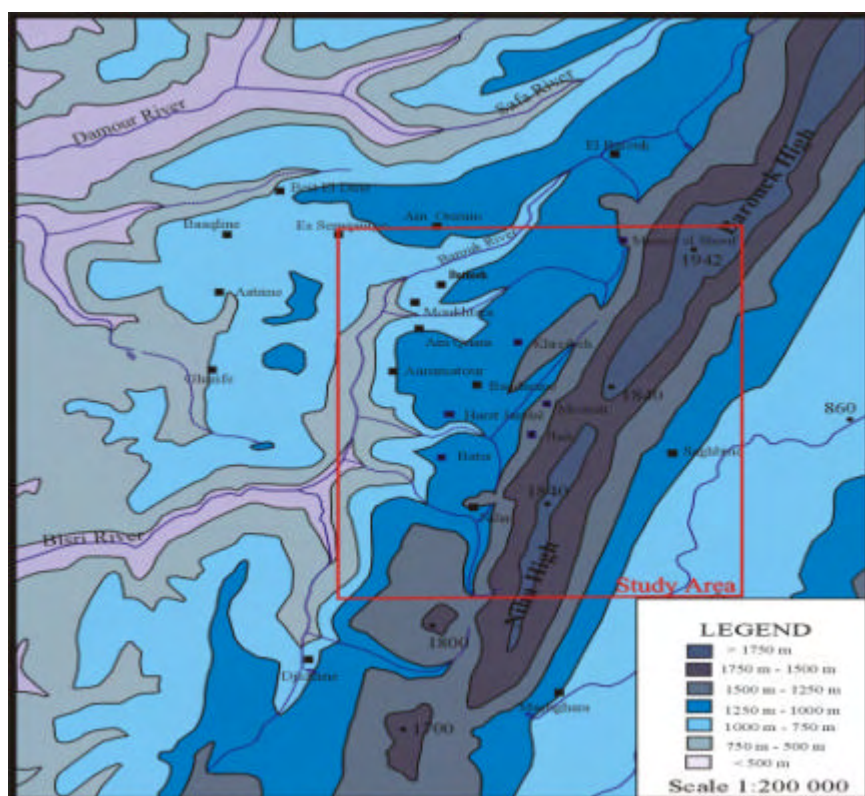


ENVIRONMENTAL IMPACT ASSESSMENT

WASTEWATER TREATMENT PLANT “AAMMATOUR” HIGHER SHOUF MUNICIPALITIES CAZA OF SHOUF



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(ARD)**

Submitted to:

**Catholic Near East Welfare Association
PONTIFICAL MISSION**

November 2003

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List of abbreviations

ARD	Arab Resources development
As	Arsenic
AUB	American University of Beirut
BIA	Beirut International Airport
BOD ₅	5-day Biochemical Oxygen Demand
BMLWWE	Beirut and Mount Lebanon Water and Wastewater Establishment
C	Composite Sample
C ₃	Hammana Formation
C _{2b}	Mdairej Formation
C ₄	Sannine Formation
Cd	Cadmium
CDR	Council for Development and Reconstruction
CNEWA\PM	Catholic Near East Welfare Association\ Pontifical Mission
Co	Cobalt
COD	Chemical Oxygen Demand
Cr	Chromium
Cu	Copper
DMR	Discharge Monitoring Report
E	East
EAAS	Extended Aeration Activated Sludge
EIA	Environmental Impact Assessment
ELV	Environmental Limit Values
EMP	Environmental Management Plan
ES	Environmental Statement
Fe	Iron
G	Grab Sample
GAS	General Awareness Seminar
GBA	Greater Beirut Area
GDP	Gross Domestic Product
Hg	Mercury
HL	Hydraulic Loading
ISWMP	Integrated Solid Waste Management Plan

M	Monthly
METAP	Mediterranean Technical Assistance Program
MLSS	Mixed Liquor Suspended Solids
MLVSS	Mixed Liquor Volatile Suspended Solids
Mn	Manganese
Mo	Molybdenum
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoIM	Ministry of Interior and Municipalities
MoI	Ministry of Industry
MoPH	Ministry of Public Health
MoPWT	Ministry of Public Works and Transport
MSW	Municipal Solid Waste
NGO	Non-Governmental Organization
NWMP	National Wastewater Management Plan
NH ₃	Ammonia
Ni	Nickel
NNE	North Northeast
ON	Organic Nitrogen
Pb	Lead
PC	Process Control
PCB	Polychlorinated Biphenyls
PP	Process Performance
Se	Selenium
Sn	Tin
SWTP	Solid Waste Treatment Plant
SOP	Standard Operating Protocol
SPASI	Strengthening the Permitting and Auditing System for Industries
SRI	Stanford Research Institute
SRT	Solids Retention Time
SSW	South Southwest
STW	Specialized Training Workshop
SWEMP	Solid Waste Environmental Management Plan
TSS	Total Suspended Solids

UNDP	United Nations Development Program
UPP	Unit of Planning and Programming
VSS	Volatile Suspended Solids
W	West
WB	World Bank
WWTP	Waste Water Treatment Plant
Zn	Zinc
1/W	Once per Week

$^{\circ}\text{C}$	Degrees centigrade
cm	Centimeter
hr	Hour
km	Kilometer
m	Meter
m^3	Cubic meters
m^3/day	Cubic meters per day
m^3/s	Cubic meter per second
mg/L	Milligrams per liter
mL	Milliliter
mm/year	millimeters per year
ppm	Parts per million

NON-TECHNICAL SUMMARY

INTRODUCTION

This Environmental Impact Assessment (EIA) has been prepared to address the potential environmental impacts that could arise from the construction and operation of a wastewater treatment plant. The intended plant will be located in the village of Aammatour, planned to serve the inhabitants of four villages of the higher Shouf Municipalities, Shouf Caza, Lebanon. Additionally, the EIA evaluates various alternative treatment technologies and presents technical criteria on which to base the selection of most suitable technology. In the Higher Shouf, four Municipalities established a union consisting of Aammatour, Haret-Jandal, Ain Qani and Baadaran, hereafter referred to as Union.

The purpose of the project is to alleviate the severe impacts of uncontrolled sewage discharges into the environment. Proper design/selection, construction and management of the wastewater treatment plants (and upgrading/construction of wastewater collection networks) would mitigate such negative impacts. The main sections of the EIA include definition of *the legal and institutional frameworks, description of the project and the environment, impacts assessment, identification of mitigation measures, and presentation of an environmental management plan (EMP)*.

LEGAL AND INSTITUTIONAL FRAMEWORKS

In the legal framework, the EIA decree has been revised by the Unit of Planning and Programming (UPP) at the Ministry of Environment (MoE), and is waiting for legislative approval. This decree sets the procedures and guidelines for the proponent of every proposed project that could have significant impacts on the environment to prepare its own EIA or Environmental Statement (ES). The MoE is the main institution responsible for the revision and approval of the EIA.

There are potential risks associated with poor waste management practices in rural areas, aggravated by the limited level of assistance from the central government. The result is that most of the rural areas in Lebanon are deprived of adequate sanitary infrastructure. A more consistent response with USAID strategic objectives would be to look for individual or cluster solutions. Therefore, the cluster or Union of these four Municipalities decided to locate their Wastewater Treatment Plant in Aammatour. Then, the implementation of complete and self-sustainable treatment plant amongst the Cluster is funded by USAID and under the direct supervision of CNEWA/PM. Moreover, CNEWA/PM will contribute in the construction of the principal wastewater collection lines within the towns to reach the plants.

Institutionally, the Union should be dealing mainly with the Urban Planning Directorate, the Ministry of Interior and Municipalities (MoIM) and the MoE, and is coordinating with the Council for Development and Reconstruction (CDR).

PUBLIC INVOLVEMENT

The project is the foremost issue being requested from the municipalities in the Higher Shouf area. During this study, the consultant and CNEWA/PM working hand in hand met numerous times with the Head of the Union, with the representatives of each municipality and with technology providers. CNEWA/PM organized on Friday 5 September 2003, a first official Projects initiation meeting in the presence of his Excellency the ambassador of the United States of America, the Shouf area deputy and USAID/Lebanon directors. During that meeting the forecasted projects for the area were presented to the public. On the 18th of October 2003 an inception workshop was undergone in the presence of various relevant ministries, NGOs and various stakeholders. Many other meetings and presentation relevant for each specific project are yet to be implemented as well. Relevant information was solicited using questionnaires distributed over the various municipalities. In compliance with EIA guidelines, a notice was posted at each concerned Municipality offices within the Union informing the public of the EIA study, the proposed wastewater treatment plant, and soliciting comments.

DESCRIPTION OF THE PROJECT

Currently, untreated sewage generated within the Union is directly being disposed off in the environment. This situation is exposing the general public to the associated negative health impacts and is leading to deterioration of water quality in the area. Proper conveyance and treatment of sewage is of utmost importance to avoid such impacts, and will be addressed by the construction of wastewater treatment plants (and collection networks) to serve the area.

It is essential to note that potable water is being contaminated by the ingress of wastewater into the potable water springs distributed down gradient to the Union of these four villages. Sewerage contamination was identified in springs mainly located in Aammatour, Moukhtara and even Butmeh. Wastewater is being discharged directly into run-off ditches and storm water galleries as well as uncontrolled septic tanks.

The direct discharge of wastewater into open ground is pronounced in Aammatour where the sewage is directed towards agricultural areas of the village.

The evaluated wastewater treatment plant typically employs conventional or modified secondary biological wastewater treatment schemes. The plants would serve total design populations of approximately 6,500 and 7000 by the years 2013 and 2023, respectively. Design populations for individual villages are specified.

In the context of analysis, the following six alternative wastewater treatment schemes were screened: (1) Preliminary treatment, (2) Primary treatment alone, (3) Secondary biological treatment through suspended growth process, (4) Secondary biological treatment through attached growth process, (5) Secondary biological treatment through suspended growth process + tertiary treatment through filtration, and (6) Tertiary treatment through filtration. The “Do Nothing” scenario is not considered a legitimate option, since wastewater is currently being discharged without treatment into the environment. With the protection of the environment being the main issue, the treatment system shall at a minimum include secondary treatment.

Accordingly, analysis of alternatives was further performed on different modifications of activated sludge systems proposed by different manufacturers of wastewater treatment plants. The alternative systems included: (1) HANS-reactor treatment system, (2) ECOLO-design treatment system, (3) Standard extended aeration activated sludge system, and (3) TECH UNIVERSAL system (EAAS+ Pressure sand filtration). Activated sludge treatment plants typically generate two main types of effluents: treated liquid effluent and waste sludge. Other miscellaneous effluents include “bulk” solids removed during the preliminary treatment, namely, screenings and grit.

After meeting stringent quality standards, treated liquid effluent can be discharged into the environment with minimal to no adverse impacts. The plant may thus discharge its treated effluents into tributaries that lead to the nearby Barouk River, to open grounds, or be reused for irrigation. The expected quality of the liquid effluents shall meet or even be lower than the standards of effluent discharge to surface water recently published by the Ministry of Environment (MoE) (Decision 8/1/2001). Table A presents the main relevant effluent standards.

Table A. Effluent Standards of Treated Wastewater*

<i>Parameter</i>	<i>Effluent Standards</i>
PH	6 – 9
BOD ₅	25
COD	125
Suspended Solids	60
Ammonia-Nitrogen as N	10
Nitrate	90

* All units in mg/L except for pH (unitless)

The best disposal route for the sludge would be to use it as a fertilizer or soil cover in agricultural lands. A probable disposal option is land filling or even use in quarries rehabilitation programs. Another option is burning in a kiln set up within a major treatment plant.

Other debris and solid wastes produced from the plant will be managed similarly to the current management of municipal solid waste.

DESCRIPTION OF THE ENVIRONMENT

The study area is located on the western slopes of the southern section of Mount Lebanon, with land elevations ranging between less than 500 m and 1250 m above mean sea level. The site is specifically located at an elevation of 700 meters from mean sea level. A generally good road network connects the villages of the Union. However, road access to proposed wastewater treatment plant sites needs to be developed.

The total annual precipitation in the area is approximately 1,000 mm. Temperature ranges from a low of -3 °C in winter to a high of 33 °C. Dominant winds are southwesterly. Continental east and southeasterly winds are frequent.

One major perennial river the Barouk River passes through the study area. The Barouk River and its tributaries dominate the Eastern section of the study area in general, the higher Shouf villages.

The geological formations outcropping within the surveyed area range in age from the lower Cretaceous to upper Cretaceous. There are mainly four formations outcropping in the study area: Abeih formation in the lower Cretaceous. Three formations belong to the Upper

Cretaceous formations: Mdairej formation (C_{2b}), Hammana formation (C₃), Sannine formation (C₄)

Two main aquifers are identified in the surveyed area: the Mdairej karstic aquifer and the Sannine karstic aquifer.

Infrastructure with respect to wastewater has been partially completed within the village, yet the connection to the forecasted plant is under construction. Developed infrastructure within the village is mainly limited to road network, telephone, electricity and water supply. A local solid waste management system does not exist; most Higher-Shouf villages rely on private solid waste management companies.

The main supplier of potable water in the area is the Barouk Water Authority. The capacity is supplemented at times by other sources, such as groundwater wells and springs. There are several wells in the area and many springs assessed in the study. Sewage related contamination has been detected in many springs in the area. Aammattour specifically benefits from one major spring that is distributed to house holds but not used for drinking purposes

Local habitants are mainly members of the active population (between 18 and 50 years old). The economy in most municipalities is driven by agriculture, trade and services and money sent by expatriates. Average household income within the Union amounts to less than six million Lebanese pounds annually.

IMPACT ASSESSMENT

The assessment of impacts indicated that negative impacts should not be significant as long as process performance is continuously controlled. No significant impacts on water resources, soil, air and biodiversity are anticipated based on the expected quality of the effluents and the planned effluent management practices.

On the other hand, positive impacts with respect to public nuisance and human health are a direct consequence of the project implementation.

MITIGATION MEASURES

Potential adverse environmental impacts induced by the construction and operation of the proposed wastewater treatment plant include (a) dust emissions from construction works, (b) generation of odors from treatment process or screenings, grit, and sludge handling and transport, (c) generation of noise from increased vehicular traffic, construction works, and

mechanical equipment such as pumps, compressors, and possibly sludge dewatering, (d) emission of aerosols from aerated treatment units, (e) degradation of receiving water quality by effluent discharge, (f) degradation of quality of receiving land by effluent residuals (screenings, grit, scum, sludge), (g) public health hazards in vicinity of discharges, treatment works, or reuse sites, and finally (h) adverse aesthetic impacts in the neighborhood of treatment works. Although the analysis of these impacts showed that they are not significant, Table B includes mitigation measures to further reduce the likelihood and magnitude of such impacts.

ENVIRONMENTAL MANAGEMENT PLAN

In order to ensure the proper operation of the plant, a management system must be implemented. This management scheme shall assure regular monitoring of effluent quality, proper staff training, and organized record keeping. Monitoring of individual processes within the plant is of equal importance to allow identification of probable causes in case of unlikely process deficiencies.

Except during plant start-up, when a thorough monitoring schedule is recommended, monitoring efforts can be limited to regular checks (weekly or bi-weekly, as needed) of effluent quality for the following parameters:

- pH and temperature
- BOD₅ and COD
- Suspended solids
- Total Nitrogen
- Total Phosphorus
- Ammonia-nitrogen
- Nitrate – nitrogen
- Phosphate
- Coliform bacteria

Sampling costs (including analysis at laboratory) would be manageable. If it is decided to reuse the effluent, fecal coliforms and chlorine residual should also be checked regularly. On-site monitoring of temperature, pH, and flow measurements would be continuous. Sludge monitoring becomes essential if it is re-used as soil fertilizer. If a more detailed monitoring scheme is judged necessary by the regulatory authorities, then a sustainable financial mechanism must be put in place to secure the necessary funds. As for the responsibility of the

different plant personnel, Table C describes the tasks and duties of the main staff that will be in charge of the proper operation of each plant.

Table B. Summary of Main Mitigation Measures

<i>Impact</i>	<i>Mitigation Measures</i>
Dust Emissions	<ul style="list-style-type: none"> ◆ Dust emissions from piles of soil or from any other material during earthwork, excavation, and transportation should be controlled by wetting surfaces, using temporary wind breaks, and covering truck loads ◆ Piles and heaps of soil should not be left over by contractors after construction is completed. Also excavated sites should be covered with suitable solid material and vegetation growth induced
Noise Generation	<ul style="list-style-type: none"> ◆ Temporary noise pollution due to construction works should be controlled by proper maintenance of equipment and vehicles, and tuning of engines and mufflers. Construction works should be completed in as short a period as possible by assigning qualified engineers and foremen ◆ Noise pollution during operation would be generated by mechanical equipment, namely transfer pumps, air blowers, and sludge dewatering units. Noise problems should be reduced to normally acceptable levels by incorporating low-noise equipment in the design and/or locating such mechanical equipment in properly acoustically lined buildings or enclosures
Odor Generation	<ul style="list-style-type: none"> ◆ Store produced residuals in closed containers and transport them in enclosed container trucks ◆ Keep always an optimum aeration rate at the aeration tanks ◆ If possible, proper landscape around the facility may serve as a natural windbreaker and minimize potential odor dispersions, if present
Soil and Water Pollution	<ul style="list-style-type: none"> ◆ Properly dispose of effluents; monitoring of effluents quality is essential to avoid misuse of the latter; re-use of effluents (sludge or treated wastewater) shall be performed as per appendix E

Table C. Main Responsibilities of Plant's Personnel

<i>Title</i>	<i>Main Tasks</i>
Plant Manager (can be for more than one plant)	<ul style="list-style-type: none"> ◆ Schedule sampling events and keep records of sampling results for compliance monitoring ◆ Prepare a report of plant's performance (accidents, compliance of effluent to standards, sludge quality, etc...) on a monthly basis during the first year, and bi-annually the following years ◆ Ascertain that mitigation measures are adhered to
Assistant plant manager	<ul style="list-style-type: none"> ◆ Conduct sampling and follow-up with the off-site chemical laboratory for results ◆ Supervise the plant's performance on a daily basis
Mechanical Engineer (part-time)	<ul style="list-style-type: none"> ◆ Ascertain the proper functioning of electro-mechanical equipment at the plant
Electrical Engineer (part-time)	<ul style="list-style-type: none"> ◆ Ascertain the proper functioning of electro-mechanical equipment at the plant
Laborer	<ul style="list-style-type: none"> ◆ Responsible for the day-to-day operation and maintenance of the plant; reports problems to management

Monitoring efforts would be in vain in the absence of an organized record keeping practice. It is the responsibility of the treatment plant management and the Union to ensure the development of a database that includes a systematic tabulation of process indicators, performed computations, maintenance schedules and logbook, process control and performance monitoring outcomes. Such a historical database benefits both the plant operator and design engineers. Also, in accordance with the requirements of the regulatory authority, the treatment plant should submit a periodic Discharge Monitoring Report (DMR) to the assigned authority. The institutional setup for the project is proposed in Figure I.

The main supervising authority for the plant would be the Union. The Union along with CNEWA\PM and the selected contractor would supervise all the activities at the plant, starting from the design and construction phases, and continuing at the operation phase where it will be mandatory for the contractor to provide constant and regular technical checkups. Operation and day-to-day management, however, would be performed by the corresponding municipalities. The MoE would have a regulatory role. The MoIM would have an enforcement role. Each plant's manager reports directly to the Union as in the following illustration of the institutional arrangement that could be followed to ascertain the proper operation of the plant, and assist the implementation of the EMP.

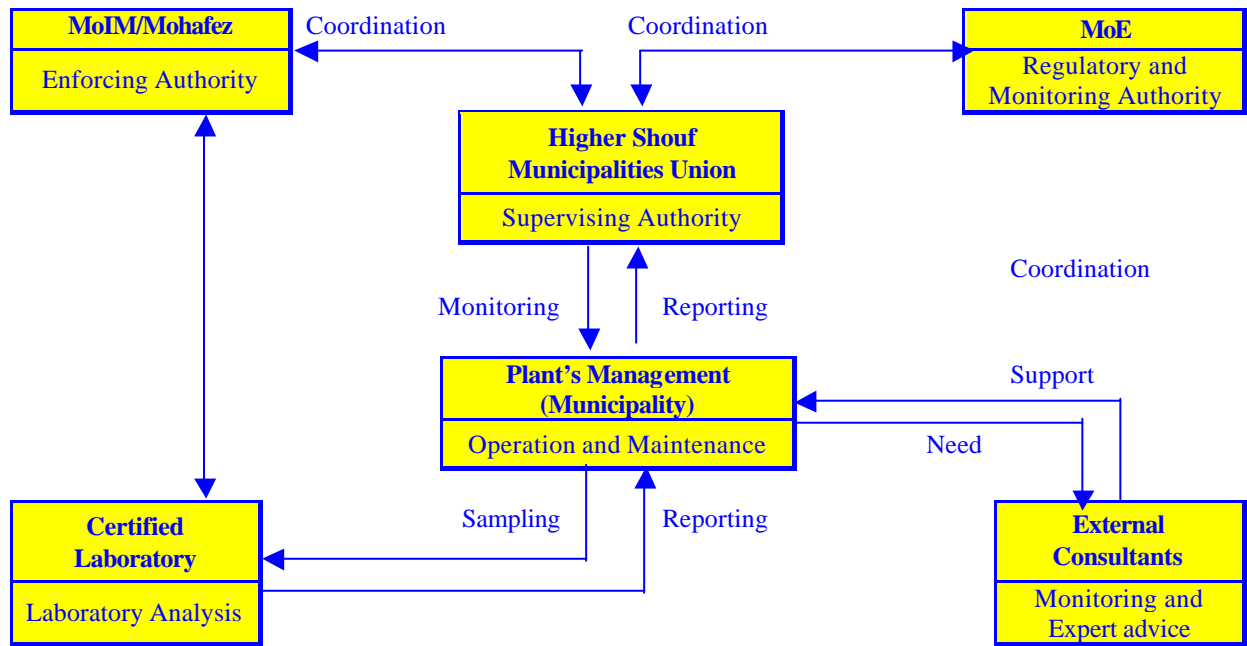


Figure I. Proposed Institutional Setting

1. INTRODUCTION

1.1. THE OVERALL CONTEXT

Lebanon has recently made significant progress towards sustainable development, and has placed more attention to environmental matters and the need to reduce the burden on the environment. The Ministry of Environment (MoE) has been able in the last 9 years to considerably improve its capabilities to fulfill its main role of protecting the environment from the various sources of pollution. Financed by international organizations, several working units within the MoE are setting new environmental standards, building an informational database for the country, and providing the framework to prevent further pollution to widespread in Lebanon.

In particular, the Unit of Planning and Programming (UPP) has revised and further developed the Decree for Environmental Impact Assessment (EIA) that is being considered for ratification by the Government. The decree states that any planned project that could cause significant environmental impacts should be subject to the preparation of an EIA that would anticipate these impacts and allow provision of mitigation measures to minimize the significance of these impacts, or even eliminate their likelihood. The decree also states that projects that could have some impacts on the environment should undergo an initial impact assessment.

1.2. BACKGROUND AND RATIONALE

Recent government initiatives in the fields of solid waste and wastewater management in Lebanon have primarily covered major cities and urban areas in the country. The Integrated Solid Waste Management Plan (ISWMP) that serves the Greater Beirut Area (GBA) and the National Wastewater Management Plan (NWMP) illustrates this challenge, for example. Limited achievements have been experienced so far in rural areas except for community-based initiatives financed primarily by international donors.

The environmental pressure experienced in Lebanese rural areas can be illustrated by the fact that over 700,000 tons of municipal solid waste (MSW) and over 100 Mm³ of raw municipal sewage are directly disposed off in the environment every year (MoE/Ecodit, 2002). A wide range of environmental, public health and socio-economic impacts result from the current situation, some of which are listed below:

- ◆ *Contamination of water resources:* Lebanon's groundwater resources are mainly of karstic nature (over 75 percent of the resources), which offer limited possibility for natural attenuation of pollutants before reaching water resources; recent surveys and studies have shown that over 90 percent of the water resources below 600 meters of altitude are contaminated (Jurdi, 2000); surface water streams are also affected by the direct discharge of untreated wastewater. As water becomes polluted, expensive treatment to make it fit for use will inevitably lead to the increase in the price consumers will have to pay when privatization of water services occur and mechanisms such as full-cost accounting are adopted to set water prices.
- ◆ *Increased health problems among the population:* inadequate disposal of solid waste and wastewater lead to the release of numerous organic and non-organic contaminants that can eventually reach human beings through diverse pathways including direct ingestion of contaminated water, ingestion of crops contaminated with polluted irrigation water and inhalation of polluted air (from open waste burning activities); for example, it is estimated that 260 children die every year in Lebanon from diarrhea diseases due to poor sanitary conditions leading to the consumption of polluted water (MoH, 1996; CBS/Unicef, 2001).
- ◆ *Negative impact on local economic activities:* uncontrolled spread of solid waste and wastewater in valleys, water courses and along roads negatively affects economic activities such as those related to tourism development or eco-tourism by reducing the attractiveness of these areas; similarly, irrigated areas can be at risk if the source of irrigation water is polluted due to poor waste management practices, thus potentially affecting the agriculture sector in some areas; additional economic impacts are attributed to poor health conditions that can affect human productivity in addition to increasing social costs. *It has been recently estimated that the cost of inadequate potable water quality, sanitation and hygiene (largely due to inadequate waste management) could exceed 1 percent of national Gross Domestic Product (GDP), or as much as 170 million USD per year (World Bank/METAP, 2003).*

Overall development constraints and obstacles in Lebanon do not favor government assistance to rural areas. Political turmoil, regional instability, and huge public debt are affecting the smooth progress of planned projects in the country, most of which are stagnant with little achievement being made. This may lead for instance to the removal of the Solid Waste Environmental Management Plan (SWEMP) financed by the World Bank (WB), which has experienced limited progress since its inception in the late 1990s.

There are potential risks associated with poor waste management practices in rural areas, aggravated by the limited level of assistance from the central government. The result is that

most of the rural areas in Lebanon are deprived of adequate sanitary infrastructure. A more consistent response with USAID strategic objectives would be to look for individual or cluster solutions.

A recent survey on waste management practices in 111 villages outside GBA (El-Fadel and Khoury, 2001) highlighted the following major challenges, in decreasing order of importance, budget deficit, lack of technical know-how, lack of equipment, lack of employees, negligence, mismanagement, lack of land and lack of public participation. These can be summarized in two major categories: 1) limited resources (financial and human) and 2) limited technical skills (technical know-how, management, and environmental awareness).

Another important issue highlighted by the survey was the high level of co-disposal of hazardous and special waste stream (over 75 percent). This significantly increases the health risk associated with poor MSW disposal. Rural areas do not have the needed infrastructure to deal with special wastes such as those generated by olive press mills, hospitals, or slaughterhouses. An additional challenge posed by these types of wastes is the low volume-generated which do not attract private sector investment for their treatment and/or valorization.

Financial support from international sources have assisted in supplying infrastructure and equipment to rural areas for solid waste and wastewater management, yet, additional challenges have been disclosed and lessons can be extracted from these experiences:

- ◆ Limited financial resources in municipalities can lead to poor operation of solid waste and wastewater technologies when funding is over;
- ◆ Insufficient training, know-how and/or commitment from municipalities can also lead to poor operation of technologies;
- ◆ Poor quality of compost, particularly due to the presence of inert materials, leads to significant problems in marketing the product to farmers; insufficient or no public participation in source separation activities contributed to this problem;
- ◆ Limited number of recycling factories in the country and the long distances usually existing between treatment facilities and these factories lead to very high and unaffordable transportation costs. Recyclable materials are poorly marketed to the consumers;
- ◆ Lack of public participation or consensus can delay or even stop the execution of such infrastructure projects.

Another important challenge that rural cluster development programs may experience is the need to obtain approval from the government. The government has demonstrated skepticism towards decentralized projects, fearing that these could be a short-term solution leading to long-term problems. Both the Ministry of Interior and Municipalities (MoIM) and the Ministry of Environment (MoE) have shown their reservations with respect to such initiatives, fearing that they could become out of their control due to difficulties in monitoring the performance of scattered projects across the country.

Implementing sustainable infrastructure projects in Lebanese rural areas requires a multi-disciplinary and clearly oriented approach with a long-sighted vision in order to overcome all the constraints presented above. The proposed approach calls for the involvement of several partners to ensure the sustainability and success of development initiatives. Figure 1.1 summarizes the overall situation of rural areas with respect to such infrastructure projects.

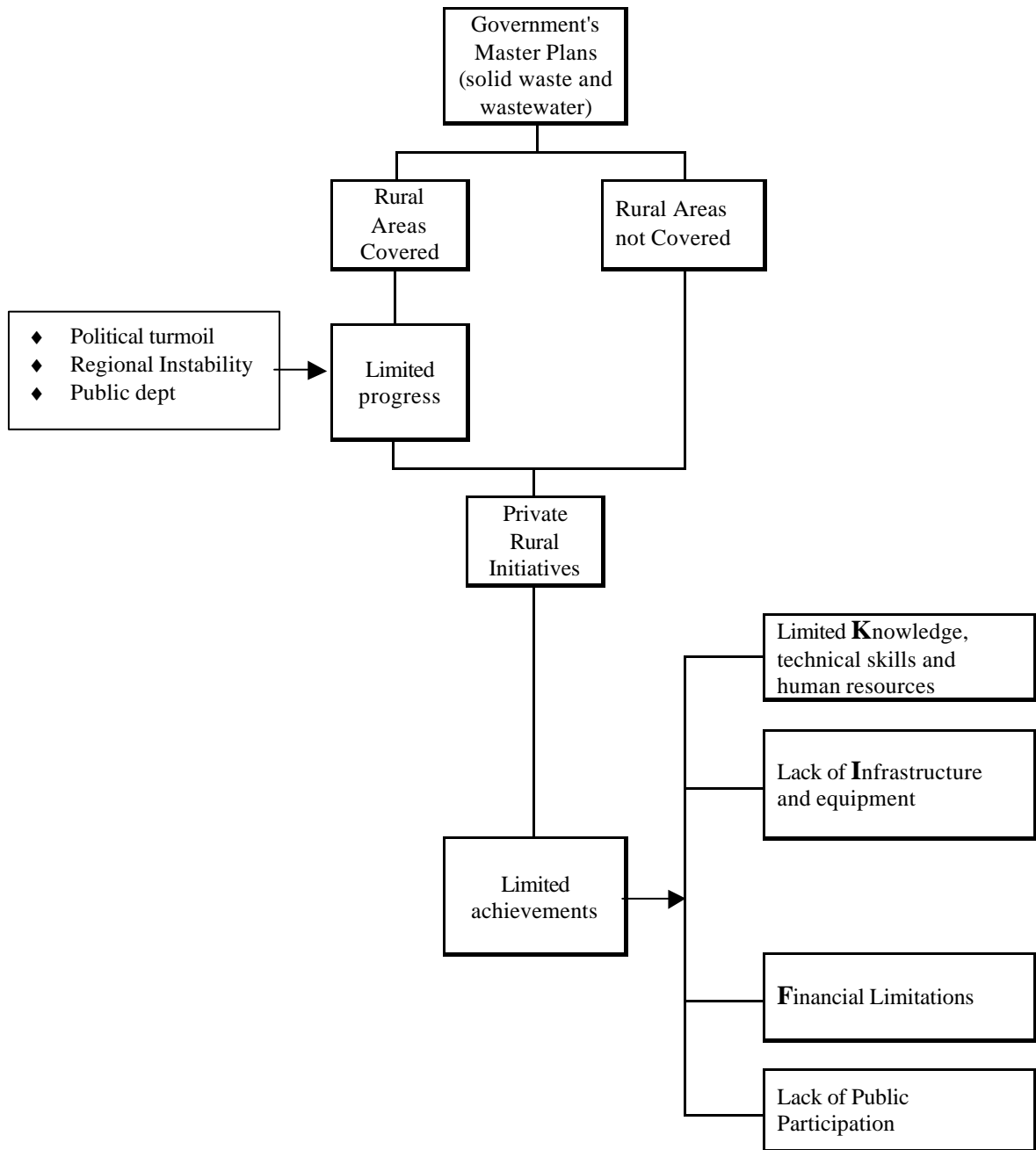


Figure 1.1. Constraints Hindering Infrastructure Development in Rural Communities in Lebanon

1.3. THE PROJECT

This EIA has been prepared to address the potential environmental impacts that could arise from the construction and operation of a *wastewater treatment plant* planned to serve the inhabitants of mainly four villages of Aammatour, Haret Jandal, Baadaran and Ain Qani in the Higher Shouf area, Shouf Caza, Lebanon. Additionally, the EIA evaluates various alternative treatment technologies and presents technical criteria on which to base the selection of the most suitable one. The purpose of the project is to alleviate the severe impacts of uncontrolled sewage discharges into the environment. Proper design selection, construction and management of the wastewater treatment plants would mitigate such negative impacts.

This EIA will address the Wastewater plant forecasted in Aammatour for the villages of Aammatour, Ain Qani, Baadaran, and Haret Jandal. The population to be served from this project would be then around 6000.

The project initiated by (CNEWA/PM) Pontifical Mission is funded by the USAID for the Union of Higher Shouf under the “Improved Environmental Practices and Policies” program

1.4. THE PROJECT LOCATION

The wastewater treatment plant is to be located within the outskirts of Aammatour village, Higher Shouf, Lebanon. The municipality of Aammatour is located approximately 60 kilometers southeast of Beirut. The proposed location of the plant is presented on the Geological Map that is included as Appendix A and on a topographic map presented within Section 5.3 of this report. The geographical coordinates of the proposed location are noted in Table 1.1. The area lies approximately between 183000 and 193000 Northing, and 137000 and 146000 Easting.

The site was proposed and selected by the proponent, assuring for down-gradient locations (waste conveyed by gravity) and distances from residential areas. The surface area of the selected parcel is around 8000 m². The location is shown on topographic map (section 5.3) and Geological Map (Appendix A).

Table 1.1. Projected Populations, Property Location and Available Acreage

<i>Area Served</i>	<i>Geographical Coordinates</i>	<i>Actual Population served</i>	<i>Projected Population Year 2013</i>	<i>Projected Population Year 2023</i>	<i>Available Land area (m²)</i>
Aammatour, Haret Jandal, Baadaran, Ain Qani, (Aammatour Plant)	137900E 189800N	6000	6500**	7000	8000*

* To be used for both plants Wastewater and Solid Waste.

** Considering the approximate average population growth is 0.8 % (Ecodit, August 2003)

1.5. THE STUDY AND THE EIA REPORT

This study was prepared in close collaboration with CNEWA/PM and the Union who contributed significantly to the overall quality of the report and the identification of the most feasible treatment systems and environmental management practices to be followed at the proposed plant. That was achieved through continuous and harmonious coordination with the union. The purpose of this EIA study is to ensure that the potential impacts from the installation and operation of the wastewater treatment plant are identified, their significance is assessed, and appropriate mitigation measures are proposed to minimize or eliminate such impacts. Additionally, the EIA has been a catalyst for CNEWA/PM and the Union to research other technologies and other vendors thus selecting the most appropriate technology for deployment. The rest of this EIA report is structured in six main sections. Section 2 provides the legislative and institutional framework. Section 3 presents background information to this project. Section 4 describes the project and associated elements. Section 5 describes the environmental setting. Section 6 assesses the impacts. Section 7 proposes mitigation measures section 8 presents an environmental management plan (EMP) that will allow managers of the facility to monitor the treatment activities to ensure process efficiency and environmental safety throughout the project's lifetime, section 9 presents the public participation program implemented to allow direct involvement of the concerned community in the implementation of the projects.

2. LEGISLATIVE AND INSTITUTIONAL FRAMEWORKS

2.1. LEGISLATIVE FRAMEWORK

The MoE was created by *Law 216* of 2 April 1993 marking a significant step forward in the management of environmental affairs in Lebanon. *Article 2* of *Law No. 216* stipulate that the MoE should formulate a general environmental policy and propose measures for its implementation in coordination with the various concerned public administrations. It also indicates that the MoE should protect the natural and man-made environment in the interests of public health and welfare and fight pollution from whatever source by taking preventative and remedial action. Specifically, the MoE is charged with developing, among others, the following aspects of environmental management:

- ◆ A strategy for solid waste and waste water disposal treatment, through participation in appropriate committees, conducting studies prepared for this purpose, and commissioning appropriate infrastructure works;
- ◆ *Permitting conditions for new industry*, agriculture, quarrying and mining, and the enforcement of appropriate remedial measures for installations existing before promulgation of this law;
- ◆ Conditions and regulations for the use of public land, marine and riverine resources, in such a way as to protect the environment;
- ◆ Encouragement of private and collective initiatives which improve environmental conditions; and
- ◆ Classification of natural sites and landscapes and to make decisions and issue decrees concerning their protection.

Furthermore, new emission standards for discharge into surface water and air have been established by the MoE (ministerial decision no. 8/1/2001), through the assistance of the SPASI (Strengthening the Permitting & Auditing System for Industry) unit at the MoE, to update the previous standards set by Law 52/1. These standards will be used as a basis to control pollution loads in the country.

Table 2.1 describes the main categories of legislation in Lebanon. In terms of environmental legislation, Table 2.2 presents the existing and proposed legislation pertinent to wastewater treatment plants.

Table 2.1. Categories of Legislation in Lebanon

Laws	Laws are passed by the Lebanese parliament. The council of ministers or deputies can propose a project of law that should pass through the appropriate parliamentary committee. In the case of environmental legislation, this committee is generally the Agriculture, Tourism, Environment and Municipalities Committee, the Public Works, Transport, Electric and Hydraulic Resources Committee, or the Planning and Development Committee. The committee reviews, assesses, and presents the law, with the amendments it introduces, for final approval by the parliament that.
Decree laws	The parliament has empowered the council of ministers to issue decree-laws without the prior approval or supervision of the parliament. Decree laws have the same legal standing and powers as laws.
Decrees	The council of ministers issues decrees that have the power of law provided they do not contravene existing laws. The council of state should be consulted before the issuing of a decree.
Resolutions	Ministers issue resolutions without the pre-approval of the council of ministers. Resolutions have the power of law provided they do not contravene existing laws. The council of state should be consulted before the issuing of a resolution.

Table 2.2. Summary of Selected Legislation Related to Wastewater Management

Legislation	Year	Brief Description
Decree No. 7975	5/5/1931	Related to the cleanliness of residences and their extensions, and wiping out of mosquitoes and flies, and discharges of substances and wastewater.
Decree No. 2761	19/12/1933	Directions related to discharge of wastewater and dirty substances.
Law No. 216	2/4/1993	The Creation of the MoE
Decree 8735	1974	It is forbidden to allow infiltration of sewage waters from cesspools or to leave them partially exposed, or to irrigate vegetables or fruits with their waters (Article 4) It reserves places assigned by each municipality for the treatment of wastes and agricultural and industrial residues (Article 13), empty sewage waters by tankers in special locations by decision of provincial or district governor until drainage canals are built (Article 15) It is forbidden to drill wells to undefined depth with the aim of disposing of sewage water (Article 3)
Ministerial Decision No. 52/1	29/7/1996	Environmental Quality Standards & Criteria for Air, Water and Soil
Law No. 667	29/12/1997	Amendment to Law No. 216, Organization of the MoE
Project Law	1997-	Code of Environment
Draft Decree	1998	All agglomerations have to be provided with collecting systems for urban wastewater at the latest by 31 December 2013 for those with a population equivalent of more than 15,000 and 31 December 2015 for those between 2,000 and 15,000 (Article 3) All urban wastewater entering collection systems shall, before discharge, be subject to secondary treatment or an equivalent treatment. This deadline for achieving this goal is 31 December 2013 for all discharges from agglomerations of more than 15,000 people and 31 December 2015 for those between 2,000 and 15,000 people (Article 4) It should be ensured that urban wastewater treatment plants are designed, constructed, operated and maintained to ensure sufficient performance under all normal local climatic conditions
Ministerial Decision No. 8/1	30/1/2000	Characteristics and standards related to air pollutants and liquid waste emitted from classified establishment and wastewater treatment plants.
Project Decree	7/2000-	Environmental Impact Assessment

Table 2.3 summarizes the two main documents that would complement the existing environmental legislation, namely the Environment Code and the EIA decree. Table 2.4 presents selected standards for discharge into surface waters (taken from the National Standards for Environmental Quality) that this study has accounted for.

Table 2.3. Code of Environment and EIA Decree

Code of Environment (1997)
<ul style="list-style-type: none"> ◆ The environmental legislation will be administered by the MoE. ◆ Permitting of new facilities with potential environmental impacts will be approved by the MoE in addition to other relevant agencies depending on the type of the project. ◆ The application of environmental legislation will be supervised by the MoE; however, the modalities of the supervision exercised by the MoE are not set. ◆ Enforcement of legislation is not addressed. It is clear that the MoE will have no enforcement role. The Ministry of Interior will continue to be responsible for the legislation enforcement. ◆ A new fund, the National Environment Fund, will be created. The fund covers expenses that should be included in the budget of the MoE. It seems that the establishment of such a fund aims at collecting donations that are specifically targeted to finance environmental projects. Moreover, the fund would also be sustained by the fines and taxes established in the Code. ◆ Environmental tax incentives are mentioned for the first time in Lebanese legislation.
The EIA decree (2000)
<ul style="list-style-type: none"> ◆ The MoE decides upon the conditions to be met and information to be provided by a project to receive a permit. ◆ The MoE must supervise the projects that are undergoing an EIA. ◆ The EIA should contain at least the following sections: institutional framework, description of the project, description of the environment, impact assessment, mitigation measures, and EMP. ◆ The EIA is to be presented to the institution in charge of granting a permit to the project depending on the type of the project. A copy of the EIA is sent by this institution to the MoE for consultative and revision purposes.

Table 2.4. Selected Standards for Discharge into Surface Waters

<i>Parameter</i>	<i>Effluent Concentration *</i>
PH	6 – 9
BOD ₅ **	25
COD***	125
Suspended Solids	60
Ammonia-Nitrogen	10
Nitrate	90

*Concentrations in mg/L except for pH (unit less)

** Biochemical Oxygen Demand

*** Chemical Oxygen Demand

2.2. INSTITUTIONAL FRAMEWORK

In addition to the MoE, other organizations play a role in environmental protection and management, in particular the Ministries of Public Health (MoPH), Interior and Municipalities (MoIM), Public Works and Transport (MoPWT), Agriculture (MoA), Industry and Petroleum (MoIP), Ministry of Energy and Water and Beirut and Mount Lebanon Water and Wastewater Establishment (BMLWWE). At a regional level, the Mohafaza, Union of Municipalities and each Municipality have direct responsibilities relating to the environment; and the Council for Development and Reconstruction (CDR) is leading the reconstruction and recovery program and has taken over certain responsibility from line ministries in areas with direct environmental implications. Table 2.5 summarizes the main responsibilities and authorities of key institutions in the country.

Table 2.5. Responsibilities and Authorities of Key Institutions in Lebanon

Institution	Water Resources	Urban Planning/ Zoning	Standards and Legislation	Enforcement	Biodiversity	Waste Water Discharge
Council for Development and Reconstruction	√	√				√
Council for the Displaced	√					√
Ministry of Agriculture			√		√	√
Ministry of Environment	√	√	√		√	√
Ministry of Housing and Cooperatives		√				√
Ministry of Energy and Water	√		√	√	√	√
Ministry of Industry and Petroleum		√	√	√		√
Ministry of Interior and Municipalities				√		
Ministry of Public Health	√		√		√	√
Ministry of Public Works and Transport	√	√	√			√
Ministry of Tourism		√	√		√	
Beirut and Mount Lebanon Water and Wastewater Establishment	√					√
Union of Municipalities	√	√		√	√	√
Municipality	√	√		√	√	√

3. BACKGROUND INFORMATION

3.1. PROJECTS INITIATION

On April 22nd, 2003 upon the request of the Higher Shouf Municipalities Union, the CNEWA/PM presented a Technical proposal and an Organizational Commitment to USAID seeking funding for the implementation of various Wastewater and Solid Waste plants in that specific region. Subsequently, USAID agreed to finance the implementation of (9) Wastewater treatment plants for 12 villages in the higher Shouf and One Solid Waste treatment plant for all the (12) villages in the area. On that basis, CNEWA/PM has commissioned Arab Resources Development, s.a.r.l. (*ARD*) to perform the EIAs for these various projects.

These municipalities include: Moukhtara, Butmeh, Maasser el Shouf, Khraibeh, Aammatour, Ain Qani, Baadaran, Haret Jandal, Niha, Bater, Mrousti, and Jebaa. All twelve villages are located to the East of Barouk River. Land elevations range between less than 800 m and 1250 m above sea level. The wastewater treatment plants are to be located in nine of these, namely, Aammatour, Moukhtara, Butmeh, Bater El Shouf, Niha, Jebaa el Shouf, Mrousti, El Khraibeh and Maasser El Shouf. The plants would serve total design populations of approximately 25000 that might reach 27000 by the year 2013 and 29000 by the year 2023. Moreover, a total of 43 Km of sewage network will be set over the union villages to reach the various treatment plants.

3.2. IMPORTANCE OF THE PROJECT

Currently, untreated sewage generated within the Union (Aammatour, Ain Qani, Baadaran, and Haret Jandal) is directly disposed off in the environment either through direct discharge into streams and rivers or through seeping septic tanks that can easily leak into ground water aquifers. This situation is exposing the general public directly to the associated negative health impacts. Additionally, the direct disposal into the environment is leading to deterioration of water quality in the area. Proper conveyance and treatment of sewage is of utmost importance to avoid such impacts, and will be addressed by the construction of wastewater treatment plants (and collection networks) to serve the population of the area.

It is essential to note that potable water is being conveyed into the potable water distribution networks of these villages from a well dug in Mrousti a village located at higher elevation than the surrounding villages. Rumors spread over these villages that various springs in the area are polluted and therefore most of the villagers rely on the distribution

network providing water from Mrousti. Various municipalities in the area performed some sporadic spring water analysis after health problems occurred in the previous years. Three main factors are leading to contamination of springs: 1) The absence of a proper wastewater collection network and treatment in the villages located on the recharge zone of these springs; 2) The karstic constitution of the recharge zone posing no filtration and direct recharge of aquifers and 3) The abundance of seeping septic tanks in the overlying area. This third factor leads to the mixing of wastewater and springs water within the various Karstic aquifers. Appendix B includes reports of laboratory analysis on spring water samples confirming the presence of sewerage related contamination within some springs in the higher Shouf area. Even though, 70% of Baadaran village sewerage is being treated at an advanced local Wastewater treatment plant the remaining 30% of the sewerage in that village still can be a potential source of contamination to underground aquifers and down gradient springs. Therefore, it is highly important to treat all the generated sewage in a village to eliminate all the threats of uncontrolled disposal of raw sewage in the environment.

Additionally, wastewater is being discharged directly from residences into run-off ditches and storm water galleries, which in turn conveys the wastewater into open land, agricultural fields and surface water bodies. This situation is mostly evident in Aammatour where raw Sewage is discharged into Olive orchards and agricultural roads subjecting the farmers to potential hazards of diseases and the consumers of olives as well. (Photograph 3.1). The wastewater from various surrounding villages is directly discharged into ecologically mature habitat in Aammatour (Photograph 3.2) and reaches the Barouk River located down gradient.



Photograph 3.1 Discharge of Wastewater on Agricultural lands and Roads.



Photograph 3.2 Discharge of Wastewater in Mature Habitat

3.3. OBJECTIVES OF THE PROJECT

The main objective of the project is to provide the necessary means to treat sewage generated at the Union, and halt the current practices of uncontrolled disposal of raw sewage in the environment. These practices are posing risk to the public health and the environment, mainly through the contamination of potable water, the groundwater and associated springs as well as affecting Agricultural production. An additional objective is to reduce disease vectors and halt the nuisance associated with open disposal of raw sewer onto roadways and open trenches resulting in the generation of odors, mosquitoes, other insect populations and. The concern of the Union of Higher Shouf for the health of the public, the protection of the environment and their drive for developing local tourism is the driving force behind this project.

3.4. THE EXECUTING OFFICE

The municipalities of Aammatour, Haret Jandal, Ain Qani and Baadaran in cooperation with the CNEWA/PM are the responsible authorities with respect to the proper construction and operation of the plants. They will oversee the works and ensure its execution and operation according to specifications.

4. DESCRIPTION OF THE PROJECT

4.1. GENERAL DESCRIPTION OF THE PLANT

The proposed wastewater treatment plant employs typical secondary biological wastewater treatment schemes. For domestic wastewater, the major objective of biological treatment is to reduce the carbonaceous BOD (Biochemical Oxygen Demand), coagulate “non-settle-able” colloidal solids, and stabilize organic matter. Moreover, the wastewater treatment plants can be categorized as suspended growth biological processes of the conventional activated sludge or extended aeration activated sludge type.

The wastewater treatment plant is located in Aammatour, and serves the villages of Aammatour, Ain Qani, Haret-Jandal, and Baadaran. As mentioned earlier, the plant would serve total design populations of approximately 6500 and 7000 by the years 2013 and 2023, respectively. Design population for individual villages is specified in Table 4.1, whereas the contribution to the total inflow of raw sewage from each village to the treatment plant is summarized in Table 4.2.

Table 4.1. Present and Projected Populations for Areas Being Served by Treatment Plant located in Aammatour

<i>Municipality</i>	<i>Present</i>	<i>Year 2013**</i>	<i>Year 2023</i>
Aammatour	3500	3780	4060
Ain Qani	900	972	1044
Haret-Jandal	200	216	232
Baadaran	1400*	1512	1624
Total	6000	~ 6500	~ 7000

* Considering that approximately 2/3 of the village population has already are being served by their local WWTP.

** Considering the average population growth 8/1000 per year (Ecodit, August 2003)

This study considers different processes, and evaluates four different treatment systems. Rather than assessing the plausibility of one treatment system, this study presents an objective evaluation of available technologies and provides CNEWA/PM and the Union with technical criteria to select the most suitable system for adoption.

Table 4.2. Contribution from each village to the total inflow of raw sewage to the treatment plant

<i>Municipality</i>	<i>Raw sewage (m³/Day)</i>
Aammatour	525*
Baadaran	210
Haret-Jandal	30
Ain-Qani	135
Total	900

*Water consumption per Capita is 150Liters/day

4.2. PROCESS THEORY (CONVENTIONAL AND EXTENDED AERATION ACTIVATED SLUDGE SYSTEMS)

The activated sludge process is an aerobic, suspended growth, biological treatment method. Suspended growth processes aim at maintaining an adequate biological mass in suspension within a reactor, by employing either natural or mechanical mixing. The process is based on the metabolic reactions of microorganisms to produce a high quality effluent by converting and removing soluble organic matter that exerts an oxygen demand. A clear effluent, low in suspended solids, is produced due to the flocculent nature of the biomass. A critical requirement in activated sludge systems is the need of oxygen to stabilize the waste. Four factors are common to all activated sludge systems: (1) flocculent slurry of microorganisms, also termed mixed liquor suspended solids (MLSS), in the bioreactor; (2) quiescent settling in the clarifier; (3) activated sludge recycling from the clarifier back to the bioreactor; and (4) excess sludge wasting to control the solids retention time (SRT). The activated sludge process is by far the most widely used biological wastewater treatment process for reducing the concentration of dissolved and colloidal carbonaceous organic matter in wastewater.

The extended aeration activated sludge process is a variation of the conventional activated sludge process. It is a completely mixed process operating at a long hydraulic detention time (18-36 hrs) and a long SRT (20-30 days). Long SRT offers two benefits: remarkably reduced production of stabilized sludge, and greater process stability. However, oxygen requirements are higher for extended aeration activated sludge systems. The system is very robust, stable, and simple to operate, thus rendering it extremely suitable for smaller communities.

Figure 4.1 depicts a flow diagram for the complete-mix modification of the activated sludge process.

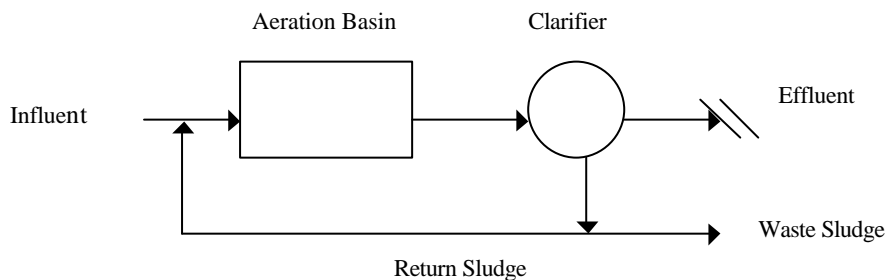


Figure 4.1. Flow Diagram for the Complete-Mix Activated Sludge Process

4.3. ANALYSIS OF ALTERNATIVES

4.3.1 Process and Technology Selection

Selection of the most appropriate technology to meet a certain long-term objective is not a simple and straightforward task. Several factors must be taken into consideration, including technical criteria, environmental considerations, and economic observations. Currently, villages of the Higher Shouf Municipalities Union simply discharge their domestic wastewater, without treatment, into the environment either in seeping septic tanks or in rivers tributaries. This situation is certainly not desirable, and the “Do Nothing” scenario is not considered a legitimate option.

In the context of analysis of alternatives, six alternative wastewater treatment schemes were screened. Table 4.3 provides a comparison of the different scenarios. The alternatives are:

Alternative 1: Preliminary treatment

Alternative 2: Primary treatment alone

Alternative 3: Secondary biological treatment through suspended growth process

Alternative 4: Secondary biological treatment through attached growth process

Alternative 5: Secondary biological treatment through suspended growth process + tertiary treatment through filtration.

Alternative 6: Tertiary treatment through filtration.

Table 4.3 Analysis of Different Scenarios of Wastewater Treatment Schemes

	<i>Preliminary treatment</i>	<i>Primary treatment</i>	<i>Secondary treatment: biological (suspended)</i>	<i>Secondary treatment: biological (attached)</i>	<i>Secondary biological (suspended) + tertiary (filtration) treatment</i>	<i>Tertiary treatment (Filtration)</i>
Unit operations & processes involved	Screening / comminutor Grit removal	Primary clarifier	Suspended growth aerobic biological reactor: Conventional or extended aeration activated sludge system Final clarifier	Attached growth aerobic biological reactor: high-rate trickling filters Final clarifier	Suspended growth aerobic biological reactor: Conventional or extended aeration activated sludge system Final clarifier Filtration	Filter media
Principal application	Removal of large objects Removal of heavy objects: sand, gravel, cinder, etc.	Removal of settleable solids and BOD	Removal of fine non-settleable solids, BOD, some NH ₃ & total phosphorus	Removal of fine non-settleable solids, BOD, some NH ₃ & total phosphorus	Removal of fine non-settleable solids, BOD, some NH ₃ & total phosphorus Further removal of suspended solids	Further removal of suspended solids
Land requirements	Minimum	Moderate	Moderate	Maximum	Moderate	Moderate
Adverse climatic conditions	-	-	Decreased microbial activity Freezing of piping and valves	Decreased microbial activity Freezing of piping and valves	Decreased microbial activity in aeration tank	-
Ability to handle flow variations	Good	Fair	Good	Good	Good	Good
Ability to handle influent quality variation	Good	Good	Good	Fair	Good (secondary) Poor (filtration)	Poor
Industrial pollutants affecting process	Minimum	Minimum	Moderate	Moderate	Moderate	Moderate
Ease of O&M	Fair	Good	Good	Good	Moderate	Moderate
Reliability of the process	Good	Good	Good	Good	Moderate	Fair

Waste products		Screenings and grit	Sludge (organic & inorganic)	Sludge (biomass) for conventional; Stabilized and reduced sludge (biomass) for EAAS	Sludge (biomass)	Sludge (biomass) for conventional; Stabilized and reduced sludge (biomass) for EAAS Filter backwash waste	Backwash waste
Typical removal efficiencies (%)	BOD₅	Small	30-40	80-85 (conventional); 80-95 (EAAS)	60-80	68-92	20-60
	COD	Small	30-40	80-85 (conventional); 80-90 (EAAS)	60-80	60-90	0-50
	TSS	Small	50-65	80-90 (conventional); 70-90 (EAAS)	60-85	84-97	60-80
	TP	Small	10-20	10-25 (conventional); 10-15 (EAAS)	8-12	26-56	20-50
	ON	Small	20-40	60-85 (conventional); 75-85 (EAAS)	60-80	80-94	50-70
	NH₃-N	Small	0	High removals depending on operational criteria (DO, BOD/TKN, temperature, alkalinity and pH, MLSS / MLVSS, return sludge rate, sludge wasting). 85-95 (EAAS)	8-15	High removals in secondary treatment depending on operational: 85-95 (EAAS) No additional removal by filtration	0

The disadvantage of a system with only preliminary and/or primary treatment options is that contaminant removal, in particularly organic, is relatively limited. When protection of the environment is an issue, a treatment system should at a minimum include secondary treatment. Although, tertiary treatment can be considered, its inclusion has to be operationally and financially justifiable. In general, as long as effluents are properly managed, a secondary treatment based on suspended growth activated sludge is a reliable process that produces acceptable levels of sewage treatment. A drawing of an EAAS treatment plant suitable for 6000 inhabitants is presented in Appendix C all along with its estimated electrical power consumption. In particular, the extended aeration activated sludge system has the following advantages, especially when deployed to service smaller communities:

- ◆ Simple design and operation;
- ◆ Provision of equalization to absorb sudden/temporary shock loads;
- ◆ High quality and well nitrified effluent meeting secondary effluent guidelines;
- ◆ Lowest sludge production of any activated-sludge process;
- ◆ Organically stable waste sludge;
- ◆ Exists in flexible pre-engineered package plants for small communities;
- ◆ Favorable reliability with sufficient operator attention;
- ◆ Nitrification likely at wastewater temperatures of more than 15°C with addition of chemicals;
- ◆ Relatively minimal land requirements and low initial costs;
- ◆ No need for primary clarification of wastewater.

Within the same context, analysis of alternatives for different modifications of activated sludge systems proposed by different manufacturers of wastewater treatment plants. Table 4.4 provides a comparison of the different systems. The alternative systems are:

Alternative 1: HANS-reactor treatment system

Alternative 2: ECOLO-design treatment system

Alternative 3: Standard extended aeration activated sludge system (EAAS)

Alternative 4: TECH UNIVERSAL system (EAAS+ Pressure sand filtration)

Table 4.4 Analysis of Different Modifications of Activated Sludge Wastewater Treatment Schemes (data supplied by system providers
(the last rows in this table(price/earthworks related) are being used by the Union and the Consultant as price/benefit indicators)

	<i>HANS-REACTOR</i>	<i>ECOLO SYSTEMS</i>	<i>STANDARD EAAS</i>	<i>TECH UNIVERSAL (EAAS + Filtration)</i>
Involved unit operations & processes	<ul style="list-style-type: none"> Balance tank Screening Aeration reactor Final clarifier Disinfection by balsam 	<ul style="list-style-type: none"> Primary separation basin Aeration basin(s) Final clarifier(s) Disinfection Aerobic sludge digestion unit 	<ul style="list-style-type: none"> Screening Grit chamber Aeration basin(s) Final clarifier(s) Disinfection Sludge holding tank Sludge filter press 	<ul style="list-style-type: none"> Screening Grit chamber Aeration basin Final clarifier Disinfection Pressure sand filter Sludge holding tank Sludge filter press
Ability to handle flow variations	Fair (need for equalization basin)	Good	Good	Good
Ability to handle influent quality variation	Good	Good	Good	Good
Industrial pollutants affecting process	Moderate	Moderate	Moderate	Moderate
Ease of operation & maintenance	Good	Good	Moderate	Fair to Moderate
Maintenance requirements	Minimal ^a	Minimal ^a	Moderate	Moderate to high
Reliability of the process	Good	Good	Good	Good
Flexibility of the system	Good	Very Good	Good	Good
Waste products	Stabilized and reduced sludge ^b	Stabilized and reduced sludge ^b	Screenings & grit Stabilized and reduced sludge ^c	Screenings & grit, Stabilized and reduced sludge, filter backwash waste ^c
Volume of sludge generated	3.8 Lit/m ³ wastewater treated ^b	90% reduction in solids entering the 1 st tank resulting in minimal amounts of inert material ^b	6.4-9.1 Lit/m ³ wastewater treated ^c	15 Lit/m ³ wastewater treated ^a
Need for preliminary treatment	Yes	No	Yes	Yes
Nitrification/denitrification capabilities	Fair to moderate ^d	Moderate to high	Moderate to high ^c	Moderate to high ^c
Noise impacts	Minimal to moderate ^d	Minimal (< 82 dBA) ^a	Moderate to high	Moderate to high
BOD₅ removal efficiency (%)	Up to 97 ^b	90-95 (< 10 mg/L in final effluent) ^a	80-95 (10-20 mg/L in final effluent) ^c	10 mg/L in final effluent
Suspended solid removal efficiency (%)	Up to 85 ^b	90-95 (< 10 mg/L in final effluent) ^a	70-90 (<20 mg/L in final effluent) ^c	10 mg/L in final effluent
Air requirements	36 m ³ /Kg BOD ₅ ^a	93-125 m ³ /Kg BOD ₅ ^a	90-125 m ³ /Kg BOD ₅ ^c 187-250 m ³ /Kg BOD ₅ ^c 280 m ³ /Kg BOD ₅ ^c	2.72 Kg O ₂ /Kg BOD ₅ ^a

Number of operational units	57 (12 in Lebanon, of which 11 for residential) ^d	>100 units (operating abroad) 1 in Lebanon	Most widely used system especially for small communities	Similar to standard EAAS
Availability of relevant literature	Very minimal	Moderate to extensive	Extensive	Extensive
Availability of certificates	Patented ^a	Design approved by USEPA ^a	Widely in use since 1950's ^c	Similar to standard EAAS
After sale service/ technical assistance	<ul style="list-style-type: none"> One month monitoring and training in the start up phase^d 10 year guarantee for Reco-Reactor^a 	<ul style="list-style-type: none"> Technical assistance in case of difficulties. Guarantee on system components for 12 months after initial start up or 18 months from the date of shipment.^a 		<ul style="list-style-type: none"> Guarantee on system components for 12 months after initial start up or 18 months from the date of shipment.^a
Land area requirements (m²)	<ul style="list-style-type: none"> 463 m² for a HL = 1000m³/day^a 	<ul style="list-style-type: none"> 683 m²(ES300)^a 	<ul style="list-style-type: none"> App. 1985 m2 for average design flow of 38m³/day^c App. 2700 m2 for average design flow of 190m³/day^c App. 3850 m2 for average design flow of 380m³/day^c 	<ul style="list-style-type: none"> N.A.
Monthly energy consumption (kWh / year)	43800 kWh/year (HL=1000m ³ /day) 3,650 kWh/month ^a	257820 kWh/year ^a (ES300; HL=1131m ³ /day)	<ul style="list-style-type: none"> 15,000 kWh/year^c (HL=38m³/day) 40,000 kWh/year^c (HL=190m³/day) 60,000 kWh/year^c (HL=375m³/day) 133,225 kWh/year^c (HL=900m³/day) 	<ul style="list-style-type: none"> N.A.

^a Documented in literature supplied by technology provider

^b Documented in literature supplied by technology provider, but lack of supportive operational data

^c Documented in published literature

^d Claimed by technology provider, but lack of supportive operational data

4.3.2 Site Selection

The most practical and economical location of the plant would be down gradient with respect to the villages (areas being served). As such, the sewage is conveyed to the plant by gravity, avoiding the need for pumping stations along the sewage collection lines, therefore minimizing operational costs and reducing the potential for a second source point of contamination. Other significant criteria in the selection of a location are the hydrological and geological settings and constraints. Hence, the potential proximity of the proposed site to nearby springs or the potential presence of direct hydrological connections with ground water is also considered. The distances of the locations from sensitive receptors such as residences and institutions are also considered.

The proposed location of the plant in Aammatour serving Ain Qani, Baadaran, Haret Jandal and Aammatour permits the discharge of treated effluents into the nearby Barouk River, given that their quality meets the Environmental Limit Values (ELV) for wastewater discharged into surface waters. Moreover, treated effluent can be used for irrigation of the nearby Olive orchards but since there is an abundance of irrigation water in the area, this option might not be used in this case.

4.3.3 Analysis of Alternative Sites

The process of site selection is a tedious process that requires deep investigation of the various available sites. However, in many instances the private property matter comes into play and limits the scopes of the selection reducing the range of choices to a tight and critical selection.

In this study a variety of lands were studied, inspected and graded. The grading system allocates a coefficient to each criterion and then grades each component according to a range between 1 and 3 based on the level of importance and relevance to the requirements. Therefore, the location having the highest grade can be considered as the best candidate for the initiation of the plant. Appendix D presents the various parcels map showing the four studied locations (Table 4.5)

Table 4.5 Analysis and grading of different available sites intended for the initiation of the WWTP in the village of Aammatour

	<i>LOCATION #1</i>	<i>LOCATION #2</i>	<i>LOCATION #3</i>	<i>LOCATION #4</i>
Land classification (Coefficient *1)	<ul style="list-style-type: none"> Degraded garrigue Shrubs and regenerating trees Grade:3 	<ul style="list-style-type: none"> Olive orchard Grade:1 	<ul style="list-style-type: none"> Olive Orchard Grade 1 	<ul style="list-style-type: none"> Old neglected orchard Gradually being replaced by wild trees and shrubs Grade:2
Impacts on Biodiversity/ old reclaimed agricultural land (Coefficient *2)	<ul style="list-style-type: none"> Minimal Grade: 3 	<ul style="list-style-type: none"> High Grade: 1 	<ul style="list-style-type: none"> High Grade: 1 	<ul style="list-style-type: none"> Average Grade: 2
Geological Compliance (Coefficient *2)	<ul style="list-style-type: none"> Yes Grade: 3 	<ul style="list-style-type: none"> Yes Grade: 3 	<ul style="list-style-type: none"> Yes Grade: 3 	<ul style="list-style-type: none"> Yes Grade: 3
Topographical Compliance (Coefficient *2)	<ul style="list-style-type: none"> Yes Grade: 3 	<ul style="list-style-type: none"> Yes Grade: 3 	<ul style="list-style-type: none"> Yes Grade: 3 	<ul style="list-style-type: none"> Yes Grade: 3
Hydrogeological Compliance (Coefficient *3)	<ul style="list-style-type: none"> Yes Grade: 3 	<ul style="list-style-type: none"> No (Spring on site) Grade: 1 	<ul style="list-style-type: none"> Yes Grade: 3 	<ul style="list-style-type: none"> Yes Grade: 3
Closeness to perennial river (discharge) (Coefficient *3)	<ul style="list-style-type: none"> Close Grade: 3 	<ul style="list-style-type: none"> Close Grade: 3 	<ul style="list-style-type: none"> Close Grade: 3 	<ul style="list-style-type: none"> Close Grade: 3
Needed level of mitigation measures (Coefficient *2)	<ul style="list-style-type: none"> Average Grade: 2 	<ul style="list-style-type: none"> Tight Grade: 1 	<ul style="list-style-type: none"> Tight Grade: 1 	<ul style="list-style-type: none"> Fair Grade: 2
Area (Coefficient *1)	<ul style="list-style-type: none"> 10000 m² Grade: 3 	<ul style="list-style-type: none"> Very Good Grade: 3 	<ul style="list-style-type: none"> Good Grade: 3 	<ul style="list-style-type: none"> Average Grade: 3
Ability for Future Expansion or upgrading (Coefficient *1)	<ul style="list-style-type: none"> Easy Grade: 3 	<ul style="list-style-type: none"> Difficult Grade: 1 	<ul style="list-style-type: none"> Difficult Grade: 1 	<ul style="list-style-type: none"> Average Grade: 2
Price of land (Coefficient*3)	<ul style="list-style-type: none"> Very expensive Grade: 1 	<ul style="list-style-type: none"> Relatively Cheap Grade: 2 	<ul style="list-style-type: none"> Relatively Cheap Grade: 2 	<ul style="list-style-type: none"> Cheap[Grade: 3
Location with respect to village (Coefficient *2)	<ul style="list-style-type: none"> Far Grade: 3 	<ul style="list-style-type: none"> Far Grade: 3 	<ul style="list-style-type: none"> Far Grade: 3 	<ul style="list-style-type: none"> Far Grade: 3
Ease of usage in Irrigation (closeness to Agricultural lands) (Coefficient *1)	<ul style="list-style-type: none"> Yes Grade: 3 	<ul style="list-style-type: none"> Yes Grade: 3 	<ul style="list-style-type: none"> Yes Grade: 3 	<ul style="list-style-type: none"> Yes Grade: 3
Total grade	61	50	54	63

As highlighted in Table 4.5, the presented sites were studied and graded with respect to various environmental and technical factors. The second highest grade corresponds to location #1 where the requirements were satisfied similarly to the case of location #4. However, financial constraints faced in the case of Location # 1 lowered the suitability of this parcel. Hence, based on the analysis and grading system presented location # 4 best complies with the requirements; therefore, the land is suitable for the initiation of the project.

4.4. DETAILED PROCESS DESCRIPTION

4.4.1 Standard Extended Aeration Activated Sludge System and TECH UNIVERSAL Extended Aeration Activated Sludge Plus Filtration System

In a standard extended aeration activated sludge system, screened raw wastewater is let to flow into aeration basin(s) in which microorganisms are mixed thoroughly with organics so that they can flocculate and stabilize organic matter. Aeration is accomplished by supplying oxygen via blowers or aerators. The mixture of microbial flocs and wastewater then flows into a final settlement tank where the activated sludge is settled. A portion of the settled sludge is recycled back into the aeration basin to maintain the proper food to microorganism ratio needed for the rapid breakdown of organic matter. The waste sludge is conveyed to sludge-handling systems for proper treatment and disposal. The effluent from the final settlement tank flows into a chlorine contact tank for disinfection. Effluents produced from EAAS systems are of high quality and well nitrified. Typical removal efficiencies for BOD₅, COD, and TSS are 80-85, 80-85, and 80-95, respectively, as reported in published literature. Figure 4.2 presents a flow diagram for conventional EAAS system. However for certain applications, specific unit operations (e.g. grit removal, sludge handling and treatment) or unit processes (e.g. disinfection) may be optional.

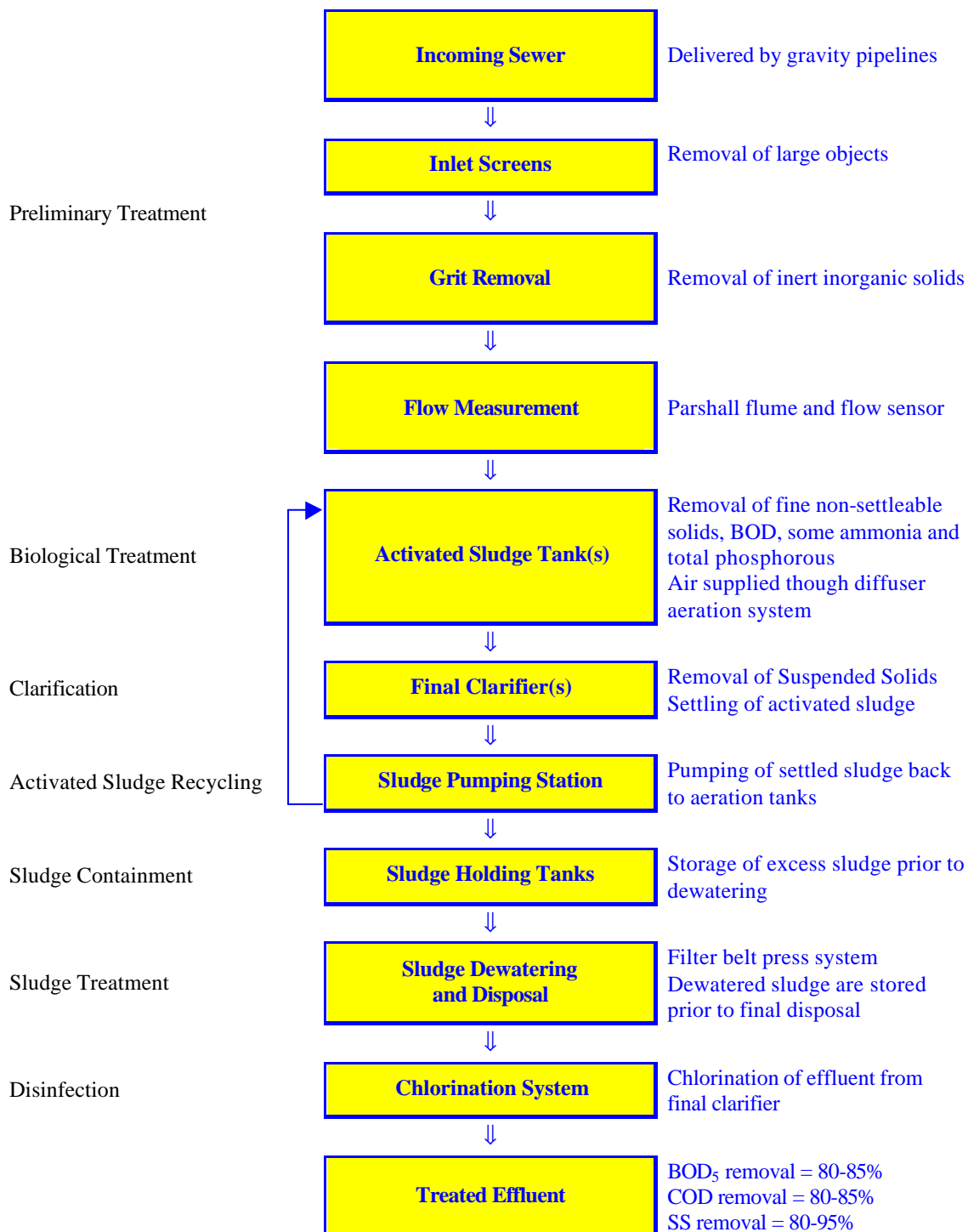


Figure 4.2 Flow Diagram of Extended Aeration Activated Sludge Treatment Plant

In the TECH UNIVERSAL system, flow schemes resemble that of a standard EAAS system except that the chlorinated effluent is further treated through a pressure sand filtration unit. This polishing step reduces BOD₅ and TSS levels in the final effluent to 10 mg/L each.

For the proper operation of the filtration unit, filter feed pumps as well as backwash pumps are incorporated into the system.

4.4.2 HANS-Reactor Activated Sludge System

The HANS-reactor is a new-patented biological treatment system for domestic wastewater. In principle, the process may be viewed as a variation of conventional activated sludge systems. In the HANS-reactor system, raw sewage flows through a screen into a two-compartment concrete equalization tank. Screened sewage is then pumped to the HANS-reactor, which is packed with special hollow-type plastic balls, termed sludge carriers. Inside each ball anaerobic decomposition takes place, while on their corrugated surfaces, aerobic processes dominate. An airlift aerator supplies oxygen for the decomposition process to take place. Within the reactor, sludge carriers are kept in constant motion (up/down). This constant collision between the balls removes excess biomass, thus acting as a self-cleaning mechanism. Then from the reactor, treated wastewater flows to a concrete final sedimentation tank for clarification. Portion of the settled sludge is pumped back into the reactor, whereas waste sludge is pumped into the equalization tank. A mix of polyzymes is added to this tank to enhance the decomposition of sludge and produce minimal quantities of stabilized sludge. When the equalization tank becomes filled with sludge to about half its capacity, it should be emptied. In this system, the tank is claimed to require emptying less frequently than the conventional system. Moreover, the tank is enclosed and its top is filled with plastic and mineral fillings to prevent penetration of gases and thus prevent odor generation. Finally, the treated effluent from the final sedimentation tank is disinfected using a solution of copper sulfate termed as “balsam” and can be discharged into surface water bodies or reused for irrigation. The purification efficiency of the HANS-reactor system is reported to be 97%; however, no supportive operational data is available. Figure 4.3 presents a schematic illustration for the HANS-reactor wastewater treatment system.

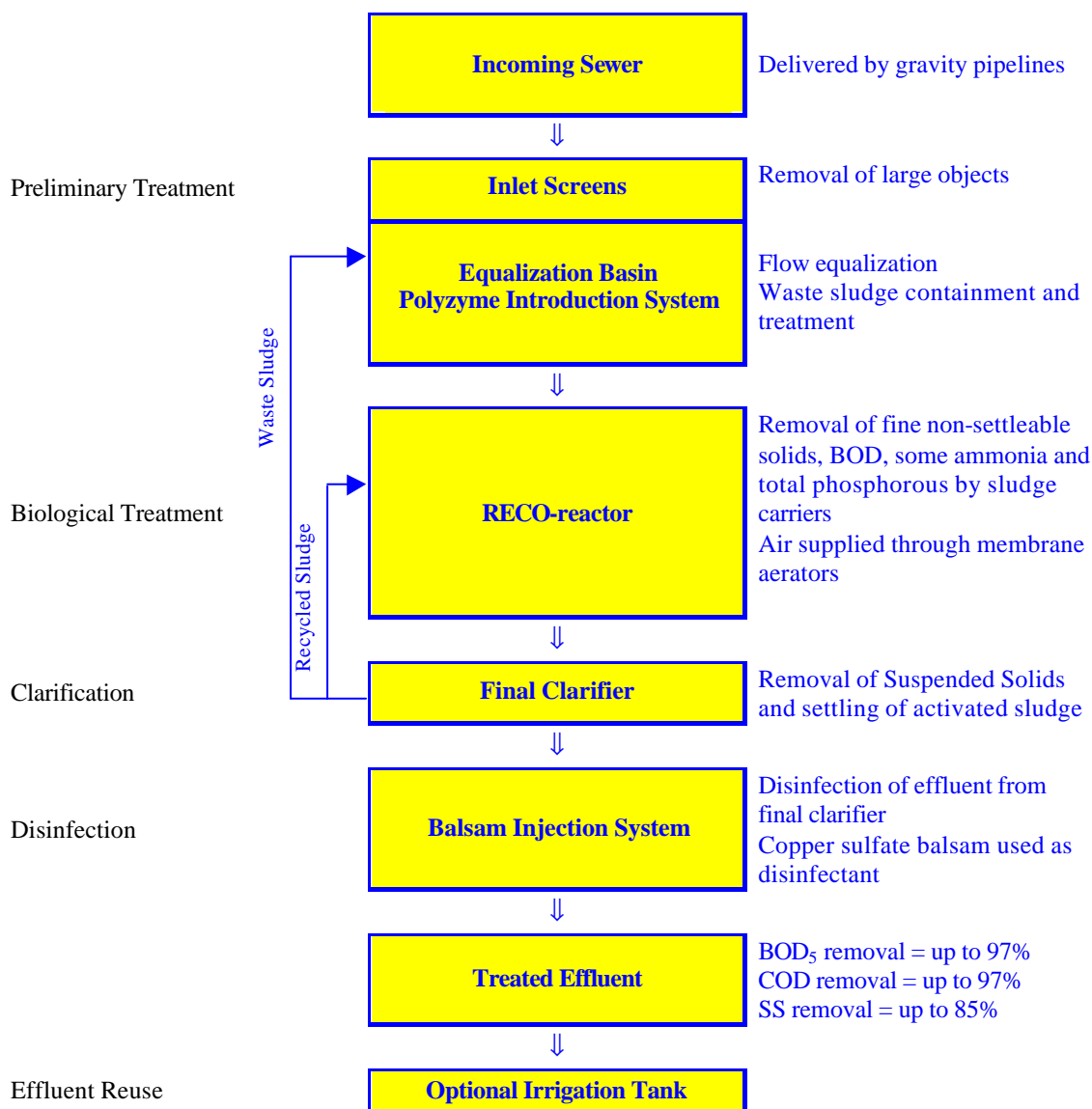


Figure 4.3 Flow Diagram of HANS-Reactor Activated Sludge Treatment Plant

4.4.3 ECOLO System

The ECOLO wastewater treatment plant employs a modified EAAS system. ECOLO design is approved by USEPA and consists of multiple long life epoxy-coated basins that can be field erected. Three separate processes take place in the ECOLO system, namely: (1) separation and sedimentation, (2) aeration, and (3) settling.

Raw wastewater flows into the primary basin of the ECOLO system. The plant influent is retained in this zone for a period of 4-6 hours during which floatables and suspended solids are trapped and allowed to surface to form a blanket above the wastewater. Below this blanket anaerobic-like biological action is induced. Over time, the trapped floatables are slowly digested while settled solids within the basin deteriorate and are depleted biologically.

The plant influent, now free of floatables and other matter, leaves the primary basin and enters the aeration zone(s). Typically, up to 30% BOD₅ and 70% suspended solids are removed in the primary separation basin.

The actual oxidation of the wastewater is completed in the aeration phase, where oxygen acts as a catalyst. Bacteriological digestion is accomplished by a mixture of self-sustained laboratory-grown bacterial cultures to increase the rate of digestion while reducing residual solids. Aeration is accomplished in multiple circular basins to optimize the aeration process and enhance biomass flocculation. Also, the multiple basin design gives the flexibility of bypassing aeration basins, especially when the initial plant size is larger than needed, so the amount of supplied oxygen is correct. Duplex blowers are employed to deliver the required amounts of oxygen and an electrical panel allows for adjustment of aeration, saving on operational costs. Inlet and outlet silencers assure a quiet blower operation, with typical sound levels of less than 82 dBA. Non-clog coarse air bubble diffusers, placed onto removable grid, allow a cone shaped dispersal of oxygen bubbles. This diffuser pattern layout in addition to the multiple basin design minimize short-circuiting and maximize mix of air to food over matter. Detention time in aeration ranges from 12-15 hours at average flow.

The effluent from the aeration basins flows into the final settling basin, where a detention time of 4 to 6 hours is scheduled. The final settling basin influent line is turned down to mid-tank depth to aid in the settling process by initiating downward momentum. Settled sludge in the hopper of the clarifier is pumped by an airlift pump and recycled to the first aeration basin. Excess sludge is wasted into the primary separation basin, from which accumulated sludge should be pumped, usually on an annual basis. Scum and/or floatables at the surface of the final clarifier are skimmed off by a surface airlift skimmer and returned to the primary separation basin. The final treated effluent, containing < 10 mg/L of BOD₅ and SS, exits the settling basin via a v-notched weir. Figure 4.4 presents a flow diagram for the ECOLO wastewater treatment system.

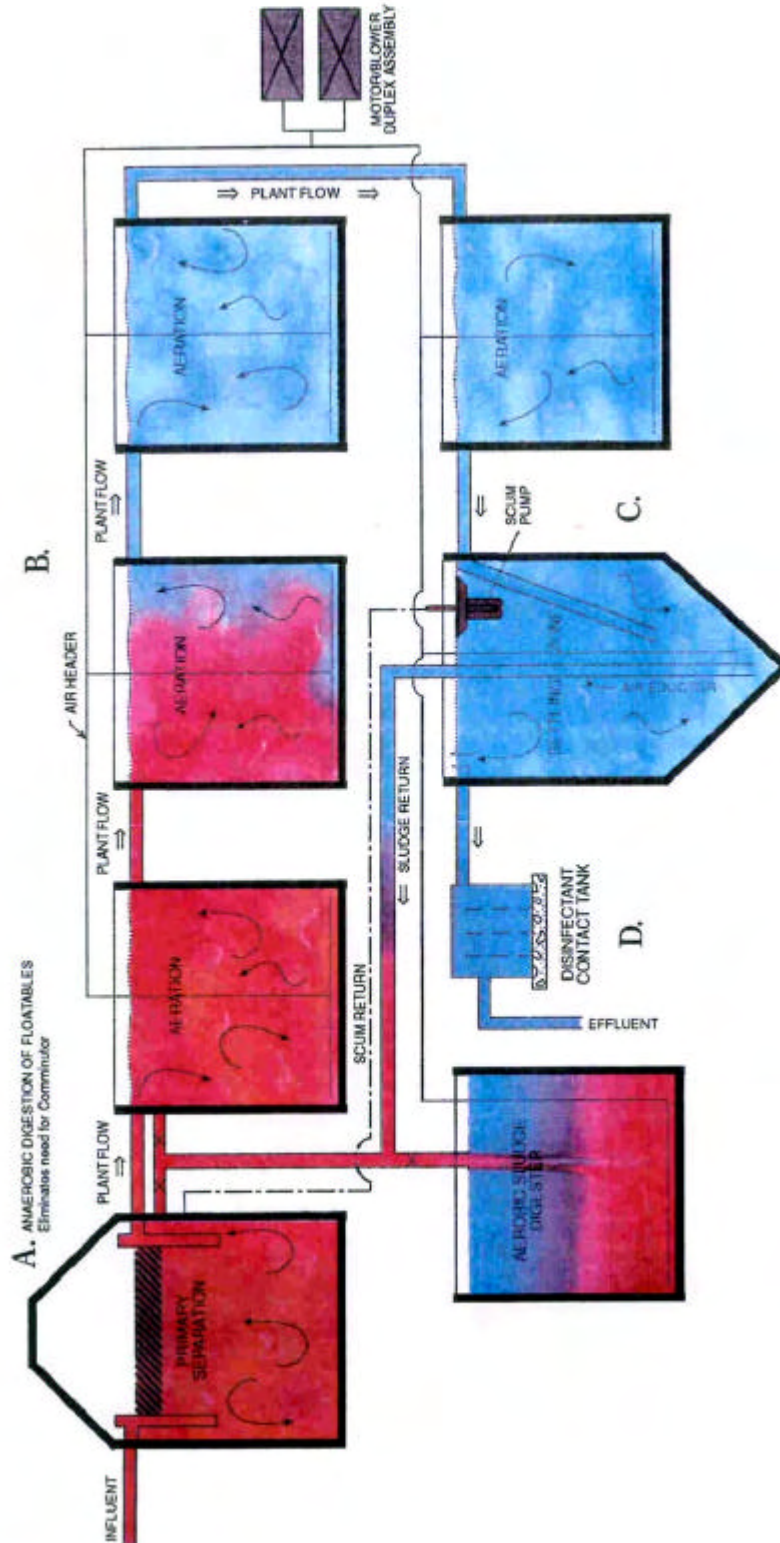


Figure 4.4 Flow Diagram of ECOLO Wastewater Treatment System

4.5. EFFLUENTS CHARACTERIZATION AND MANAGEMENT

Activated sludge treatment plants typically generate two main types of effluents: treated liquid effluent and waste sludge. Other miscellaneous effluents will include “bulk” solids removed during the preliminary treatment, namely, screenings and grit.

4.5.1 Liquid Effluent

4.5.1.1 Liquid Effluent Characteristics

The quantity of liquid effluent that will be generated daily is equivalent to the quantity of sewage received by the plant. The average daily volume of generated treated effluent from the waste water treatment plant by year 2013 and 2023 can be calculated from the projected design population (Table 4.6). In the calculations, an average daily per capita sewage generation of 150 Lit is assumed. It should be noted that quantities of generated liquid effluents would be much less during the first years of operation.

Table 4.6. Average Daily Volumes of Treated Liquid Effluents

<i>Municipality</i>	<i>Present Effluent Flow (m³/day)</i>	<i>Effluent flow by year 2013 (m³/day)</i>	<i>Effluent flow by year 2023 (m³/day)</i>
Aammatour	525	567	609
Baadaran	210	226.8	243.6
Haret-Jandal	30	32.4	34.8
Ain-Qani	135	145.8	156.6
Total	900	972	1044

The expected quality of the liquid effluents varies with the type of adopted treatment technology. However, with the proposed systems the expected quality should meet or even be lower than the standards of effluent discharge to surface water as summarized in Table 4.7.

Table 4.7. Expected Quality of Treated Wastewater

<i>Parameter</i>	<i>Effluent Concentration</i>				<i>Effluent Standard^d (ES)</i>
	<i>HANS-Reactor</i>	<i>TECH Universal</i>	<i>ECOLO system</i>	<i>EAAS</i>	
BOD ₅ (mg/Lit)	< ES ^a	≤ 10 ^b	≤ 10 ^b	10-20 ^c	25
Suspended Solids (mg/Lit)	< ES ^a	≤ 10 ^b	≤ 10 ^b	≤ 20 ^c	60

a. Claimed by the technology provider, no documented reference

^b Documented in literature supplied by the technology provider

^c Documented in published literature (Qasim, S. R., 1999)

^d Environmental Limit Values (ELV) for wastewater discharged into surface waters, as specified in the National Standards for Environmental Quality

4.5.1.2 Liquid Effluent Management

The treated effluent should meet very stringent quality standards and thus its disposal into the environment should not cause adverse impacts. However, to avoid any risk of contaminating nearby springs or underground waters, the hydrological as well as geological settings have been evaluated in Section 5.5 and are being accounted for. The quality of treated liquid effluent should meet the Environmental Limit Values (ELV) for wastewater in order to be discharged into surface waters. Hence, the effluent generated from the Aammatour plant may be discharged into the minor seasonal drainage stream located at the Western side of the plant that leads directly into Barouk River or the effluent pipe may be extended to discharge directly into the river. Moreover, if feasible, the treated effluent could be used for irrigation purposes in the surrounding Olive orchards. As stated before, irrigation water in this area is supplied from the abundant springs therefore treated effluent might not be used for Agricultural purposes. Appendix E provides EPA guidelines for wastewater re-use in the biological environment.

4.5.2 Sludge Effluent

4.5.2.1 Sludge Characteristics

The estimated volume of generated sludge varies with the type of adopted treatment technology. For the HANS-reactor, the sludge generation rate is reported to be 3.8 Lit/m³ of wastewater treated. For the ECOLO systems, the sludge generation rate is reported as negligible. Typical sludge generation rate for an EAAS system is published to be 6.4-9.1 Lit/m³ of wastewater treated. Typical quality of sludge generated after EAAS treatment is depicted in Table 4.8 and Table 4.9. Once the plants are operational, detailed sludge characterization will be necessary to assess the best disposal option for it.

Table 4.8. Typical Ranges for Chemical Composition of Activated Sludge

<i>Parameter</i>	<i>Typical Range</i>
Total dry solids (%)	0.83-1.16
Nitrogen (N, % of TS)	2.4-5.0
Phosphorus (P ₂ O ₅ , % of TS)	2.8-11.0
PH	6.5-8.0
Organic acids (mg/L or ppm as acetic acid)	1,100-1,700

Table 4.9. Typical Metal Content in Wastewater Sludge

<i>Metal</i>	<i>Dry Sludge (mg/Kg or ppm)</i>	
	<i>Range</i>	<i>Median</i>
As*	1.1-230	10
Cd*	1-3,410	10
Cr	10-99,000	500
Co	11.3-2,490	30
Cu*	84-17,000	800
Fe	1,000-154,000	17,000
Pb*	13-26,000	500
Mn	32-9,870	260
Hg*	0.6-56	6
Mo	0.1-214	4
Ni*	2-5,300	80
Se*	1.7-17.2	5
Sn	2.6-329	14
Zn*	101-49,000	1,700

* Metals that are regulated for land application of wastewater sludge

4.5.2.2 Sludge Management

The best disposal route for the sludge would be to use it as a fertilizer or soil cover in agricultural lands, landscapes, in silviculture (woodland exploitation) or in reforestation. However, these options should be carefully monitored to avoid any negative impacts. Appendix E presents a summary of EPA guidelines that need to be followed to ensure that sludge is applied on soils in a way to minimize adverse impacts on soil quality and vegetation. The Agricultural use option is highly dependent on the demand of such a product in the market and the level of acceptance from the farmers. Moreover, since the Solid Waste Treatment Plant (SWTP) (Section 3.1) is located in the same site with the Waste Water

Treatment Plant (WWTP) the sludge produced can be integrated in the composting process as well. The most probable disposal option would be land filling, if an adequate disposal site is available and authorized by the MoE.

4.5.3 Miscellaneous Wastes

Other debris and solid wastes produced from the plant will be managed similarly to the management of the municipal solid waste in the area.

4.6. PLANT CONSTRUCTION

The size of a plant varies according to the location and the population that it serves. The following information provides an indication of the resources needed to build the plant for the size encountered in the Union.

4.6.1 Extended Aeration Activated Sludge System

A site visit on the 14th of August 2003 to the village of Baadaran where an EAAS plant is serving 80% of the village population (2560 Capita) therefore, approximately treating an inflow or a hydraulic loading of 384m³/day to a tertiary level of treatment and occupying an approximate area of 800-1000 m² (Photograph 4.1)

For an EAAS plant serving 6000 capita, the total volume of excavation will be approximately 6500 m³ for an area 2000m² with a depth range of excavation of 2-3 meters. It is expected that 17 truck-trips/day will be necessary to finalize the excavation works in a period of 4 weeks or 24 working days.

The excavated material will be either sent to quarries where it can be re-utilized (preferred option) or for final disposal in the nearest landfill. A total volume of 600 m³ of reinforced concrete will be used to construct the plant. Concrete will either be delivered as ready-mix concrete, which will require 75 trucks (8 m³ each), or be prepared on site.

The latter option will require 30 trucks for gravel, 14 trucks for sand, and 6 trucks for cement. Sixty (60) tons of reinforced steel will be needed, requiring 4 additional trucks. Construction works and the final installation and operation will be phased over 5-6 months, which account for the time necessary to procure electro-mechanical equipment. After completion of concrete works and installation of all electro-mechanical equipment, piping, and fixtures, a testing and start-up period of 2 months will be provided to ensure that plant is working according to specifications.



Photograph 4.1: EAAS system in the village of Baadaran

4.6.2 HANS-Reactor Activated Sludge System

A site visit to the village of Bchetfeen, Shouf Caza, where a HANS-Reactor activated sludge system was being installed, revealed that the plant occupies a land area of approximately 245 m² (9m × 27m). The plant consisted of a two-compartment concrete equalization and separation primary basin, concrete housing for the HANS-reactor, and a concrete final clarifier. A small concrete housing was also built for the pumps and storage of chemicals/supplies. All basins were erected on a concrete platform (the plant would require less than 100 m³ of reinforced concrete). The technology supplier claimed that the plant would serve a current population of 3,500 capita and a projected population of 7,000 capita.

4.6.3 ECOLO System

In this section, plant construction specifications pertain to an ECOLO system plant accommodating a hydraulic loading of 1131.5 m³/day, and thus serving 8000 capita (ES300). The plant is installed on a concrete foundation having a minimum thickness of six inches and an area of 19.81 m × 34.44 m. For such a plant, the total volume of required excavation will be approximately 2421 m³. The excavated material, if suitable, may be used for backfilling, or else it can be sent to quarries for reutilization or disposed in the nearest landfill. Before backfilling, basins are tested for leakages. The volume of backfilling in ES300 amounts to 1151 m³. Additionally, a total volume of 148 m³ of reinforced concrete will be used to construct the plant. Concrete will either be delivered as ready-mix concrete or be prepared on site. The man hours needed to install an ES300 plant is approximately 420. Basins in the

ECOLO system are field erected and can be easily bolted, sealed, cleaned, and painted; thus, the entire plant can be finished in a relatively short period of time.

After completion of civil works and installation of all basins, electro-mechanical equipment, piping, and fixtures, a testing and start-up period will be initiated and resumed until a stable biology is achieved and the operation is optimized.

5. DESCRIPTION OF THE ENVIRONMENT

5.1. GENERAL SETTING

Two parallel mountainous ranges, Mount Lebanon and Anti Lebanon, separated by the Bekaa plain are the dominating topographic features of Lebanon (Figure 5.1). These topographic features extend in a NNE-SSW direction. The study area is located on the Eastern slopes of the southern section of Mount Lebanon, where the lowest elevations coincide with the Barouk River (Figure 5.2).

The four villages composing the Union of Municipalities are located on the Eastern side of Barouk River. Land elevations ranging between less than 664 m and 1053 m above sea level (Figure 5.2).

A generally good road network (Figure 5.3) connects the four villages. However, the road connection to the proposed site for the wastewater plant as well as the solid waste treatment plant needs rehabilitation and renovation in order to be suitable for a fairly heavy traffic of Municipal waste collection trucks as well as the excavation and building machinery during plant construction phases.

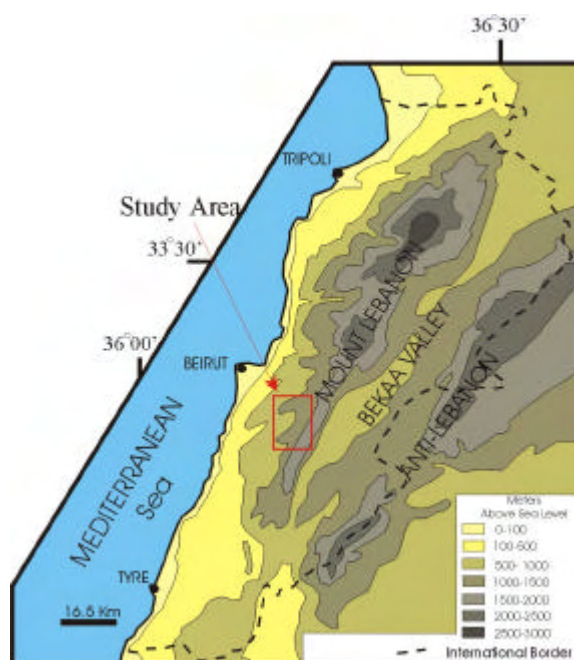


Figure 5.1. Topographic Map of Lebanon

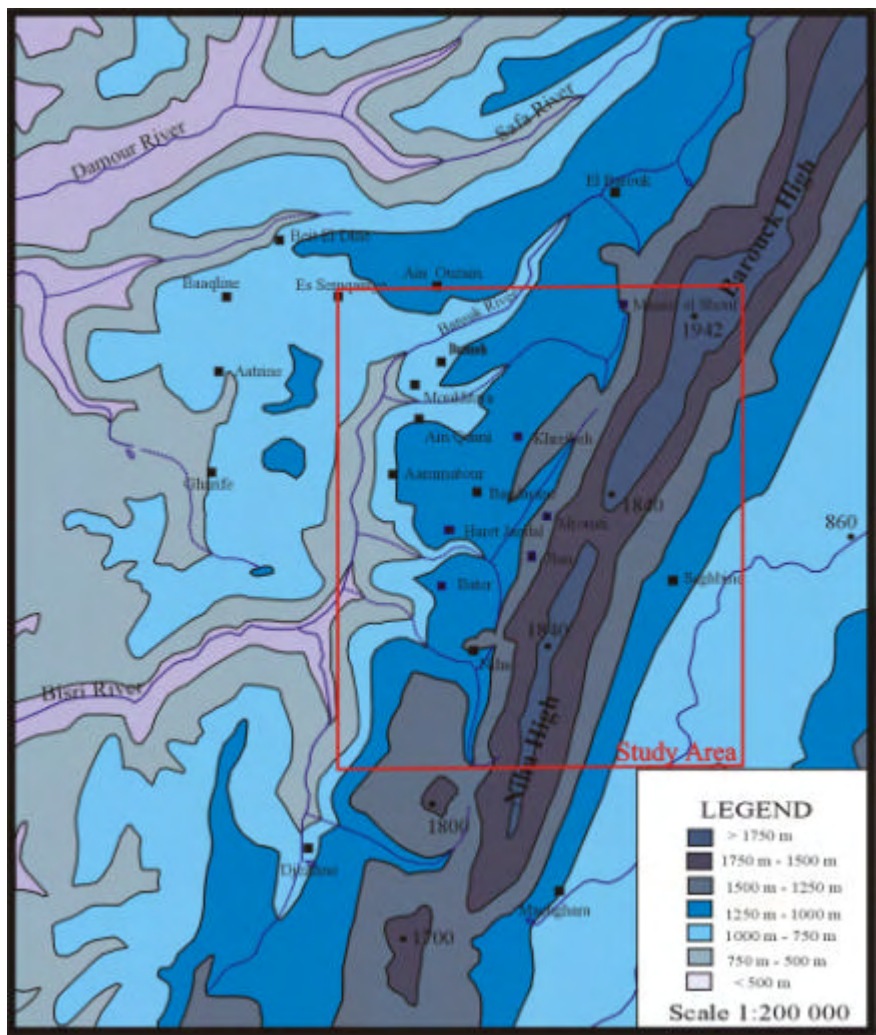


Figure 5.2. Topographic map of the study area (scale 1:200,000)

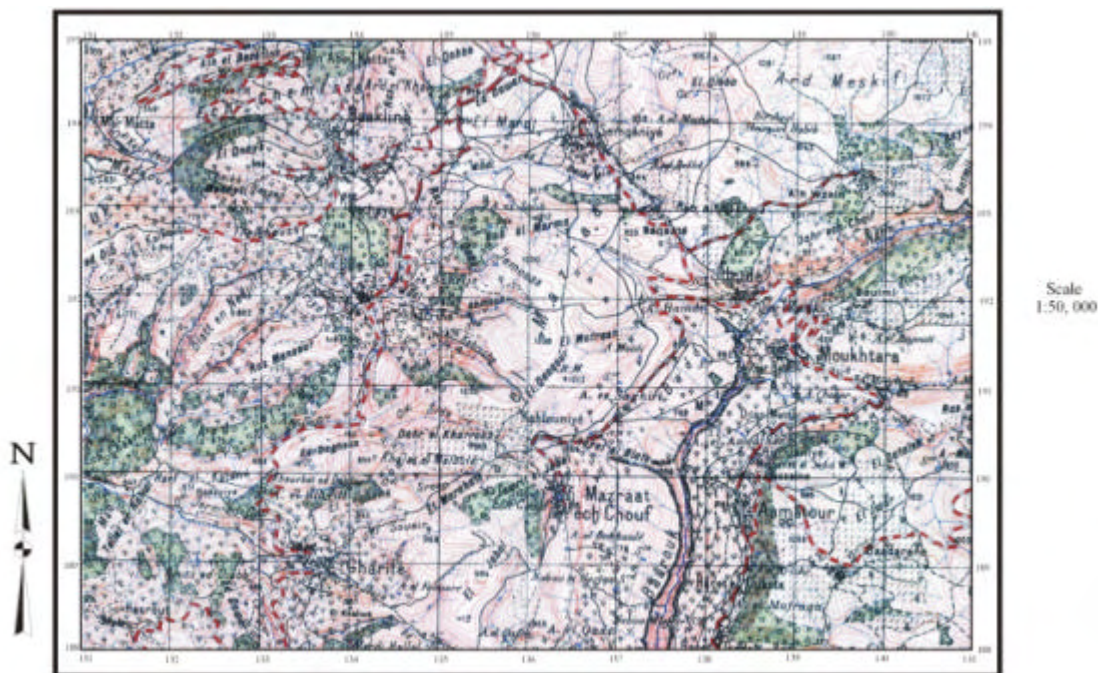


Figure 5.3 Detailed topographic map of study area showing the road network

5.2. METEOROLOGICAL SETTING

The topographic features of Lebanon, in general, influence to a great extent the climate of the country. The climate of the Lebanese coast is of Mediterranean subtropical type, where summers are hot and dry; and winters are mild and wet. On the other hand, snow covers the mountains of the two ranges at times for several months per year, at times. The two mountain ranges tend to have a cool and wet climate in contrast to that of the coastal zone.

Meteorological information including primarily precipitation, ambient temperature, as well as wind direction and speed, are essential data for adequately assessing environmental impacts. Unfortunately, meteorological records are seldom available, except for few locations in the country where stations are operating, in particular the Beirut International Airport (BIA) and the American University of Beirut (AUB) stations. Recently, new stations have been installed across different regions of the country, providing a better coverage of meteorological parameters. Examples include stations installed in the first quarter of the year 1999 in the Barouk region and in the Deir El Qamar village. Currently these stations record temperature, humidity and precipitation, and are closest to the study area.

5.2.1 Precipitation

The two mountain ranges of Lebanon are perpendicular to the path of atmospheric circulation. They intercept humidity and receive high rainfall compared to areas with similar

locations (Figure 5.4). Figure 5.5 depicts monthly rainfall distribution from data collected at the AUB station (between 1996 - 1998 and between 1877 - 1970) at the Jdeidet El Shouf station, which is located in towards the Northwestern side of the Barouk River facing Moukhtara (between 1944 - 1970) and Gharife located to the Western side of the Barouk River (between 1965 - 1970). Precipitation data was obtained from BIA records, Service Météorologique du Liban (1977) and from AUB records. The following observations can be made:

- ◆ The total annual precipitation is 975, 1,215, 660.3, and 887 mm at Gharife (1965-1970), Jdeidet El Shouf (1944-1970), AUB (1996-1998), and AUB (1944-1977), respectively.
- ◆ Precipitation patterns show large seasonal variations with more than 80 percent of the annual rainfall typically occurring between November and March.
- ◆ A marked decrease in precipitation levels is noticed at the AUB station, with approximately 25 percent decrease between the two reported periods.
- ◆ Based on the above observations, about 80 percent of precipitation that is 780 mm in Gharife and 972 mm in Jdeidet El Shouf are probably distributed between November and March. On the other hand, if the same pattern of precipitation levels decrease has occurred in the mountains, similarly to the decrease noticed in the coastal area precipitation in Gharife and Jdeidet El Shouf would be approximately 732 and 912 mm. This is however yet to be confirmed by future data.

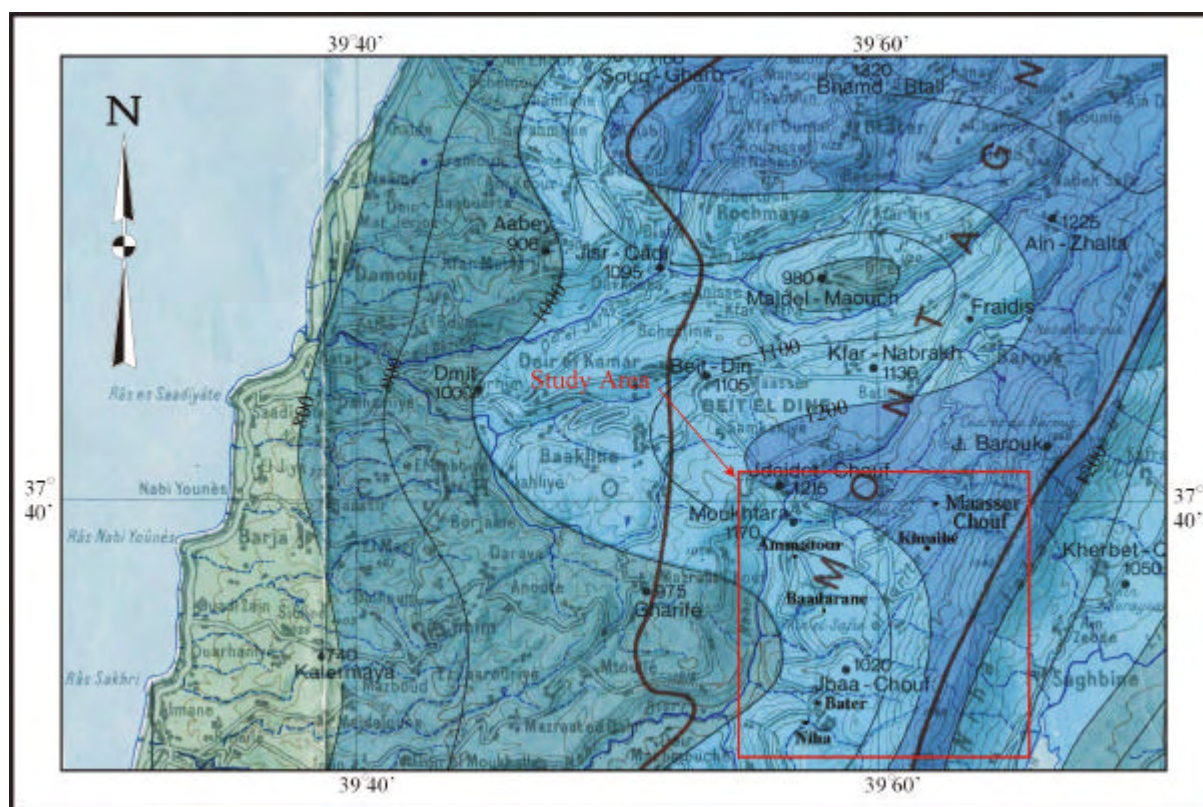


Figure 5.4. Pluviometric Map of the higher Shouf Area and Surroundings (scale 1: 200 000)
(Service Météorologique du Liban, 1977)

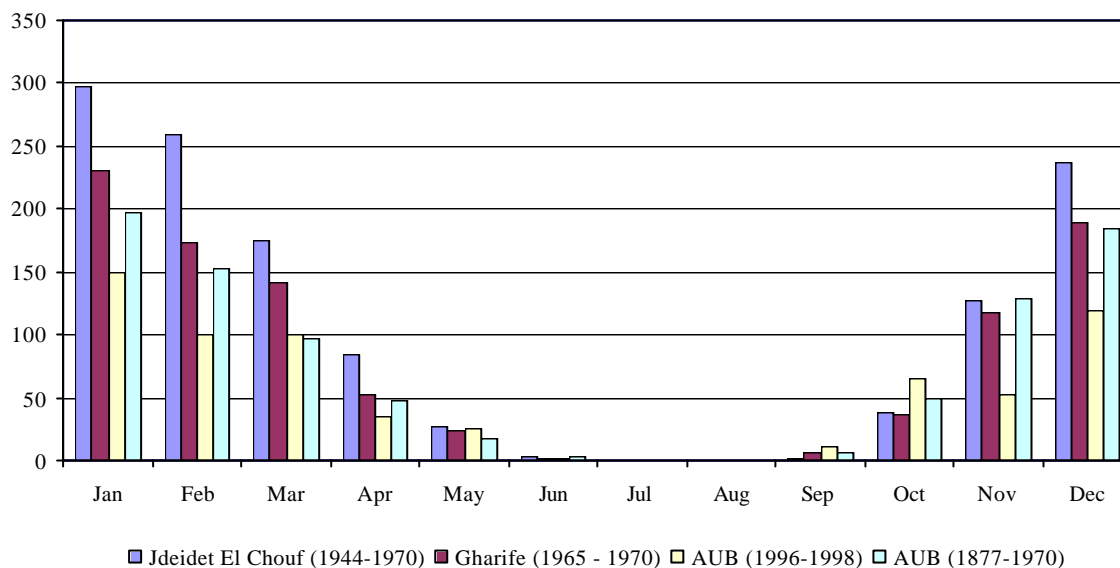


Figure 5.5. Precipitation Data from AUB (34 m), Jdeidet El Shouf (770 m) and Gharife (680 m) Stations (Elevations are from mean sea level).

5.2.2 Temperatures

The mean temperature along the coastal plains is 26.7° C in summer and 10° C in winter. The temperature gradient is around 0.57 °C per 100-m altitude (Blanchet, 1976). January is typically the coldest month with daily mean temperatures falling to -4 °C in the mountains and 7 °C in Saida, on the west coast. The warmest months are July and August, when mean daily temperatures can rise to 28 °C in the mountains and 33 °C on the coast. Figure 5.6 depicts monthly temperature distribution from data collected at the AUB station (between 1996 and 1998, and between 1931 and 1970), at Kfar Nabrah station (between 1956 and 1970) and at Gharife (1964-1970). The Kfar Nabrah station is located in the extreme northern part of the area. The following observations can be made:

- ◆ Average monthly temperatures in Kfar Nabrah vary between 7.7 °C in January and 22.4 °C in August.
- ◆ Average monthly temperatures in Gharifie vary between 9.4 °C in January and 22.2 °C in August.
- ◆ Temperature records did not change significantly at the AUB station between the two-recorded periods.

The average annual temperature is 15.4 and 16.2 in Kfar Nabrah and Gharifie village respectively. Temperature in the study area does not vary much (Figure 5.6), variation is probably in the order of 1 °C as documented between Gharifie and Kfar Nabrah. However, since

temperature records did not change much between the two-recorded periods in the AUB station the average yearly temperature in the study area would be approximately 15.8°C.

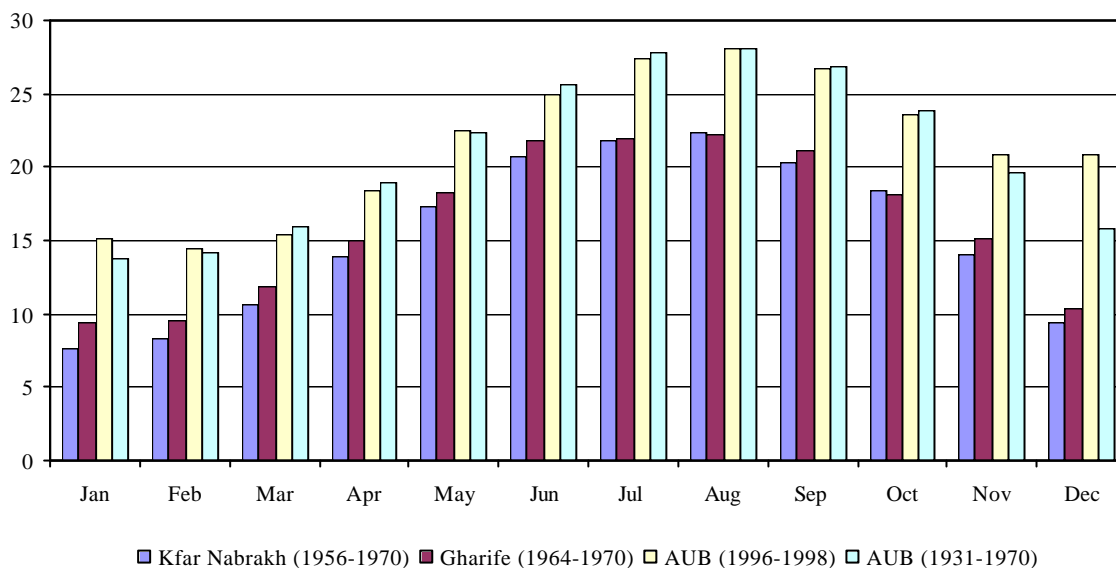


Figure 5.6. Average Monthly Temperature Data from AUB (34 m), Kfar Nabrahk (1020 m) and Gharife (680 m) Stations (Elevations are from mean sea level)

5.2.3 Winds

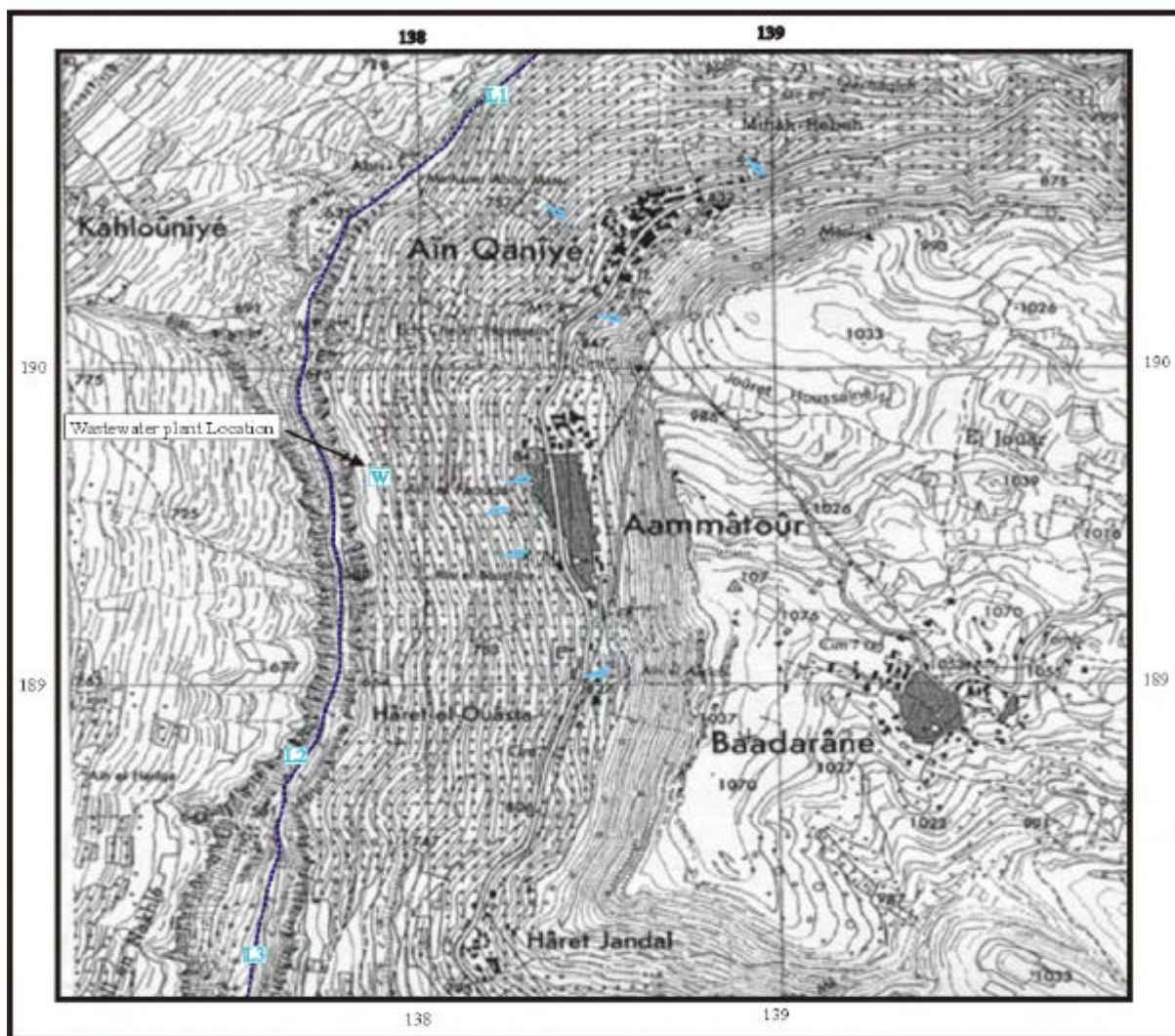
Dominant wind directions are southwesterly; continental east and southeasterly winds are also frequent. The two mountain ranges have a major impact on wind direction, and contribute to reducing the incidence and strength of the south-easterly and north-westerly winds on the mountain backed shoreline and in the Bekaa valley. Strongest winds are generally observed during the fall season. Wind data is available at AUB and BIA stations, in Tyre, Tripoli, Cedars, Dahr El Baidar, and Zahle. Wind data close to the study area is not available. Dominant wind direction is oriented in the NNE and NE (Service Météorologique du Liban, 1969). Nevertheless, since the study area covers a wide range of settings from valleys to hights, locals were consulted regarding the general wind directions in the proposed locations.

5.3. SITE SETTING

As mentioned above, with the agreement of Aammatour municipality, the respective four municipalities proposed a location for the treatment plants (WWTP and SWTP). The data presented in this section was either collected through field visits, research, and/or in consultation with municipality officials or local citizens. Climate data were mainly obtained from records from Kfar Nabrahk and Gharife stations.

After thorough investigation of the four proposed sites for the treatment plant one was selected based on its compliance to the various criteria presented earlier. The approximate area of

that parcel is 8,000m². The municipality intends to exchange this parcel with a land bought earlier (Photograph 5.1). The average land elevation is approximately 650 m above sea level (Figure 5.7). The site borders a small seasonal drainage canal that becomes active only with heavy rainfalls. Average slope inclination of the surface topography is approximately 15-20%, down sloping in a Southwesterly direction towards the cliff, present on the western side, overlaying the Barouk River. The proposed site is located among olive orchards from the Southern side and the Northern side and an Agricultural road on the Eastern side as well as a road newly initiated on the southern side (Photograph 5.2). Road accessibility to the proposed site is available at the present but it is in a bad condition and needs rehabilitation in order to provide easy accessibility to the site by most vehicles.



Scale 1:20,000

LEGEND






-  Approximate location of spring
-  Perennial river
-  Intermittent river
-  Approximate Location of wastewater treatment plants
-  Approximate Sampling Location of Barouk River.

Figure 5.7. Topographic Map of the western side of Aammâtour showing the proposed location of the treatment plant.

Precipitation levels in the area ranges between 900 and 1100 mm/year (Service Meteorologique du Liban, 1977). According to local inhabitants, the general wind direction is from the proposed site location towards the NNE and NE directions. Average annual temperature at Aammatour is approximately 15 °C (Service Meteorologique du Liban, 1977).



Photograph 5.1. The proposed wastewater treatment site located towards the Western direction of the village of Aammatour Photograph looking towards the north



Photograph 5.2. Agricultural road on the Southern side of the parcel showing part of the waste water Network along with a storm water canal. This road ends at the Western edge of the land

5.4. TECTONIC SETTING AND SEISMICITY

Lebanon is located on the eastern coast of the Mediterranean Sea, along the Dead Sea Transform fault system. The Dead Sea Transform fault system in Lebanon has several surface expressions, represented in major faults (Yammouneh, Roum, Hasbaya, Rashaya and Serghaya faults), in uplifts as high mountainous terrain (Mount Lebanon and Anti Lebanon), and from the seismic activity record. Recent work has categorized the Lebanese section of the Dead Sea Transform fault as being a strong seismic activity zone (Khair *et al.*, 2000).

The studied area lies west of the Yammouneh Fault and east of the Roum Fault and south of Beit El Dine fault (Figure 5.8) Harajli *et al.* (1994) proposed ground acceleration in this part of Lebanon, where the area of study is allocated, to be 0.20g.

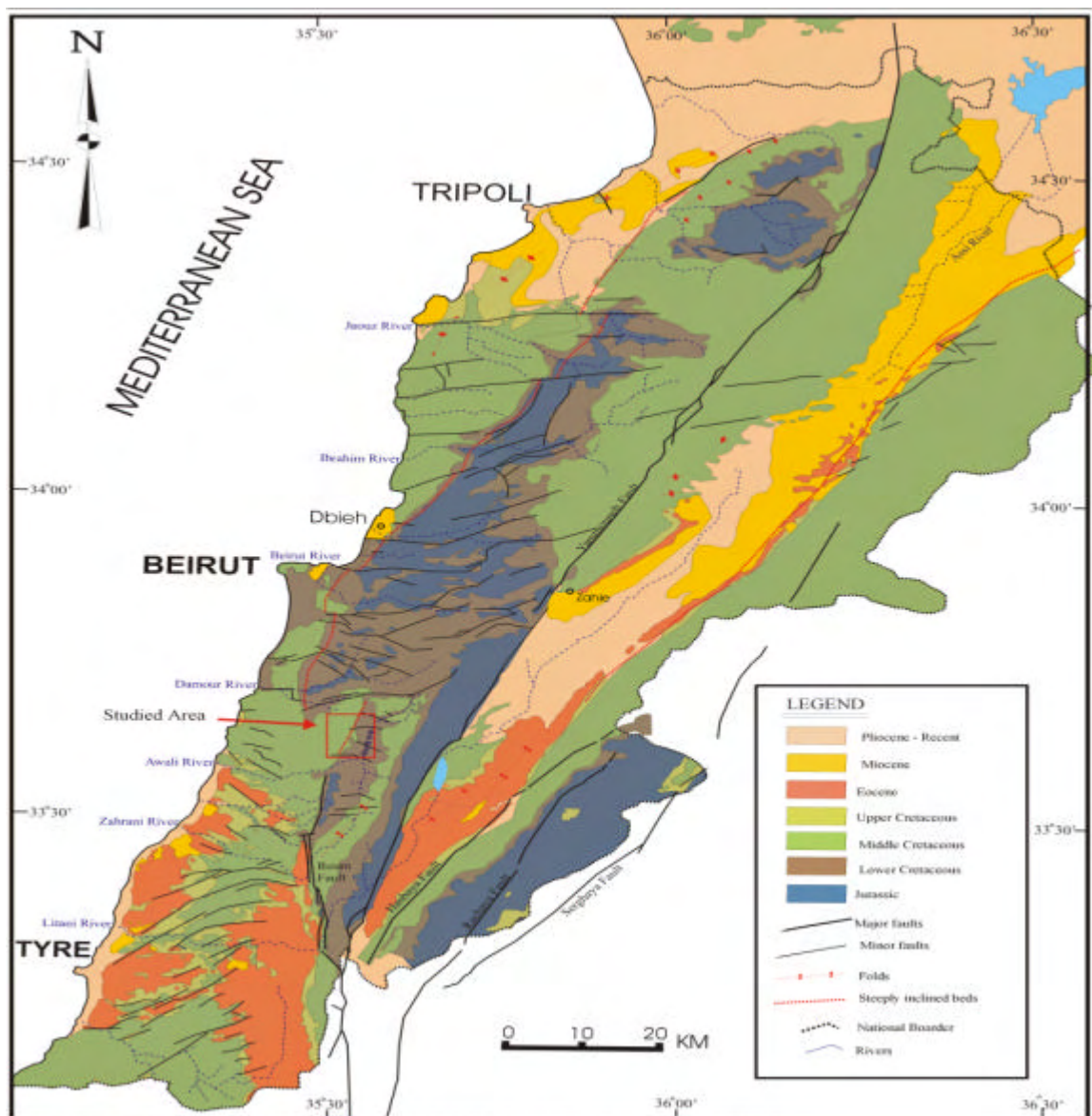


Figure 5.8. Tectonic map of Lebanon showing the studied area modified from Dubétrét (1955)

Figure 5.8. Tectonic Map of Lebanon

5.5. GEOLOGICAL SETTING

The geology of the studied area, including subsurface stratigraphy and structure, was developed based on: 1) review of available maps and literature, 2) analysis of aerial photographs, and 3) geological surveys and site visits conducted by ELARD geologists. The result was the generation of a geological map at a scale of 1:20,000 covering the area of study, reaching approximately 90 Km2 and lying within grid coordinates: 183 000 and 193 000 Northing, and 137 000 and 146 000 Easting. The geological map of the study area is included in Appendix A. Two geological cross-sections (A-B & E-F) illustrate the subsurface Stratigraphy and structure, underneath the proposed sites are presented in Figure 5.9.

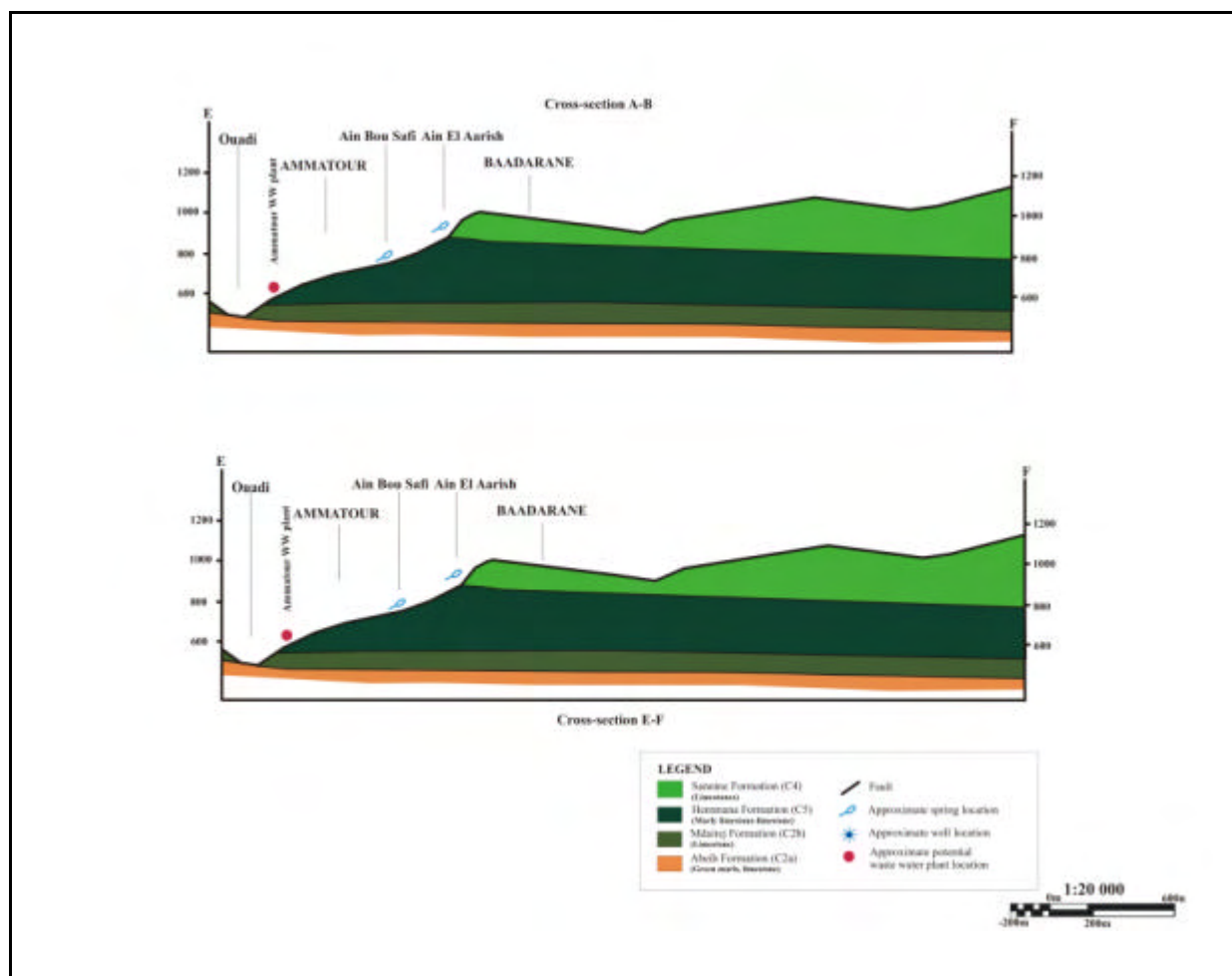


Figure 5.9: Cross sections showing the geological Stratigraphy and structure underneath the proposed site in Aammatour.

5.5.1 Stratigraphy

There are mainly four formations outcropping in the study area. The three formations belong to the Upper cretaceous formations. The outcropping formations are described in the following section.

5.5.1.1 *Cretaceous*

5.5.1.1.1 The Abeih Formation (C_{2a})

This formation is outcropping at the sides of the Nahr El Barouk River Valley. This formation consists in its upper part of yellowish and brownish fossiliferous limestone, while it consists in its lower parts, of intercalations of blue and green marls, and yellowish limestone. This formation reaches a thickness of 150m in the study area.

5.5.1.1.2 The Mdairej formation (C_{2b})

This formation consists in a cliff extended along the two sides of El Barouk River valley. This cliff is formed of hard grayish micritic massive limestone rich in calcite veins. This formation is approximately 50m thick (Figure 5.9)

5.5.1.1.3 The Hammana formation (C3)

This formation outcrops mainly in Aammatour, Haret Jandal, Ain Qani villages. It is characterized by creamish to greenish marly limestone. Quartz geode can be found along ephemeral stream beds. This formation is also highly fossiliferous, as molded gastropods and fossilized oysters are frequently found. A distinctive yellowish limestone bed of 25m thickness, known as the *Banc de Zummoffen* is present in the middle of this formation. This formation has a thickness of approximately 300-400m in the studied area.

5.5.1.1.4 The Sannine formation (C4)

The Sannine formation outcrops in Baadaran and El Khraibeh villages, mainly in elevated areas. This formation consists in its lower levels of marly limestone that grades into thin beds of gray limestone especially along stream beds in the valleys. In its upper part this formation is composed of massive gray limestone. The thickness of this formation in the studied area reaches approximately 600m (Figure 5.9). The lower limit of the Sannine Formation is characterized by massive limestones and dolomites, above the green or grey marls of the Hammana Formation (Photograph 5.3).



Photograph 5.3. Photo in Baadaran village showing the boundary between the Sannine Formation (on top) and the Hammana Formation(below). Location of the boundary is present at the bottom of the cliff.

5.5.2 Structure

Formations in the study area are dipping slightly generally towards the west. Structural disturbances mainly through faults have a slight influence on the bedding attitude in the study area.

There exist two dominant trends for faulting in the study area; faults trends either Northwest-Southeast, or north-south. Faults in the study area are normal faults with relatively small throw.

There exist a minor anticline towards the North of the study area, with a fold axis oriented N50E, with dipping limbs of 10° towards the Southwest and 30° towards the Northeast.

5.5.3 Hydrogeological Setting

The hydrogeology of the surveyed area was developed based on: 1) the review of available maps and literature; 2) the hydro geological surveys and site visits conducted by ARD specialists. The hydrogeology of the studied area was studied based upon geological maps, pluviometric and climatic data related to the studied area, field surveys undergone by ARD specialists.

There exist in the study area two main aquifers: The Mdairej aquifer underlain by the Abeih aquiclude, and the Sannine aquiferous Formation underlain by the Hammana aquiclude.

5.5.3.1 *Aquifers*

The two important aquifers present in the study area are the Sannine karstic aquifer, and the Mdairej karstic aquifer.

5.5.3.1.1 Mdairej aquifer (C_{2b})

Forty five meters of massive limestone cliff constitute the aquiferous member of the Mdairej Formation. Being located between two aquicludes; namely the Abeih Formation at the bottom, and the Hammana formation at the top, the Mdairej formation has a high potential of water bearing capacity, which remains, however limited due to the relatively small thickness. Its position between two aquitards improves its ability to maintain all water infiltrating in the form of recharge

5.5.3.1.2 Mdairej Aquifer (C_{2b} Formation)

The Mdairej aquifer represents an important confined karstic aquifer between the Abeih and Hammana aquitards. Its water storage capacity is however limited because of its relatively small thickness (about 50 m). However, its position between the two aquitards improves its ability to maintain all water infiltrating in the form of recharge.

5.5.3.1.3 Sannine Aquifer (C₄ Formation)

The Sannine formation constitutes the most important aquifer in the Cretaceous sequence. It is a karstic aquifer characterized by significant amount of groundwater flowing in channels, faults, and fractures. However it is worth noting that the Sannine aquifer has a relatively low thickness of maximum 200m in the study area as noted in the cross sections (REF). The Sannine aquifer is composed of a recharge zone in the elevated areas, while the discharge zone is located at lower altitudes at its boundary with the Hammana formation. According to the UNDP (1970) report, the infiltration coefficient of this aquifer reaches 40%.

The Sannine aquifer represents one of the main aquifers in Lebanon and is the most productive aquifer in the Cretaceous sequence. It is characterized by its high secondary porosity causing ground water to flow mainly through fractures, joints and channels, which is a typical occurrence in karstic aquifers.

The Sannine aquifer acts as a source for several types of karstic springs. Being underlain by the Hammana aquitard a karstic spring line has developed along this its lower boundary. Those springs show discharges that typically increase rapidly during the winter season and decrease to almost dryness during the summer season. The Sannine aquifer is considered to be the major aquifer in the study area, covering approximately 60 % of it. Surface and underground features reveal the advanced karstic nature of this aquifer. These features include solution joint, solution pits, lapiaz, grooves, and sinkholes. Cavities in the rock are often filled with calcite and cave

deposits. The thickness of the topsoil on this formation ranges from few centimeters up to few meters. According to the UNDP (1970) report the amount of infiltration in this aquifer is approximately 40%.

5.5.3.2 *Aquicludes (Abeih and Hammana Aquicludes; C₃-C_{2b} Formation)*

The Hammana and the Abeih formation constitute aquicludes with poor hydraulic properties because of the low porosity, consequently the low hydraulic conductivity for argillaceous limestone, clays and marls. Therefore, forming impermeable boundaries for the Sannine and Mdairej aquifers, which prohibit exchange of water between the different hydrostratigraphical units. According to the UNDP (1970) report, the infiltration coefficient of this aquifer does not exceed 10-15%.

5.5.3.3 *Well Survey*

A well survey was conducted along with the spring survey. This survey revealed the presence of 5 wells in Baadaran, Haret Jandal, and Aammatour areas. All the wells have poor yields of 1liter/sec, and are generally used for domestic purposes. The wells are all tapping the Hammana formation down to a depth around 200-210m; this is mainly why discharges of these wells are relatively low. The 5 wells and their characteristics (owner, discharge, and usage) are listed in Table 5.1, whereas, the locations of identified wells are presented on the geological map in (Geological Map, Appendix A). As it is noticeable, the number of wells present in the studied area is limited; this is due to the fact that abundant sources of water are available, with relatively large number of springs available.

Table 5.1: Characteristics of surveyed wells

<i>Well's name</i>	<i>Area</i>	<i>Owner</i>	<i>X Coordinate</i>	<i>Y coordinate</i>	<i>Z(m)Elevation from sea level;</i>	<i>Discharge l/sec</i>	<i>Tapping aquifer</i>	<i>Usage</i>
1	Baadaran	F. Abou Chaqra	139365	189193	1050	1l/s	C3	Ab
2	Baadaran	-	139244	189432	1040	1l/s	C3	Do/Dr
3	Baadaran	Public	140328	189119	1062	1l/s	C3	Ab
4	Haret Jandal	Dr. Mallak	138286	188347	850	1l/s	C3	Do
5	Haret Jandal	Mayor	138247	188474	810	1l/s	C3	Do

Do.: Domestic
 Dr.: Drinking
 NA: Not Available
 Ab.: Abandoned

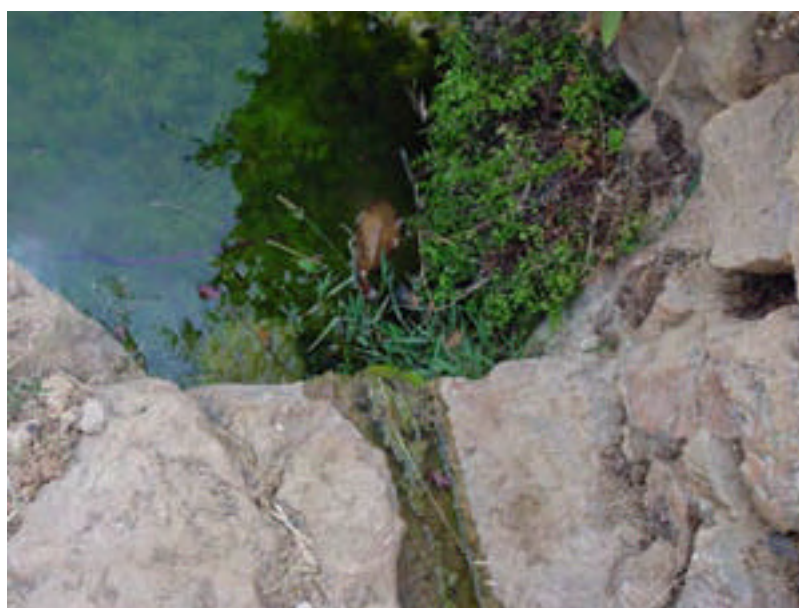
5.5.3.4 Spring Survey

For the purpose of the hydro geological study of the area, a spring survey was conducted by ARD team in Aammattour, Baadaran, and Haret Jandal villages. This survey revealed the presence of 12 major springs. The locations of the identified springs are presented on the geological map (Appendix A) The springs with significant discharges exceeding the 20l/sec were encountered at the boundary between the Sannine and Hammana formation, where all the water coming from the recharge zone in the Sannine aquifer discharges at the impermeable boundary between the Hammana aquiclude and the Sannine aquifer since it cannot penetrate into the impermeable formation. The most important springs are Ain El Aarish, Ain Haret Jandal (Photograph 5.4), and Nabaa Mershed.

As for springs originating from the Sannine formation, they discharge at the marly section of the Sannine formation, especially for Ain El Aadass, and Ain El Mrah, and Ain Qbayl (Photograph 5.5), which discharges decrease significantly in the Summer time. The surveyed springs characteristics are shown in Table 5.2. Most springs with low yields are used locally by surrounding houses for drinking and domestic purposes, whereas some other springs are not used at all for domestic or drinking purposes but are used for irrigation. Springs with significant discharges, such as Nabaa Haret Jandal spring, and Ain El Aarish spring provide respectively Haret Jandal and Aammattour with significant amount of water for various purposes.



Photograph 5.4: Part of Haret-Jandal spring diverted into potable water network.



Photograph 5.5: Ain Qbal spring with a reduced flow during summer

Table 5.2: Results of surveyed springs

Spring name	Aquifer	X coordinate	Y coordinate	Z coordinate	Discharge (l/sec)
Nabaa Mershed	C3-C4	139949	190926	770	>20
Ain Mashour	Boundary C3-C4	140377	190331	880	Seepage in the valley
Nameless Spring (Khraibeh)	C4	141628	190287	1030	0.15
Ain El Aadass	C4	141453	189559	1060	Dried
Ain Es Saifiyye	C3-C4	138928	187968	910	4
Ain Qbayl	C3-C4	139689	188887	1030	Seepage zone
Ain Mrah	C3-C4	140838	189014	1070	1
Ain El Aarish	C3-C4	138800	189000	1000	>50
Ain El Fokor	C3-C4	138220	189650	840	0.5
Nabaa Bou Safi	C3-C4	138380	189020	800	1
Nabaa el Shraifiyye	C3-C4	138660	187937	830	10
Nabaa Haret Jandal	C3-C4	138770	187990	880	>50

5.5.3.5 Hydrogeological budget

The studied area receives approximately 912mm of precipitation per year. Considering an area of recharge 17km², the amount of water that precipitates over this area is 15.5Mm³ per year. According to UNDP (1970), the infiltration coefficient for the Sannine aquifer is about 40%, i.e., the amount of water infiltrating into the Sannine aquifer is about 40% of the total amount of water originating from precipitation. Therefore the amount of groundwater in the Sannine aquifer is 6.2Mm³. According to the well, and spring survey conducted in the study area, the total amount of water discharged from the aquifer per year is around 4.1Mm³. Table 5.3 shows a simplified form of the water budget calculation.

Table 5.3 Calculation of the water budget steps

<i>Surface of Recharge (Sannine aquifer)</i>	17Mm ²
<i>Precipitation</i>	0.912m
<i>Total Water budget</i>	15.5 Mm ³
<i>Infiltration coefficient (UNDP, 1970)</i>	40%
<i>Recharge</i>	6.2 Mm ³

These calculations imply a remnant of approximately 2 Mm³ of groundwater in the aquifer per year.

5.5.4 Hydrological Site Setting

The waste water plant is located on the Eastern flank of Nahr El Barouk River. The Aammatour waste water is located on the marly member of the Hammana formation, which constitutes an impermeable formation that mitigates the potential contamination to percolate into the aquiferous formation underlying it (Figure 5.10). The presence of this marly formation presents natural attenuation of any negative impacts on ground water due to its lower infiltration. The marly formation underlies the limestone member of the Hammana formation, called *banc de Zummoffen*; furthermore, the site is located downstream to the most important springs in the area, namely Ain El Aarish Spring, Ain Mershed, and Nabaa Haret Jandal Spring. The Hammana beds are slightly dipping 05° towards the East.



Scale 1:20, 000

LEGEND

- | | | | |
|--|---|--|--|
| | Sannine Formation (C4)
Gray marls, marly limestones and dolomites | | Approximate location of a fault with dip angle
Dashed when inferred |
| | Hammama Formation (C3)
Brown-green marls, and gray marly limestones | | Approximate location of geological boundary |
| | Mdeirij Formation (C2b)
Light gray micritic limestone | | Dip and Strike |
| | Approximate location of spring | | Perennial river |
| | Approximate location of Well | | Intermittent river |
| | | | Approximate Location of wastewater treatment plants |
| | | | Approximate Location of Barouk River Sampling |



Figure 5.10. Geological map of the Aammatour Wastewater plant

5.5.5 Hydrological Setting

One major perennial river the Barouk River passes through the study area. The Barouk River and its tributaries dominate the Eastern section.

5.5.5.1 The Barouk River

The Barouk River is fed primarily by the Barouk spring that is situated at about 10 km outside the area northeast of Aammatour village. Flow measurements previously conducted at that spring indicate that its flow varies between 0.3 and 2.8 m³/s, at dry and wet seasons, respectively (Guerre, 1969; Edgell, 1997). A hydrograph of this spring is represented in Figure 5.11 showing the average discharge measured between 1945 and 1969 (UNDP, 1970). The largest discharge is approximately 2.14 m³/s and the lowest is approximately 0.34 m³/s. This range could be representative of the flow of the surface water close to the source of the river. Further down stream from the Barouk River, along the Awali section, a gauging station was positioned in Marj-Bisri where records of discharge rate are presented as Figure 5.12.

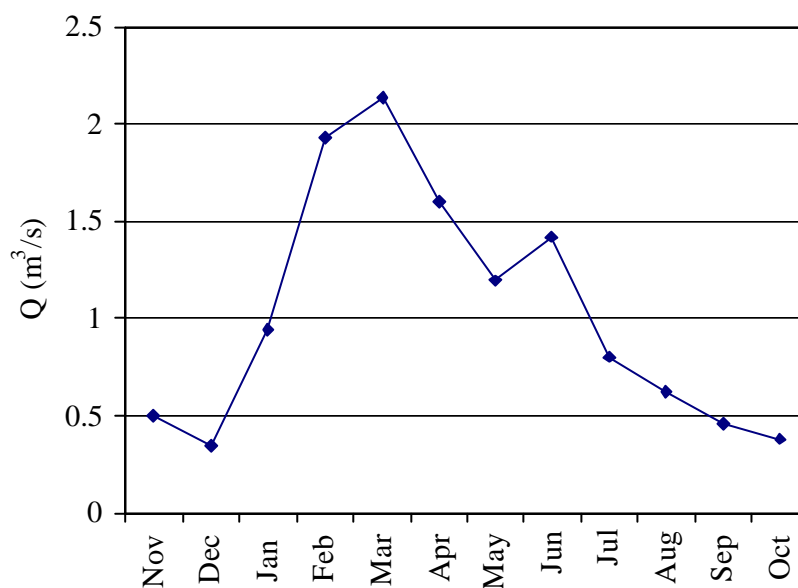


Figure 5.11. Hydrograph of Barouk Spring (1945–1969)

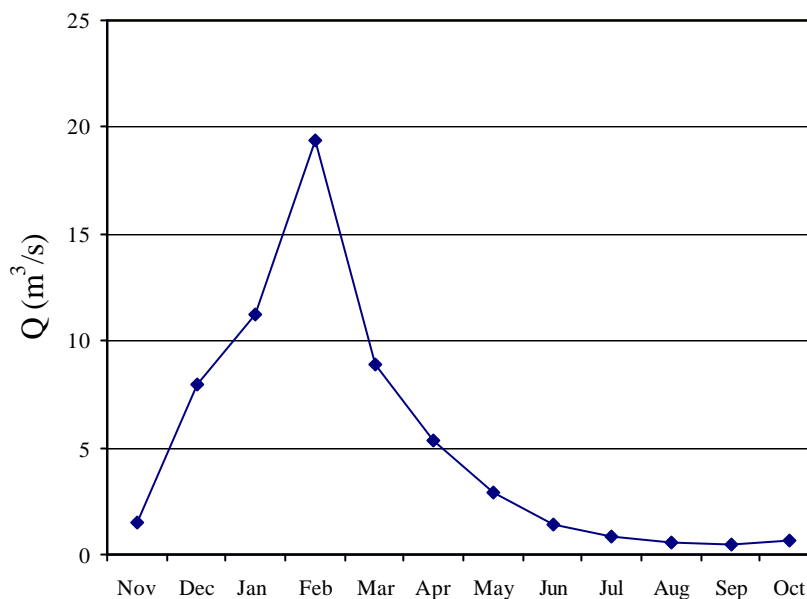


Figure 5.12. Hydrograph (1929-1955) of the Awali River on the Marj Bisri Station (UNDP, 1970)

5.6. WATER QUALITY

5.6.1 Spring Analysis

The main supplier of potable water in the area is the Potable Water Well in Mrousti distributing water to most of the villages of Higher Shouf. In Aammatour, El Arish spring is one of the major springs in that specific village and is used to supply drinking water to households but previous latest analysis of the spring showed contamination evidence; mainly, local springs are being harnessed for irrigation. It was observed that some of the local populations, however, do use spring water for domestic chores. Table 5.4 presents analytical results of water samples collected from selected springs in the area of the respective villages. Photograph 5.6 shows the sampling process on the Ain Mourchid Spring. Table 5.5 presents analytical results of collected effluent from Baadaran treatment plant, using an EAAS system as portrayed earlier (Photograph 5.7). The low BOD₅ value is the result of the extended aeration process, however; the relatively high value for the fecal coliform can be correlated to the fact that during the summer season the Chlorination process is stopped since the effluent might be used for irrigation purposes. It is important to note that sewerage related contamination is detected in springs hydraulically down gradient of populated areas located on the recharge zone (that is of a Karstic nature) and/or located directly over the designated spring, in the like of the water samples from springs in Aammatour, Baadaran, and Ain Qani. The highest value of fecal coliform was encountered in Al Fokor spring located in the village of Aammatour. No biological contamination was detected in Haret Jandal spring which is drawn by a pipe to supply the village with potable water. This spring is located up-

gradient of the private spring of Al-Nada mineral water plant and most probably is being recharged from an unpopulated zone.

The laboratory analytical reports of water samples collected from springs and rivers and analyzed during this study are included in Appendix B.

Table 5.4. Laboratory Analytical Results of Five springs in Higher Shouf Municipalities Union (Samples Collected on 09/09/2003)

<i>Sample ID</i>	<i>Spring name / location</i>	<i>Faecal Coliform (CFU/100 ml)</i>	<i>Biochemical Oxygen Demand (mg/l)</i>
1	Ain el Arish (Aammatour)	5	<2
2	Ain Mourchid (Moukhtara)	10	<2
3	Ain el Fokor (Aammatour)	295	<2
4	Ain el Sayfiyeh(Baadaran)	5	<2
5	Ain Haret Jandal	0	<2
6	Maximum Allowable Levels *	0	5

*Drinking Water Standards per Ministerial Decision 52/1



Photograph 5.6. Sampling operation at Ain-Mourchid location.

Table 5.5 Analytical results of collected effluent from Baadaran treatment plant

<i>Sample ID</i>	<i>Spring name / location</i>	<i>Faecal Coliform (CFU/100 ml)</i>	<i>Biochemical Oxygen Demand (mgO2/l)</i>
1	Effluent (Baadaran Plant)	1045**	<2
2	Allowable Levels *	2000	25

* National Standards for Environmental Quality

** CFU/10ml



Photograph 5.7. Treated effluent discharge from the EAAS treatment plant in the nearby intermittent channel in Baadaran.

5.6.2 Barouk River Analysis:

General quality assessment of rivers and canals:

The Barouk River which bounds the union of villages of higher Shouf as well as El Souwajani villages was sampled at 3 random locations in order to measure the level of contamination or pollution due to the uncontrolled raw sewage discharges into that river. Table 5.6 presents analytical results of water samples collected from the Barouk River. The samples were collected at three different locations along the study area (Figure 5.7):

- Location 1: the outskirts of Butmeh village.
- Location 2: Southern boundaries of the study area.
- Location 3: Marj Bisri Area

According to a general quality assessment of rivers and canals presented in Table 5.7, the concerned river could be classified as of a grade A. Therefore, water quality in Barouk River is considered good, since there is no major industrial waste water discharge in the area. However, this type of chemical grading does not take into consideration the bacteriological criteria of the water. It is then conclusive that the main cause of Barouk river degradation is the uncontrolled raw sewage discharged upstream of the sample collection locations.

Table 5.6. Laboratory Analytical Results of three samples collected from random locations over the Barouk River. (Results as population count per 100 ml)

<i>Sample Location</i>	<i>Faecal Coliform (CFU/100ml)</i>	<i>Biochemical Oxygen Demand (mg/l)</i>	<i>Ammonia (mg N/l)</i>
Location 1	510	<2	<0.01
Location 2	23	<2	<0.01
Location 3	22	<2	0.01

Table 5.7 Chemical grading for Rivers and Canals (Thames river-Standards 2000)

<i>Water Quality</i>	<i>Grade</i>	<i>Dissolved Oxygen (% saturation)</i>	<i>Biochemical Oxygen Demand (mg/l)</i>	<i>Ammonia (mg N/l)</i>
Good	A	80	2.5	0.25
	B	70	4	0.6
Fair	C	60	6	1.3
	D	50	8	2.5
Poor	E	20	15	9.0
Bad	F*			

*Quality which does not meet the requirements of grade E in respect of one or more determinates.

5.7. ECOLOGICAL CONTEXT (BIODIVERSITY)

Ecologically, the proposed location is not in an area of special concern, such as areas designated as having national or international importance (e.g. world heritages, wetlands, biosphere reserve, wildlife refuge, or protected areas). The project will not lead to the extinction of endangered and endemic species, critical ecosystems, and habitats.

The proposed location is situated in the Eu-mediterranean zone and the project site extends over two ecosystems (Southern and Northern areas) with different vegetation communities and levels of disturbance (Photograph 5.8) The Southern area contains a developed mixed *Quercus* and *Pistacia sp.* community with trees of various ages, then towards the Northern side, the vegetation community degrades into a zone with shrubs and few growing trees and in the northern

area the ecosystem is a degraded garrigue containing *Spartium* and *Sarcopoterium* communities forming a dense vegetation cover.



Photograph 5.8 Two distinct ecosystems

From the Eastern side the ecosystem is characterized as a neglected old olive orchard with some terracing with a rich regenerating community with a relatively high level of diversity, containing mixed *Quercus* species, trees of various ages, and a number of wild fruit trees as well as some remaining old olive trees (Photograph 5.9).



Photograph 5.9. Rich regenerating community

The dominating vegetation community is mixed oaks (*Quercus* spp.) also containing pine trees (*Pinus* spp.), wild fruit trees (*Prunus* spp, and *Pistacia* spp.) (Photograph 5.10 and Photograph 5.11), shrubs, and river side plants and berries.



Photograph 5.10 *Pistacia* spp.



Photograph 5.11 Wild pears

Towards the Western side, the dense oak community degrades into a *Calcycotome villosa*, *Spartium junceum* communities (Photograph 5.12) also with a dense cover and containing mixed shrubs and few growing trees (Photograph 5.13).



Photograph 5.12. *Calycotome villosa*, *Spartium junceum* communities



Photograph 5.13. Growing trees.

The Northern side of the site is the most disturbed and is characterized as a degraded garrigue covered by a *Sarcopoterium sp* community with various shrubs and grasses (Photograph 5.14). Moreover, this area show clear evidence of an occurrence of a fire in the previous years, this is a clear proof of the degraded and new regeneration conditions.



Photograph 5.14. *Sarcopoterium sp* showing a degraded garrigue

The proposed site contains three areas with various degrees of disturbances. The Northern area is the most disturbed and therefore the most suited for the proposed project where any construction and operation works will not lead to significant impacts. On the other hand, the Southern side of the site contains high levels of diversity and rich vegetation communities therefore the construction of the facility will lead to adverse disturbances such as the destruction of habitats, cutting down of trees, and loss of important species.

5.8. INFRASTRUCTURE STATUS

Infrastructure with respect to wastewater networks is under construction in the municipalities within the Union, especially in Aammatour and Haret Jandal, where the internal infrastructure is being completed within the villages, around 2000m are already executed and another 2500m are under construction. PM will contribute in the process with around 3264 m. However, in Ain Qani and Baadaran the internal network is completed but the connection to the plant needs to be set. Around 1.2 Kilometers of network are needed to hook the internal network of Ain Qani to the main line leading to the plant. A complete main network layout map in the Union villages varying between a 12 inch and 10 inch diameter PVC pipes is shown in Appendix F. Infrastructure within the towns is mainly limited to road network, telephone, electricity and water supply. The supply of water was elaborated in the hydrological section (section 5.5.3). Moreover, a local solid waste management system in the area does not exist and private companies manage solid wastes. However, the same site for the WWTP in Aammatour will harbor a SWTP intended to serve all 12 villages of the Higher Shouf when the contract ends with the company managing the wastes in these villages. Since mid 1997, the municipal solid waste is being disposed off in roadside containers/dumpsters that is managed and hauled off by Sukleen,

the solid waste collection company operating out of Beirut. However, the contract between the Union and Sukleen / Sukomi will be terminated in the beginning of 2004, leaving the area without a clear alternative for solid waste management.

Wastewater treatment facilities are not available. Domestic sewage is generally disposed of into “unregulated” septic tanks or discharged directly onto open grounds. The construction of sewage networks is planned and in the process of installation as stated earlier.

With regards to managing and maintaining the infrastructure within the Union, the capabilities of the municipalities are limited. Although, no public works department exists within the municipalities, infrastructure installation is being completed in the four villages.

5.9. SOCIO-ECONOMIC STATUS

Socio-economic information about the Union was obtained during informal meetings with Mayors and municipal council members of the various municipalities of the four villages during the field visits and through the filling of specifically prepared questionnaires (Appendix H). Table 5.8 presents some socio-economic information relevant to this study.

Local habitants are mainly members of the active population (between 20 and 50 years old); the average age all over the surveyed villages is around 40 years. The economy in most municipalities is mainly driven by public and private sector employments. Trade and services are also prevalent. Money sent by expatriates (people from the towns living abroad) is a main driver of the local economies as well. Tourism is very limited. Industry is present mainly in the form of small varied industries like welding, carpentry. Only one big mineral water bottling company is located in Haret Jandal.

Average household income within the Union amounts to less than six million Lebanese pounds annually (or around 500,000 Lebanese pounds monthly).

Table 5.8 Socio-Economic Information (as given by Municipalities and Union)

<i>Municipality</i>	<i>Population</i> Year-round/ Seasonal	<i>Priority for the Community</i>	<i>Economy Driver</i>	<i>Health & Educational Services</i>	<i>Farms & Farming</i>	<i>Gas Stations Lube Oil Service Car Mechanics</i>	<i>Industry</i>
Aammatour	3500 5000	Wastewater treatment & collection,	Employed (40%) Services & Trade (30%) Agriculture (15%) Industry (5%) Others (10%)	1 Clinic 1 School	Olive & vine Groves	2 Gas Stations 2 Lube Oil 1 Mechanic	Carpentry, Olive Pressing, Food industry
Haret Jandal	200 450	Plant & network	Employed (80%) Services & Trade (10%) Agriculture (10%)	1 Private School	Olive & vine Groves	4 Mechanics	2 mineral water bottling companies
Baadaran	2000 3000	Completed wastewater plant serving 70% of population & Storm water networks serve	Employed (50%) Services & Trade (5%) Agriculture (10%) Industry (5%) Others (30%)	1 Clinic 1 Public School	Olive & vine Groves	No gas stations 1 Mechanic	Aluminum industry Iron Welding
Ain Qani	900 2500	Wastewater & Stormwater networks	Services, Agriculture, Industry	1 School (not operational)	None	1 Gas Stations 1 Mechanic	No industry

6. IMPACT IDENTIFICATION AND ANALYSIS

On-site and off-site impacts can be induced during the construction of the plant, and later during its operation. On-site impacts result from construction activities carried out within the construction site. The impacts of off-site work result from activities carried out outside the construction site yet are directly related to the project. In the case of wastewater treatment plants, the main potential receptors are soil, surface, and ground water bodies. Identification of potential impacts is facilitated by the use of a matrix that shows the main activities at the wastewater treatment plant, the major perturbation factors, and the environmental media affected (Table 6.1). The extent of impacts depends primarily on the effluents management practices that would be adopted during plant operation.

6.1. IMPACTS ON WATER RESOURCES

6.1.1 Impacts during Construction

No major on-site impacts on water resources are anticipated during the construction phase of the plants. Care should however be exercised when handling fuel and oil (hydraulic, transmission, engine, etc.) to power and maintain the different equipment on site. Measures should be taken to avoid spillage of such material to the ground, as these contaminants would eventually reach the groundwater. Dumping excavated and construction material into nearby watercourses should be prohibited. Additionally, all earth-moving and other equipment should be in good working condition and well maintained (no leaks).

Off-site impacts on water resources may occur from the reckless disposal of domestic as well as industrial wastes, typically liquid and solid, generated from the residential units, offices, and equipment and vehicles maintenance units at the contractor's construction site. Where proper waste segregation and disposal is practiced, the likelihood of these impacts to occur will be negligible, if not nil.

Table 6.1. Impact Identification Matrix

Phase	Activities								
Construction	Earth moving			√					√
	Excavation							√	√
	Truck movement		√					√	
	Erection							√	
Operation	Sewage conveyance	√							
	Preliminary Treatment	√		√	√				
	Secondary Treatment		√					√	
	Sedimentation			√					
	Sludge holding			√	√				
	Sludge return							√	
	Sludge dewatering							√	
	Disinfection						√		
	Effluent disposal					√	√		
	Sludge disposal			√	√	√	√		
	<i>Perturbation factor</i>	Sewage	Gas Emission	Solid waste	Odors	Heavy metals	Chemicals	Noise	Dust
	<i>Environmental Media</i>								
	River					√	√		
	Ground water	√		√		√	√		
	Agricultural soil					√	√		
	Nuisance		√	√	√			√	√
	Air quality		√						√
	Biodiversity		√		√	√	√	√	√

6.1.2 Impacts during Operation

During operation, the main activities that could possibly impact the natural resources are the effluent management practices. Proper management of both the treated wastewater and the generated sludge is essential. Less commonly, flooding of the wastewater plant as well as leakage from the treatment basins can threaten groundwater resources. These should be avoided by adopting proper engineering codes and adequate preventive measures.

In general, secondary wastewater treatment, and specifically extended aeration activated sludge treatment systems, produces a highly treated and well-nitrified effluent that usually meets secondary effluent quality standards. Also, in designs where disinfection is incorporated, bacterial population in the discharged effluent will be significantly suppressed. Thus, the proposed facility's discharge effluent quality is expected to meet the Environmental Limit Values (ELV) for wastewater discharged into surface waters, as specified by Ministerial Decision 8/1/2001. When secondary effluent guidelines are met, the effluent can be safely used for irrigation translating into a "positive" impact, especially in agricultural areas suffering from water shortage. In the absence of agricultural lands or when the produced effluent volumes exceed water demand, the effluent can be safely discharged into nearby streams, if existent, given the stream sustains a minimum flow of 0.1 m³/sec. Depending on the proximity of the plant to receiving water bodies, effluent discharge can be either direct or through extended pipes. It is essential that discharge points be downstream of vital springs. In the absence of nearby perennial streams, the geological setting of the area should be thoroughly considered before discharging the effluent on land. In many instances, stricter ELV should be implemented if a perennial stream is absent or the discharge is next to a bathing area or in case of the presence of down-gradient springs. In the case of Aammatour plant, its proximity to Barouk River which maintains a perennial flow of 0.1 m³/s, favors the discharge of the treated wastewater as long as it meets ELVs.

Screenings, grit, and sludge generated from the wastewater treatment process should be properly managed to avert additional potential impacts on water resources. When reused, sludge application on land should also be carefully practiced. Sludge may contain significant levels of heavy metals and other contaminants that would leach to the soil and water resources, and eventually up the human chain. With appropriate practice (Appendix E), the likelihood of these impacts to occur will be minimal.

6.2. IMPACTS ON SOIL

6.2.1 Impacts during Construction

The total volume of soil and rock that would be excavated during plant construction is relatively small and thus should not lead to major erosion problems and impacts on soils.

Soil pollution from on-site as well as off-site works may occur by the intentional or accidental leakage of used chemicals, fuel, or oil products (from equipment and vehicles) on construction sites. Such practices should be strictly avoided and utmost precautions and workmanship performance should be adopted for the disposal of such hazardous products.

6.2.2 Impacts during Operation

The main concern during operation of the plant is related to soil quality rather than soil quantity, and is primarily attributed to generated Sludge management. Generated Sludge from wastewater treatment plants is usually used as soil fertilizer due to its relatively high nutrients content (whether used on site or off-site). However, if sludge application is not properly conducted, it can cause damage to soil fertility by breaking the C/N ratios and/or creating an imbalance in nutrient levels, possibly pollute the soil, and as mentioned earlier, eventually reach the groundwater. Proper soil application depends not only on the sludge quality, but also on the soil physical and chemical properties, which would dictate whether the soil is suitable for receiving such material. Also, even if the soil is suitable, sludge application should not exceed a certain maximum application rate. These measures are further elaborated in Appendix E.

6.3. IMPACTS ON HUMAN AMENITY

Human amenity is defined inhere as general comfort of persons that could eventually be disturbed by factors such as dust, noise, and odors.

6.3.1 Impacts during Construction

The main impacts on human amenity during plant construction are related to dust and noise generation. An increase in ambient particulate matter may be observed primarily during the excavation activities. However, given the fact that excavation will last for a limited period of time, the impacts from potential dust generation will probably not be significant. On the other hand, appreciable increases in noise levels may be expected during excavation and erection of the plant. The noise impacts from excavation and associated truck movements are however limited to construction phase.

6.3.2 Impacts during Operation

The main amenity impacts during plant operation are related to noise and odors. Noise may be generated mainly from the blowers and generator operation. However, if adequate noise reduction/suppression measures are undertaken, the generated noise should not significantly affect human amenity.

Odors emitted at a wastewater treatment works may easily reach the local inhabitants; especially if prevalent the wind direction is towards the residential areas. Inlet works, grit channels, screening and grit handling, aeration tanks, and sludge holding and dewatering units are the main sources of odor at the wastewater treatment facility. However, in many instances, odors can be reduced or prevented through normal housekeeping and improved operation and maintenance design procedures. Odors may be primarily produced from storage of sludge on-site; therefore, sludge management (proper storage, handling and off-site transportation and disposal) should be properly handled. Proper handling procedures are presented in Section 7 and should be abided by in order to ensure an extended life span for the plant and its sustainability.

6.4. IMPACTS ON PUBLIC AND OCCUPATIONAL SAFETY

6.4.1 Impacts during Construction

In any civil works, public as well as construction staff safety risks can arise from various construction activities such as deep excavations, operation and movement of heavy equipment and vehicles, storage of hazardous materials, disturbance of traffic, and exposure of workers to running sewers. Because of the short duration and non-complexity of the construction phase, such activities are controlled and consequently the associated risks are minimal. Proper supervision, high workmanship performance, and provision of adequate safety measures will suppress the likelihood of such impacts on public and occupational safety.

6.4.2 Impacts during Operation

During the operational phase of the plant, occupational safety is at a higher risk than public safety. Fortunately, various mitigation measures can be easily adopted to minimize occupational hazards. Such measures are detailed in section 7 and should be stringently considered.

6.5. IMPACTS ON BIODIVERSITY

6.5.1 Impacts during Construction

The proposed site contains three areas with various degrees of disturbances. The Northern area is the most disturbed and therefore the most suited for the proposed project where any construction and operation works will not lead to significant impacts. On the other hand, the Southern side and Western side of the site contains high levels of diversity and rich vegetation communities therefore the construction of the facility will lead to adverse disturbances such as the destruction of habitats, cutting down of trees, and loss of important species.

Building the plant on the Northern side of the site would not lead to significant environmental impacts on the present biodiversity. Throughout construction, however, efforts should be taken to conserve present trees, especially in the Southern side and the Western side. Potential negative impacts affecting biodiversity during project construction are summarized in Table 6.2. The main construction activities having negative results on the biodiversity are earth-moving activities, erection of the plant, and construction waste material and effluent discharges. However, the potential negative impacts are not considered very significant if the project only affects the degraded Northern part of the ecosystem, will not lead to the extinction of species (if trees are conserved), and will not affect any sensitive or critical area.

The location is proposed on a somehow degraded and disturbed area, the present regenerating and the old and rich *Quercus* community should be conserved.

Table 6.2. Potential Negative Impacts on Biodiversity

Impact	Cause
Habitat loss or destruction	Construction works
Altered abiotic/site factors	Soil compaction, erosion
Mortality of individuals	Destruction of vegetation
Loss of individuals through emigration	Following disturbance or loss of habitat
Habitat fragmentation	Habitat removal and/or introduction of barriers like roads
Disturbance	Due to construction noise, traffic, or presence of people
Altered species composition	Changes in abiotic conditions, habitats...
Vegetation loss	Soil contamination due to disposal of oils and hazardous material

6.5.2 Impacts during Operation

With proper management of effluent material, negative impacts on biodiversity during operation of the plants should be minimal. On the contrary, the projects could lead to positive environmental impacts on the biodiversity level if plans are developed to protect surrounding areas. Inclusion of original species in the proposed landscape plan could be adopted to alleviate visual impacts and compensate loss of communities, if any.

6.6. IMPACTS ON HUMAN HEALTH AND SANITATION

The current lack of proper solid and liquid waste management is surely having a negative impact on human health and the environment. Current and historical dumping of

wastes, whether in open dumps or in sinkholes, is directly polluting the environmental and water resources of the area, and is furnishing breeding habitats for rodents and diseases to flourish. Such impacts will be mitigated by the deployment of a proper sewer collection system and by the treatment of the collected sewage. Of utmost importance is the coverage of the collection systems to the whole villages. Wherever a property cannot deliver to the system its sewage by gravity drainage, proper measures in the form of secure septic systems or pumping stations should be installed.

As a whole, the projects would lead to POSITIVE impacts with respect to human health. Improvements in health conditions are likely to occur as the result of improvements in surface and groundwater qualities as well as sanitation conditions.

Additional POSITIVE impacts would be observed at the socioeconomic and agriculture levels. The proposed projects will create certain job opportunities for skilled and unskilled labor. Moreover, if the treated effluent is to be reused for irrigation, the projects may have long-term positive impacts on agriculture, especially that at some locations farmers are currently using raw sewage for irrigation. Moreover, the stabilized sludge can be used as well in agricultural, municipal landscape, silviculture and fertilization practices therefore alleviating organic or synthetic fertilizer costs on farmers. The cutting edge in that specific site is that both Solid Waste Composting plant and the WWTP will be present the same location so sludge can be easily integrated in the composting process. With careful monitoring of Compost quality, the compost would be of an added value and ensure a quick acceptance of this byproduct in the market.

6.7. IMPACTS ON ARCHAEOLOGICAL, TOURISTIC AND CULTURAL SITES

Although not applicable to any proposed location, the impacts of the deployment of wastewater treatment plants on archaeological, touristic and cultural sites is positive, considering this specific area this has high Eco-tourism capabilities. This is particularly important since a major nature reserve (Arz El Shouf reserve) is located in the area and several ecotourism activities are being initiated by NGOs such as the SRI (Stanford Research institute) project, funded by USAID

7. MITIGATION MEASURES

7.1. DEFINING MITIGATION

In the Environmental Impact Assessment context, mitigation refers to the set of measures taken to eliminate, reduce, or remedy potential undesirable effects resulting from the proposed action, here the municipal wastewater treatment plant. Mitigation should be typically considered in all the developmental stages of the facility, namely, the site selection process, as well as the design, construction and operation phases. Once set, tender documents should clearly describe mitigation measures and workmanship to be adopted by the contractors or operators.

7.2. MITIGATING ADVERSE PROJECT IMPACTS

As identified earlier, potential adverse impacts of the proposed wastewater treatment plant may include dust emissions, odor and aerosol generation, noise generation, degradation of natural resources, production of residuals, public health hazards and adverse aesthetic impacts. Proposed mitigation measures for the above mentioned adverse impacts are discussed in the following paragraphs. Table 7.3 summarizes such mitigation measures, their monitoring for actions affecting environmental resources and human amenity. Such measures should be set as primary conditions on the contractor, the supervising engineers, the WWTP administration and operating staff in order to assure a proper management of the plant as well as the implementation of the Environmental Management Plan (EMP) discussed in section 8.

7.2.1 Mitigating Dust Emissions

Dust emissions from piles of soil or from any other material during earthwork, excavation, and transportation should be controlled by wetting surfaces, using temporary wind breaks, and covering truck loads. Piles and heaps of soil should not be left over by contractors after construction is completed. Also excavated sites should be covered with suitable solid material and vegetation growth induced after construction completion, no soil surface should be kept bare subject to erosion.

It is the responsibility of the Supervision Engineer to monitor for the mitigation of such impacts.

7.2.2 Mitigating Noise Pollution

Temporary noise pollution due to construction works should be controlled by proper maintenance of equipment and vehicles, and tuning of engines and mufflers. Construction

works should be completed in as short a period as possible by assigning qualified engineers and foremen. It is the responsibility of the Supervision Engineer to monitor for the mitigation of such impacts.

Noise pollution during operation would be generated by mechanical equipment, namely pumps, air blowers, and sludge dewatering units. Noise problems should be reduced to normally acceptable levels by incorporating low-noise equipment in the design and/or locating such mechanical equipment in properly acoustically lined buildings or enclosures. In the presence of adequate buffer zones between the facility and residential areas, noise control measures are minimized.

7.2.3 Mitigating Obnoxious Odors

Odors emitted at wastewater treatment works may be potential nuisance to the general public. Inlet works, grit channels, screening and grit handling, aeration tanks, and sludge holding and dewatering units are the main sources of odor at the wastewater treatment facility. However, in many instances, odors can be reduced or prevented through normal housekeeping and improved operation and maintenance design procedures. When kept clean, sludge transfer systems, such as conveyors, screw pumps, and conduits, will not generate odors.

The primary mitigation measure for odor control remains the proper siting of the facility. The plant should be located at a site where prevailing winds mostly blow away from nearby residential areas. Due to the fact that prevailing wind in the area is towards NNE-NE; the adequate buffers from treatment units should be considered and respected. The Aammatour plant is located at a further distance than the minimum required buffer distances from the treatment units stated in Table 7.1, used as a guide.

Table 7.1. Suggested minimum buffer distances from treatment units

Operation unit/process	Buffer distance (m)
Sedimentation tank	120
Aerated tank	150
Aerated lagoon	300
Sludge holding tank	300
Sludge thickening tank	300
Sludge drying beds (open)	150
Sludge drying beds (covered)	120
Sludge digester	150

Activated sludge tanks do not normally emit an objectionable odor when a dissolved oxygen level of ≥ 2 mg/L is maintained in the mixed liquor. Thus it is essential to execute a regular program of maintenance to prevent the clogging of diffuser plates to maintain adequate dissolved oxygen levels in the aeration tanks, which in turn minimizes the chances for the production of odorous compounds. Regular cleaning of aeration tank walls and floors, washing weirs, and removing scum regularly, also helps in odor reduction.

Where odor emissions could lead to complaints, the provision of covers to the odor sources should be considered, especially for sludge holding tanks and sludge dewatering systems. To reduce odors from final settlement tanks and sludge holding tanks, logical operational solutions include: increasing the pumping rate of the thickened sludge, monitoring a low sludge blanket level, and increasing the influent flow rate to the sludge holding tank without losing thickening. Tank mixing during off-shifts will also minimize the release of trapped gas during the day. Occasional tank draining and filling it with chlorinated water further reduces odor problems. To reduce odors from dewatering units, pH adjustment or introduction of chemicals may be employed. The odorous air from enclosed unit operations, such as belt presses, may be collected at a central area and relevant odor treatment processes applied. An affordable measure to partly reduce odor problems can be storing produced residuals in closed containers and transporting them in enclosed container trucks. Flow regulating chambers, drainage valves, standby pumps, as well as electric standby generators should be provided to reduce the possibility of wastewater flooding within the wastewater treatment plant site, which results in possible generation of obnoxious smell. The presence of multiple aeration basins in the plant also reduces overflowing problems.

Proper landscaping around the facilities may serve as a natural windbreaker and minimize potential odor dispersions. When odor becomes an evident public nuisance, synthetic windbreakers (e.g. walls) should be employed to maintain odor nuisance within each site.

7.2.4 Mitigating Aerosol Emissions

The process of aeration may result in the emission of sprays or aerosols. To limit such emissions, adequate feedboards should be considered, or suppression hoods, splash plates or deflectors be incorporated on the rotors, if employed.

7.2.5 Mitigating Impact on Biodiversity

Recommended mitigation measures to minimize or eliminate the impacts on the biodiversity at all proposed locations, include:

- Avoid deforestation activities; plan the building sites and roads on areas void of trees.
- Design a landscape plan that enhances the landscape esthetic value using local and native population flora.
- When detected, sensitive species or habitats should be conserved.
- All waste resulting from construction works, land reclamation, or any other activity should be collected and disposed properly in an allocated disposal site. Littering in the project area and surrounding areas should be prevented.

Table 7.2 presents additional mitigation measures specific to the location:

Table 7.2 Additional Mitigation of Impacts on Biodiversity Specific to the Location

Location	Mitigation Measures (specific)
Aammatour	Building the plant on the Northern side of the site would not lead to significant environmental impacts on the present biodiversity Design a landscape plan that reintroduces and uses the already existing species in the old community. Carefully design the plant and access road rehabilitation to minimize removal of trees Avoid removal of mature trees on the Southern side of the location. Avoid alteration of abiotic factors

7.2.6 Mitigating Degradation of Receiving Water Quality

In general, secondary wastewater treatment, and specifically extended aeration activated sludge treatment systems produce a highly treated and well-nitrified effluent that meets secondary effluent quality standards. Disinfection, if employed, further suppresses bacterial population in the discharged effluent. Thus, the proposed facilities' discharge effluent quality is expected to meet the Environmental Limit Values (ELV) for wastewater discharged into surface waters, as specified in the National Standards for Environmental Quality. When secondary effluent guidelines are met, the effluent can be safely used for irrigation. In the absence of agricultural lands or when the produced effluent volumes exceed water demand, the effluent can be safely discharged into nearby streams, if existent, given the stream sustains

a minimum flow of 0.1 m³/sec. It is essential that discharge points be downstream of vital springs. In the absence of nearby perennial streams, the geological setting of the area should be thoroughly considered before discharging the effluent on land.

To attain the expected safe effluent discharge, skilled and trained operator is necessary for proper process loading, optimization, control, and thus performance. Furthermore, the discharge of industrial wastewater and oil/grease into the treatment facility should be prohibited and illegal discharge controlled by the concerned authority. In instances where grease and oils are present in incoming raw sewage, Grease and Oil interception tanks should be integrated in the facility designs; the detention time should exceed a period of 30 minutes. Operational upsets due to ambient temperature variations should be overcome by the provision of adequate preventive measures such as proper covers and thermal accessories. The implementation of training recommendations, maintenance plans, and process and effluent monitoring programs should be *mandatory*. Sufficient instrumentation and standby equipment (blowers, pumps, and electric generators) should be provided to ensure an uninterrupted and controlled operation, thus avoid inefficient process performance. Drains and bypasses should be designed for emergency cases.

In situations where mandated secondary standards are not met, additional process control should be attained, further effluent treatment considered, or alternative effluent disposal schemes adopted, given the quality of effluent is acceptable for the proposed applications or discharge.

7.2.7 Mitigating Impacts from Residual Storage, Handling, Transport, and Reuse/Disposal

The residuals resulting from extended aeration activated sludge treatment systems include screenings, grit, scum, and sludge. To reduce potential impacts of such residuals, proper handling, storage, transport, and disposal/reuse strategies should be adopted.

Screenings: In case the plants are equipped with screens, these are to be cleaned regularly and screenings drained on a platform. Drained screenings should be collected in closed containers for ultimate transport and disposal at a nearby municipal solid waste disposal site. Hauling of screenings is to be carried by closed-top trucks.

Grit: In case of Grit removal device presence: Grit consisting of sand and gravel, from properly designed and operated gravity grit separators, is generally inert in nature, low in organic content, and relatively innocuous. Thus, the proper design and operation of grit chamber serves as the primary mitigation measure. Grit is to be washed daily and separated

such that organic particles that are trapped with the grit will be recycled back into the flow stream. This will maintain odorless clean grit in open storage. The washed grit is then transported to an allocated municipal solid waste disposal site (in this case available at the site) or it could be disposed on a nearby rubble land, if available.

Scum: Adequate scum collection and removal facilities are to be provided in the final settlement tanks of the extended aeration activated sludge system to prevent floating material and scum to be carried with the effluent and deteriorate its quality. Collected scum can be treated with the sludge.

Oil and grease should not pose a serious problem since their discharge into the wastewater treatment plant is prohibited to ensure high purification efficiency and avoid operational upsets. However, the safe incorporation of an interceptor tank to trap grease will reduce any chances encountering troublesome grease persistence in the system.

Sludge: Due to the long solids retention time (SRT) and the prevailing aerobic conditions in extended aeration activated sludge systems, the production of wasted sludge is somewhat reduced and the waste sludge is organically more stable. Thus, toxic and obnoxious gases are less expected to emanate. The proper design and operation of proposed sludge handling and treatment units will mitigate sludge-induced impacts. The dewatered sludge storage area should be bounded to contain any surplus liquids, which should be returned to the inlet works. Adequate storage capacities are to be provided on-site. Transport of sludge should be by top-covered trucks. Truck drivers should be instructed not to have the truck wheels come in contact with the sludge when loading, and not to overload to avoid spillage along travel roads. It is recommended to use the produced sludge for agricultural landscape fertilization programs, land reclamation etc; thus, agreements are to be set up with proper authorities or private individuals for sludge reuse. Since the wastewater discharged into the plant is basically of domestic origin, the concentration of heavy toxic metals in the sludge is expected to be very low. Moreover, the sludge can be incorporated within the composting process therefore, enhancing the compost quality.

Nitrification and denitrification are expected to occur in an extended aeration system, thus the impact of excess nitrates on the soil will also be overcome. Appropriate methods and proper management at the agricultural sites also have to be implemented to minimize adverse impacts due to sludge reuse. Farmers should not spread the sludge onto land by hand as to avoid health risks as well as proper and specific guidelines should be implemented, incorporating the sludge or compost into the soil by mixing and adequately covering with soil. Protective clothing should also be worn. Sludge should not be applied to wet or frozen soils. Farmers should be well trained and informed to accept the issue of using sludge as organic fertilizer.

In the absence of adequate markets for sludge reuse, alternative environmentally sound sludge management strategies should be considered. This may be proper landfilling, incineration, or land reclamation.

7.2.8 Mitigating Adverse Aesthetic Impacts

To avoid possible visual impacts resulting from the existence of wastewater treatment facilities, the following steps are to be implemented:

- ❑ Maintaining cleanliness within each treatment plant (preventing spillovers, cleaning roads and ground, etc.).
- ❑ Appropriate landscaping of the plant grounds with planting of suitable trees, grass, and flowers.
- ❑ Fencing and screening the site with appropriate trees to obstruct the plant components from onlookers and area inhabitants. (All along with some noise reduction).

7.2.9 Mitigating Public and Occupational Health Hazards

The likelihood of impacts on public and occupational safety can be significantly suppressed by the following mitigation measures:

- ❑ Restricting unattended public access to the wastewater treatment plants by proper fencing and guarding.
- ❑ Surrounding excavated locations with proper safety barriers and signs.
- ❑ Controlling movement of equipment and vehicles to and from the site, especially in the construction phase.
- ❑ Properly labeling and storing chemicals, oils, and fuel to be used on-sites.
- ❑ Emphasizing safety education and training for system staff. Enforcing adherence to safety procedures.
- ❑ Providing appropriate safety equipment, fire protection measures, and monitoring instruments.
- ❑ Providing hand railing around all open treatment units, except where sidewalls extend ≥ 1.1 meters above ground level.
- ❑ Properly rating electrical installations and equipment and, where applicable, protecting them for use in flammable atmosphere.
- ❑ Providing sufficient lighting which complies with zoning requirements.

As a conclusion, proper supervision, high workmanship performance, and provision of adequate safety measures will alleviate public and occupational risks.

Table 7.3. Mitigation Measures, Monitoring, and Estimated Costs for Actions Affecting Environmental Resources and Human Amenity

<i>Action</i>	<i>Potential impact</i>	<i>Mitigation measures</i>	<i>Monitoring of mitigation measures / responsibility</i>	<i>Estimated cost of mitigation (USD)</i>
A. During Construction				
Excavation and earth movement	<ul style="list-style-type: none"> Dust emission 	<ul style="list-style-type: none"> Wetting excavated surfaces Using temporary windbreaks Covering truck loads 	Supervision engineers	Included within contract
	<ul style="list-style-type: none"> Noise generation 	<ul style="list-style-type: none"> Restriction of working hours to daytime Employing low noise equipment Proper maintenance of equipment and vehicles, and tuning of engines and mufflers 	Supervision engineers	Priced within contract
	<ul style="list-style-type: none"> Erosion 	<ul style="list-style-type: none"> Proper resurfacing of exposed areas Inducing vegetation growth 	Supervision engineers	ditto
	<ul style="list-style-type: none"> Disturbance to biodiversity 	<ul style="list-style-type: none"> Conservation of present trees and used as wind brakes. Inducing vegetation growth 	Supervision engineers	ditto
Dumping of excavated and construction material into nearby watercourses	<ul style="list-style-type: none"> Surface and groundwater pollution 	<ul style="list-style-type: none"> Prohibition of uncontrolled dumping. Disposal at appropriate locations Education of workers on environmental protection 	Supervision engineers	ditto
Discharge of wastes (chemicals, oils, lubricants, etc.) on-site	<ul style="list-style-type: none"> Soil and water pollution 	<ul style="list-style-type: none"> Prohibition of uncontrolled discharge. Proper disposal of hazardous products Education of workers on environmental protection 	Supervision engineers	ditto
Storage of hazardous material, traffic deviation, deep excavation, movement of heavy vehicles, exposure to running sewers, etc.	<ul style="list-style-type: none"> Hazards to public and occupational safety 	<ul style="list-style-type: none"> Proper supervision for high workmanship performance Provision of adequate safety measures, and implementation of health and safety standards 	Supervision engineers	ditto

B. During Design & Operation				
Inadequate process design and control	<ul style="list-style-type: none"> • Generation of obnoxious odors 	<ul style="list-style-type: none"> • Improving operation and maintenance design procedures • Provision of covers where possible • Landscaping a proper natural windbreaker around the facility 	Design engineers	ditto
		<ul style="list-style-type: none"> • Maintaining proper cleanliness and housekeeping • Transportation of odorous byproducts in enclosed container trucks • Diluting, masking or treatment of odorous emissions 	WWTP administration and operating staff	
	<ul style="list-style-type: none"> • Impaired aesthetics 	<ul style="list-style-type: none"> • Maintaining cleanliness around and within the plant • Proper fencing and landscaping 	WWTP administration and operating staff	ditto
	<ul style="list-style-type: none"> • Aerosol emissions 	<ul style="list-style-type: none"> • Allowing adequate feedboards for aeration basins • Employing suppression hoods or splash deflectors on rotors 	Design engineers	ditto
	<ul style="list-style-type: none"> • Noise generation 	<ul style="list-style-type: none"> • Incorporating low-noise equipment • Locating mechanical equipment in proper acoustically-lined enclosures 	Design engineers	ditto
	<ul style="list-style-type: none"> • Public & occupational hazards 	<ul style="list-style-type: none"> • Restricting unattended public access • Providing adequate safety measures and monitoring equipment • Emphasizing safety education and training for system staff • Implementing health and safety standards 	WWTP administration and operating staff	ditto

Inappropriate effluent management practices	<ul style="list-style-type: none"> • Pollution of effluent receiving water bodies 	<ul style="list-style-type: none"> • Monitoring of effluent quality for surface water, groundwater, or marine discharge • Effluent discharge in accordance with MoE’s ELV 	MoE or MoEW	N/A
	<ul style="list-style-type: none"> • Contamination of crops and vegetables irrigated with effluent 	<ul style="list-style-type: none"> • Monitoring the suitability of effluent for crop irrigation • Training farmers for the proper handling of effluent 	MoE or MoA	N/A
Inappropriate screenings and grit management practices	<ul style="list-style-type: none"> • Soil and groundwater pollution at storage and disposal sites 	<ul style="list-style-type: none"> • Proper washing, draining, and separating of screenings and grit • Hauling in closed-top trucks and disposal at an allocated municipal solid waste disposal site. 	WWTP administration and operational staff	Operation and maintenance
Inappropriate sludge management practices	<ul style="list-style-type: none"> • Soil and groundwater pollution at sludge storage, disposal, or reuse sites 	<ul style="list-style-type: none"> • Proper design and operation of sludge handling and treatment units • Provision of adequate storage areas and capacities on-site • Proper sludge transport by top-covered trucks • Monitoring of sludge quality prior to disposal or reuse • Training farmers for the proper handling and use of sludge at the agricultural sites 	Design engineers and operational staff Design engineers WWTP administration and operation staff WWTP administration and operation staff Ministry of Agriculture or private companies	Operation and maintenance

8. ENVIRONMENTAL MANAGEMENT PLAN

The proper implementation of a comprehensive environmental management plan (EMP) will ensure that the proposed wastewater treatment plants meet regulatory and operational performance (technical) criteria.

8.1. OBJECTIVES OF THE ENVIRONMENTAL MANAGEMENT PLAN

Environmental management/monitoring is essential for ensuring that identified impacts are maintained within the allowable levels, unanticipated impacts are mitigated at an early stage (before they become a problem), and the expected project benefits are realized. Thus, the aim of an EMP is to assist in the systematic and prompt recognition of problems and the effective actions to correct them, and ultimately good environmental performance is achieved. A good understanding of environmental priorities and policies, proper management of the plants (at the municipality and the Union levels), knowledge of regulatory requirements and keeping up-to-date operational information are basic to good environmental performance.

8.2. MONITORING SCHEMES

Two monitoring activities have to be initiated for the proposed wastewater treatment plant to ensure the environmental soundness of the project. The first is *compliance monitoring*, and the second is *impact detection monitoring*. Compliance monitoring provides for the control of wastewater treatment operational activities, while impact detection monitoring relates to detecting the impact of the operation on the environment. Together, the objective is to improve the quality and availability of data on the effectiveness of operation, equipment, and design measures and eventually on the protection of the environment.

8.2.1 Compliance Monitoring

In this context, compliance to the regulations set by the Ministry of Environment to limit air, water, and soil pollution shall be observed. Compliance monitoring requirements include *process control testing*, *process performance testing*, and *occupational health monitoring*. Compliance monitoring shall be the responsibility of the treatment plant administration (municipality and the Union), thus monitoring activities shall be budgeted for accordingly.

For effective compliance monitoring, the following shall be assured:

- Trained staff (plant operator, laboratory staff, maintenance team, etc.) and defined responsibilities

- Adequate analytical facility (ies), equipment, and materials.
- Authorized Standard Operating Protocols (SOPs) for representative sampling, laboratory analysis, and data analysis.
- Maintenance and calibration of monitoring equipment.
- Provision of safe storage and retention of records.

In the proposed wastewater treatment facility, qualified plant operators and laboratory staff should carry out process control and performance testing. The technical staff that would run the plants shall attend training programs to improve their qualifications and update their information. Both Contractors and Consultants would be involved in knowledge transfer to operators and management.

For an extended aeration activated sludge system a comprehensive list of *process control parameters* is presented in Table 8.1. It is noteworthy to mention that the wastewater treatment plant proprietor or operator should cooperate with the technology provider for a better approach in process control. This course of action is needed since a precise process control strategy translates into a better process performance, and thus compliance. Accurate process control is even more essential at the start-up phase of the activated sludge system to ensure a subsequent uniform operational phase.

Table 8.1. Process control parameters for an EAAS system

Sampling Location	Analytical Parameter	Sample	
		Type ¹	Frequency ²
Plant influent ³	Flow	In situ	D
	pH	In situ	D
Mixed liquor	Dissolved oxygen	In situ	D
	pH	In situ	D
	Temperature	In situ	D
	Total Suspended Solids	C	1/W
	Volatile Suspended Solids	C	1/W
Return activated sludge line	Flow	In situ	D
	Total Suspended Solids	C	1/M
Waste activated sludge line	Flow	In situ	D
	Total Suspended Solids	C	1/M
Final settlement tank effluent	Depth of blanket at mid tank	G	D
Post-chlorination	Residual chlorine	G	1/W
Sludge holding tank contents (if applicable)	pH	G	D
	Temperature	G	D
	Dissolved oxygen	G	D
	Alkalinity	G	1/W
Settled sludge in holding tank (if applicable)	Volatile acids	G	1/W
	pH	G	D
Sludge supernatant	Biochemical Oxygen Demand ₅	C	1/W

¹ G: grab sample; C: composite sample (usually 24-hr composite grab samples every 8 hours, or 24-hr automatic sampler)

² D: daily, 1/W: once per week, 1/M: once per month Frequency may be adjusted as needed.

³ Metals and organic compounds are less often determined, usually until a problem arises.

As for *process performance monitoring*, the list of recommended parameters is exhaustive; however, abundance is highly recommended especially during the first months of plant operation. Once a preliminary database is built, less frequent analysis can be performed, especially for the relatively invariable parameters. Table 8.2 summarizes the recommended process performance parameters for an extended aeration activated sludge system. Note that sampling frequencies are reduced at later stages of the operational phase. The plant operator may adjust the schedule of sampling in accordance to the operational characteristics of the system, and previous monitoring experience; however, utmost responsibility should be taken for uninterrupted compliance.

Table 8.2. Process performance parameters for an EAAS system

Sampling Location	Analytical Parameter	Sample Type ¹	Sampling Frequency ²		
			Early Operational Phase	Advanced Operational Phase	Minimums sampling
Plant influent ³	Biochemical Oxygen Demand ₅	C	1/M	1/2M	1/3M
	Total Suspended Solids	C	1/M	1/2M	1/3M
	Total Nitrogen	G	M ⁴	1/2M ⁴	1/3M
	Ammonia	G	M ⁴	1/2M ⁴	1/3M
Final settlement tank effluent	Biochemical Oxygen Demand ₅	C	1/W	1/2W	M
	Total Suspended Solids	C	1/W	1/2W	M
	pH	In Situ	D	D	D
	Total Nitrogen	G	1/2W ⁴	M ⁴	1/2M
	Ammonia	G	1/2W ⁴	M ⁴	1/2M
	Nitrates	G	1/2W ⁴	M ⁴	1/2M
	Nitrites	G	1/2W ⁴	M ⁴	1/2M
Post-chlorination	Fecal coliforms	G	1/W	1/2W	M
Sludge holding tank contents (if applicable)	Nitrates	G	1/W	M	1/2M
	Ammonia	G	1/W	M	1/2M
	Total solids	C	1/W	1/2W	M
	Volatile solids	C	1/W	1/2W	M
Settled sludge in holding tank (if applicable)	Nitrates	G	1/W	M	1/2M
	Ammonia	G	1/W	M	1/2M
	Total solids	C	1/W	1/2W	M
	Volatile solids	C	1/W	1/2W	M

¹ G: grab sample; C: composite sample (usually 24-hr composite grab samples every 8 hours, or 24-hr automatic sampler)

² D: daily, 1/W: once per week, 1/2W: once per two weeks, M: monthly, 1/2M: once per two months, Frequency could be reduced if compliance violations are infrequent.

³ Metals and organic compounds are less often determined, usually until a problem arises.

⁴ Total nitrogen, ammonia, nitrates, and nitrites analyses can be excluded if influent concentrations for these parameters are within set standards, or if nitrogen removal is not within the capabilities of the employed wastewater treatment scheme.

It is noteworthy to mention that initial comprehensive characterization of the wastewater to be treated is necessary for proper plant design, operation, and future monitoring. Moreover, though analytical monitoring is essential, frequent observations of the aeration tanks and clarifier characteristics, such as aeration patterns, turbulence, foaming, and effluent clarity play an important part in performance monitoring. The frequency of monitoring can be reduced if it is necessary after constant recorded compliant values are obtained over a period of 2-3 years of normal operation. During plant start-up, when a thorough monitoring schedule is recommended, monitoring efforts can be limited to regular checks (weekly or bi-weekly, as needed) of effluent quality for the following parameters:

- pH and temperature
- BOD₅ and COD
- suspended solids
- Total Nitrogen
- Total Phosphorus
- ammonia-nitrogen
- Nitrate – nitrogen
- Phosphate
- Coliform bacteria

However, in case of any sudden change in any value trend it is imperative to reapply the advanced operational phase frequency in order to depict the anomaly.

The quality of dewatered sludge should also be checked before its disposal or reuse as soil fertilizer. Typically, analysis of wastewater treatment plant sludge is performed on composite samples for the parameters set forth in Table 8.3. Since the sewage discharged into the plant is mainly of domestic origin, concentrations of toxic compounds such as PCBs and pesticides are expected to be negligible. Thus, analyzing the sludge for such compounds is not mandatory, especially that they incur relatively high analysis costs. Additionally, high levels of metals are not expected to be present. However, it is advisable to test the generated sludge for metal content and toxic organic compounds on a 6-month or annual basis. Moreover, bacterial and nutrient levels (NPK value) in the wastewater sludge should be determined regularly. It is important that contractors/suppliers of the plant located in Aammatour shall account for the presence of gas stations, lube oil service shops and auto-mechanics in their final design of the plants. Good housekeeping and the installation of oil/water separators or grease traps would be requested from such facilities.

Table 8.3. Sludge quality monitoring parameters

Total Solids	Copper
pH	Lead
Total Nitrogen	Mercury
Ammonia-Nitrogen	Molybdenum
Nitrate-Nitrogen	Nickel
Phosphorus	Selenium
Potassium	Zinc
Arsenic	Polychlorinated Biphenyls
Cadmium	Pathogens

It is necessary to install in-line analytical meters and measuring devices, especially for regular daily measurements, to ensure sampling reproducibility. Automatic samplers may also be useful at specific locations. The on-site presence of an analytical facility facilitates process control and performance monitoring subsequently ensuring compliance.

8.2.2 Impact Detection Monitoring

As mentioned earlier, impact detection monitoring relates to detecting the impact of the operation on the environment. Such monitoring shall be the responsibility of the municipal authorities. An independent monitoring organization shall be set up and financed by the concerned municipalities, or monitoring activities will be contracted to a specialized private organization. Impact monitoring includes periodic sampling from downstream wells, springs, and surface waters, and analyzing samples by preset biological as well as chemical quality control tests. The tests performed over the various springs, wells and rivers in this study, prior to the implementation of the various treatment plants, should be used as a basis in order to assess the expected positive effects or impacts of waste water management over the various receiving water bodies in the area subsequently over the environment.

8.3. RECORD KEEPING AND REPORTING

Monitoring efforts would be in vain in the absence of an organized record keeping practice. It is the responsibility of the treatment plant administration, in this case the municipality, to ensure the development of a database that includes a systematic tabulation of process indicators, performed computations, maintenance schedules and logbook, and process control and performance monitoring outcomes. Such a historical database benefits both the plant operator and design engineers. The treatment plant should submit a periodic Discharge Monitoring Report (DMR) to the assigned regional authority, namely the Mohafaza. Such record keeping shall be requested and assured by the Union.

8.4. CAPACITY BUILDING

Considered as corner stone of the EMP the capacity building program consists of 2 major parts: Specialized Training Workshops (STW) and General Awareness Seminars (GAS).

8.4.1 Operators Training

One year training to municipality staff that will operate the plant will be provided by the contractor, supporting then the overall sustainability of the project.

8.4.2 Specialized Training Workshops (STW)

STWs consist of a combination of theoretical lectures, focused training sessions, and field demonstrations that are believed to maximize workshop impacts. A highly technical training manual will be distributed to the participants to serve as a basis for future reference and application of proper environmental guidelines.

8.4.3 General Awareness Seminars (GAS)

General awareness seminars are targeted to the local community in general. Issues addressed in a GAS are less technical than those in STWs, and aim at raising awareness and improve environmental practices of the local population. It would be however rather difficult and expensive to provide these seminars to a very large portion of the local communities during the duration of the project. It is believed to be a more sustainable approach to TRAIN THE TRAINERS who will subsequently train and raise awareness in the community. These trainers include primarily school professors and NGO's that could take over this educational role. Topics to be included in these seminars could be environmental impacts from poor disposal practices, role of the local community in improving the environment and other general topics aimed to increase environmental awareness.

Awareness manuals and ready-made presentations will be prepared and provided to these trainers as tools to be used in raising awareness. Trainers would attend awareness seminars provided in schools and other public locations in order to get acquainted with the principle. Several GASs would be conducted (at least 3 per cluster) in order to initiate the environmental awareness in the rural communities.

8.5. INSTITUTIONAL ARRANGEMENTS

No matter how meticulously an environmental management scheme has been prepared, it will fail in the absence of predefined responsibilities and strong technical bodies. Compliance monitoring shall be the responsibility of the treatment plant administration (municipalities or a contracted operator) and thus its activities shall be budgeted for accordingly. However, in accordance with the requirements of the regulatory authority (MoE), the treatment plant should submit a periodic Discharge Monitoring Report (DMR) to the assigned enforcement authority (Mohafaza/MoIM). The assigned authority will be responsible for drawing conclusions based on the monitoring data, and deciding on specific actions to alleviate pollution impacts.

On the other hand, impact detection monitoring shall be the responsibility of the municipal authorities. Ideally, an independent monitoring organization is set up and financed

by the concerned municipalities in the Union, or monitoring activities are contracted to a specialized private organization. Figure 8.1 is an illustration of such institutional arrangement.

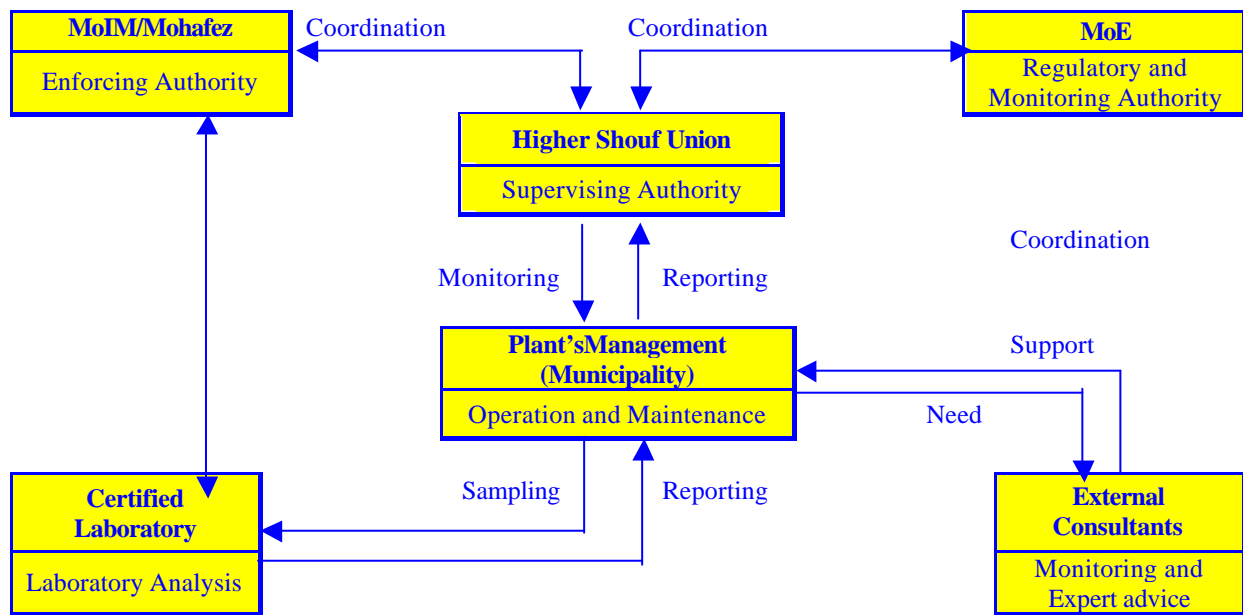


Figure 8.1. Proposed Institutional Setting

9. PUBLIC INVOLVEMENT AND PARTICIPATION

Public involvement started early in the process during the municipal election campaigns in 1997. The project then became the foremost issue being requested from the municipalities by the constituents. The Union meetings kept the various municipalities abreast of the project. Since it was a publicly initiated and supported project, public involvement was assured.

During this EIA study, the consultant met numerous times with the Mayors of the 4 villages (Aammatour, Ain Qani, Baadaran, Haret Jandal), all along with the assistance of PM representatives, to present the findings regarding many aspects concerning the site location, network distribution, springs assessments, most appropriate technologies and many other aspects required to finalize the study. Additional meetings were also set between ARD and PM to set the Specifications, Requirements and Standards requested for compliance of contractors in the bidding process

In the preliminary stages of the study the municipalities were requested to fill out a questionnaire tailored towards obtaining additional relevant and specific information. The requested information related to the physical and biological environment, the socio-economic situation in the various municipalities, and general requirements pertinent to the EIA process.

Appendix H includes a sample of a questionnaire that each municipality was requested to complete.

Also in conformity with EIA guidelines, a notice was posted for duration of at least 18 days at each concerned municipality within the Union informing the public about the EIA study that is being conducted and the proposed treatment plants, and soliciting comments. A copy of the notice is included in Appendix I along with the EMP compliance form signed by the concerned municipality.

On September 5, 2003, a social event initiated by PM. in the presence of the funding organization USAID and Mr. Walid Joumblat, was held in order to present to the various proponents the planned projects prospected for the higher Shouf area.

On October 18, 2003, under the public participation program an Inception Workshop was also held to present to the various participants the overall description of the intended project, joining as well the different stakeholders to discuss the project. The various stakeholders present included municipality members, representatives of local community, local NGOs, Government representatives, Project partners and USAID. The meeting was very

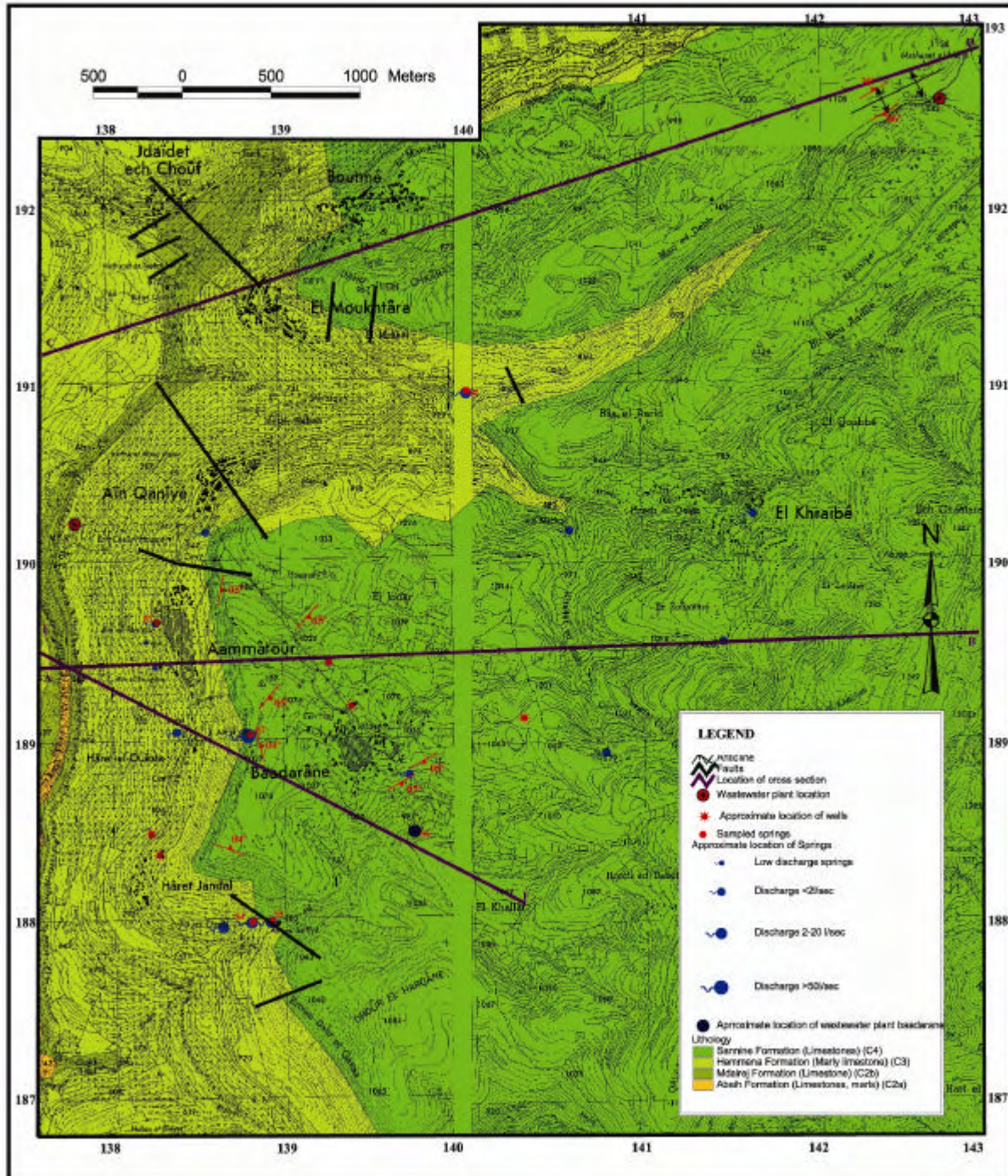
instructive and various questions and concerns were raised throughout the sessions. Appendix G includes a copy of official invitation letter, meeting agenda, the list of official invitees, actual attendance, Minutes of the meeting and the presentation for the workshop.

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APPENDIX A GEOLOGICAL MAP OF THE STUDY AREA



**APPENDIX B
LABORATORY ANALYTICAL RESULTS – SPRINGS WATER
– BAROUK RIVER.**

APPENDIX C
ARCHITECTURAL DRAWING OF AN EAAS PLANT

APPENDIX D AAMMATOUR PLANT SITE LOCATION ON PARCEL MAP

(Location #4 is the site highlighted in red)



APPENDIX E SLUDGE AND EFFLUENT MANAGEMENT

INTRODUCTION

Sludge and effluent disposal by surface application is performed in an environmentally safe manner according to different restrictions and considerations. The US EPA formulated 40 CFR Part 503 to regulate the use or disposal of sludge in order to protect public health and the environment. In specific, subpart B of the part 503 rule prohibits the land application of sewage sludge that exceeds specified limits. Those standards should be followed as they represent the most comprehensive international standards developed according to risk analysis.

Effluent cannot be directly disposed to land unless it complies with the wastewater quality standards (guidelines for water re-use or disposal suggested by the EPA). Furthermore, sludge cannot be frequently disposed on the same soil. If land application is to be performed, sludge should be collected and stored, and then applied according to an application rate, which depends on the site characteristics, and on the sludge quality (level of pollutants) (according to sludge disposal guidelines suggested by the EPA).

The present appendix presents the restrictions preventing land application of the proposed effluent and provides the standards and considerations that should be achieved if land application was to be the sludge disposal method. The difference between sludge disposal and effluent disposal should be considered: effluent disposal is performed according to the wastewater quality standards, and sludge disposal according to sewage sludge standards, and with different application rates.

LAND TREATMENT

Land treatment is characterized as spreading the waste (effluent or sludge) on the soil surface or incorporating it into the upper few centimeters by mechanical manipulation. The method of application depends on the physical, chemical, and toxic nature of the waste and the rate of biodegradation desired. Sprinkler, flood, or drip-type application could be used to apply liquids. Because of their fluid nature, they penetrate the soil and thus, do not require mechanical soil incorporation unless they carry significant amounts of solids. The single purpose of land treatment as opposed to land utilization is final disposal of the waste with little or no demand of the waste to function as a resource.

Destruction of the soil for vegetative growth is not a part of land treatment. Land treatment must provide sound, environmentally safe disposal of waste residuals through biological, chemical, and physical interactions occurring in soils. The inorganic metal components are expected to biodegrade through the activity of the indigenous soil microorganisms. The inorganic metal components are expected to attenuate (or immobilize) primarily through physical-chemical interactions with the soil (Fuller, 1988).

Table E.1 and Table E.2, present the general requirement for sludge disposal and effluent disposal on forestlands. Detailed analysis and considerations will be presented in the report.

Table E.1. Summary of typical characteristics of sewage sludge land application practices (EPA, 1992)

<i>Characteristics</i>	<i>Forest land application</i>
Application rates	Varies: normal range in dry weight of 10 to 220 t/ha/yr. (4 to 100 T/ac/yr.) depending on soil, tree species, sludge quality, etc. typical rate is about 18 t/ha/yr. (8 T/ac/yr.)
Application frequency	Usually applied annually or at 3 to 5-year intervals
Useful life of application site(s)	Usually limited by accumulated metal loading in total sewage sludge applied. With most sewage sludge a useful life of 20 to 55 years or more is typical.
Sewage sludge scheduling	Scheduling affected by climate and maturity of trees.
Application constraints	Limited by part 503 agronomic rate management practice requirement.

Table E.2. EPA guidelines for water reuse in wildlife habitats (EPA, 1992)

<i>Factor</i>	<i>Requirement</i>
Treatment	Secondary and disinfection
Effluent quality	BOD < 30 mg/l SS < 30 mg/l Fecal coliform < 200 fecalcoli/100ml (The number of fecal coliform organisms should not exceed 800/100 ml in any sample)
Effluent monitoring	BOD – weekly SS - daily Coliform - daily Cl ₂ residual – continuous
Other considerations	Ground water monitoring Temperature pH

SLUDGE DISPOSAL

EPA REQUIREMENTS FOR SLUDGE DISPOSAL

EPA developed the federal part 503 rule (40 CFR Part 503) that establishes requirements for land application of sewage sludge. Subpart B of the part 503 rule prohibits the land application of sludge that exceeds pollutant limits termed “ceiling concentration limits” for 10 metals and places restrictions on sludge exceeding additional pollutant limits which are the cumulative pollutant loading rate limits and the annual pollutant loading rate limits. The requirements for land disposal are presented in Table E.3, and further explained in the following sections.

Table E.3. Part 503 land application pollutant limits for sewage sludge (EPA, 1995)

<i>Pollutant</i>	<i>Ceiling concentration limits (mg/kg)</i>	<i>Cumulative pollutant loading rate limits (kg/ha)</i>	<i>Annual pollutant loading rate limits (kg/ha per 365-day period)</i>
Arsenic	75	41	2.0
Cadmium	85	39	1.9
Chromium	3,000	3,000	150
Copper	4,300	1,500	75
Lead	840	300	15
Mercury	57	17	0.85
Molybdenum	75	--	--
Nickel	420	420	21
Selenium	100	100	5.0
Zinc	7,500	2,800	140

Ceiling concentration limits (EPA, 1995)

All sewage sludge applied to land must meet part 503 ceiling concentration limits for 10 regulated pollutants. Ceiling concentration limits are the maximum allowable concentration of a pollutant in sewage sludge to be land applied. If the ceiling concentration of any one of the regulated pollutants is exceeded, the sewage sludge cannot be land applied.

Cumulative pollutant loading rates (CPLRs)

A CPLR is the maximum amount of pollutant that can be applied to a site by all sludge applications. When the CPLR is reached at the application site for any one of the 10 metals no additional sludge can be applied.

Annual pollutant loading rates (APLRs)

APLR is the maximum amount of a pollutant that can be applied to a site within a 12-month period from sludge. The pollutant concentration in sludge multiplied by the “whole annual sludge application rate” must not cause any of the APLR to be exceeded.

Pathogen requirements (EPA, 1995)

The density of fecal coliform in the sewage sludge must be less than 1,000 most probable number (MPN) per gram total solids (dry-weight basis) or the density of *Salmonella* sp. bacteria in the sewage sludge must be less than 3 MPN per 4 grams of total solids (dry-weight basis).

Vector Attraction Reduction Requirements (EPA, 1995)

Subpart D in Part 503 establishes 10 options for demonstrating that sludge that is land applied meets requirements for vector attraction reduction (Table E.4). The options can be divided into two general approaches for controlling the spread of disease via vectors (such as insects, rodents, and birds):

- Reducing the attractiveness of the sewage sludge to vectors (Options 1 to 8).
- Preventing vectors from coming into contact with the sewage sludge (Options 9 and 10).

Compliance with the vector attraction reduction requirements using one of the options described below must be demonstrated separately from compliance with requirements for reducing pathogens in sewage sludge. Thus, demonstration of adequate vector attraction reduction does not demonstrate achievement of adequate pathogen reduction. Part 503 vector attraction reduction requirements are summarized below:

Table E.4. Summary of Vector Attraction Reduction Requirements for Land Application of Sewage Sludge Under Part 503 (U.S. EPA 1992b)

Requirement	What Is Required?	Most Appropriate For:
Option 1: Reduction in volatile solid content 503.33(b)(1)	At least 38% reduction in volatile solids during sewage sludge treatment	Sewage sludge processed by: · Anaerobic biological treatment · Aerobic biological treatment · Chemical oxidation
Option 2: Additional digestion of anaerobically digested sewage sludge 503.33(b)(2)	Less than 17% additional volatile solids loss during bench-scale anaerobic batch digestion of the sewage sludge for 40 additional days at 30°C to 37°C (86°F to 99°F)	Only for anaerobically digested sewage sludge
Option 3: additional digestion of aerobically digested sewage sludge 503.33(b)(3)	Less than 15% additional volatile solids reduction during bench-scale aerobic batch digestion for 30 additional days at 20°C (68°F)	Only for aerobically digested sewage sludge with 2% or less solids—e.g., sewage sludge treated in extended aeration plants
Option 4: specific oxygen uptake rate for aerobically digested sewage sludge	SOUR at 20°C (68°F) is <1.5 mg oxygen/hr/g total sewage sludge solids	Sewage sludge from aerobic processes (should not be used for composted sludge). Also for sewage

treated in an aerobic process 503.33(b)(4)		sludge that has been deprived of oxygen for longer than 1–2 hours.
Option 5: aerobic processes at greater than 40°C 503.33(b)(5)	Aerobic treatment of the sewage sludge for at least 14 days at over 40°C (104°F) with an average temperature of over 45°C (113°F)	Composted sewage sludge (Options 3 and 4 are likely to be easier to meet for sewage sludge from other aerobic processes)
Option 6: addition to alkali 503.33(b)(6)	Addition of sufficient alkali to raise the pH to at least 12 at 25°C (77°F) and maintain a pH =12 for 2 hours and a pH <11.5 for 22 more hours	Alkali-treated sewage sludge (alkalies include lime, fly ash, kiln dust, and wood ash)
Option 7: moisture reduction of sewage sludge containing no un-stabilized solids 503.33(b)(7)	Percent solids <75% prior to mixing with other materials	Sewage sludge treated by an aerobic or anaerobic process (i.e., sewage sludge that do not contain un-stabilized solids generated in primary wastewater treatment)
Option 8: moisture reduction of sewage sludge containing un-stabilized solids 503.33(b)(8)	Percent solids <90% prior to mixing with other materials	Sewage sludge that contain un-stabilized solids generated in primary wastewater treatment (e.g., any heat-dried sewage sludge)
Option 9: injection of sewage sludge 503.33(b)(9)	Sewage sludge is injected into soil within 8 hours after the pathogen reduction process so that no significant amount of sewage sludge is present on the land surface 1 hour after injection.	Liquid sewage sludge applied to the land.
Option 10: incorporation of sewage sludge into the soil 503.33(b)(10)	Sewage sludge must be applied to the land surface within 8 hours after the pathogen reduction process, and must be incorporated within 6 hours after application.	Sewage sludge applied to the land.

PHYSICAL CHARACTERISTICS OF POTENTIAL LAND APPLICATION SITES (EPA, 1995)

The physical characteristics of concern are:

- Topography (Table E.5)
- Soil permeability, infiltration, and drainage patterns
- Depth to ground water
- Proximity to surface water

Potentially unsuitable areas for sewage sludge application:

- Areas bordered by ponds, lakes, rivers, and streams without appropriate buffer areas.
- Wetlands and marshes
- Steep areas with sharp relief.
- Undesirable geology (karst, fractured bedrock) (if not covered by a sufficiently thick soil column).
- Undesirable soil conditions (rocky, shallow).
- Areas of historical or archeological significance.
- Other environmentally sensitive areas such as floodplains or intermittent streams, ponds, etc., as specified in the Part 503 regulation.

Table E.5. Recommended Slope Limitations for Land Application of Sludge

Slope	Comment
0-3%	Ideal; no concern for runoff or erosion of liquid or dewatered sludge.
3-6%	Acceptable for surface application of liquid or dewatered sludge; slight risk of erosion.
6-12%	Injection of liquid sludge required in most cases, except in closed drainage basin and/or areas with extensive runoff control. Surface application of dewatered sludge is usually acceptable.
12-15%	No liquid sludge application without effective runoff control; surface application of dewatered sludge is acceptable, but immediate incorporation is recommended.
Over 15%	Slopes greater than 15% are only suitable for sites with good permeability (e.g., forests), where the steep slope length is short (e.g., mine sites with a buffer zone downslope), and/or the steep slope is a minor part of the total application area.

Soil Permeability and Infiltration

Permeability (a property determined by soil pore space, size, shape, and distribution) refers to the ease with which water and air are transmitted through soil. Fine-textured soils generally possess slow or very slow permeability, while the permeability of coarse-textured soils ranges from moderately rapid to very rapid. A medium textured soil, such as a loam, tends to have moderate to slow permeability.

Soil Drainage

Soils classified as (1) very poorly drained, (2) poorly drained, or (3) somewhat poorly drained may be suitable for sewage sludge application if runoff control is provided. Soils classified as (1) moderately well drained, (2) well drained, or (3) somewhat excessively drained are generally suitable for sewage sludge application. Typically, a well-drained soil is at least moderately permeable.

Surface Hydrology, Including Floodplains and Wetlands

The number, size and nature of surface water bodies on or near a potential sludge land application site are significant factors in site selection due to potential contamination from site runoff. Areas subject to high runoff have severe limitations for sludge application.

Ground Water

For preliminary screening of potential sites, it is recommended that the following ground water information for the land application area be considered:

- Depth to ground water (including historical highs and lows).
- An estimate of ground water flow patterns.

The greater the depth to the water table, the more desirable a site is for sludge application. Sludge should not be placed where there is potential for direct contact with the ground-water table. The actual thickness of unconsolidated material above a permanent water table constitutes the effective soil depth. The desired soil depth may vary according to sludge characteristics, soil texture, soil pH, method of sludge application, and sludge application rate. Recommended Depth to Ground Water:

- Drinking Water Aquifer: 2 m
- Excluded Aquifer (not used as potable water supplies): 0.7 m

The type and condition of consolidated material above the water table is also of major importance for sites where high application rates of sewage sludge are desirable. Fractured rock may allow leachate to move rapidly. Unfractured bedrock at shallow depths will restrict water movement, with the potential for ground water mounding, subsurface lateral flow, or poor drainage. Limestone bedrock is of particular concern where sinkholes may exist. Sinkholes, like fractured rock, can accelerate the movement of leachate to ground water. Thus, potential sites with potable ground water in areas underlain by fractured bedrock, by unfractured rock at shallow depths, or with limestone sinkholes should be avoided.

Table E.6. Soil Limitations for Sewage Sludge Application to Agricultural Land at Nitrogen Fertilizer Rates

Soil features affecting use	Degree of soil limitation		
	Slight	Moderate	Severe
Slope ^a	Less than 6%	6 to 12%	More than 12%
Depth to seasonal water table	More than 1.2 m	0.6 to 1.2 m	Less than 1 m
Flooding and ponding	None	None	Occasional to frequent ^b
Depth to bedrock	More than 1.2 m	0.6 to 1.2 m	Less than 0.61 m
Permeability of the most restricting layer above a 1-m depth	0.24 to 0.8 cm/hr	0.8 to 2.4 cm/hr	Less than 0.08 cm/hr
Available water capacity	More than 2.4 cm	1.2 to 2.4 cm	Less than 1.2 cm

^a Slope is an important factor in determining the runoff that is likely to occur. Most soils on 0 to 6% slopes will have slow to very slow runoff; soils on 6 to 12% slopes generally have medium runoff; and soils on steeper slopes generally have rapid to very rapid runoff.

^b Land application may be difficult under extreme flooding or ponding conditions.

Metric conversions: 1 ft = 0.3048 m, 1 in = 2.54 cm.

CLIMATE

Analysis of climatological data is an important consideration for the preliminary planning phase. Rainfall, temperature, evapotranspiration, and wind may be important climatic factors affecting land application of sludge, selection of land application practices, and site management. Table E.7 highlights the potential impacts of some climatic regions on the land application of sludge.

Table E.7. Potential Impacts of Climatic Regions on Land Application of Sewage Sludge

Impact	Warm/Arid	Warm/Humid	Cold/Humid
Operation Time	Year-round	Seasonal	Seasonal
Salt Buildup Potential	High	Low	Moderate
Leaching Potential	Low	High	Moderate
Runoff Potential	Low	High	High

SELECTION OF LAND APPLICATION PRACTICE (EPA, 1995)

Table E.8 presents an example of a ranking system for forest sites, based on consideration of topography, soils and geology, vegetation, water re-sources, climate, transportation, and forest access. Several other considerations should be integrated into the decision-making process, including:

- Compatibility of sewage sludge quantity and quality with the specific land application practice selected.
- Public acceptance of both the practice(s) and site(s) selected.
- Anticipated design life, based on assumed application rate, land availability (capacity), projected heavy metal loading rates (if Part 503 cumulative pollutant loading rates are being met), and soil properties.

Table E.8. Relative Ranking for Forest Sites for Sewage Sludge Application

<i>Factor</i>	<i>Relative Rank</i>
Topography	
Slope	
Less than 10%	High
10-20%	Acceptable
20-30%	Low
Over 30%	Low
Site continuity (somewhat subjective)	
No draws, streams, etc., to buffer	High
1 or 2 requiring buffers	Acceptable
Numerous discontinuities	Low
Forest System	
Percent of forest system in place	Low-High
Erosion hazard	
Little (good soils, little slope)	High
Great	Low-Acceptable
Soil and Geology	
Soil type	
Sandy gravel (outwash, Soil Class I)	High
Sandy (alluvial, Soil Class II)	High
Well graded loam (ablation till, Soil Class IV)	Acceptable
Silty (residual, Soil Class V)	Acceptable
Clayey (lacustrine, Soil Class IV)	Low
Organic (bogs)	Low
Depth of soil	
Deeper than 10 ft	High
3-10 ft	High
1-3 ft	Acceptable
Less than 1 ft	Low
Geology (subjective, dependent upon aquifer)	
Sedimentary bedrock	Acceptable-High
Andesitic basalt	Acceptable-High
Basal tills	Low-Acceptable
Lacustrine	Low
Vegetation (sensitive-rare)	Low-high

SOIL SAMPLING AND ANALYSIS TO DETERMINE AGRONOMIC RATES (EPA, 1995)

Designing the agronomic rate for land application of sewage sludge is one of the key elements in the Part 503 rule for ensuring that land application does not degrade ground water quality through nitrate contamination. The Part 503 rule defines agronomic rate as: the whole sludge application rate (dry weight basis) designed: (1) to provide the amount of nitrogen needed by the vegetation on the land and (2) to minimize the amount of nitrogen in the sludge that leach beyond the root zone of the vegetation grown on the land to the ground water (40 CFR 503.11(b)).

Designing the agronomic rate for a particular area requires knowledge of (1) soil fertility, especially available N and P; and (2) characteristics of the sludge, especially amount and forms of N (organic N, NH_4 , and NO_3). The complex interactions between these factors and climatic variability (which affects soil-moisture related N transformations) make precise prediction of crop N requirements difficult.

Major constituents that may need to be tested in soils include:

- $\text{NO}_3\text{-N}$ as an indicator of plant-available N in the soil. Where applicable, these tests should be made for calculating initial sludge application rates, and can possibly be used in subsequent years.
- C/N ratio, which provides an indication of the potential for immobilization of N in sludge as a result of decomposition of plant residues in the soil and at the soil surface. This is especially relevant for forestland application sites as well as for agricultural purposes.

DETERMINING SEWAGE SLUDGE APPLICATION RATES FOR FOREST SITES (EPA, 1995)

Sewage sludge application rates at forest sites usually are based on tree N requirements.

Nitrogen dynamics of forest systems are somewhat complex because of recycling of nutrients in decaying litter, twigs and branches, and the immobilization of the NH_4 contained in sludge as a result of decomposition of these materials.

Concentrations of trace elements (metals) in sludge may limit the cumulative amount of sewage sludge that can be placed on a particular area.

Nitrogen applications cannot exceed the ability of the forest plants to utilize the N applied, with appropriate adjustments for losses.

Cumulative metal loading limits cannot exceed the cumulative pollutant loading rates (CPLRs) in the Part 503 rule.

Nitrogen Uptake and Dynamics in Forests

In general, uptake and storage of nutrients by forests can be large if the system is correctly managed and species respond to sludge. The trees and understory utilize the available N from sludge, resulting in an increase in growth. There is a significant difference between tree species in their uptake of available N. In addition, there is a large difference between the N uptake by seedlings, vigorously growing trees, and mature trees. Finally, the amount of vegetative understory on the forest floor will affect the uptake of N; dense understory vegetation markedly increases N uptake.

Calculation of sludge application rates requires considerations of nitrogen transformations in addition to N mineralization and ammonia volatilization from the sewage sludge: (1) denitrification, (2) uptake by under-story, and (3) soil immobilization for enhancement of forest soil organic-N (ON) pools.

Nitrogen Leaching

Typically, N is the limiting constituent for land applications of sludge because when excess N is applied, it often results in nitrate leaching. The N available from sludge addition can be microbially transformed into NO_3^- through a process known as nitrification. Because NO_3^- is negatively charged, it easily leaches to the ground water with percolating rainfall.

EQUIPMENT FOR SEWAGE SLUDGE APPLICATION AT FOREST SITES (EPA, 1995)

There are four general types of methods for applying sewage sludge to forests: (1) direct spreading; (2) spray irrigation with either a set system or a traveling gun; (3) spray application by an application vehicle with a spray cannon; and (4) application by a manure-type spreader.

The main criterion used in choosing a system is the liquid content of the sewage sludge. Methods 1, 2, and 3 are effective for liquid sewage sludge (2% to 8% solids); Methods 1 and 2 can be used for semi-solid sewage sludge (8% to 18% solids); and only Method 4 is acceptable for solid sewage sludge (20% to 40% solids).

SCHEDULING (EPA, 1995)

Sludge applications to forest sites can be made either annually or once every several years. Annual applications are designed to provide N only for the annual uptake requirements of the trees, considering volatilization and denitrification losses and mineralization from current and prior years. An application one-year followed by a number of years when no

applications are made utilizes soil storage (immobilization) of nitrogen to temporarily tie up excess nitrogen that will become available in later years.

In a multiple-year (e.g., every 3 to 5 years) application system, the forest floor, vegetation, and soil have a prolonged period to return to normal conditions, and the public can use the site for recreation in the non-applied years. Application rates, however, are not simply an annual rate multiplied by the number of years before reapplication, but rather need to be calculated so that no NO₃ - leaching occurs.

Scheduling sludge application also requires a consideration of climatic conditions and the age of the forest. High rainfall periods and/or freezing conditions can limit sewage sludge applications in almost all situations. The Part 503 regulation prohibits bulk sewage sludge from being applied to forest land that is flooded, frozen, or snow-covered so that the sewage sludge enters wetlands or other surface waters.

EFFLUENT DISPOSAL

CRITERIA DETERMINING EFFLUENT DISPOSAL (FULLER, 1988)

Effluent acceptable for disposal should meet certain criteria of quality. Superimposed on these are loading rates. The effluent should first meet the following requirements before the loading rate is determined:

- Capability of biodegradation of solids or soluble components
- No long-term toxicity to plants or microorganisms
- Each migration at practical rates of application to the ground water
- No adverse influence on the natural physical and chemical properties of the soil at reasonable rates of application
- No long-term limitation of land productivity

Further criteria and explanations will be provided in the following section.

The criteria determining loading rates are:

1. Effluent quality: Organic matter, BOD, COD, total organic carbon, TOC, heavy metals, total dissolved solids (TDS), suspended solids (SS), nitrogen, phosphorus, sodium absorption ratio (SAR), boron, bacteriological composition, organic chemicals, organic solvents.

2. Soil quality: Texture, structure, permeability, infiltration, presence of confining soil barriers, depth to water table, drainage
3. Climate: Rainfall amount and intensity factor, temperature, wind velocity and direction, evapotranspiration.
4. Topography: Slope, soil and water erosion potential, flood hazard, topography of watershed
5. Geologic formation: Depth to bedrock, limestone
6. Groundwater: depth to ground water, direction and rate of flow, perched water tables, and location, depth, and quality of wells.

EPA EFFLUENT RE-USE CRITERIA

The effluent should not alter the natural ecosystem present in the site, meaning that it should not lead to plant toxicity or underground water contamination. Effluents from tanneries are not usually disposed in forestlands, and this application is currently examined and studied. Until further advances and clarifications, the effluent should have the quality of reclaimed water for irrigation (which is developed to protect plant and human health) if it is to be disposed in forests. The following criteria and requirements should be achieved (Table E.9 and Table E.10).

Reclaimed water quality

The constituents in reclaimed water of concern are salinity, sodium, trace elements, excessive chlorine residual, and nutrients.

- **Salinity:** Salt accumulation can be especially detrimental during germination and when plants are young even at relatively low concentrations. Salinity may be reported as TDS. ($\text{TDS mg/l} * 0.00156 = \text{EC mmhos/cm}$). Salinity depends on the plant salt tolerance, and on the soil drainage and leaching characteristics (soils should be properly drained and adequately leached (leaching requirements) to prevent salt buildup). The extent of salt accumulation in the soil depends on the salt concentration in the water and the rate at which it is removed by leaching.
- **Sodium:** the potential influence sodium may have on soil properties is indicated by the sodium-adsorption-ratio ($\text{SAR} = \text{NA} / \{ \sqrt{[(\text{Ca} + \text{Mg})/2]} \}$). Sodium salts influence the exchangeable cation composition of the soil, which lowers the permeability, which impairs the infiltration of water into the soil.
- Trace elements of greatest concern at elevated levels are: Cd, Co, Mb, Ni, and Zn.

- Chlorine residual: free chlorine residual at concentrations less than 1mg/l usually poses no problems to plants. However, some sensitive plants may be damaged at levels as low as 0.05 mg/l. some woody plants may accumulate chlorine in the tissue to toxic levels. Excessive chlorine has similar leaf-burning effect as sodium and chloride when sprayed directly on foliage. Chlorine at concentrations greater than 5 mg/l causes severe damage to most plants.

Table E.9. Recommended limits for constituents in reclaimed water for irrigation of plants (EPA, 1992)

<i>Constituent</i>	<i>Long-term use (mg/l)</i>	<i>Remark</i>
Aluminum	5.0	Can cause non-productivity in acid soils, soils with pH 5.5-8 will precipitate the ion and eliminate toxicity
Arsenic	0.1	Toxicity to plants varies widely ranging from 12 mg/l to < 0.05 mg/l
Beryllium	0.1	Toxicity to plants varies widely ranging from 5 mg/l to < 0.5 mg/l
Boron	0.75	Toxicity to many sensitive plants at 1 mg/l, most grasses relatively tolerant at 2.0 to 10 mg/l
Cadmium	0.01	Toxic to some plants at levels as low as 0.1 mg/l
Chromium	0.1	Lack of knowledge on toxicity to plants
Cobalt	0.05	Tends to be inactivated by neutral and alkaline soils
Copper	0.2	Toxic to a number of plants at 0.1 to 1.0 mg/l
Fluoride	1.0	Inactivated by neutral and alkaline soils
Iron	5.0	Contributes to soil acidification and loss of essential P and Molybdenum.
Lead	5.0	Can inhibit plant cell growth at high concentrations
Lithium	2.5	Mobile in soil, toxic to some plants at low doses (0.075mg/l)
Manganese	0.2	Toxic to some plants at a few tenths to a few mg/l in acid soils
Molybdenum	0.01	
Nickel	0.2	Toxic to a number of plants at 0.5 to 1.0 mg/l; reduced toxicity at neutral or alkaline pH
Selenium	0.02	Toxic to plants at low concentrations
Vanadium	0.1	Toxic to many plants
Zinc	2.0	Reduced toxicity at increased pH (6 or above) and in fine textured soils
Other parameter		
Constituent	Recommended limit	Remarks
pH	6.0	Indirect effects on plant growth
TDS	500-2,000 mg/l	Above 2,000 mg/l can be regularly used only if all plants are tolerant and soils are permeable
Free chlorine residual	< 1 mg/l	

Table E.10. EPA suggested guidelines for water reuse in wildlife habitats

Factor	Requirement
Treatment	Secondary and disinfection
Effluent quality	BOD < 30 mg/l, SS = 30 mg/l Fecal coliform = 200 fecal coli/100ml (The number of fecal coliform organisms should not exceed 800/100 ml in any sample)
Effluent monitoring	BOD – weekly, SS – daily, Coliform – daily, Cl ₂ residual – continuous
Other considerations	Ground water monitoring, Temperature, pH

APPENDIX F
SEWAGE NETWORK MAP FOR AAMMATOUR

APPENDIX G: INCEPTION WORKSHOP \ PUBLIC INVOLVEMENT, MINUTES OF MEETING

- **Official Invitation Letter:**

Attention: Name, Position

Project: Improved Environmental Practices and Policies – USAID
Solid Waste and Wastewater Management in the
Higher Chouf - Mount Lebanon

Subject: Invitation to Inception Workshop

Dear Mr. /Ms. Name,

The United States Agency for International Development (USAID) has recently launched its Improved Environmental Practices and Policies Programme aiming at improving waste management capabilities in rural areas in Lebanon.

USAID executes such programmes with the assistance of local partners. The Pontifical Mission with the technical support of ARD (environmental consultants), are assisting in the implementation of this programme in the Higher Chouf area, which covers 12 municipalities and a total population of up to 25,000 persons.

The project will include the construction of one solid waste treatment center and nine wastewater treatment plants and associated sewer networks. The construction activities are supported by a comprehensive training, awareness and public participation plan, which will contribute to the sustainability of the project by providing increased environmental awareness, improved technical capabilities, and enhanced coordination and partnership among the different project stakeholders.

These activities are initiated with the launching of an inception workshop. This workshop offers the opportunity to 1) promote coordination with the government, 2) promote coordination with project partners (such as farmers, recycling factories, local community) from the early stages of the project, 3) inform the local community about the project and 4) obtain comments and suggestions for improved results.

Your participation in the inception workshop would therefore be valuable to the overall sustainability and success of the project (see attached agenda).

Your confirmation is highly appreciated.

Thank you,

Issam Bishara
Regional Director – CNEWA/Pontifical Mission

- **Meeting Agenda**

9:30 - 10:00 **Registration**

10:00 - 10:30 **Introductory speeches**

Union of Higher Chouf Municipalities, Mr. Hikmat Mallak
CNEWA/Pontifical Mission, Mr. Rabih Seba
United States Agency for International Development, Ms. Sana Saliba

10:30 - 11:00 **Project presentation**

Arab Resources Development (ARD), Dr. Walid Chahine

11:00- 12:00 **Questions & Answers**

12:00 – 12:30 **Brunch**

- **List of official invitees to the Inception Workshop on the 18th of October 2003:**

1. Table listing the Various ministries and their Coordinates:

<i>Ministries\ official councils</i>	<i>Director General</i>	<i>Coordinates\ Phones and Fax numbers</i>	<i>Version of invitation letter to be sent in</i>
Ministry of Environment (MoE)* (2 persons)	Dr. Berj Hatjian	Tel:04\522222 04\523593 Fax:04/525080	Arabic
Ministry of Interior and Municipalities(MoIM)	Mr. Attalah Ghacham	Tel:01\750083 Fax:01/340240	Arabic
Ministry of Energy and Water(MoEW)	Dr. Fady Comair	Tel:01\565100-1-2-3-4 Fax: 01/576666	Arabic
Ministry of Health(MoH)	Dr. Walid Aammam CC: to Dr. Farid Karam	Tel:01\615773-4-5-6 01/615724-5 Fax:01/615730	Arabic
Minsistry of Public Work and Transport(MoPWT)	Eng. Fady Namar	Tel:05\456482 05\455821-2 Fax: 05/459660	Arabic
Ministry of Industry (MoI)	Eng. Fady Samaha	Tel:01\427046 01\427006 Fax:01/424677	Arabic
Ministry of Agriculture (MoA)	Eng. Louis Lahoud	Tel:01\200280-1 Fax:01/200280-1	Arabic
CDR Council of Development and Reconstruction	Dr. Jawdat Abou Jawdeh	Tel:01\980096-7 01\981431-4 Fax:01\981252-3	Arabic

* To invite two concerned personnel involved in Wastewater and Solid waste management

2. Table listing the various NGOs as USAID partners and environmental organizations:

<i>USAID Partners</i>	<i>Director General</i>	<i>Coordinates\ Phones and Fax numbers</i>	<i>Version of invitation letter to be sent in</i>
World Vision			English
Ymca	Mr.Ghassan Saiyah	Tel\Fax:01\490640 Email:ymca@ymca-leb.org.lb	English
Mercy Corps		Tel:01\611586 Fax:01\611585 Email:mci@sodetel.net.lb	English
CHF		Tel:	English
SRI		Tel:	English
AFDC	Mr.Akram Chehaib Mr. Mounir Bou Ghanem	Tel: 01\752670 03\493281 Fax:05\280430 01\983917 Email:afdc@afdc.org.lb	Arabic\English
ARZ EL SHOUF	Mr. Nizar Hani	Tel:05\311230 03\628472 03\513854 Fax:05\311230	Arabic\ English

3. Table of Recycling Companies in Lebanon:

<i>Category</i>	<i>Company</i>	<i>Contact</i>	<i>Location</i>	<i>Tel. Number</i>
Paper, cardboard	Solicar	Antoine Ghanem	Wadi Chahrour	01-940248/9
	Sipco	Mohammed Ghandour	Kfarchima	01-433500/53
	Sicomo	Jihad Azar	Kabb Elias	08-805039
	C.b.c	Laurent Chidiac	Jbeil	09-444023
	Ninex	George Abou Jaoude	Zouk Mosbeh	09-218400/1/2
Plastics	Hariri	Yehya Hariri	Saida	03-247790
	Rocky	Robert Khoury	-	03634400
	Lebanese recycling works	Elie Debs	Naher el Mot	01-888057 03-259065
Metals	Liban fonderies	Sami Nassar	Roumieh	03-703246
	Ugtal	Khaled Zouein	Taanayel-Bekaa	08-511747
	Tanak factory	-	Choueifat	08-432011

• **List of Attendance at the Workshop:**

Name	Company - Institution	Telephone	Fax	E-mail
Riyad Zein El-Dine	Mayor of Khraybeh	03-819467		
Mahmoud Slim	Mayor of Jbaa	03-827303		
Walid Abou Chakra	P.S.P. Aammatour	03-655534		
Elie atef	Baadaran	03-451736		
Nabil el-Debis	P.S.P. Moukhtara	03-600545		
Marwan Zein el Dine	Butmeh	03-816302		
Ra'fat Baz	President of Baadaran Association			
Ghazi Issa	Cooperative Housing Foundation CHF	03-368092 01-853263		
Omar Kanaan	Secretary of Cultural and Social council for West-Bekaa and Rachaya	01-814123 01-790002/3	01-869011/26	omar.kanaan@dargroup.com
Chadia Abed El-Saed	Responsible of Women's Union (P.S.P.)	05-510335		
Jean Saleme	YMCA	03-628284		
Kawkab Abed El-Samad	Responsible of Women's Right board in Aammatour	03-726316 05-311580		
Samir Abou Chakra	Mayor of Aammtour	03-707067	05-310441	
Mansour Zein el Dine	President of municipality of Butmeh	05-310610		
Mireille Akl	World Vision Lebanon	04-401980	04-401982	miray_akl@wvi.org
Izzat Saad el Dine	President of municipality of Jbaa	03-641441		
Racha Abou chakra	Scouts of Aammatour	03-894605		
Hiba Abed El-Samad	Scouts of Aammatour	03-757724		

Sayed Bou Zayab	Ministry of Industry	01-426607 03-431911	01-423809	
Sana Saliba	USAID	04-543600	04-544251	salibasg@state.gov
Sanaa' Halal	Repesanting Jbaa	03-678604		
Wakiaa Al-Barasighi	La Cime School - Haret Jindel	03-710399		
Hsein Hani	President of municipality of Baadaran	03-341174		
Khalil Awdeh	Director of the public school in Bater	03-775652		
Zouheir el Hisin		03-513167		zouheirh@cdr.gov.lb
Mahmoud Abou Assi	Agriculture cooperation Maasser El-Chouf	03-352670		
Farouk Merhebi	Habitat	01-753209	01-753209	fmerhebi@inco.com.lb
Melhem Mezher	Mayor of Niha	03-899588		
Jalal Raydan	PSP	03-836881		
Mahmoud Abou Chakra	President of Municipality of Aammatour	03-750970		
Mansour Abou Chakra	Director of the Public School of Aammatour	03-362278		
Maamora Abou Chakra	COOP of Aammatour	03-200360	05-506288	
Sami Nassar	Liban Fonderies - Beyrouth	01-897619		
Rifaat Azzam	PSP	03-220048		
Randa Hamadeh	Ministry of Public Health	01-611174/5	01-615761	randa_ham@hotmail.com
Naji Haddad	Mayor	03-495527		
Nadim Noujaim	President of Municipality of Maasser El-Chouf	05-350380		

Amine Abdul Sanad	Inspection Central	03-898790		
Raed Abou Chakra	NGO: Nashiton min agil el bi'ah- Aammatour	03-695891		
Walid el Achkar	PSP	03-386985		
Nasib zein El-Dine	Liwa' Newspaper	03-208291		
Sobheh Al-Doubeyssi	Vice president of Mristi municipality	03-674103		
Nabil Abdallah	Mercy Corps	03-236425		nabdallah@lb.mercycorps.org
Jihad Azar	Sicomo	08-500550	08-500809	
Wissam Abou Daher	Shouf Cedar Society	05-311230 03-505205	05-311230	wissam@shoufcedar.org
Nizar Hani	Shouf Cedar Society	03-513845	05-311230	nizar@shoufcedar.org
Wahib Ghaith	President of the municipality of Niha	03-702721		
Mohamad Abou Chakra	Member of Niha Municipality			
Nami Khattar	Head of municipality of Bater	03-885121		
Noura Khattar	Scouts of Bater	03-422541		
Georges Chakar	Association "Abnak Maasser El-Chouf"	03-630133		
Nidal El-Achkar	Technical school of agriculture of Baaklene	05-506910		
Samih Abdelsamad	Public School of Khreibeh	08-506592		
Hossam Bashnak		03-331904		
Elie Debs	Lebanese Recycling Works	03-659065	01-888057	eliodebs@hotmail.com lrw@post.com
Wajfi Abdessamad	Engineer	03-676377		waj_d@hotmail.com
Hadi Abou Chakra	Responsible of Youth and sports in P.S.P.	03-531295		hadi_abuchacra@hotmail.com

- **Minutes of Meeting:**

After the presentation of Dr. Walid Chahine where the intended program and detailed projects for the Higher Shouf Area were highlighted; many concerns were raised by the various attendees about the presented projects tackling the waste water and solid waste management in the Higher Shouf area.

Some of the main issues that were presented and discussed:

1. *Objectives of the inception workshop*
2. *Solid waste and wastewater management in rural areas in Lebanon*
3. *Project description*
4. *The CNEWA/Pontifical Mission approach*
5. *The Infrastructure*
6. *The Knowledge*
7. *The Financial sustainability*
8. *Environmental Impact assessment*
9. *The expected outputs*

ARD confirmed that the issue of locating the parcels where each municipality intends to build the plants on is studied and a complete detailed EIA will be presented before any approval or implementation.

Some main concerns in higher Shouf area were presented by the head of Aammatour municipality who confirmed that many health threats to the villagers is due to the infiltration of raw sewage into various springs in the area, hence, the urgent need for sewage treatment.

Furthermore, the fact that the imminent Municipal Solid Waste Management contract termination with the private company Sukleen made the issue of solid waste treatment a problem to be solved urgently. Above all he showed as example, that around 57 million Lebanese Pounds were due on the municipality of Aammatour for that same private company.

ARD stressed as well that the Solid Waste Treatment Projects would reduce the high cost of solid waste management incurred on the various municipalities by private companies, and assuring that the success of the programs lay in the hands of the local community acceptance and commitments.

Finally, many of the attendees welcomed the projects and urged the concerned parties to start the implementation phases as soon as possible.

**APPENDIX H :
PUBLIC INVOLVEMENT:QUESTIONNAIRE**

**APPENDIX I:
OFFICIAL NOTICE / EMP COMPLIANCE FORM**