develops one or two options selected by the community and households in more detail. This analysis should include, in addition to a more detailed technical and financial analysis that began in a previous step, a specific proposal for a way to manage the services, including defining the relationship with a Joint Services Council and the PWA, a specific plan for incorporating hygiene behavior change, identification of the policy issues that must be addressed to move forward, and a preliminary assessment of the environmental impacts of the proposed plan. All technical options under review by this point should have been discussed and be acceptable by PWA. This step should also address the issue of availability of land for the selected options. The levels of participation by the community should also be defined

Public consultation to discuss detailed option(s). After the options have been thoroughly developed, they should be presented to the stakeholders for their reaction. As in the earlier steps that included consultation with the community, these discussions should include both the municipality in general and institutional stakeholders. The specific strategy for holding these discussions will vary depending on the size and complexity of the stakeholders. The purpose of the meeting is to elicit stakeholder reactions and to use that information in making a final decision. This consultation should, also, include a decision by the community on acceptable levels of community participation.

Decision by municipality on which option to select. The final decision is the municipality's, using its normal decision-making mechanism. In many countries, the mayor and local council, in some combination, decide. One of the benefits of placing the decision in the hands of local elected officials is that it reinforces the role of local government in general. Local governments must take into account the expressed wishes of community when making decisions, and this methodology allows for this consideration. Ultimately, however, the decision should be made by those who have been elected for that purpose, with some assistance from the consultant team in order to consider fully the technical, financial, social, institutional, health, and environmental issues. This step also includes the communication of the decision to the public.

At this point, if a funding mechanism has been identified, technical design should be detailed and assistance should be given in the preparation of tender documents. The construction contract could be tendered through a Steering Committee, which could include representatives from the PWA, JSC, Village Council, consultant/NGO and the donor.

4.4 COMMUNITY BASED CONSTRUCTION

Once the construction contract has been awarded, a system of construction supervision needs to be established through the consultant/NGO and the community in which the roles are well defined. The timely execution of construction activities that are the responsibility of the community is essential.

During construction, system specific O&M manuals should be prepared by the consultant/NGO in close collaboration with the builder and the community. This time should also be used for the initial training of operation technicians, managers, accountants, etc.

Once the works are completed, they should be handed over to the Village or Municipal Council, representing the JSC, or whoever has been empowered with the management of the facility. Follow up visits by the consultant/NGO should be done periodically to monitor the continuing O&M efforts and community acceptance.

4.5 COMMUNITY BASED HEALTH AND ENVIRONMENTAL EDUCATION

There needs to be long-term health, hygiene and environmental education campaigns that ensure that healthy and hygienic practices are adopted in order to make the best use of the investments made in sanitation. These campaigns will be established based on the environmental health assessment previously carried out. They are a specific objective of one of the Task 2 tasks.

In conclusion, this strategy is intended to firmly place the responsibility for improving sanitation services on local authorities rather than a central agency. The implication of this decentralized approach is that the financing of improved services is more closely tied to municipal finance. The strategy clearly is placing emphasis on the sustainability – both institutional and financial – of the system. Simply looking for low cost technologies for wastewater collection and treatment, even when these systems are not financially sustainable, is not a sound strategy. Finally, the strategy relies on full consultation with the municipality so that a system is not developed where there is no demand.

4.6 COMMUNITY BASED O&M

The community must be fully invested in the program so that, when ongoing operations and maintenance issues come up, the community knows how to deal with them. To this end, it is recommended that all materials be locally and cheaply available and that local construction capability be used, as much as possible. The actual daily operation of the any WWTP should be left, as much as possible, in the hands of locally based personnel, whilst more technical tasks could be carried out by “regional” personnel. The definition of the management structure is critical for the long-term sustainability. The clear definition of the task and roles of the different levels of personnel is also very important. Assistance should be given in the preparation of realistic O&M budgets as well as the associated wastewater tariffs. It is likely that the wastewater fees will be included in the water bills. This management support should be given for more than one year of operation.

4.7 ON-GOING MONITORING AND EXPERT SUPPORT

It is critical, particularly when introducing new types of systems into community, that provisions be made to provide at least medium term support to management as well to the O&M aspects. One of the major problems with most foreign donor programs has been

that they consist of short-term intervention, which does not give them a chance to build capacity within the community to deal with ongoing O&M and with institutional issues.

4.8 FINANCIAL CONSIDERATIONS

Within the context of financial considerations that have to be discussed with the communities, an approach of openness and transparency regarding all costs is important. The contribution of each (central agency, municipality, households, donor agency, bank, etc.) towards the costs must be determined. This would include in-kind contributions, such as labor, local materials, etc.

Amongst the costs that must be considered are:

- *Household Capital Costs*. These might include transforming their toilet to a pour flush system. Other capital costs, depending on the system, are the interceptor tank, connections to the sewerage system, etc. Again, the actual financial or in-kind contribution of the household must be well defined.

- *Household O&M Costs.* These might include costs of emptying the sludge from the interceptor tank (this cost might be included in the municipal water bill, but the household would end up paying for it) or the septic tank/SDT, the increased cost of flushing the toilet, any repairs to the system within the property of the household.

- *Collection Capital Costs.* These would include all the material and labor costs for the installation of the sewer network, including such appurtenances as manholes and clean-out units for settled sewage. The relative labor contribution between the household and the construction contractor needs early agreement.

- *Collection O&M costs.* These costs are often calculated as a percentage of collection capital costs.

- *Treatment Capital Costs.* The capital costs of the treatment system are calculated based on the design finally approved with the community and the actual cost of construction. Consideration needs to be given, as well, to the cost of expanding the system in the future if wastewater production increases with the population and with improved water supply systems. This would include operator training costs.

- *Treatment O&M Costs.* The treatment O&M costs can either be estimated as a percentage of capital costs, or can be taken in a more case specific situation, where actual O&M costs are estimated. These would include cost of personnel, vehicles, O&M equipment, vacuum tankers, etc.

- *Benefit of water reuse.* If the final effluent from the treatment system is sold to farmers, this income can be used to diminish burden of paying the recurrent O&M costs.

Even if it is likely that all (or most) capital costs will be paid by an outside agency, the recurrent O&M costs will have to be paid by the community for the system to be sustainable.

4.9 IMPLEMENTATION SCHEDULE FOR WEST BANK VILLAGES

This scope of work covers a feasibility study. Follow on tasks will cover community preparation. This will be followed by design and construction of one or two pilot programs for wastewater in the West Hebron villages. West Hebron is considered a higher priority

for a wastewater program because water upgrades are more imminent in this area than in the Nablus area.

5 WEST HEBRON PILOT PROGRAMS

A pilot program provides the first step to finding a solution for adequate sanitation in all the West Hebron and South Nablus study villages. Three potential sites have been short-listed in order to test an off-site treatment technology. It was decided to pilot only centralized collection and treatment systems because for on-site systems, only one real option exists (a septic system) and this is already being widely piloted and is quite well handled by NGOs using community labor. This USAID program has the advantage of being able to draw upon engineering expertise in design and construction management for the first Palestinian village-level full-scale centralized treatment system.

West Hebron was chosen as the focus because provision of adequate water is more imminent here than in the South Nablus cluster. In addition, the candidate villages already have a *relatively* good level of water supply, making the sanitation pilot program feasible, i.e. wastewater flow exists). This does not mean that other villages (in South Nablus or remaining villages in West Hebron) are not in need of a sanitation intervention. Rather, this pilot program should provide a blueprint for replication in other villages as and when funding becomes available.

It is imperative to note that only the general components of a technical design are outlined herein. A detailed design will be required to finalize treatment selection based on a cost/benefit analysis, and to develop tender documents.

5.1 SITE SELECTION

The following criteria were used in selecting program sites:

1. Population size between 1000 and 5000. PWA's policy is that populations of more than 5000 will need a conventional sewerage approach. Centralized collection and treatment is not economically feasible for populations of less than 1000.
2. Topography
    a. Reuse potential (availability of agricultural lands)
    b. Availability of land for treatment plant
    c. Minimization of pumping
3. Willingness to participate of following entities:
    a. Village Council
    b. The community as assessed by an NGO working in the area
    c. Community initiative in independent or NGO-aided programs
4. Economic level of the community (with a view to the community's being able to afford connection fees, construction costs, O&M costs etc.)
5. Political Area A or B (i.e. those areas under Palestinian civil control) in order to keep institutional oversight for the program within an administration most likely to have the Palestinian villagers' best interests in mind.
6. Must be in a village that already gets a sufficient water supply for there to *be* a serious wastewater disposal problem (this is the criteria that focused efforts on the West Hebron cluster).

Out of a choice of 28 potential sites in West Hebron, seven were pre-selected. Based on discussions with PWA and SCF, only three were short-listed: Deir Sammit, Nuba and the El Kum group. The name "El Kum Group" is a group of three villages El Kum, El Muwarraq and Beit Maqdum administered by one Joint Village Council (JVC). Data was collected on these candidate sites by:

- Discussions with PWA
- Discussions with SCF, which is active in the region

- Municipal survey as described in Section 2.1
- Site visits.

The data collected allowed scoring of each village for each selection criteria. The villages were ranked on a scale of 1-5 for each criterion; the results are summarized in Table 5-1 below.

Table 5-1 Ranking of Pilot Sites

Criterion No.	Nuba	Deir Samit	Al-Kum Group
1	5	5	5 (3 villages)
2 a 2 b 2 c	3 5 N/A	4 5 N/A	4 5 N/A
3 a 3 b 3 c	5 4 2	5 5 5	4 5 5
4	N/A	N/A	N/A
5	5 (Area B)	5 (Area B)	5 (Area B)
6	5	3	2
Total	**42**	**46**	**43**

N/A: Not available (inadequate data for ranking)

As shown, certain selection criteria could not be adequately judged at this preliminary step. Economic conditions were too difficult to assess due to current economic stresses brought on by the *intifada*. The topography with respect to pumping also requires detailed study. These issues will have to be investigated further during design to constitute a more quantitative analysis. If funds are not available to conduct all three pilots, the ranking can be used to prioritize needs. In addition, further discussions with the village council and community must be conducted to bolster initial perceptions as to willingness to participate.

5.2 GENERAL CHARACTERISTICS

The general characteristics of each site are summarized in Table 5-2.

Table 5-2 General Characteristics of Pilot Villages

Village Name	2001 pop.	Average No of Households	Pop. Density	Previous/ Ongoing NGO intervention	Other self initiated programs	Topography	Village Council "attitude"	Remarks
Deir Samit	4,860	694	16 p/ha	3 Years of public awareness campaign, with communal SDT unit serving 35 houses under construction by SCF.	Initiating and managing a solid waste collection program	Most of village houses are built on hilly areas surrounding a wadi.	The head of the village council and some members of the council who attended the meeting showed a good willingness to co-operate. This also was clear in the site visit that took place to the communal SDT project under construction	
Al Kum, Al-Muwarraq & Beit Maqdum	2,232	319	22 p/ha	3 Years of public awareness campaign by SCF in addition to implementing 10 SDT units.	Expanding village school	The villages are built on three separated hills with moderate slopes	Executive manager of the village council was very co-operative in the meeting, while the general secretary of the council, who attended the meeting later, did not show much co-operation towards the project.	During the site visit, the inhabitants showed interest to have SDT units.
NUBA	3,799	543	19 p/ha	3 Years of public awareness campaign by SCF in addition to a proposed project for communal SDT that is funded by SCF and will be implemented by PHG		Mostly hilly	The head of the village council and some of the members of the council who attended the meeting showed very good willingness to cooperate especially when they understood that there will not be any conflict with the PHG program already underway.	

5.3 COMMUNITY PARTICIPATION AND PROGRAM ADMINISTRATION

Within the context of community participation, the steps defined in Chapter 4 should be followed. These must be adapted to the villages that are to be included in the Pilot Program, and should include specifically the following tasks:

- **Community preparation: demand creation**

  Determination of the interest of local officials and *organization of introductory public meeting*. All three communities being considered for the Pilot Program have had a certain amount exposure to environmental health education and are even involved in some sanitation activities. However, a determination has to be made whether the communities are willing to commit to a community-wide wastewater solution and are also willing to address the financial sustainability of the system for the long term.

- **Community-based Technical Design**

  Preliminary Data Collection, Identification and Costing of the Range of Feasible Technical Options, Discussion of Feasible Options with Municipal Stakeholders and Households, Detailed Analysis of Selected Technical Option, Public Consultation to Discuss Detailed Option, Decision by Municipality. For a design solution to be appropriate, the community has to be involved at all steps of the design process. These steps will have to be closely coordinated between the environmental health assessment and implementation, institutional assessment and implementation components of Task 2 and the designers. This feasibility study has already restricted the number of technical solutions likely to be appropriate. However, these were seen with a very broad brush that will have to be refined and defined in close collaboration with the communities.

  It would also be very important to carry out baseline survey of sanitation KAP for the effectiveness of the long term health and hygiene education activities to be properly evaluated.

  This implies an assignment of personnel through Task 2 and Task 3 specifically to the Pilot Program for both the community development (environmental health and institutional) and the design aspects who will have to work together for an extended period.

  These steps would result in the preparation of procurement documents for the construction aspects of the Pilot Program.

- **Community-based Construction**

  Construction supervision will have to be well coordinated between the community activities (such as preparation of household property for connections and/or interceptor tanks), professional construction supervision (through the designer) and the builder.

  At this time, initial training should occur for operation technicians, managers, accountants as well as a good understanding given to the households of their responsibilities within the new system.

- **Community-based Health and Environmental Education**

  For best use of the investments being made in sanitation, it is important that the households participate in community-based Health and Environmental Education throughout the Pilot Program. A Pilot Project specific Health and Environmental Education Program will have to be elaborated and implemented.

- **Community-based O&M**

  Assistance will have to be given to make sure that all O&M tasks are correctly carried out and that the recurrent costs associated with O&M are being covered through WW tariffs.

- **On-going Monitoring, Evaluation and Expert Support**

  To be able to obtain all the useful lessons from the Pilot Program, it is important, not only to carry out regular monitoring of all the activities associated with keeping the Sanitation system functioning correctly that could call on expert support on an as-needed basis, but also to carry out an evaluation a significant amount of time after construction activities (at least one year). This evaluation would not only concern construction aspects, but also an evaluation of behavioral change with respect to the baseline KAP survey carried out at the beginning of the Pilot Program.

If it is decided to go ahead with the Pilot Wastewater Program, a careful assessment of personnel requirements will have to be made for both the community development aspects as well as the design aspects.

5.4 TECHNICAL APPROACH

Potential technical approaches have been discussed in Section 3.4. Because of the limited information available, and because community involvement is integral to any technical approach, further analysis of technical options would be futile at this point. However, it is recommended that a project funded under this VWS program should pilot a centralized collection and treatment system rather than on-site systems. The field of rural on-site sanitation has more than adequate donor exposure. Several attempts are underway by NGOs to pilot better on-site or septic systems incorporating institutional and technical changes that have frustrated past efforts. The VWS program has the benefit of drawing upon the best technical resources available in the field of wastewater treatment. It is of better value to apply these expensive resources at innovating a good off-site approach than in construction of more septic systems. Off-site systems will be the trend of the future as population density grows, a pilot program should attempt to find a technical solution that would be replicable not just for current conditions in rural areas but is appropriate as villages grow and become denser. Major technical issues for off-site systems that need to be resolved in design are: sludge disposal, off gas disposal, effluent reuse.

5.5 PROGRAM COSTS

The assumptions for cost analysis are presented in Annex 5. Table 5-3 below summarizes the program costs for all three pilot sites. It is important to note that a general estimate was made for the WWTP, the cost should be in the same order of magnitude whether anaerobic tanks, algal ponds or UASB technique is designed.

Table 5-3 Summary of Costs

	Deir Samit	Nuba	El Kum Group
Population Served 2003	5,304	4,145	2,435
House Connections	$ 150,000	$ 120,000	$ 70,000
Small-bore Sewers*	$ 1,000,000	$ 780,000	$ 460,000
Interceptor Tanks*	$ 950,000	$ 740,000	$ 430,000
WWTP	$ 450,000	$ 390,000	$ 240,000
Subtotal Construction costs	**$ 2,550,000**	**$ 2,030,000**	**$ 1,200,000**
NGO for Community Participation 10%	$ 255,000	$ 203,000	$ 120,000
Design and Constr. Mgmt. 15%	$ 421,000	$ 335,000	$ 198,000
Contingencies 25%	$ 807,000	$ 642,000	$ 380,000
TOTAL CAPITAL COSTS:	**$ 4,000,000**	**$ 3,200,000**	**$ 1,900,000**
ANNUAL O&M COSTS 1.5%	$ 60,000	$ 48,000	$ 28,500

*Costs for small-bore sewers were used for estimating purposes, the decision whether to use these, simplified or conventional sewers, or a combination of all three, is a detailed design decision

Pump station: note that costs for a pump station were not included in this estimate for the following reasons:

- These rural villages could probably not bear the cost of operations of a pump station, nor are they likely to have skilled labor for O&M
- The capital costs would increase greatly
- The situation would likely become one where the WWTP is taken out of service and the interceptor tanks are used as improvised cesspits resulting in the same unsanitary situation as exists currently

Therefore, it is strongly recommended that the designers work with the Village Council to encourage allocation of a suitable plot of land that would allow gravity flow from most of the households in the village. The Council would debate the situation as one of increased capital costs for land acquisition (the cost of which would be mostly borne by USAID) versus ongoing O&M burden. This is another reason why the community must be integrally involved in design. If the design shows that there is no option but to use pumping, this should be considered as a reason for not proceeding with the pilot program at that site.

ANNEX 1

DATA COLLECTED FROM THE MUNICIPAL QUESTIONNAIRES

WEST HEBRON AND SOUTH NABLUS VILLAGES

ANNEX 2

ESTIMATED WATER DEMANDS AND WASTEWATER OUTPUTS

Wastewater flow values were derived by taking 60% of the projected water demand (20% removed for system losses between water supply and households, and another 20% removed for water consumption in the household).

ANNEX 3

REPORTED BOD AND TSS LEVELS IN PALESTINE

ANNEX 4

MINISTRY OF ENVIRONMENTAL AFFAIRS
TREATED WASTEWATER STANDARDS
DRAFT GUIDELINES

ANNEX 5

WWTP COST CALCULATIONS

Basis of Cost

Costs for the four components of a WW treatment system were estimated: House connections, small-bore sewers, interceptor tanks and the WWTP itself. The cost estimate is presented on the spreadsheets that follow.

Due to: 1) the qualitative nature of this study, 2) the availability of several previous well-designed West Bank wastewater studies, and 3) because the final treatment technology cannot be decided until the design phase (either anaerobic tanks or UASB), it was not possible to attempt a detailed cost breakdown for a wastewater treatment. The strategy taken was: take the cost of previous WWTPs; and make adjustments for land price and inflation, and apply the ratio of the WWTP cost per capita (and as a cross-check, the ratio of WWTP cost per flow) to the three villages.

Notes:

1. House connection costs were included although it is expected that villagers and/or the Village Council will have the wherewithal to pay for them.
2. Costs from previous studies did not show logical economies of scale, that is, cost per capita did not reduce with increasing population size. Therefore, an incremental 5-10% increase was added to the cost calculations.

ANNEX 6

Bibliography and References

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Wastewater Production Estimation for the West Hebron Villages

West Hebron Villages	Population 2001	Population 2003	Population 2013	Water Demand (m3/day) 2013	Wastewater Production (m3/day) 2013
Al Bira	268	292	423	63	38
Al Burj	2,091	2,281	3,303	496	297
Al Jaba'	769	839	1,214	182	109
Al Kum	1,130	1,233	1,785	268	161
Al Majd	1,544	1,685	2,440	366	220
Al Muwarraq	496	541	784	118	71
As Simiya	1,446	1,578	2,285	343	206
Beit ar Rush al Fauqa	830	905	1,311	197	118
Beit ar Rush at Tahta	421	459	665	100	60
Beit 'Awwa	7,081	7,727	11,189	1,678	1,007
Beit Maqdum	606	661	958	144	86
Beit Mirsim and Abu Suhweila	284	310	450	67	40
Beit Ula	8,039	8,773	12,704	1,906	1,143
Beit Ummar	10,742	11,722	16,974	2,546	1,528
Deir al 'Asal al Fouqa	1,569	1,713	2,480	372	223
Deir al 'Asal at Tahta	518	565	818	123	74
Deir Samit	4,860	5,304	7,680	1,152	691
Idhna	15,973	17,431	25,242	3,786	2,272
Iskeik	143	157	227	34	20
Jala	215	235	340	51	31
Kharas	6,043	6,595	9,550	1,432	859
Khirbet Salama	286	312	451	68	41
Nuba	3,799	4,145	6,003	900	540
Safa	938	1,024	1,483	222	133
Sikka	684	746	1,080	162	97
Surif	11,404	12,445	18,021	2,703	1,622
Tarqumiya	12,465	13,603	19,698	2,955	1,773
Tawas	126	137	198	30	18

Wastewater Production Estimation for the South Nablus Villages

South Nablus Villages	Population 2001	Population 2003	Population 2013	Water Demand (m3/day) 2013	Wastewater Production (m3/day) 2013
Burin Cluster					
Asira Al Qibliya	2,015	2,199	3,184	478	287
Burin	2,897	3,162	4,578	687	412
Einabus	1,957	2,135	3,092	464	278
Iraq Burin	679	741	1,073	161	97
Madama	1,462	1,595	2,310	346	208
Rujeib	3,452	3,767	5,455	818	491
Sarra	2,549	2,782	4,029	604	363
Tell	4,179	4,560	6,603	990	594
Urif	2,503	2,731	3,955	593	356
Aqraba Cluster					
Aqraba	6,991	7,629	11,047	1,657	994
Awarta	5,123	5,590	8,095	1,214	729
Duma	1,957	2,135	3,092	464	278
Jalud	399	436	631	95	57
Jurish	1,219	1,330	1,927	289	173
Majdal Bani Fadel	1,926	2,101	3,043	456	274
Osarin	1,437	1,568	2,270	341	204
Qaryut	2,177	2,375	3,439	516	310
Qusra	3,916	4,273	6,188	928	557
Talfit	2,637	2,877	4,167	625	375

Reported BOD and SS Levels in Palestine

City	BOD		SS	N.T or TKN	Year	Reference
	Influent	Effluent				
Hebron	520 mg/L				1997	Taffouh sewage / Final Design Report. *Page 77*
Hebron	1025 mg/L				2001	Hebron Wastewater Master Plan CH2MHILL. *Page 3-8*
Upstream of Dura Discharge:			**TS. mg/L:**			
Al-Fawwar/Yatta cross road		386 mg/L	1578		2000	Dura Municipality. Phase 2 report. *Pages: 29, 30*
Samou' Well		414 mg/L	1594		2000	Dura Municipality. Phase 2 report. *Pages: 29, 30*
Abu-Al A'sajeh #1		485 mg/L	1970		2000	Dura Municipality. Phase 2 report. *Pages: 29, 30*
Abu-Al A'sajeh #2		486 mg/L	1722		2000	Dura Municipality. Phase 2 report. *Pages: 29, 30*
Dahariya #1		170 mg/L	1816		2000	Dura Municipality. Phase 2 report. *Pages: 29, 30*
Dahariya #2		118 mg/L	1716		2000	Dura Municipality. Phase 2 report. *Pages: 29, 30*
Dura		550 mg/L			2000	Dura Municipality. Phase 2 report. *Pages: 29, 30*
Ramallah	600 Kg/day				1994	Design, Wastewater treatment and Reuse strategy. *Page 22*
Ramallah		600 mg/L			1994	Measured, Wastewater treatment & Reuse strategy. *Page 22.*
Ramallah	820 mg/L				1994	Measured, Wastewater treatment & Reuse strategy. *Page 22.*
Ramallah		640 mg/L		79 (TKN)	2000	PCBS, Wastewater statistics May 2000. *Page 60*
Ramallah	525 mg/L					Taffouh sewage / Final Design Report. *Page 77*

City	BOD		SS	N.T or TKN	Year	Reference
	Influent	Effluent				
Hebron	520 mg/L				1997	Taffouh sewage / Final Design Report. *Page 77*
Hebron	1025 mg/L				2001	Hebron Wastewater Master Plan CH2MHILL. *Page 3-8*
Bethlehem	660 mg/L				1997	Taffouh sewage / Final Design Report.*Page 77*
Al-Bireh	750 mg/L				1997	Taffouh sewage / Final Design Report.*Page 77*
Jifna	1100 mg/L		745 (SS) Average		1998	Average sample, study report (PECDAR). *Page 30.*
Nablus	1185 mg/L			120 (TKN) PCBS. *Page 60*	1997	Taffouh sewage / Final Design Report.*Page 77*
Tulkarem	250 mg/L				1997	Taffouh sewage / Final Design Report.*Page 77*
Tulkarem	800 mg/L				2000	PCBS, Wastewater statistics May 2000.*Page 60*
Jenin	1100 mg/L		1430 (SS) *Page 78*		1997	Taffouh sewage / Final Design Report.*Page 77*
Jenin	800 mg/L				2000	PCBS, Wastewater statistics May 2000.*Page 60*

Cost Analysis from Previous Studies

Study Site Proposed System	Design Yr Population Served	WWTP Avg Daily Design Flow (m3/d)	WWTP Only Cost	O&M Costs Incl sewers + pumps	WWTP/O&M Cost Ratio	WWTP Costs Per Capita	WWTP Cost Per Avg Flow ($/m3/d)	Comments
Doura Feas Study Phase 1 Anaerobic Ponds + Intermittent Sand Filters	30,000	2,786	$ 2,167,000	$ 95,800	4%	$ 72	$ 778	Not poss to extract land costs. Annual O&M incl tanker svc. WWTP Price is YR2000 Capital Investment for wYR2010 design pop
DHV: Kalandia Camp Anaerobic+ Intermittent Sand Filters	16,000	1,536	$ 772,100	$ 29,000	3.8%	$ 48	$ 503	Pumping required so O&M cost high
DHV: Fawwar Camp Anaerobic+ Intermittent Sand Filters	7,700	739	$ 451,500	$ 6,000	1%	$ 59	$ 611	No pumping
DHV: Arroub Camp Anaerobic+ Intermittent Sand Filters	10,600	1,018	$ 569,383	$ 8,000	1%	$ 54	$ 559	No pumping
DHV: Fara Camp Anaerobic+ Intermittent Sand Filters	8,300	797	$ 476,250	$ 5,000	1%	$ 57	$ 598	No pumping
					Average:	$ 58	$ 610	
					St Dev	$ 9	$ 103	

DHV 1995 UNRWA Refugee Camp Study: WWTP Costs with Adjusted Land Price

	Land Cost (from report 1995$)	WWTP Cost (from report 1995$)	WWTP Cost Adjust to 2003$ (+5%)	Land Unit Price (from report $/m2)	Adjusted Land Cost at $10/m2	Adjusted WWTP Cost
Kalandia Camp	77	662	695	5	$ 154	$ 772
Fawwar Camp	42	390	410	5	$ 84	$ 452
Arroub Camp	65	501	526	6	$ 108	$ 569
Fara Camp	18	385	404	2	$ 90	$ 476

Village Name	Current Population 2001	Sewer Design Yr Population 2003	WWTP Design Yr 2013 Pop 2013	Water Distr Network Length from Water Pre-Desg Report (m) 2003
Deir Samit	4,860	5,304	7,680	25,033
Nuba	3,799	4,145	6,003	19,566
Al Kum Group	2,232	2,435	3,527	11,494
Al Kum Group Components:				
Al Kum	1,130	1,233	1,785	5,818
Al Muwarraq	496	541	784	2,555
Beit Maqdum	606	661	958	3,121

Cost Breakdown

1. House Connections (2003 Population)

	Deir Samit	Nuba	Al Kum Group	Cost Basis
No HH 2003	758	592	348	7persons/HH PCBS Statistic
Unit Cost ($/HH)	200	200	200	Same as Ramallah WW Master Plan
Total Cost:	$ 151,529	$ 118,435	$ 69,578	

2. Small-Bore Sewers (2003 Population)

	Deir Samit	Nuba	Al Kum Group	Cost Basis
Sewers Length 2003 (m)	25,033	19,566	11,494	Same as Water Distr Length
Unit Cost ($40/m)	40	40	40	Ramallah WW M Plan
Total Cost:	$ 1,001,320	$ 782,640	$ 459,760	

3. Interceptor Tanks (2003 Population)

	Deir Samit	Nuba	Al Kum Group	Cost Basis
No HH 2003	758	592	348	7persons/HH PCBS Statistic
Unit Cost ($/HH)	1250	1250	1250	SCF: communal SDT avg $1000/HH, Individual SDT $1500/HH
Total Cost:	$ 947,054	$ 740,221	$ 434,862	

4a. WWTP BASED ON COST PER CAPITA (2013 Population)

	Deir Samit	Nuba	Al Kum Group	Cost Basis
Population 2013	7,680	6,003	3,527	
Unit Cost $/capita	$ 58	$ 64	$ 67	$58 is avg from prev studies, add 10% to Nuba and 5% to Al Kum to Adjust for economies of scale
2013 WWTP Cost	$ 445,779	$ 383,283	$ 236,454	
2% for Additional Land for 2023 expansion	$ 8,916	$ 7,666	$ 4,729	
5% Contingencies Treatment Technique	$ 44,578	$ 38,328	$ 23,645	
Total Cost:	$ 454,695	$ 390,949	$ 241,183	

4b. CROSS-CHECK: WWTP BASED ON COST PER AVG DAILY FLOW

	Deir Samit	Nuba	Al Kum Group	
WW Avg Flow 2013 m3/d	691	540	317	
Unit Cost $/flow	$ 590	$ 649	$ 681	Avg from Prev studies w economies of scale adjustment
2013 WWTP Cost	$ 407,808	$ 350,635	$ 216,313	
2% for Additional Land for 2023 expansion	$ 8,156	$ 7,013	$ 4,326	
5% Contingencies Treatment Technique	$ 40,781	$ 35,064	$ 21,631	
Total Cost:	$ 456,745	$ 392,711	$ 242,270	

SUMMARY OF COSTS

	Deir Samit	Nuba	El Kum Group
Population Served 2003	5,304	4,145	2,435
House Connections	$ 150,000	$ 120,000	$ 70,000
Small-bore Sewers	$ 1,000,000	$ 780,000	$ 460,000
Interceptor Tanks	$ 950,000	$ 740,000	$ 430,000
WWTP	$ 450,000	$ 390,000	$ 240,000
Subtotal Construction costs	$ 2,550,000	$ 2,030,000	$ 1,200,000
NGO for Community Participation 10%	$ 255,000	$ 203,000	$ 120,000
Design and Constr Mgmt 15%	$ 421,000	$ 335,000	$ 198,000
Contingencies 25%	$ 807,000	$ 642,000	$ 380,000
TOTAL CAPITAL COSTS:	**$ 4,000,000**	**$ 3,200,000**	**$ 1,900,000**
ANNUAL O&M COSTS 1.5%	$ 60,000	$ 48,000	$ 28,500
Reality Check:			
Capital Cost/ Capita (2003 pop)	$ 754	$ 772	$ 780
O&M Cost/Capita (2003 pop)	$ 11.31	$ 11.58	$ 11.70
Annual O&M Cost/m3 WW	$ 0.24	$ 0.24	$ 0.25