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Report: Assessment of the Pilot Village Wastewater Projects

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Executive Summary

In 1982 the Government of Egypt (GOE) enacted Law 48, which set stringent standards for wastewater effluent entering water courses in an effort to limit and control water pollution. By 1984, the requirement for developing solutions to wastewater problems in rural Egypt had emerged as a high priority item. At this time the local engineers in the governorate had some experience in designing sewers and manholes, but lacked the capacity to design treatment plants and had limited capacity to supervise wastewater construction work. And there were no programs, on any level, that addressed the following wastewater treatment issues:

- What technological solutions should be applied in rural Egypt?
- What design criteria can be used and who can do the design work?
- Who should be responsible for the design and construction phases?
- Who can perform operations and maintenance at the local level?
- What level of financial resources is required and what are the possible sources of financing?
- What are the training needs of local engineers and technicians?
- What communities should receive priority treatment?

THE WASTEWATER PILOT PROGRAM

The wastewater pilot program, which began under the Basic Village Services (BVS) project and continued through the Local Development II Provincial (LD II-P) project, evolved as a means of answering these questions. Its basic objective was to ***upgrade local Egyptian technical and administrative capacity to plan, implement, operate, and maintain appropriately-scaled, village-level wastewater systems using suitable financing schemes.***

By 1989 the program had expanded to include 24 villages using five different types of wastewater treatment facilities: eight package extended aeration plants, four oxidation ditch facilities, five submerged fixed film reactor facilities, six

stabilization ponds, and one modified aerated stabilization pond.[1]

FINDINGS AND ACCOMPLISHMENTS OF THE PILOT PROGRAM

A major accomplishment of the pilot program is that it has helped make governorate officials, central governorate agencies, and private sector consultants and contractors more aware of the issues involved in the management of wastewater service. It also produced the first 24 working wastewater systems designed and implemented by local entities in Egypt. Replication of the program has resulted in the planning and implementation of an additional 50 rural systems to date.

Another legacy of the program is a set of "how-to" manuals that cover the entire project implementation cycle—financing, planning, design, contracting, construction, operation, and maintenance.

Perhaps most important, the pilot program has provided insights concerning the following major issues.

Wastewater treatment technologies for rural Egypt. There was an early concern that the wastewater technologies used in the pilot program might be inappropriate for rural Egypt because of their expense and intensive maintenance requirements. This was demonstrated to be true for the more mechanically intensive technologies, such as extended aeration. However, one of the driving factors in choosing technologies is Law 48/1982, which requires high effluent qualities from wastewater treatment plants. Although less sophisticated treatment technologies, such as stabilization ponds, have proven capable of meeting the required effluent standards, their associated land requirements are many times greater than more mechanically intensive technologies. If this controversial law is to be enforced, more mechanically intensive technologies may be necessary in areas where land availability is low.

Thus, given the restrictions imposed by Law 48/1982, the pilot facilities found to be most appropriate for rural Egypt were stabilization ponds and modified aerated stabilization ponds, both of which require little mechanical equipment but relatively large amounts of land. Simple extended aeration facilities may be necessary for agricultural areas where land is at a premium.

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[1]Although there were five types of facilities, only three basic technologies were used: extended aeration (package plants and oxidation ditches), submerged fixed film reactor systems, and stabilization ponds (both aerated and non-aerated).

Design capabilities, criteria, and responsibility. Local consulting firms were found to have the capability to design functional wastewater facilities, although they were frequently hindered by low fees. Also, wastewater treatment plan review at the governorate level has improved to the point where it is now considered adequate. Design criteria was specified in a document produced by Chemonics as part of the pilot program, and the importance of design review has been emphasized in the ongoing technical assistance and training efforts.

Construction capabilities and responsibilities. Local contractors have demonstrated the capacity to construct functional wastewater facilities, although the quality of the work must be improved to keep functional failures (that is, extraordinary remedial repair costs) at a reasonable level. One conclusion was that an increase in the local construction supervision effort, not necessarily in the capital expended, could improve construction quality. Standard terms of reference were developed for selecting construction supervision consultants, and four construction supervision manuals—two for technicians and two for engineers—were prepared. Also, a manual that details contract execution was provided.

Performance of O&M at the local level. The ability to administer and carry out long-term O&M resides within local governorate entities, although these entities are in the early stages of a maturation process. O&M systems are not necessarily well-organized at the local level, but organization is improving. Several manuals have been prepared for sewage collection system and wastewater treatment plant operation, and a document on establishing a village-level wastewater utility was provided. Though facilities may not operate at peak efficiency, they are nevertheless providing a valuable service.

Prioritization of needs and financial capabilities. The pilot program showed that priority needs should be established through a governorate-level water and wastewater sector plan, and provided terms of reference for developing such plans. Financial mechanisms were evaluated and proposed in several LD II-P publications.

Training needs of local engineers and technicians. Throughout the pilot program, on-the-job and classroom training was provided in the areas of plan review, construction supervision, and operation and maintenance as part of routine technical assistance. Additional/ongoing training must be provided as a continuation to previous work to help perpetuate the skills and knowledge required for future wastewater development needs.

A set of recommendations for future projects is provided in the assessment report based on these and other, more specific, findings.

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Section 1

Introduction

This assessment report pertains to the 24 rural wastewater systems—comprising collection systems and treatment plants—provided under the auspices of the Basic Village Services (BVS) and Local Development II Provincial (LD II-P) projects. Together, these systems constitute the program known, in the parlance of USAID/Cairo, as the Wastewater Pilot Program. Throughout this report the 24 systems will be referred to as the pilot program.[1]

This pilot program is the first effort to provide wastewater service exclusively for Egypt's rural wastewater sector, and represents a significant investment in the sector. A review of the pilot program's implementation process, from planning through the on-line functioning of the facilities, allows the GOE, USAID, and other donors and consultants engaged in the rural wastewater sector to examine the principles that formed the basis of USAID's involvement in the BVS and LD II-P projects.

GUIDING PRINCIPLES OF THE PILOT PROGRAM

The approach used in this pilot program sought to provide an answer to the rather broad question: How can development best occur in the complex environment of a developing country?

Historically, there have been two approaches to this issue. One postulates that external components are essential for development, as they are the only solution to providing a product of sufficient quality to be sustainable. This approach implies that quality or durable infrastructure cannot be produced at the local level in the environment of a developing nation without reliance on external resources.

A second approach argues that initial product quality is less important than the local capacity for sustaining infrastructure, and references historical examples to support this stance. The pilot program adopted this second approach to providing infrastructure, preferring to encourage the development of local resources rather than to rely on external resources.

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[1]Fifty additional wastewater projects have been executed by the LD II-P project as a replication or expansion phase of the pilot program. Together, the replication effort and the pilot program represent a present-day (1992) capital expenditure of approximately LE 100,000,000 (US $33,000,000)

Recognizing the need to address the issue of local autonomy versus central control, and the political constraints on project selection, location, and implementation, the pilot program's philosophy was to advocate local control of decision-making and project implementation. The ultimate concern was that the program produce an overall benefit to the community and contribute to development goals. Another priority was that the technology selected should both fulfill the requirements of Law 48/1982 and be appropriate for rural Egypt. Quality of physical structures was considered a dependent variable in the development equation—thus compromises were made and interim solutions utilized as the program matured.

EVOLUTION OF THE PILOT PROGRAM

Unlike a conventional pilot program, this program was not conceived of purely as a study in which projects are carefully selected, a firm set of standards and guidelines applied, and systems developed to ensure adherence to the program rules. Instead, it evolved as a practical response to a great need for rural wastewater treatment, and attempted to subsume projects with varied origins under one umbrella that could function as something of a proving ground. Section 2 provides a more complete history of the pilot program; the important point is that it was an evolving program, managed and implemented by local authorities, which attempted to correct and refine itself as it progressed.

Technical assistance provided during the pilot program focused on establishing and upgrading local knowledge, experience, and practices through the implementation of projects. This learning by doing was meant to inculcate the ability to conduct future local projects without outside intervention. Thus, technical assistance focused on providing advice and training to officials, planners, engineers, technicians, and plant operators in the governorates, marakez, and villages, and ***final decision-making was left in the hands of local officials.***

Early problems were not interpreted as a sign that the pilot program was failing, but were used as a mechanism to provide incremental changes in the program through modifications to the ongoing training program and technical assistance efforts.

BASIS FOR THIS ASSESSMENT

The basic intent of this assessment is to examine the series of procedures and activities used during the pilot program and

recommend improvements to the project implementation process. The resulting improved process would be suitable for the implementation of sewerage and wastewater treatment facilities in the Egyptian rural wastewater sector. It would also allow the involved parties—the GOE, governorates, cities, marakez, and villages—to make better decisions and take the actions necessary to implement required facilities.

The assertions and descriptions concerning problems that occurred during the pilot program's implementation are meant to be used as learning tools, not as attempts to cast aspersion or assign blame. A specific purpose in providing this assessment is to determine the nature of such problems, where they occurred, and how they could be obviated by changes to the implementation process. Documenting the experience in this manner is in line with the philosophy of institutionalization, and provides information for formulating a national program.

In fact, the LD II-P training program case studies have focused on some of these "problems and solutions" to help engineers and technicians avoid the same pitfalls. Thus, the lessons learned from this program and the changes and/or adjustments required to improve the process are a significant outcome of the pilot program.

While the pilot program included 24 projects, this assessment is primarily concerned with the 17 projects in Damietta Governorate. Performance data was gathered for a sample made up of seven Damietta facilities and one Menufiya plant.

OBJECTIVES OF THIS REPORT

The information provided by this assessment report will be valuable for establishing sector policy and shaping future programs and projects for rural wastewater infrastructure and local capacity building.

Further, from the standpoint of the governorates, marakez, villages, and other GOE institutions, this assessment highlights valuable "lessons learned" that are directly applicable to the further development of the entire sector. The specific information provided will help the institutions involved overcome many of the constraints which hampered the pilot program's formulation: the lack of acceptance of standards; the problems encountered in construction, start-up, and operation of the physical systems; and the large technical assistance requirements.

The objectives of this assessment report are to:

- Assess the implementation process used to produce the physical infrastructure (products) of the program.
- Assess and compare the program's physical products in relation to the process components of planning, design, construction, and O&M.
- Provide a concise account of the "lessons learned" from implementing the pilot program, and discuss the actions required to improve the individual components of the process.
- Provide recommendations for the replication of the pilot projects concerning sector policy, technology choice, manpower/training requirements, quality considerations, financial options, and the use of the manuals and guidelines produced under LD II-P to assist in replication of the process.

The report is aimed toward GOE officials involved in national and rural infrastructure development, engineering consultants, USAID officials, and officials of other bilateral and multilateral donor agencies.

REPORT FORMAT

Following this introduction, Section 2 of this report provides a brief history of the pilot program, while Section 3 reviews and assesses the overall implementation process and the physical products of individual process components. Performance data and other operation and maintenance features of each treatment technology are presented in Section 4. Section 5 presents conclusions and recommendations stemming from the experience garnered during the pilot program's implementation, which may be useful in future sector interventions and expansion of the program to a nationwide level.

Appendix A provides a table of all LD II-P projects (both pilot projects and replication projects). Appendix B describes the technologies used for the pilot project facilities.

The publications annotated in Appendix C were prepared by Chemonics under the LD-II-P program in relation to the planning design, construction, O&M and sustainability of rural wastewater systems, and are valuable adjuncts to this assessment. Parties interested in the development of the sector will wish to be familiar with the contents of these documents.

Appendix D lists the training courses held in conjunction with the LD II-P project.

The detailed technical information provided in appendices E, F, and G will probably be of greatest interest to engineers directly involved in the design, construction, and O&M of future wastewater systems.

Section 2

History of the Pilot Program

This section reviews the nature and history of the pilot program, and discusses how the various projects came to be included in the program.

DUAL NATURE OF THE PROGRAM

The pilot program's concern with both the project implementation *process* and the resultant *physical infrastructure* reflects that of the overall LD II-P project.

Figure 2.1 illustrates the relationship of the pilot program components in terms of inputs, outputs, purposes, and overall goal. The outputs provided by the pilot program are physical infrastructure (product) and systems and procedures for establishing and maintaining such infrastructure (process). The combination of this product and process will ultimately lead to the provision of village wastewater service.

As shown in Figure 2.1, feedback obtained during the pilot program was used to refine the input to improve both process and product. This continuous feedback loop allowed the program to build on previous experience.

THE TWO PHASES OF THE PILOT PROGRAM

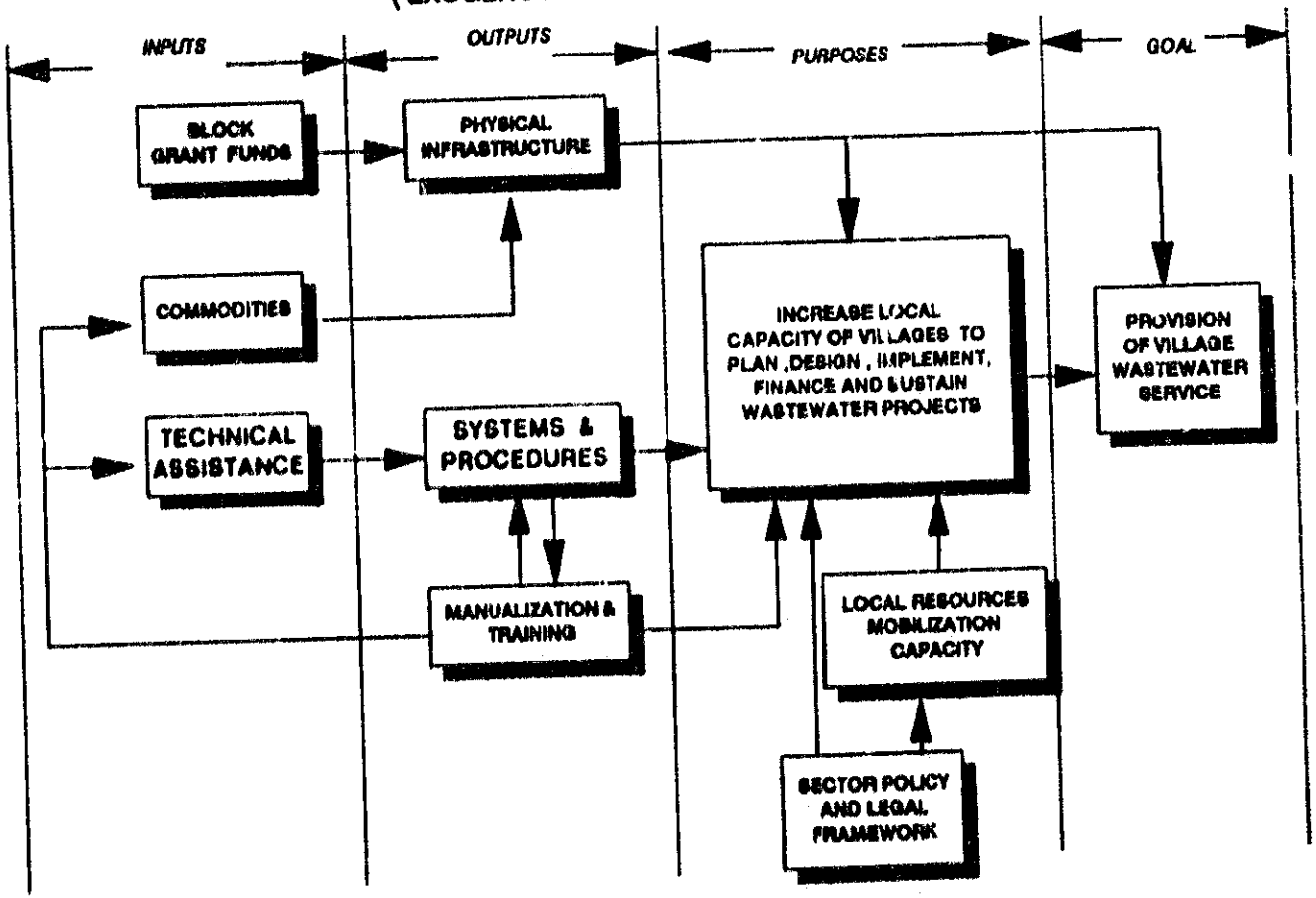
Most of the 24 projects in the pilot program were developed or conceptualized under the BVS project, and implemented under the LD II-P project.

Two primary objectives of the BVS project were to increase decision-making and authority at the local level and to provide for the upgrading of local capacity. These overriding principles were emphasized in all aspects of the work: physical infrastructure projects were considered secondary to achieving the objectives of decentralization and capacity building. In effect, this situation necessitated an acceptance of compromises to infrastructure quality, which increased the problems and O&M costs. These additional costs were considered part of the overall price tag for decentralization

LD II-P activities were superimposed on the BVS program, and thus inherited its established ground rules and standards. The LD II-P project provided technical assistance to improve the process of implementing village wastewater projects. The

FIGURE 2.1 : LOGIC FRAMEWORK OF WASTEWATER PILOT PROGRAM *

(EXOGENOUS FACTORS OMITTED)



* ADAPTED FROM FIGURE 1, CHEMONICS PUBLICATION M&E 4.01 PUBLISHED MARCH 1991;ORGINAL LOGFRAME INDICATES EXOGENOUS FACTORS AS INPUTS SYSTEMS & PROCEDURES,PHYSICAL INFRASTRUCTURE, LOCAL CAPACITY, POLICY, RESOURCE MOBILIZATION AND PROVISION OF BASIC SERVICES.

main limitation of the wastewater program activities under LD II-P resulted from the fact that advisors were constrained to providing technical assistance to governorate staff engineers, but had no authority for influencing the actual planning, design, or construction of the pilot program projects.

Functioning under this constraint, the LD II-P wastewater program had to cope with the expected shortcomings in project design and construction, and mitigate for design and construction oversights as part of the technical assistance provided for O&M.

COMPONENT PROJECTS OF THE PILOT PROGRAM

The 24 projects that compose the pilot program are identified in Table 2.1, together with certain features of each project. It is important to recognize that no magic formula was used to select 24 as the number of wastewater systems to include in the pilot program. These projects were included in the program because they represent a cross-section of projects that emerged from a series of converging actions made by the GOE; Damietta, Menufiya, New Valley, and South Sinai governorates; the BVS and LD II-P projects; and USAID. Thus, the pilot program was an amalgam of projects that evolved into a practical on-the-ground program.

One advantage of this type of program evolution was that it did not cause any delays in LD II-P activity in the rural wastewater sector. Unlike a conventional pilot program in which one would wait for final results before any real-life applications, it was posited that activities in the sector could easily continue using the lessons learned as the pilot program progressed.

These lessons have been incorporated into a replication effort involving the construction of 50 wastewater systems outside the auspices of the pilot program. Twenty-two additional projects, covering 35 villages, are under study or have completed the design phase and are awaiting tender. Appendix A lists all 96 LD II-P wastewater projects and their locations.

Table 2.1: Projects Included in the Pilot Program

Governorate	Village Council	Facility Type*	Governorate Type
Damietta	Meit El Kholy	EA-1	Delta
	El Serw		
	Sharabas		
	El Westany		
	Kafr El Arab		
	El Roda		
	El Ghonimeya		
	Meit El Ghal		
	Kafr El Battikh	EA-2	
	Kafr Soliman		
	El Khyata		
	El Rahamna		
	Kafr Saad El Balad	SFFR	
	El Barashiya		
	Daqahla	SP-2	
	Aadliya	SP-1	
	Kafr El Ghab	SFFR	
Menufiya	Sahel El Gawaber		
	El Kom El Akhdar		
New Valley	Boulaq	SP-1	Desert
	Balat		
South Sinai	Dahab		
	Nuweiba		
	Sharm El Sheikh		

Key to Facilities:
- SP-1 Stabilization pond (anaerobic, facultative, maturation x 3)
- SP-2 Stabilization pond (anaerobic, aerated facultative, maturation x 3)
- SFFR Submerged fixed film reactor
- EA-1 Extended aeration (SOAF package plant)
- EA-2 Extended aeration (Oxidation ditch)

Technologies Used

As shown in Table 2.1, five different categories of projects were included in the 24 individual projects: stabilization ponds, modified aerated stabilization ponds, submerged fixed film reactors (SFFR), oxidation ditches, and extended aeration package (SOAF) plants. Figure 2.2 shows, on a relative scale, how these technologies compare in terms of land requirements, ease of construction, local component production capacity. Capital and O&M costs are discussed in Sections 3 and 4, respectively. More detailed descriptions of these technologies are provided in Appendix B.

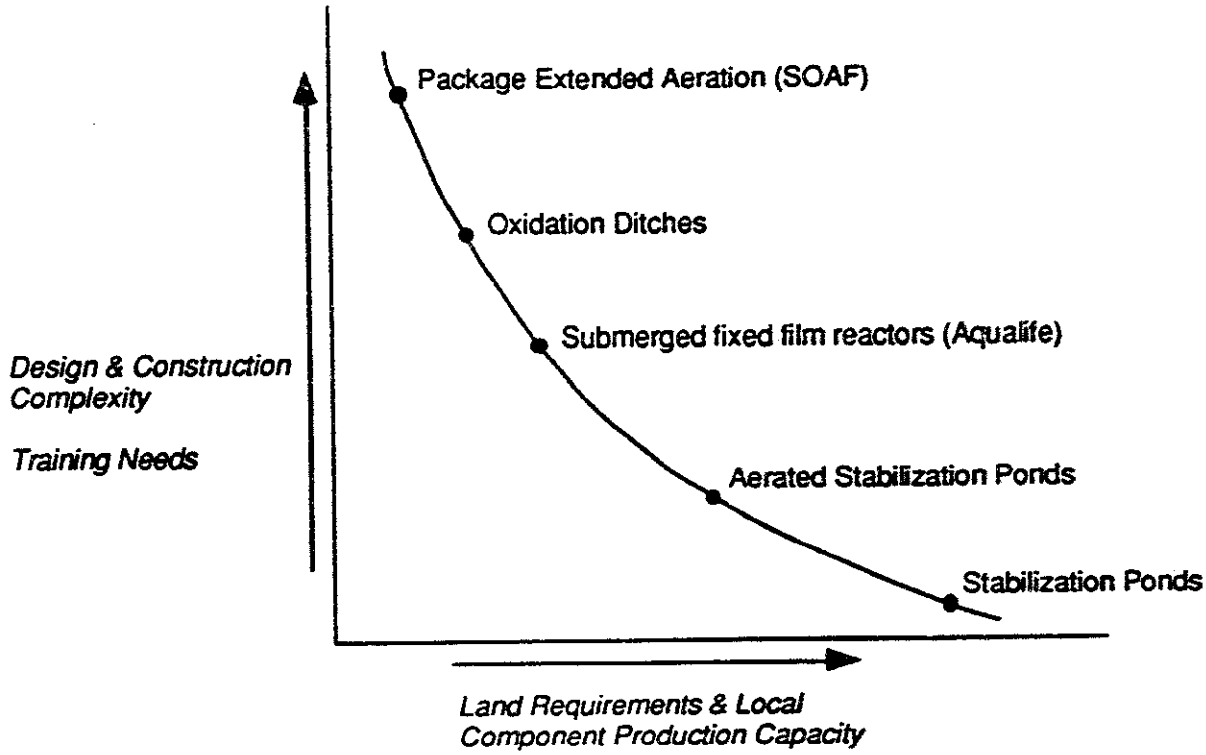


Figure 2.2: Land Constraints versus System Complexity & Training Needs

History and Selection of Projects

The development and inclusion of the projects within the pilot program are discussed below.

BVS study group

The pilot program's formal activities under the BVS project commenced in 1985. In recognition of the acute wastewater pollution problem in Egypt's rural areas—especially in the densely populated villages in the Delta, the Organization for Reconstruction and Development of Egyptian Villages (ORDEV) and USAID decided the BVS project should include a pilot program to recommend alternative technologies appropriate for rural Egypt.

An extensive study prepared as part of BVS project activities in 1985 dealt with treatment alternatives for rural villages.[2] The findings of this report were presented in a workshop to ORDEV and other GOE representatives in November 1985. USAID agreed to include projects derived from this report and identify appropriate treatment for financing under the BVS project.

The 1985 report recommended treatment plants utilizing stabilization pond or modified aerated stabilization pond

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[2] *Preliminary Designs for Pilot Wastewater/Drainage Projects in Six Delta Villages: Master Report* (BVS publication ENG-R-15(E)), September 1985.

technology for villages whose conditions required the installation of sewage collection systems and a combination pour/flush family latrine program with composting of septage and solid waste for villages in which no sewers were necessary. Six projects were recommended, and five were implemented. The implemented program included stabilization ponds and modified aerated stabilization ponds, but not the composting system, as it proved impossible to obtain Menufiya Governorate's concurrence to adopt this alternative.[3]

As implemented, these five projects included one stabilization pond, one modified aerated stabilization pond, and three treatment systems based upon a submerged fixed film reactor system (SFFR, trade name Aqualife). These three SFFR units were included in the pilot program because they appeared to be less expensive than either the aerated or regular stabilization technologies, since the only mechanical need was a pumping unit, and because the overall land requirements were much smaller than those for stabilization ponds.

Damietta package plants

The eight projects in Damietta Governorate using a packaged extended aeration treatment technology now included in the wastewater pilot program were originally planned by Damietta Governorate. A contract for all the mechanical equipment required for the wastewater treatment plants was negotiated between the governorate and the SOAF Corporation of Nantes, France (thus, the designation of these plants as SOAF plants).

Originally, these package plants were to be fully funded under Damietta Governorate's budget. However, a shortfall was discovered after the construction bids were received, and the governorate requested USAID to allow the commitment of almost one million Egyptian pounds of Damietta's BVS allocation to finance the civil works.

The National Organization for Potable Water and Sanitary Drainage (NOPWASD) was retained by Damietta for the engineering services related to these eight projects. Only conceptual plans and general specifications were utilized as the basis of tendering. A design-build construction contract was let for all eight plants in August 1983, and construction was started but serious delays were encountered. After a long period during which little or no work was accomplished by the original contractor (who was said to have encountered serious financial difficulties) the contractor was released and the contract re-tendered. The new civil works contractor

[3]The governorate reacted to complaints by the village proposed to be served by this technology, which claimed the technology was second-rate and the village would be relegated to second-class status.

started in mid-1989 and work was completed for these systems by 1991.

BVS/LD II-P involvement with these eight projects originated from the decision by USAID to allow BVS project funds to be used to fund the civil works portion of the eight treatment plants.

The use of extended aeration technology for wastewater treatment was not a popular decision with either the GOE or USAID. The process was considered too complex for proper operation by local village staff; the plants require a great deal of imported equipment and are expensive to operate. However, once BVS funds were earmarked for these projects, they were included, albeit reluctantly, as part of the pilot program. Technical assistance on plant operation was provided through the LD II-P project in an attempt to maximize the return on the investment.

Damietta oxidation ditches & SFFR plants

The 1985 BVS study was preceded by a request from Damietta Governorate to the BVS project for assistance in selection of appropriate treatment technology. The governorate planned to use part of its BVS allocation to fund wastewater system construction. Villages dedicating one half feddan of land at a distance of 500 meters from residential areas as sites for the anticipated wastewater treatment plants were eligible for governorate funding. Six villages dedicated the required land, and the governorate, not wanting to lose the initiative, requested the BVS project to recommend suitable treatment technology for these sites.

Oxidation ditch treatment technology was utilized.[4] With the proper O&M, this process was envisioned to produce a treated effluent whose quality levels would meet the requirements of Law 48/1982, fit the land constraints, and be easier to build than conventional extended aeration wastewater treatment plants.

The governorate engaged NOPWASD as its consultant to prepare the design and tender documents for the five villages recommended by the report. NOPWASD prepared only conceptual drawings and general specifications, rather than the detailed drawings and specifications that a full consulting service would normally provide as part of the tender documents. The program was taken forward based upon the conceptual drawings.

The bids received exceeded the governorate's available budget, and Damietta decided to construct only four of the six oxidation ditch wastewater treatment plants. Design-build

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[4]*Damietta Governorate: Complete Sewage Treatment for Small Plants—Damietta Villages*, NOPWASD, 1986.

contracts were let for the four oxidation ditch plants. The remaining money was used to construct two additional systems using the SFFR treatment technology.

South Sinai & New Valley projects

Five projects in the pilot program are located in South Sinai and New Valley governorates.

The South Sinai projects originated from a reconnaissance study commissioned by the Sinai Development Authority in 1984. South Sinai is a well-known tourist center, and hotels and other tourist facilities were being constructed rapidly, stressing the existing infrastructure severely.

The first study was quickly followed by the preparation of a detailed engineering plan for water and wastewater facilities, which contained five separate sets of contract documents for new, expanded, and rehabilitated wastewater system facilities. The wastewater projects—all of which used stabilization ponds for the treatment—were funded partly through allocations from BVS and later, LD II-P. These projects were included in the pilot program at the request of USAID.

The South Sinai contracts were tendered based upon detailed documents prepared by a local engineering consulting firm. Some construction delays occurred, but these lasted only a few months. South Sinai Governorate engaged the same consulting firm to act in its behalf for the management and construction supervision and employed a private company to provide O&M services, on a contract basis, for both the treatment plants and collection systems.

Early in the LD II-P project, New Valley Governorate requested funds for the design and feasibility studies for wastewater treatment plants in four villages. Later funding cycles financed the implementation of these four projects, which used stabilization pond technology. Two of these were included in the pilot program because of their location in a desert governorate and the fact that they were not design-build contracts.

FUNDING HISTORY

One of the LD II-P project goals under the pilot program was to improve and expand the capacity of local governorates to finance basic services projects. During the pilot program (and for the 50 replicate projects) funding was provided primarily by USAID through the GOE. Local contributions included capital and donated land.

After distribution to the governorate, funds were disbursed to the villages. There were no set guidelines for village disbursement, which followed a local political process.

Once funds were received, it became the village council's responsibility to set aside engineering, construction, and contingency amounts from the total. Originally, ten percent of the total disbursement was set aside to cover O&M or recurrent costs.

TECHNICAL ASSISTANCE AND TRAINING

Technical assistance for facilities planning and design was provided beginning in 1988 through field trips to the governorates. Ongoing construction and O&M technical assistance was provided through regularly scheduled field trips, and information gathered was utilized to identify training needs and to formulate and produce training manuals and workshops. Appendix C provides a list of publications produced during the LD II-P project that deal with the provision of wastewater service.

Both onsite and classroom training was provided. Evaluations were conducted at the end of each training session and findings were incorporated to update manuals and future training sessions. Over 700 persons representing 20 governorates were trained in the technical training programs. Participants included local governorate officials, who were trained in project planning, development, and implementation, and technicians and engineers, who were trained on detailed technical topics. Appendix D lists the formal training sessions that were held.

Technical assistance and training coincided with the design, construction, and commissioning of the facilities (1988 - 1992). All pilot program facilities are now operating. Remedial action is still ongoing at specific facilities.

Section 3

Assessment of Project Implementation

This section assesses the implementation process that was utilized in the pilot program and discusses the resultant products. The implementation process includes the methods, means, practices, systems, and logistics of performing each project implementation step—planning, design, contracting, construction, operation, and maintenance—necessary to produce the physical infrastructure product.

Following a brief discussion of the overall implementation process, each of these steps is discussed separately.

OVERALL IMPLEMENTATION PROCESS

Responsibility for Implementation

Both the individual steps and overall implementation process of the wastewater pilot project are directly applicable to any infrastructure project. The sponsoring entity for the wastewater pilot program was the GOE, working through the governorates. The governorates in turn worked through the marakez and village councils. USAID and its contractor, Chemonics International, were also involved; USAID providing the financing and performing oversight functions, and Chemonics providing technical assistance and administrative functions.

The large number of entities involved in the implementation of the 24 individual projects had varying levels of responsibilities throughout the process, as shown in Table 3.1.

Assessment of the Funding Process

The pilot program was implemented without the usual public sector constraints regarding financing. As discussed in Section 2, funding was accomplished through the GOE, primarily by means of grants from USAID through the BVS and LD II-P projects. If a village wastewater project was accepted into the pilot program, investment financing, at the limit specified, was assured.

TABLE 3.1 - IMPLEMENTATION PROCESS RESPONSIBILITY MATRIX

GOVERNORATE	NO OF SYSTEMS IN PILOT PROGRAM	TREATMENT TECHNOLOGY PROVIDED	RESPONSIBILITY FOR PLANNING		RESPONSIBILITY FOR DESIGN		RESPONSIBILITY FOR CONTRACTING		RESPONSIBILITY FOR CONSTRUCTION SUPERVISION		RESPONSIBILITY FOR TAKEOVER		RESPONSIBILITY FOR SYSTEM O&M	
			PLANTS	COLLECTION NETWORK	PLANTS	COLLECTION NETWORK	PLANTS	CONNECTION NETWORK	PLANTS	CONNECTION NETWORK	PLANTS	CONNECTION NETWORK	PLANTS	CONNECTION NETWORK
DAMIETTA	6	Extended Aeration (BOAF)	Governorate and NOPWASD	N/A(1)	Design(2) Build Contract	Governorate Housing Dept Engs	Governorate Finance Dept	Governorate Housing Dept	Governorate Housing Dept	Governorate Housing Dept	Special Committee	Governorate Housing Dept	Village Council	Village Council (3)
	4	Extended Aeration (Oxidation Ditch)	Governorate and BVS/NUS	N/A(1)	Design Build Contract	Governorate Housing Dept Engs	Governorate Finance Dept	Governorate Housing Dept	Governorate Housing Dept	Governorate Housing Dept	Special Committee	Governorate Housing Dept	Village Council	Village Council
	2	SFFR-3	Governorate BVS/NUS USAID	N/A(1)	Turnkey Design Build Contract	Governorate Housing Dept Engs	Governorate Housing Dept	Governorate Housing Dept	Governorate Housing Dept	Governorate Housing Dept	Special Committee	Governorate Housing Dept	Village Council	Village Council
	1	SFFR-2	Governorate BVS/NUS USAID	BVS/NUS, Village Council	Design Build Contract	BVS/NUS	USAID	Governorate Housing Dept	USAID	Governorate Housing Dept	USAID, Governorate Representatives	Governorate Housing Dept	Village Council	Village Council
	1	Stabilization Pond	Governorate BVS/NUS	Design Build Contract	Design Build Contract	BVS/NUS	Governorate Housing Dept	Governorate Housing Dept	Governorate Housing Dept	Governorate Housing Dept	Special Committee	Governorate Housing Dept	Village Council	Village Council
	1	Aerated Stab. Pond	Governorate BVS/NUS	Governorate BVS/NUS	Design Build Contract	BVS/NUS	Governorate Housing Dept	Governorate Housing Dept	Governorate Housing Dept	Governorate Housing Dept	Special Committee	Governorate Housing Dept	Village Council	Village Council
Menufiya	8	SFFR-1	Governorate BVS/NUS USAID	BVS/NUS Village Council	Design Build Contract	BVS/NUS	USAID	Governorate Housing Dept	USAID	Governorate Housing Dept	USAID Governorate Representatives	Governorate Housing Dept	Village Councils	Village Councils
New Valley	2	Stabilization Pond	Private Consultant	Private Consultant	Private Consultant	Private Consultant	City Councils	City Councils	Private Consultant	Private Consultant	City Private Consultant	City Private Consultant	City Councils	City Councils
South Sinai	3	Stabilization Pond	Private Consultant USAID	Private Consultant	Private Consultant	Private Consultant	Governorate	Governorate	Private Consultant	Private Consultant	Private Consultant	Private Consultant	Private Consultant	Private O&M Company

Notes

(1) N/A = no formal design effected
(2) Design build and turnkey contracts include designs furnished as part of the design build or turnkey contractors tender contracts were let from conceptual drawings and general specifications prepared by NOPWASD
(3) One Village, Meit El Kely, hired a private company for contract O&M

Villages contributed land for treatment plant sites and other needs. These contributions varied by project, but in most cases amounted to 10-15 percent of the project cost. For the pilot projects, main gravity sewers were financed by BVS/LD II-P funds, while laterals were financed by the villages involved.

Although functional for the pilot program, this funding approach is not adequate to cover identified replication needs. Studies have concluded that existing wastewater project construction capital funding mechanisms at the local and GOE levels are inadequate to replicate the pilot program at the projected required level.[5] The estimated capital necessary for projects that are needed to address approximately 60 percent of Egypt's rural population (35,000,000 people) was estimated at $2,000,000,000 in 1990 dollars (LE 6,660,000,000). At the present GOE allocation level of LE 80,000,000 per year, it would take more than 80 years to meet today's needs. This figure does not deal even consider major replacement capital, which is needed for facilities after approximately 20 years. Present population growth and inflation rates exacerbate the situation.

However, these studies also researched the sources of revenues generated at the governorate and lower levels of local administration for the financing of the recurrent cost budget (O&M) and identified existing local fees and charges that could be mobilized and/or enhanced to generate O&M funds.

Assessment of Costs

One of the objectives of the pilot program was to collect capital and recurrent cost data that would be valuable for establishing a national rural sector wastewater program. Table 3.2 presents a summary of capital costs associated with the 17 pilot projects in Damietta Governorate. However, for the following reasons the use of these cost data to project per capita, volumetric, or present worth cost values is not recommended.

- No engineering cost estimates were developed before contracts were awarded for bid comparison, as there was no historical data to formulate them. Essentially, the pilot program was to provide the historical data base for future engineering cost estimates.
- Cost data reflects the inexperience of engineers and contractors. The costs associated with the

[5] *Concept Paper: Rural Wastewater Financing—Egypt* (LD II-P publication ENV-R-4) and *Design of a Revolving Loan Fund for Local Capital Investments* (LD II-P publication LF 4-01).

TABLE 3.2 : WASTEWATER SYSTEM COMPONENT COSTS FOR DAMIETTA GOVERNORATE (LE)

VILLAGE NAME	Meit el kholy		El Serw		Sharabas		El Westany		Kafr El Arab		El Roda		EL Ghoniymeya	
SERVED POPULATION	10,000		20,000		10,000		10,000		10,000		20,000		10,000	
TREATMENT TECHNOLOGY	Ext. Aeration		Ext. Aeration		Ext. Aeration		Ext. Aeration		Ext. Aeration		Ext. Aeration		Ext. Aeration	
TREATMENT PLANT														
Land value(est.)	15,000	1982	20,000	1982	15,000	1982	12,000	1982	12,000	1982	20,000	1982	9,000	1982
Access road	57,000	1985	29,600	1985	30,300	1985	11,250	1985	36,100	1985	72,500	1985	79,700	1985
Power supply	32,000	1985	32,000	1985	29,000	1985	16,000	1985	26,000	1985	61,900	1985	61,900	1985
Water supply	3,300	1985	4,100	1985	1,100	1985	2,800	1985	5,700	1985	12,100	1985	4,300	1985
Construction														
Civil	201,600	1986	281,011	1986	288,480	1986	347,440	1989	347,440	1989	694,800	1989	347,440	1989
Mech.	50,400	1986	70,253	1986	72,120	1986	86,860	1989	86,860	1989	173,700	1989	86,860	1989
Mech. Equipment	260,000	1982	276,000	1982	260,000	1982	260,000	1982	260,000	1982	276,000	1982	260,000	1982
Actual cost	619,300		713,164		696,000		736,350		774,100		1,311,000		849,200	
1992 cost	2,245,314		2,521,653		2,428,151		2,093,225		2,206,522		3,253,504		2,426,499	
SEWERAGE SYSTEM														
a_ Collection sys														
House connection	416,000	1986	567,000	1986	329,000	1986	710,500	1986	304,500	1986	549,500	1986	224,000	1986
Gravity sewers	75,000	1984	66,700	1984	50,900	1984	57,800	1984	35,900	1984	49,000	1984	56,650	1984
Subtotal col. sys														
Actual cost	491,000		633,700		379,900		768,300		340,400		598,500		280,650	
1992 cost	1,564,656		1,979,851		1,201,249		2,370,071		1,063,596		1,851,489		912,445	
b_ Pump Station														
Land value	5,200	1982	7,200	1982	5,600	1982	5,600	1982	5,800	1982	7,500	1982	6,000	1982
Civil works	48,000	1984	40,000	1984	60,150	1984	53,370	1984	38,500	1984	49,100	1984	43,000	1984
Mech. works	41,900	1986	55,800	1986	40,000	1986	40,000	1986	40,000	1986	52,000	1986	40,000	1986
Power Supply	24,000	1986	25,400	1986	22,900	1986	23,000	1986	27,500	1986	23,000	1986	49,650	1986
Subtotal pump st.														
Actual cost	119,100		128,400		108,650		121,970		111,800		131,600		138,650	
1992 cost	435,365		459,035		395,173		452,272		403,009		481,506		489,736	
c_ Force main														
Actual cost	27,000	1984	23,100	1984	22,400	1984	25,028	1984	31,400	1984	19,400	1984	25,100	1984
1992 cost	116,095		99,326		96,316		107,616		135,014		83,416		107,925	
Actual cost	637,100		785,200		510,950		915,298		483,600		749,500		444,400	
1992 cost	2,116,115		2,538,212		1,692,738		2,929,959		1,601,619		2,416,414		1,510,106	
Total Actual cost	1,256,400		1,498,364		1,206,950		1,651,648		1,257,700		2,060,500		1,293,600	
1992 cost	4,361,429		5,059,864		4,120,889		5,023,184		3,808,141		5,669,918		3,936,605	

VILLAGE NAME	Meet Abu Ghalib		Kafr El Battikh		Kafr Soliman		El Rahamna		El Khayatte		Kafr El Ghab		K S El Balad	
SERVED POPULATION	10,000		25,000		15,000		15,000		15,000		25,000		15,000	
TREATMENT TECHNOLOGY	Ext. Aeration		Ox. Ditches		Ox Ditches		Ox Ditches		Ox. Ditches		SFFR		SFFR	
TREATMENT PLANT														
Land value(est.)	16,000	1982	12,000	1984	15,000	1984	25,000	1984	7,000	1984			14,500	1984
Access road	43,300	1985	22,400	1985	35,200	1985	19,900	1985	43,900	1985			24,400	1985
Power supply	15,300	1985	44,500	1985	13,800	1985	73,000	1985	65,000	1985	36,405	1986	20,000	1985
Water supply	6,700	1985	26,300	1985	7,200	1985	6,000	1985	8,800	1985	11,500	1986	14,493	1985
Construction														
Civil	347,440	1989	643,500	1988	321,750	1988	321,750	1988	321,750	1988	24,000	1986	232,000	1986
Mech.	86,860	1989	786,500	1988	393,250	1988	393,250	1988	393,250	1988	36,000	1986	58,000	1986
Mech Equipment	260,000	1982	179,500	1984	89,800	1984	89,800	1984	89,800	1984	900,000	1986	138,400	1984
Actual cost	775,600		1,714,700		876,000		928,700		929,500		1,007,905		501,793	
1992 cost	2,218,246		3,631,818		1,876,499		2,039,767		2,032,984		2,585,442		1,257,081	
SEWERAGE SYSTEM														
a. Collection sys														
House connection	388,500	1986	1,099,000	1989	388,500	1989	416,500	1989	462,000	1989	700,000	1986	455,000	1986
Gravity sewers	75,100	1984	45,000 100,000	1985 1989	60,000	1985	60,000	1985	63,000 80,000	1984 1989	197,750	1987	80,000	1984
Subtotal col sys														
Actual cost	463,600		1,244,000		448,500		476,500		605,000		897,750		535,000	
1992 cost	1,482,971		2,733,115		886,319		934,703		1,207,484		2,582,254		1,702,608	
b. Pump Station														
Land value	5,500	1982	6,000	1984	5,500	1984	5,600	1984	6,200	1984	12,000	1986	7,500	1984
Civil works	50,300	1984	85,000	1985	49,000	1985	40,200	1985	50,000	1985	158,500	1987	50,000	1984
Mech. works	40,000	1986	69,500	1988	60,000	1988	60,000	1988	55,000	1988	93,755	1987	70,300	1988
Power Supply	21,800	1986	56,100	1986	54,000	1986	35,600	1986	32,500	1986	124,960	1989	21,700	1986
Subtotal pump st														
Actual cost	117,600		216,600		168,500		141,400		143,700		389,215		149,500	
1992 cost	434,869		641,998		484,684		398,840		416,910		879,454		457,809	
c. Force main														
Actual cost	21,750	1984	70,000	1986	36,000	1985	40,000	1985	39,700	1985	87,635	1987	80,000	1981
1992 cost	93,521		250,823		128,995		143,327		142,252		218,064		347,855	
Actual cost	602,950		1,530,600		653,000		657,900		788,400		1,374,600		765,400	
1992 cost	2,011,361		3,125,936		1,500,197		1,476,870		1,766,627		3,679,772		2,508,273	
Total Actual cost	1,378,550		3,245,300		1,529,000		1,586,600		1,717,900		2,382,505		1,267,193	
1992 cost	4,229,607		6,757,754		3,376,697		3,516,637		3,709,611		6,265,214		3,765,353	

VILLAGE NAME	El Barashiya		Daqahla		Adliya	
SERVED POPULATION	8,000		12,000		8,000	
TREATMENT TECHNOLOGY	SFFR		Aerated Stab.Pond		Stab Ponds	
TREATMENT PLANT						
Land value(est.)	20,000	1984	50,000	1986	32,000	1986
Access road	5,900	1985	32,125	1986	49,320	1986
Power supply	20,000	1985	27,000	1986	33,700	1986
Water supply	2,350	1985	9,500	1986	12,600	1986
Construction						
Civil	232,000	1988	180,000	1986	186,000	1986
Mech	58,000	1988	20,000	1986		1986
Mech Equipment	138,400	1984	38,000	1986		1986
Actual cost	476,650		356,625		313,620	
1992 cost	1,184,427		914,802		805,000	
SEWERAGE SYSTEM						
a. Collection sys						
House connection	196 000	1986	301 000	1986	136 500	1986
Gravity sewers	60 000	1984	89 700	1984	125,000	1984
Subtotal col sys						
Actual cost	256 000		390,700		261,500	1984
1992 cost	843,242		1,284,475		945,084	
b. Pump Station						
Land value	6,000	1984	10,500	1986	9,000	1986
Civil works	40,000	1984	172,000	1986	165,000	1986
Mech. works	70,400	1988	71,400	1986	63,000	1986
Power Supply	10,895	1986	49,600	1986	104,900	1986
Subtotal pump st						
Actual cost	127,295		303,500		341,900	
1992 cost	376,305		906,246		1,020,908	
c. Force main						
Actual cost	40,000	1984	49,500	1984	52,500	1984
1992 cost	171,993		212,841		225,740	
Actual cost	423,295		743,700		655,900	
1992 cost	1,391,540		2,403,562		2,191,712	
Total Actual cost	899,945		1,100,325		969,720	
1992 cost	2,575,966		3,318,364		2,996,712	

implementation of remedial works recommendations should be included in the project cost database.[6] The remedial works are intended to correct basic project deficiencies.

- Capital costs reflect contractor bid responses to projects that ranged from design/build tenders to ones that were let according to the standard format of consultant prepared contract drawings and specifications.
- The projects spanned a period of ten years during which the Egyptian Pound experienced significant depreciation.[7]

The general characteristics of each cost component are discussed below.

Collection system costs

Collection system costs are associated with the installation of sewers and house connections. Part of these costs were funded at the local village level by the village council or households. The total cost of the collection system is directly proportional to:

- Length of the system
- Diameter and material of the pipe
- Depth of excavation for installing the pipe
- Local soil conditions (groundwater table and type of soil)
- Number of people served (the number of house connections)

House connection costs were gathered from sources of questionable accuracy and gravity sewer costs reflect only those portions now complete. Total costs for community service may be several times the listed amount.

Pumping station costs

Pumping station costs consist of the cost for power supply, land and civil, mechanical and electrical works. The total cost of a pump station is typically directly proportional to:

- Flow or pumping capacity

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[6] LD II-P is currently preparing an internal report that addresses the deficiencies and omissions in the pilot projects. The cost of the remedial work should be added to the capital cost database.

[7] *The Impact of Inflation and Population Growth on the USAID Agreements Funds Investment as Provincial Infrastructure*, 1992 in-house LD II-P report.

- Pumping system used (separate wet well/dry well system, suction lift pump system or submersible pump system)

The cost variability shown in Table 3.2 reflects differences in land cost estimates and pump stations used.

Force main costs

Force main costs include costs for civil work and material. The cost of a typical force main is directly proportional to:

- Length of the main
- Diameter and material of the pipe
- Local soil conditions (groundwater table and type of soil)
- Topography of the area (the more varied the elevation changes of the terrain the greater the required number of clean-out manholes and air relief valves)

Depth of excavation for installing a force main is relatively constant, unlike collection systems, where depth can vary considerably. In addition, the pilot projects were in an area of flat topography. Therefore, clean-out manholes and gas relief valves did not vary appreciably among projects. The variance in costs shown in Table 3.2 is a function of total system length, and pipe material and diameter.

WWT facility capital costs

Wastewater treatment facility costs consist of the cost for the site access roadway, water and power supply, land and civil, mechanical and electrical works. Typically, the total cost of a treatment facility is directly proportional to:

- Flow or capacity
- Type or complexity of the treatment facility (stabilization pond, modified aerated stabilization pond, fixed film or extended aeration)

The cost variables of land, access roadways, water and power supply, and pumping requirements are usually handled separately as they are site specific. Therefore, within and among given treatment technologies, capital cost comparisons can be conducted on a flow or capacity basis. A flow-based comparison will usually exhibit an economy of scale—the larger the capacity of the facility the less the cost per flow unit. There is a general lack of consistency shown in the capital costs for the pilot program wastewater treatment facilities. Until recommended remedial work costs are included in the existing database, the use of these cost data should be restricted to ballpark estimates.

WWT facility present worth costs

An important concept in the selection of appropriate technology is consideration of the impact of O&M costs. This was not part of the technology selection process in the pilot program, which dealt solely with capital costs. Present worth values for five selected facilities—one for each facility type—have been adjusted for a flow of 1100 m^3/day and presented in Table 3.3 to indicate relative recurrent costs over a period of time. No consideration is given to inflation or increasing power costs, which would adversely affect all but the stabilization pond technology.

Table 3.3: Present Worth Costs for Five Sample Projects

FACILITY	O & M/ year,	LE x Present Worth O&M*
Aadliya - SP-1	8,400	89,600
Daqahla - SP-2	41,100	438,000
Kafr Saad El Balaad - SFFR	43,0000	458,900
El Rahamna - EA-1	115,100	1,227,600
El Serw - EA-2	115,100	1,227,600

Present worth factor = 10.6, interest = 8% for 25 years

PLANNING

Because the pilot program aimed to finance and build village wastewater projects as a tool for furthering decentralization, planning was concentrated at the facility level. With the exception of the villages recommended by the 1985 BVS study, the functions of the individual systems/facilities were not optimized through comprehensive analyses. Low fees for planning often prevented the expenditure of adequate resources for the planning activity; in some cases this resulted in assigning inexperienced engineers to the projects.

Experience with the pilot program showed that analyses for individual project planning should be conducted within a regional planning approach. For example, facilities planning for collection systems should use detailed street maps of the villages under study. If these are not available, part of the planning fee should include an allocation for topographic surveys so that maps can be prepared. Further, future housing patterns should be estimated and population projections for the design year should be included in the planning process.

The LD II-P publications *Guidelines: Methodology and Terms of Reference to Conduct Rural WS/WW Needs Assessment and Strategic Planning* (EE 5-07) and *Manual: Rural WW Project*

Planning (EE5-09) should aid future programs in improving this type of analysis.

DESIGN

Assessment of the Design Process

Engineering designs were a weak link in the pilot program. Several factors caused this situation:

- Many engineers involved in the design-build contracts were inexperienced and took short cuts or adapted textbook solutions that were not always applicable to the specific sites. This led to poor designs, particularly for the wastewater treatment plants, but also for sewage collection systems.
- Low fees obviated performing detailed alternative analyses and obtaining experienced design engineers, even in some cases in which highly regarded engineering firms were employed.
- The lack of experienced engineers at the governorate, markaz, and village levels hindered the proper review of design drawings and specifications. This situation also resulted in the preparation of poor tender documents and led to problems during construction. All of these combined to adversely affect facilities O&M.

The plan and design review process instituted as part of the LD II-P project did lead to some improvement in design as the pilot program progressed into the 1990-91 period. Design efforts on projects that commenced subsequent to the pilot program showed some improvement. Future project designs should be greatly enhanced if the procedures in the LD II-P training publications *Design Manual for Wastewater Treatment Works* and *Design Manual for Sewerage Systems and Pump Stations* are followed.

Several problems with the overall design process for wastewater treatment became apparent through discussions with others in the Egyptian wastewater sector. These problems are strikingly similar to the design shortcomings observed during the pilot program, which are discussed below.

Design reviews

The design functions for most of the wastewater treatment plants in the pilot program were performed under design-build or turn-key contracts. In such contracts, design drawings and specifications are submitted by engineers engaged by the general contractor. The detail in these should be sufficient to assure the parties reviewing the tender

submission (that is, the governorate engineers or their appointed representatives) that the constructed facility will function as required.

The projects in New Valley and South Sinai were designed by private consultants. However, because of the construction schedule, LD II-P staff had time only for a cursory review of these designs.

Thus, in all cases LD II-P engineers had little opportunity to provide detail design reviews. Further, when such opportunities did arise, LD II-P recommendations were not always considered since the LD II-P project role was seen as providing technical assistance to the governorate engineering staff rather than to any consultants engaged by the governorate for design.

Technology choice

The selection of technologies appropriate for local Egyptian conditions is often the most important factor in the successful implementation and efficient performance of a wastewater system. Many of the consultants in the pilot program had limited experience in wastewater treatment, conveyance, or disposal systems applicable to small rural communities.

Factors driving selection included choosing technologies that would meet the requirements of Law 48/1982, preserve agricultural land, and fit available capital budgets. Thus, the design approach was to select well-established technologies; little stress was placed on selecting more innovative recent technologies, with the exception of the SFFR systems. Further, the low financial remuneration provided for many of the pilot plant feasibility studies made most of the efforts ineffective in terms of finding the most appropriate designs.

Some design consultants used drawings and documents from their previous projects in an effort to perform the design within the allotted fee structure. Such drawings and documents did not always address the unique requirements for the projects.

Design products

Level of Detail. In order for projects to be properly implemented, high-quality, detailed design drawings and specifications are imperative. The level of details given by a consultant in any engineering project depends primarily on the firm's previous experience and the qualifications of the staff assigned to the job. There is a cut-off point below which no consultant will be able to provide reasonable details for the remuneration available.

A review of tender documents for the pilot program strongly indicates that the level of detail provided was, in almost every case, limited. The reason appears to be two-fold. First, the remuneration provided for design work was insufficient; consultants accepted the work, but subsequently produced sub-standard designs. Second, many local consultants selected for the work lacked the experience to be able to produce the high level of detail required.

Material Selection. Materials specification is another important element of the design documents, as the type of material used has a direct impact on the life of structures. The selection of improper materials for critical elements can lead to failure soon after the commissioning of a project.

Egyptian engineering consulting firms in all sectors are under pressure to select as many local construction materials as possible. This practice was apparent in the pilot plant construction program.

Unfortunately, at the present time, the local Egyptian market can provide a limited amount of the requisite mechanical equipment or components required for wastewater treatment projects. Inexperienced consulting firms and the pressures to reduce costs and use local materials often resulted in materials being specified that were not adequate for the purpose.

General design comments

A thorough analysis of the LD II-P pilot program design documents highlighted some design concerns common to most projects. Table 3.4 presents these by the engineering discipline to which they apply.

Appendix E presents detailed comments related to facility design. These comments are arranged according to the type of wastewater treatment process to which they apply.

CONTRACTING

The contracting or tendering efforts in the pilot program were another problematic area that should be improved in future projects. Both Egyptian law and local practices provide an adequate basis for proper contracting procedures. However, the system must be streamlined to reduce delays. The first step should be to define specifically the entities involved and the responsibility of each party. Many different entities may be involved, depending on the governorate and the size of the tender. With so many involved parties,

Table 3.4: Common Design Problems in the Wastewater Pilot Program

Design Area	Problems	Issues/Actions for Replication
Environmental Engineering & Planning	Nonstandard contract documents & specifications	Provide standard specifications for use by governorates.
	Site configurations for facilities often were not considered during individual unit design. Hydraulic designs were often incomplete; in some cases the operational characteristics of pump stations were not compatible with plant capacity.	These are basic issues that should be addressed as a matter of routine.. A list of standard elements to consider would help alleviate these problems.
	Feasibility studies rarely included alternatives for unit operations & often appeared to recommend what was used on other projects.	The purpose of feasibility studies is to define easy-to-maintain solutions suitable for local conditions. More money must be made available for these studies, & consultants should have to prequalify.
Civil Engineering	Standard design approaches were not provided in many cases, such as location of structures, contingency planning for future expansion, road construction & traffic circulation within the plant site, & environmental suitability—including the protection of equipment against sun & dust	Develop a list of standard elements that should be addressed routinely. Utilize only those consultants with relevant experience. Ensure sufficient funds are available to provide the necessary level of detail.
	Lack of standard criteria for building design.	Make standard governorate specifications available.
	Lack of consideration for the relationship between existing features (roads, boundaries, utilities) & design drawings for internal roadways & storm drainage facilities.	Basic issue that should be a matter of routine.
	Designs for structural concrete often did not provide details or reinforcement bar schedules & frequently specified low-grade steel	Standard practice if sufficient funds are available to compensate designer.
	Masonry & brickwork were often specified for retaining walls & water-retaining structures	This is a poor practice that should be avoided.
	Specifications covered only general materials such as concrete & masonry work.	Include detailed specifications for component products such as water barriers, isolating materials, & anti-corrosion lining.
Mechanical & Electrical Engineering	Unsuitable materials & equipment were used because of inadequate specifications.	Use detailed specifications that target the appropriate products for the situation..
		Mechanical equipment for standard unit processes should be utilized only if manufactured under license in Egypt & not fabricated without prior experience.

misunderstandings as to each party's responsibility may lead to mass confusion.

Improvements to the process could be effected by prequalifying contractors and by the governorates establishing permanent committees to review tenders and negotiate contracts.

The contracting process would be greatly enhanced by formalizing the use of the LD II-P project documents *Guidelines: Model Contract Documents for Rural Infrastructure Projects* (EE5-15), *Construction Supervision Manual for Engineers, 2nd edition* (EE5-08), and *Construction Supervision Manual for Engineers and Technicians Vol. 2* (EE5-16). By formally adopting the procedures recommended in these publications governorates could clarify the process and individual steps involved for all parties and thus decrease delays.

CONSTRUCTION

Assessment of the Construction Supervision Process

Construction supervision for the projects in the pilot program was performed by governorate housing department engineers or by consulting engineering firms engaged by the governorate. In almost every instance the governorate engineers lacked the experience necessary to perform adequate field supervision services. There was also a general lack of understanding among governorate engineers as to what legal mechanisms they could use to force the contractors to re-do work or to provide remedial work.

Further, these inexperienced engineers were required to supervise contractors who, in many instances, had little experience in wastewater facility construction. Too frequently, inadequate tender documents and lack of details provided by engineering drawings and specifications allowed contractors great leeway in interpreting plan requirements. Because of their inexperience they often misinterpreted the requirements and provided improper materials and poor concrete work. Much of the work was flawed and was not corrected by the governorate's field supervisors due to their lack of experience, and lack of knowledge concerning the legal mechanisms available for obtaining compliance from the contractors.

The situation improved as a result of the LD II-P project's training courses and the thousands of hours of technical training provided by the LD II-P advisors. Throughout the construction phase of the pilot program, the LD II-P project provided extensive technical assistance to engineers and technicians in those governorates directly involved and

those which will shortly become involved with the construction supervision of wastewater systems. This assistance included classroom training, on-site inspection, the introduction of systems for control, and the instigation for involving the private sector in the supervision process.

Many of the problems related to techniques utilized by contractors are not readily solved by construction supervision alone. This point is further discussed below and in Appendix F, which details specific problems by technology.

Capabilities of Local Engineers and Technicians For Construction Supervision

Progress has been observed in terms of increased construction supervision capabilities, most particularly in the overall attitude and acceptance by engineers and technicians of the importance of this aspect of the work and in their general desire to improve the standard and quality of the finished product. This change in attitude has been achieved through both classroom and on-site training. Although obvious to those intimately involved, it is difficult to demonstrate quantitatively. A more concrete example of progress has been the simple introduction of site notebooks to record daily problems.

Despite this new potential capacity and the extensive assistance provided, the overall effort continues to be hindered by two basic factors. The first is the technicians' general lack of basic construction experience. The second consists of the institutional and organizational obstacles faced by personnel in their day-to-day work.

Many governorate and local-level personnel have had little or no direct supervision experience with civil or mechanical engineering works. This includes not only the direct technical aspects, but also the procedural and construction management techniques required to control, monitor, and supervise a project. Because of the lack of on-the-ground experience, it is extremely difficult to build in-depth capacity in personnel through periodic training programs.

Many specific examples of institutional and policy related factors, which negate good construction supervision, can be cited. Government salaries are too low to attract more experienced personnel and provide little incentive for producing an acceptable performance. Also, within the governorates and local units, basic tools are absent—filing systems are meager, tracking systems are not used, and equipment such as tapes, surveying instruments and sampling and testing facilities are not available. The necessity of such basics has been emphasized during the training programs and through all technical field assistance.

A final institutional problem is that regular transportation is not available in most local units. Effective supervision of facilities requires a daily presence during which the contractor is physically supervised and his work is checked. Without proper transportation and equipment this is virtually impossible.

Another aspect which impacts on supervision but is difficult to quantify, is the inability of governorate personnel to adopt a professional position on the project. During construction supervision and administration of the contract an engineer must be able to position himself impartially between the contractor and the contract. This involves a physical and mental approach of conducting business with the contractor in a very firm and controlled manner.

In most cases local engineers were unable to do this. This may be primarily cultural, in that friendship or congeniality must always be displayed between two parties in business. Regardless of the cause, this type of environment is not appropriate for Egypt's rural construction arena. It is difficult for the field supervisors to share an office with a contractor and accept his hospitality and then turn around and inform this contractor that an unacceptable piece of work must be demolished and rebuilt at his expense.

Improving the effectiveness of locally performed construction supervision is an important goal as it can enhance product quality without increasing overall costs.

Capabilities of Local Contractors

The limited capital investment available for the projects often resulted in the use of contractors with little experience in wastewater facility construction. In many instances these contractors were more familiar with other disciplines or had been engaged previously in building of domestic or commercial structures.

Wastewater facilities require special expertise in the construction of water retaining structures, special consideration in the preparation and installation of materials and equipment, and knowledge in pre-commissioning equipment trials. The contractors participating in the pilot program lacked these skills. In addition, they were unfamiliar with standard Egyptian construction procedures and techniques, Egyptian legal requirements, and payment procedures. The role of the supervising governorate engineers was thus made more difficult; the complexity of the supervisory role coupled with the supervisors' lack of experience meant that the construction process began on a

negative note, despite extensive technical assistance from the LD II-P project advisors.

Assessment of Construction Products

Table 3.5 reviews common construction problem that were universal for all technologies used in the pilot program. Additional details concerning construction products are provided in Appendix F.

Contract Documents

The use of detailed specifications and comprehensive tender documents can improve construction quality enormously. However, enforcing requirements on a contractor who may be wholly unfamiliar with such procedures will require a dedicated effort.

The importance of contract documents was discussed under the design section. Strong contract documents impact heavily on the construction stage and ultimately affect quality. The initial part of the document, as an industry standard, sets out all the legal requirements that bind the two parties, together with the procedures the contractor must follow including the general conditions of the contract, program schedule, shop drawing review, as-built information, commissioning, and preparation of operations and maintenance manuals. Next come the specifications, which must be detailed. A detailed bill of quantities must be included, so that the engineer will be able to measure the contractor's progress and provide interim payments.

A myriad of circumstances prevented the use of detailed contract documents for the pilot program projects. For example, the extended aeration package (SOAF) plants were not initially funded under the BVS/LD II-P projects, but were incorporated into the program when the governorate of Damietta utilized BVS funds to complete the civil works. The oxidation ditches were tendered as design-build contracts based upon NOPWASD concept drawings and general specifications. The SFFR treatment plants were also provided by means of a design-build contract.

A positive contribution by the LD II-P project technical assistance contractor was to initiate a three-stage review process: the governorate tendering for a consultant followed by a feasibility study, preliminary design, and final design.[8]

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[8]Guidelines for terms of reference are provided in LD II-P publication *Model Contract Documents for Rural Infrastructure Projects* (EE5-15, January 1992) to assist the governorates in monitoring the output of the consultants work.

Table 3.5: Common Construction-Related Problems Universal to All Technologies

Construction Activity	Problem Affecting Quality	Action Required
Surveys & cadastrals	Lack of vertical & horizontal controls	Utilize national irrigation department bench system. Document control loops.
Groundwater	Installation of pipe & structure foundations	Specify dewatering requirements in tender documents
Pipe bedding material	Bedding material not consistently installed	Document bedding material installation
Structural fill	Not compacted	Perform & document compaction procedures & tests
Retaining walls	Inadequate design	Correct design to match application
Concrete		
Formwork	Loose forms & steel migration	Specify use of steel forms of standard dimensions that allow control of steel placement
Reinforcing steel	Spacing too tight for aggregate penetration Insufficient coverage of reinforcing steel	Specify type 57 reinforcing steel. Use spacing biscuits.
Mixing	Oversized aggregate & high water-to-cement ratio	Document aggregate quality & water volumes. Specify requirement for slump tests & test cubes.
Placing & consolidation	Inadequate placement & lack of consolidation	Specify placement methods & vibration requirements
Curing	Improper curing practices	Specify curing, screeding, troweling, & floating requirements.
Coatings	Cosmetic or improper surface preparation	Specify surface preparation & placement requirements. Eliminate cosmetic coatings.
Joints	Inadequate treatment of cold joints	Specify placement of cold & expansion joints. Reject unspecified joints.
Pipe penetrations	Inadequate penetration methods	Specify & install appropriate materials.
Materials of construction	Inadequate for application	Specify & install appropriate materials
Electrical components	Inadequate for application	Specify layouts
	Lack of design detail	

This system was meant to produce a higher standard of contract documents and there is no doubt that the projects that have started subsequent to the pilot program have improved in terms of detailed specifications and drawings. However, the level of detail has still not reached that which is necessary to ensure quality during construction. Once again, this is a result of the low remuneration which the consultants receive. To ensure construction quality, contract specifications still require substantial upgrading.

The LD II-P project has attempted to resolve this problem through alternative approaches such as highlighting specific items in various training courses. For example, the importance of and methods for scheduling is taught to governorate engineers. Unfortunately, familiarizing local engineers with these techniques does not guarantee enforcement of them on a contractor unless the specifications require such procedures. Likewise commissioning procedures have been addressed but cannot be enforced without specifications.

COMMISSIONING

Site commissioning is the formal action by which the village "takes over" or assumes the total responsibility for all wastewater system facilities. The action certifies that the construction contractor's work is complete. It is a very serious step and one which demands caution on the part of the village or owner.

During the pilot program smooth takeover activities were difficult to achieve. Construction problems necessitated actions by governorate staff (often prompted by advice from LD II-P staff construction advisors) to ensure that such problems were rectified prior to takeover, and this caused a great deal of confusion at many sites as this was the first such experience for the involved parties.

A positive outcome of the program is that takeover requirements are now familiar to the governorates and village councils which were involved in these projects. Even so, the takeover function must be improved if the rural wastewater program is to become national in scope.

DESCRIPTION OF THE O&M PROCESS

The O&M function rests with the system owner, which in the case of the pilot program was the village council. Proper facilities O&M is impossible to accomplish unless the required technical, administrative, management, and financial resources are considered as integral parts of the

village administration. Such integration must occur as early as possible within the project cycle; delay until takeover will usually cause significant problems.

The pilot program's O&M efforts have met with mixed results. Many problems caused by errors in design or construction had to be overcome by an inexperienced, though extremely motivated, village council staff. Most of the pilot program wastewater systems operate fairly well most of the time. However, this level of success required hundreds of hours of specific training for the village staff members, supplemented by thousands of hours of intense TA on the part of LD II-P project staff.

The O&M efforts of the pilot program are well documented in the hundreds of field trip reports and special publications published by the LD II-P project. These activities also prompted some 14 publications (see Appendix C), which should aid the O&M efforts of future programs. Section 4 of this report provides additional details concerning the performance and O&M needs of eight of the pilot program facilities.

CONCLUSIONS CONCERNING THE IMPLEMENTATION PROCESS

As discussed above, improvements are necessary for all components of the implementation process. Critical needs appear in the financial, design, construction, and O&M components of the process. Design and construction elements are further discussed in Appendices E and F, while Section 4 and Appendix G deal with performance and O&M data. However, unless action is taken to implement the revolving loan system, or some other viable capital financing mechanism, replication of the pilot program is impractical.

Recommendations pertaining to the component steps of the implementation process are presented in Section 5.

Section 4

Wastewater Treatment Plant Performance

This section of the assessment report presents:

- The results of a detailed testing program undertaken to measure the efficiency of the wastewater treatment technologies employed in the pilot program
- An analysis of the physical characteristics of the facilities and equipment provided for the wastewater treatment plants and pump stations and a discussion of the effects these systems have on O&M
- A comparison of the wastewater treatment technologies utilized in terms of O&M costs and ease of operation

Appendix G presents a detailed assessment of problems encountered with each technology as they affect O&M, together with the short- and long-term solutions to these problems.

TESTING PROGRAM

A detailed study was performed at eight pilot projects to determine how well the treatment plants were complying with Las 48/1982. This section presents the results of the laboratory analyses for these plants. This testing program required a determination of the actual treatment capacities of the wastewater facilities and process units as compared to plant design criteria and the effectiveness of the requirements. In addition, personnel and other recurrent costs, ease of operation and maintenance, and staff training requirements are identified.

Specifically, the study determined:

- Daily average and maximum flows that can be treated through the various unit processes and operations
- Range of hydraulic loadings, solids, and five-day biochemical oxygen demand (BOD_5) loadings that could be applied to the various unit processes to obtain maximum removal efficiencies in each unit process
- Changes to plant operations that would improve treatment efficiencies

- Facilities requiring additional units to treat increased future flows
- Operations cost for each facility, and staffing and training requirements by treatment technology
- Ease of operation and level of sophistication for each treatment technology/facility
- Actual performance of each treatment technology in terms of the quality of effluent produced

The wastewater treatment facilities included in this study are listed in Table 4.1.

Table 4.1: Pilot Projects Included in Performance Testing

Village	Governorate	Treatment Technology
Aadliya	Damietta	Stabilization Pond
Daqahla	Damietta	Aerated Stabilization Pond
Kom Al Akhdar	Menufiya	SFFR Type 1
Kafr Saad El Balad	Damietta	SFFR Type 2
Barashiya	Damietta	SFFR Type 2
Kafr Soliman	Damietta	Extended Aeration (Oxid. Ditch)
Meit El Kholy	Damietta	Extended Aeration (Pkg SOAF)
El Serw'	Damietta	Extended Aeration (Pkg SOAF)

METHODOLOGY UTILIZED FOR STUDY

The laboratory study covered each stage of the facilities' operations (that is, prestart-up, start-up, and normal operation). Seven of the facilities are operated by village O&M staff; the eighth, Meit El Kholy, is operated by a private O&M contractor. All facilities received a great deal of technical assistance under the LD II-P project.

Generally, the treatment plants' incoming flows are close to or above their design flows (a few were lower due to a slower-than-anticipated house connection rate). Influent flow measurements were estimated using sewage pumping station records and measurements of wet well draw-downs. The facility performance evaluation data and other information were collected as part of the technical assistance and follow-up visits to these facilities by the LD II-P project's technical advisors.

The program for collecting and analyzing samples from the plants was conducted between June and December 1991. Samples were collected from each facility during three separate sampling periods, with grab samples collected together with half-day composite samples. Because flow is

intermittent to these facilities (sometimes only three pumping cycles per day), influent samples could be collected only at times when the sewage pumping stations were operating. Effluent samples also were affected by intermittent flow, but not to the same extent because of the hydraulic head that built up in the facilities during peak flow periods.

Laboratory analyses were completed at the new Damietta wastewater laboratory located at the Anniya wastewater treatment plant. This laboratory is equipped to perform tests for BOD_5, suspended solids, chemical oxygen demand (COD), and ammonia nitrogen. Experienced chemists were hired for a three-month period to perform tests and to train the Anniya laboratory staff to perform these tests for future operations.

Fecal coliform testing, performed on samples from the stabilization ponds and modified aerated stabilization pond were tested at the Mansoura University Environmental Sciences laboratory. All sample analyses were in accordance with industry standards.[9]

Laboratory quality control was checked for the suspended solids and BOD_5 tests using standards established by the US Environmental Protection Agency (USEPA). Additional duplicate and split samples were checked regularly using less stringent standards.

Laboratory results for the suspended solids analysis under EPA quality control standards showed a 95 percent confidence level. Similar quality control checks for the BOD_5 testing were not satisfactory. This has been attributed to the laboratory staff's unfamiliarity with the seeding procedure required by the EPA quality control methods. Since sample seeding was not required for the treatment facility influent and effluent samples, the results for the BOD_5 test on split samples using less stringent standards were acceptable.

PRESENTATION OF TESTING RESULTS

This section presents and discusses performance data associated with the eight wastewater treatment facilities reviewed as a part of this study. This discussion of the facilities performance addresses only those factors now affecting the overall efficiency of individual wastewater treatment technologies. A significant number of design and construction faults associated with each of the technologies are foreseen as becoming treatment process performance

[9]The analyses were conformed to those described in ***Standard Methods for Water and Wastewater***, 17th edition, 1989.

limiting factors in the future; these are addressed in Appendix G.

Summary of WW Technology Performance Data

Table 4.2 presents a summary of organic and solids influent and effluent data for the eight facilities included in the sampling and analysis study. The average influent values for biochemical oxygen demand (organic loading) and total suspended solids (solids loading) were approximately one half of the values used in the actual design process. The significance of removal efficiencies is discussed below by technology type.

Table 4.2
Summary of Influent Characteristics & Treatment Plant Performance

Village	Facility Type	Influent		Effluent		% Removal*	
		BOD	SS	BOD	SS	BOD	SS
Aadliya	SP-1	370	311	98	72	78	67
Daqahla	SP-2	400	374	25	32	98	94
Kom El Akhdar	SFFR-1	320	300	129	111	60	63
Kafr Saad El Balad	SFFR-2	409	415	75	67	73	81
Barashiya	SFFR-2	435	442	30	27	95	97
Kafr Soliman	EA-2	322	367	37	50	94	91
Meit El Kholy	EA-1	468	541	25	24	98	98
El Serw	EA-1	457	470	24	45	96	97
AVERAGE		398	403				

* *Figures shown are averages*

SP-1	Stabilization pond (anaerobic, facultative, maturation x 3)
SP-2	Stabilization pond (anaerobic, aerated facultative, maturation x 3)
SFFR-1	Submerged fixed film reactor type 1 (no anaerobic pretreatment)
SFFR-2	Submerged fixed film reactor type 2 (with anaerobic pretreatment)
EA-1	Extended aeration (SOAF package plant)
EA-2	Extended aeration (oxidation ditch)

Performance of Stabilization Ponds

Two types of waste stabilization ponds were reviewed. One pond system installed at Aadliya village was of a standard configuration (anaerobic, facultative, and series maturation). The second stabilization pond system, installed at Daqahla village included four floating aspirating-type aerators in the facultative deep bottom cell. In each case the pond systems were receiving daily flows well above their design values.[10]

[10]The Daqahla facility was receiving flows that were 200 percent of the design value, while Aadliya facility was receiving flows at 250 percent of its design value.

In each facility the anaerobic ponds were operated in parallel. Good scum blankets were developed in the anaerobic ponds and odors were not a problem. Due to the high daily sewage flows pond interconnecting valve boxes were surcharged. In addition, pond freeboard depths were very close to the top.

Table 4.3 shows the results of performance testing. The Daqahla aerated stabilization pond facility is performing well with better than 90 percent removal of BOD_5 and suspended solids, even with the interference of very high daily flows. However, the first maturation pond downstream of the aerated facultative cell is developing a significant bottom sludge blanket. The problem is a result of the escape of suspended solids from the aerated cell to the first maturation pond. The floating aerators were repositioned to try to provide a better chance for quiescent conditions around the effluent end of the facultative pond, but a floating skirt installed around the effluent pipe outlet may be required to improve this condition further.

Another problem at the Daqahla facility is the presence of aquatic plants (duckweed) in the maturation ponds; these plants are beginning to smother suspended algae and lower the dissolved oxygen levels. Floating mats of dead duckweed require frequent removal from the maturation ponds and disposal of the collected duckweed is a problem. Duckweed mats in the aerated facultative cell are not considered a problem because of the external source of aeration provided. Again, an effluent baffle skirt would help to prevent duckweed escape into the maturation ponds.

The Aadliya stabilization pond facility is not performing as well as the Daqahla facility, with only 70 percent removal of BOD_5 and suspended solids. However, Aadliya's high effluent total BOD_5 and suspended solids conditions are primarily due to the high influent flows and escape of algae within the effluent flow. The small amounts of floating scum and dead algae were not seen to be a performance limiting problem.

In both cases the wastewater treatment facilities are operating satisfactorily and require very little operator attention. Both stabilization pond systems require facility expansion works to adequately handle existing flows. Appendix G includes tables detailing the major performance-limiting problems and possible solutions for the stabilization pond facilities.

Table 4.3: STABILIZATION POND WWT FACILITY SAMPLING DATA SUMMARY

BASIC DATA	Sampling Date	RAW INFLUENT		SEPTIC TANK				FACULATIVE POND (Aerated)				FINAL EFFLUENT			
		BOD5	SS	Effluent BOD5		Effluent SS		Effluent BOD5		Effluent SS		Effluent BOD5		Effluent SS	
		(mg/l)	(mg/l)	(mg/l)	% removal	(mg/l)	% removal	(mg/l)	% removal	(mg/l)	% removal	(mg/l)	% removal	(mg/l)	% removal
Village Name: Daqahla	3 Aug. 91	350	362	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	6	98%	21	94%
Type of WWTP: Aerated Stab. Pond	28 Sept. 91	353	280	109	69%	177	37%	111	-2%	163	8%	35	90%	48	83%
Design Flow: 620 m3/day	28 Oct. 91	498	480	170	66%	167	65%	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	35	93%	26.5	94%
Actual Flow: 1250 m3/day	30 Oct.91 *	300	306	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	19	94%	22.5	93%

BASIC DATA	Sampling Date	RAW INFLUENT		SEPTIC TANK				FACULATIVE POND				FINAL EFFLUENT			
		BOD5	SS	Effluent BOD5		Effluent SS		Effluent BOD5		Effluent SS		Effluent BOD5 (1)		Effluent SS	
		(mg/l)	(mg/l)	(mg/l)	% removal	(mg/l)	% removal	(mg/l)	% removal	(mg/l)	% removal	(mg/l)	% removal	(mg/l)	% removal
Village Name: Aadliya	6 Aug. 91	445	232	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	98	78%	76	67%
Type of WWTP: Stabilization Pond	28 Sept. 91	254	354	88	65%	235	34%	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	66	74%	62	82%
Design Flow: 330 m3/day	28 Sept. 91	725	1668	122	83%	216	87%	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	60	92%	79	95%
Actual Flow: 825 m3/day	22 Oct. 91	404	316	207	49%	198	37%	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	126	69%	82	74%
	22 Oct. 91	353	328	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	117	67%	83	75%
	4 Nov. 91	235	232	153	35%	173	25%	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	97.5	59%	104	55%
	9 Nov. 91	374	342	228	39%	219	36%	110	52%	115	47%	104	72%	67	80%

Note: (1): Effluent BOD5 samples are all non-filtered (one set of filtered samples for Aadliya facility were in the range of 20-30 mg/l BOD5)

*: Grab Samples

xxx: No sample taken

Performance of Extended Aeration WW Treatment Facilities

Two types of extended aeration (activated sludge) wastewater treatment systems were reviewed. The first type, a standard extended aeration facility with mechanical equipment purchased as a complete package from the French company SOAF, will be referred to as SOAF in the remainder of this text. The second type of extended aeration facility reviewed is the oxidation ditch.

Both types of facilities were installed and operating in Damietta governorate. The facilities differ in the type of aeration equipment used (mechanical aerators for the SOAF facility and aspirating aerators for the oxidation ditch) and the configuration of the aeration basins. One other difference is that the SOAF facilities include a grit and scum removal pretreatment process and the oxidation ditches do not.

Wastewater operating staff for the El Serw and Kafr Soliman facilities came from the village utilities department. All facility process control and operating actions were performed by village staff with regular technical assistance provided by Chemonics, with the exception of Meit el Kholy, which was operated by a private O&M contractor. Appendix G includes detailed tables showing the major performance-limiting problems and their solutions for the SOAF and oxidation ditch facilities.

As shown in Table 4.4 both types of extended aeration facilities performed well in removing BOD_5 and suspended solids, with 90 percent removal efficiencies noted at each type of facility.

SOAF plants

The two SOAF facilities were receiving influent flow rates at 150 percent of their daily design limits, but were still able to assimilate the waste stream and obtain good removal efficiencies because of the over design of the aeration basins (detention time and aerator capacity) with respect to the rest of the facility. The SOAF facilities were designed based on an influent BOD_5 concentration of 900 mg/l. Actual BOD_5 strength is in the range of 400-600 mg/l; thus the facility operates at relatively low mixed liquor suspended solids (350 mg/l) levels in order to maintain a healthy balance between the incoming sewage load and the biological mass in the aeration basins.

Laboratory samples were collected during steady state conditions at the SOAF plants and do not reflect hourly peak (250 percent above design average) flow disturbances to the unit processes. Aeration basin dissolved oxygen levels were maintained above 2 mg/l with all aerators running during peak temperature summer months. Basin mixing was complete with no dead spots. However, operating staff have

File: A-Lab3

Table 4.4: WASTEWATER FACILITY SAMPLING DATA SUMMARY

BASIC DATA		Sampling Date	RAW INFLUENT		AERATION BASI		RETURN SLUDG		THICKEND SLUDGE		FINAL EFFLUENT			
			BOD5	SS	Mixed Liquor		Sludge conc.		Sludge conc.		Effluent BOD5		Effluent SS	
Village Name:	Meit El-Kholy		(mg/l)	(mg/l)	(mg/l)	% volatile	(mg/l)	% volatile	(mg/l)	% volatile	(mg/l)	% removal	(mg/l)	% removal
Type of WWTP:	Extended Aeratio	29 July 91	450	487	2700	62%	xxxxxx	xxxxxx	xxxxxx	xxxxxxx	7.5	98%	8.3	98%
Design Flow:	550 m3/day	26 Aug. 9	386	395	1315	66%	3174	68%	xxxxxx	xxxxxxx	18	95%	37	91%
Actual Flow:	800-1000 m3/day	30 Sept. 9	607	856	3060	73%	*****	65%	xxxxxx	xxxxxx	46	92%	30	96%
Design Infl. BOD5/SS:	(900/600)	30 Sept. 9	540	656	3060	66%	xxxxxx	xxxxxxx	*****	0.61	32	94%	24	96%
Actual BOD5/SS:	(450/450)	19 Oct. 91	431	426	3391	64%	xxxxxx	xxxxxxx	xxxxxx	xxxxxx	27	94%	20	95%
		19 Oct. 91	486	484	3404	64%	3220	65%	*****	0.63	23	95%	26	95%

BASIC DATA		Sampling Date	RAW INFLUENT		AERATION BASI		RETURN SLUDG		THICKEND SLUDGE		FINAL EFFLUENT			
			BOD5	SS	Mixed Liquor		Sludge conc.		Sludge conc.		Effluent BOD5		Effluent SS	
Village Name:	El-Serw		(mg/l)	(mg/l)	(mg/l)	% volatil	(mg/l)	% volatile	(mg/l)	% volatile	(mg/l)	% removal	(mg/l)	% removal
Type of WWTP:	Extended Aeratio	22 July 91	464	398	1930	64%	4311	63%	xxxxxx	xxxxxxx	18	96%	11	97%
Design Flow:	1100 m3/day	23 Sept. 9	450	546	3233	60%	4226	61%	xxxxxx	xxxxxxx	32	93%	55	90%
Actual Flow:	1700/m3/day	23 Sept. 9	492	606	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	34	93%	61	90%
Design Infl. BOD5/SS:	(900/600)	16 Oct. 91	458	464	3428	62%	*****	68%	*****	0.55	22	95%	26	94%
Actual BOD5/SS:	(450/450)													

BASIC DATA		Sampling Date	RAW INFLUENT		AERATION BASI		RETURN SLUDG		THICKEND SLUDGE		FINAL EFFLUENT			
			BOD5	SS	Mixed Liquor		Sludge conc.		Sludge conc.		Effluent BOD5		Effluent SS	
Village Name:	Kafr Soliman		(mg/l)	(mg/l)	(mg/l)	% volatil	(mg/l)	% volatile	(mg/l)	% volatile	(mg/l)	% removal	(mg/l)	% removal
Type of WWTP:	Extended Aeratio	18 Aug. 9	415	565	2890	61%	*****	64%	xxxxxx	xxxxxxx	26	94%	48	92%
Design Flow:	1250 m3/day	24 Sept. 9	205	179	2757	65%	*****	67%	*****	0.68	26	87%	32	82%
Actual Flow:	1115 m3/day	13 Oct. 91	437	356	xxxxxx	xxxxxx	xxxxxx	xxxxxxx	xxxxxx	xxxxxxx	58	87%	70	80%
Design Infl. BOD5/SS:	(1000/850)	13 Oct. 91	313	334	3217	68%	8486	68%	*****	0.69	13	96%	19	94%
Actual BOD5/SS	(450/450)													

Note: xxxx: No sample taken
* : Grab sample

been reluctant to operate these aerators either continuously or based on dissolved oxygen and operating conditions. Instead, they operate using a manual timer (30 minutes ON and then 30-minutes OFF). Dissolved oxygen levels drop to near zero after only five minutes with the aerators turned off.

Suspended solids escape from the clarifiers is not uncommon during peak flow periods when the weirs and effluent trough are completely flooded. The short sidewall depth of these clarifiers (2.4 meters) also contributes to this loss of suspended solids. The sludge holding tanks are substandard in their design and ability to decant clear supernatant from the settled sludge. (See Appendix G for details.) In addition, the thickened sludge from the bottom of the tank is too thin (1.5 percent solids), resulting in a dilute and voluminous sludge being applied to the drying beds.

The sludge drying bed process is a bottleneck to the entire treatment system and limits the overall efficiency of the plant. A performance limiting problem not noted in the laboratory data is the shortage of sludge drying bed area—only 0.02 m^2/capita. Sludge wasting, the heart of the process control program, is compromised when the drying beds are full because the aeration basin solids inventory levels become excessive and a biological process upset usually occurs. The maximum time available for sludge drying is only 8-10 days assuming an optimistic thickened sludge concentration of 2 percent.

In addition, the drying bed media installed at the facilities is the wrong type and is insufficient in quantity, and the drying bed underdrain piping has been installed at the wrong slope with oversized filtrate drain holes.

Power failures lasting 12 hours are not uncommon at the facility.[11] However, the biological process has recovered in most instances. Return sludge pumping (screw pumps) performed well without major faults or failures; however, these pumps are oversized and contribute to the peak flow hydraulic problems with the clarifiers noted earlier.

The grit/scum removal process performed well as long as frequent (four times per day) grit pumping was performed to prevent grit pipe plugging. Large amounts of grit and scum (0.5 m^3) were removed from the incoming flow each day. A suitable location for the ultimate disposal of the collected grit and scum has been a problem for the village staff. The influent raw sewage mechanical bar screen performed well but is not needed for this size facility, for which a manually cleaned bar screen is adequate.

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[11]The SOAF facilities are in the process of purchasing stand-by power generating equipment.

Oxidation ditch plant

The oxidation ditch facility at Kafr Soliman village, was receiving influent flow rates slightly below the design value of 1250 m^3/day. BOD_5 and suspended solids removal efficiencies were slightly less than the results achieved in the SOAF facilities. This is primarily due to the lack of scum baffles and surface rake arms in the clarification process. In addition, the clarifier straight edge weir is not level. Each of these items contributes to the escape of suspended solids with the effluent flow. Fortunately, these clarifiers have deep sidewalls (3 meters), which help prevent sludge blanket loss during peak flow periods.

The aeration process performed well with measured dissolved oxygen concentrations between 1.5 and 3.0 mg/l. However, the four installed aerator units per aeration basin must all be in operation to maintain these minimum oxygen concentrations during peak flow periods. During the hot summer months the oxygen concentrations begin to fall near the minimum acceptance level.

Aeration basin mixing is adequate with only minor suspended solids settling at the surface. Frequent aerator fouling and bearing wear has been noted. In addition, aerator propeller wear is occurring. These conditions have resulted in an inordinate amount of aerator down-time, which affects the performance of the aeration process and results in lower BOD_5 removal.

Because the oxidation ditch facilities do not include a grit/scum pretreatment removal process, the aeration basins have developed a bottom layer of settled grit and, in some cases, floating scum patches. The accumulated grit is believed to be contributing to the early wear of the aerator propellers. Floating and suspended debris, which has passed through the manually cleaned bar screen, is often found plugging the water lubrication holes in the aerator units, causing overheating and damage to the ceramic sleeve bearings. Fine mesh screens installed down stream of the existing course screens should improve this situation. The relatively small diameter of the aeration basin outlet pipe in relation to the incoming sewage peak flow rates causes the water level in the aeration basins to rise and flood the basin effluent weir box. Basin sidewall water depths rise during this period and, in some instances, threaten to cover the aerator air intake openings.

The clarification process performs well in settling and concentrating solids and is not affected by peak flows, primarily because the aeration basins absorb these flow surges before they reach the clarifiers. Rising sludge clumps can be seen floating on the surface of the clarifier along with scum and carry over plastic debris from the aeration process. This

floating material escapes over the clarifier weir with the effluent flow. Scum baffles and surface rake arms are needed to improve this situation (especially important because there are no preceding primary clarifiers). The clarifier bottom sludge collectors do not scrape all of the floor bottom (because of poor placement of scraper blades and a tank bottom circle that is not completely round), which contributes to the floating sludge problem.

The return sludge system wet well and submersible pumps are able to handle the return sludge needs for the plant. However, return sludge rate control is difficult to adjust because of the manual gate valves on the clarifier bottom sludge piping. The sludge thickening process has performed well with thickened solids concentrations in the range of 3 percent after modifications were made to construct a baffle around the inlet pipe, and operating staff replaced fill and draw practices with constant sludge feed to the thickener. Waste sludge feed to the thickener is difficult to control (the gate valve is off of RAS pump header) and requires frequent adjustment to maintain the slow feed rate needed.

As with the SOAF technology, another performance-limiting problem not noted in the laboratory data is the shortage of sludge drying bed area, problems with incorrect drying bed media being installed, and the effect these have on the overall performance of the plant. The sludge drying bed process is a bottle neck to the entire oxidation ditch treatment system and limits the overall efficiency of the plant. The area provided for sludge drying is inadequate (0.05 m^2/capita) and the maximum time available for sludge drying is only 11-15 days, assuming a thickened sludge concentration of 3 percent. In addition, the drying bed media installed at the facilities is the wrong type and insufficient in quantity. Furthermore, the drying bed underdrain piping has been installed at the wrong slope with oversized filtrate drain holes. Access to the sludge drying beds for removing the dried sludge is difficult and the steel plate cover over the sludge inlet channel make an unsafe walkway.

Facility power failures are frequent (one per week lasting four hours or more). The stand-by electricity power generator has functioned well but the village system for fuel storage needs improvement.

Performance of Submerged Fixed Film Reactor (SFFR) Treatment Systems

The SFFR treatment system is installed in five different pilot program villages. Three of these installations were reviewed as a part of this study. Two different configurations of the SFFR treatment system are discussed: Type 1, which includes a manual bar screen and SFFR treatment basin only, and

Type 2, which includes Type 1 components plus a pretreatment septic tank and final effluent chlorine dosing and contact tank. The two types of SFFR treatment systems performed quite differently with respect to overall BOD_5 and suspended solids (SS) removal efficiencies. The Type 1 plant, without the pretreatment septic tank, showed a much lower treatment capacity with only 60 percent BOD_5 and SS removal efficiencies. The Type 2 plant performed much better with removal efficiencies in the 80 to 90 percent range. Both types experienced re-circulation pump intake fouling; screens subsequently installed around the pump suction opening alleviated the problem.

Table 4.5 summarizes the performance data for the SFFR plants.

Type 1 SFFR plants

The Type 1 SFFR treatment system performed well mechanically; the submersible pump and air inductor venturi were generally trouble-free. However, the raw sewage organic load to the system could not be assimilated adequately to achieve Law 48/1982 quality effluent—only 60 percent removal of BOD_5 and SS was achieved. The final effluent from the plant can be compared to the primary effluent discharged from the septic tank process in the Type 2 plants.

The BOD_5 and SS exiting the Type 1 plant is primarily due to suspended alga and floating sludge. A coagulant (alum) to aid settling may improve the situation but would increase the amount of settled sludge. Copper sulfate added to the SFFR basin may help control algal growth. A larger effluent weir length (to slow down the overflow rate) or an adjustable draw-off configuration is not expected to improve the situation since the solids are completely suspended.

Dissolved oxygen (DO) measurements in the SFFR basin showed shallow depth O_2 levels between 0.5 and 1.0 mg/l near and around the SFFR unit (at the influent end of the plant). The outlet end of the plant had DO levels in the range of 1.5 to 3.0 mg/l, dropping quickly to as the measurement probe was lowered below a 10-15 cm depth. Measurements of pH were between 7.5 and 8.0 throughout the SFFR basin.

The Type 1 plants are experiencing significant rates of grit and sludge accumulation within the SFFR treatment basin (2-3 meter depths after 12 months of operation). Floating scum and septic sludge mats can be seen in the windward corners of the SFFR basin. Adequate provisions for removal of the settled sludge and grit have not been provided at the facility, resulting in the need for long periods of flow by-passing to allow for the hand digging and removal of the sludge mass. Furthermore, the village operating staff have not found an

Table 4.5: WASTEWATER FACILITY SAMPLING DATA SUMARY

BASIC DATA	SAMPLING DATE	RAW INFLUENT		SEPTIC TANK				SFFR TREATMENT BASIN		FINAL EFFLUENT			
		BOD5	SS	Effluent BOD5		Effluent SS		BOD5	SS	Effluent BOD5		Effluent SS	
		(mg/l)	(mg/l)	(mg/l)	% removal	(mg/l)	% removal	% removal	% removal	(mg/l)	% removal	(mg/l)	% removal
Village Name: Kom El Akhdar	29 Dec. 91	312	256	xxxxxxx	xxxxxx	xxxxxxx	xxxxxxx	59%	64%	128	59%	92	64%
Type of WWTP: SFFR Type-1 plant	6 Jan 92	328	354	xxxxxxx	xxxxxxx	xxxxxxx	xxxxxxx	60%	63%	131	60%	131	63%
Village Name: Sahel El Gawaber	6 Jan 92	292	276	xxxxxxx	xxxxxxx	xxxxxxx	xxxxxxx	50%	32%	147	50%	188	32%
Type of WWTP: SFFR Type-1 plant													
Village Name: Kafr Saad El-Balad	3 Oct. 91	488	488	180	63%	275	44%	27%	65%	132	73%	95	81%
Type of WWTP SFFR Type-2 plant	21 Oct. 91	419	428	161	62%	150	65%	60%	55%	64	85%	67	84%
	26 Oct. 91	305	294	147	52%	115	61%	82%	80%	26	91%	23	92%
	26 Oct. 91 *	395	384	xxxxxxx	xxxxxxx	xxxxxxx	xxxxxxx	xxxxxxx	xxxxxxx	19.5	95%	28	93%
	11 Nov. 91	425	449	143	66%	144	68%	46%	42%	77	82%*	83	82%
Village Name: Barashiya	14 Oct. 91	432	468	105	76%	98	79%	80%	87%	21	95%	13	97%
Type of WWTP: SFFR Type-2 plant	14 Oct. 91 *	364	238	xxxxxxx	xxxxxxx	xxxxxxx	xxxxxxx	xxxxxxx	xxxxxxx	16	96%	15	94%
Design Flow: 600 m3/day	29 Oct.91	480	459	105	78%	119	74%	69%	72%	33	93%	33	93%
Actual Flow: 510 m3/day	3 Nov. 91	395	400	118	70%	160	60%	69%	78%	36	91%	36	91%

*: Grab samples.

xxx: No sample collected

appropriate location for the final disposal of the removed sludge.

Type 2 SFFR plants

The Type 2 SFFR treatment system also performed well mechanically; the submersible pump and air inductor venturi were generally trouble-free. In addition, the facility produced a good quality effluent with overall removal efficiencies in the 85-90 percent range for BOD_5 and SS. The final effluent from the plant can be compared to a typical anaerobic and facultative pond series installation (without maturation).

Treatment was accomplished in two stages, with 60 percent of the influent BOD and SS removed in the anaerobic process preceding the SFFR basin. Average BOD_5 and SS effluent loadings from the anaerobic tanks were 150 mg/BOD_5 and 150 mg/l SS). A further 25 percent of the original influent BOD_5 and SS was removed in the SFFR basin. The SFFR basin received a relatively low strength waste stream (150 mg/l BOD_5 and SS) from the anaerobic process and was able to assimilate 60 percent of this before discharging to the drain. Final effluent concentrations of BOD_5 and SS were usually low (30-40 mg/l) and periods when the concentration exceeded this can be attributed to increased levels of suspended algae. Bottom sludge accumulation and excessive floating sludge and scum was not a performance-limiting problem with these plants.

Common Problems Affecting the Performance of the Village Wastewater Systems

The overall performance of each of the village wastewater treatment systems now in operation could be improved with the implementation of some standard remedial work in the area of design, reconstruction, and in some cases, better O&M practices. Most of the performance-limiting items which have been experienced could be addressed during the feasibility and design stage of future village wastewater projects. Table 4.6 lists some of these common performance problems and associated issues that should be considered for future village wastewater projects.

COMPARISON OF THE FIVE TYPES OF WW TREATMENT FACILITIES

As discussed in Section 2 of this report, the ease of design and construction, and local production capacity for components for the five pilot program technologies vary inversely with their requirement for land. Except for land availability, which is a limiting factor for some geographic locations, ease of operation and O&M cost are the most critical factors in choosing which technology to use. The following discussion

Table 4.6: COMMON PROBLEMS AFFECTING THE PERFORMANCE OF EACH TECHNOLOGY

TREATMENT PLANT UNIT PROCESS OR AREA	DESIGN, CONSTRUCTION, & OPERATIONAL PROBLEMS AFFECTING FACILITY PERFORMANCE	ISSUES/ACTIONS FOR REPLICATION
Sewage Flows	Many of the recently commissioned WWTP facilities receive daily flows well above design values.	Before design of sewage pumping stations & WWTPs, accurate wastewater service area, served population, & per capita wastewater flow estimates should be made. Control additional connections to completed sewage network.
Sewage Pumping Station	Sewage pumping station discharge flow rates exceed total daily & peak hourly flow limits for treatment facilities	Design of sewage pumping stations (especially pump sizes) should be coordinated with the WWTP design flow criteria
	Sewage pumping station wetwells are oversized. Wetwells end up being used as flow storage tanks, which contributes to high peak flows at the WWTP	Avoid oversized wetwell capacity at the sewage pumping station because it promotes grit & scum separation.
	Existing horizontal pumps are difficult to prime. Operators overfill wetwell to help the priming process, causing flows to back up & settle in gravity sewers.	Submersible type sewage pumps should generally be used in future P.S. designs. These will lower overall cost of the P.S. (smaller civil works), be easier to operate (no priming problem), & help keep wetwell free from settled grit & scum.
	Existing horizontal bar screens (mounted one meter above wetwell floor) are impossible to clean properly & create a operational safety hazard.	P.S designs should include removable, easy-to-clean, manual basket barscreens, & wetwell inlet flow isolation valves should be installed for easy maintenance & repair access.
WWTP facility commissioning	No formal program is specified in the construction contract specifications detailing steps to follow & responsibility for equipment & unit process testing & commissioning.	Future WWTP designs should include details in the specifications regarding facility & equipment testing & commissioning.

TREATMENT PLANT UNIT PROCESS OR AREA	DESIGN, CONSTRUCTION, & OPERATIONAL PROBLEMS AFFECTING FACILITY PERFORMANCE	ISSUES/ACTIONS FOR REPLICATION
Measurement of treatment facility sewage flows	No meaningful daily flow data is currently available to facility operations staff. Because installed flow meters are either overly complicated (ultrasonic type) or too crude & inaccurate (simple weir), village staff use P.S. pump running hours to approximate daily sewage flows.	Simple propeller-type, in-line water flow meters, with only one moving part and no need for calibration, should be installed at the effluent end of the plant where solid materials are less likely to foul the meter. Meter by-pass capability is required to allow for monthly cleaning of meter propeller.
Electrical power supply systems	The unreliability of village electrical power supply severely limits the overall performance of the activated sludge, SFFR, & aerated lagoon type treatment plants. (not a problem for stabilization ponds)	Future facility designs (except for stabilization ponds) should include stand-by electrical power generators, phase sequence wrong detectors, ground fault protection devices, & high/low voltage detectors.
Materials selected for the treatment facility	Improper & weak materials used for walkways, control panels, slide gates, bar screens, etc. limits the immediate performance of the facilities & over burdens (financially & technically) the village as facility owner.	Future WWTP designs should specify high quality materials for all facility components. Village facilities require special consideration in materials selection to reduce the financial & technical burden on the village owner in repairing or replacing short life components.
Plant wash water system	No facility includes a plant wash water loop serving the facility unit processes; thus, important tank cleaning & general housekeeping is not being performed.	Ensure inclusion of a plant wash water system including one inch isolation valves & hoses at each tank & unit process. Use plant effluent water as water supply or onsite well points.
Tank drain lines	No WWTP facility constructed to date includes tank drains, which greatly limits dewatering & inspection is greatly limited due to these missing drain lines.	Future WWTP designs should ensure all tanks & basins include provisions for tank draining.
Electrical wiring & equipment power junction boxes	Poor wiring construction is evident in all treatment technologies except stabilization ponds. Unsecured & partly open electrical power junction boxes are common	Future WWTP facility designs should provide clear & detailed specifications for all facility electrical work. Closer construction supervision is needed to control the quality of electrical work.

TREATMENT PLANT UNIT PROCESS OR AREA	DESIGN, CONSTRUCTION, & OPERATIONAL PROBLEMS AFFECTING FACILITY PERFORMANCE	ISSUES/ACTIONS FOR REPLICATION
	Outside equipment electrical control panels constitute a safety problem because of weak mounting, poor circuit mounting, & lack of waterproofing & wiring protection.	Outside electrical control panels should be avoided , except for emergency STOP switches. Normal controls are better located inside control buildings. If outside control cabinets are used they must be nema-4 type waterproof units.
Chlorine feed systems	Installed chlorine feed systems are inadequate in terms of their design function, safety precautions, feed control capabilities, & materials selection. The addition of chlorine to the final effluent flow is insignificant with regard to the receiving drain's water quality & water reuse potential. Limited availability & relative high cost of chlorine is prohibitive to village WWT plant's operation.	If WWTP systems must include final effluent disinfection, the chlorine system specified should be a complete package unit supplied from a single supplier. Homemade chlorine feed systems pieced together from various parts should be avoided. In general, chlorination facilities should be avoided in village WWT plants. If possible, a waver on final effluent disinfection should be obtained from the applicable government organization.
Plant safety facilities & equipment	Lack of proper walkways & handrails, flotation devices & safety ropes, emergency power STOP controls, and electrical power ground fault protection devices..	WWTP worker safety should be a priority consideration during the design of each area of the treatment facility. Future designs should include a better understanding of the operator's daily job requirements & provide a safe work environment.
Septage vacuum tanker off-loading facilities	Septage vacuum tanker trucks are still discharging directly to the drains or to the sewage pumping station wetwell because off-loading facilities at the WWT plants have not been provided.	Future designs should include provisions for receiving the discharge from septage waste haulers. Truck access & prescreening facilities are needed. The off-loading station should include a sloped driveway with large drains & clean-outs. A good supply of plant wash water should be provided.
Grit removal pretreatment process systems	Village raw sewage includes large amounts of sand, grit, & scum, which is abrasive to downstream equipment & accumulates in the bottom of tank structures	Except for stabilization ponds, for which this is not a problem, WWTP design should include provisions for pretreatment & removal of grit & scum

compares the different technologies according to these two factors.

Ease of Operation and Maintenance Comparison

Wastewater treatment technology ease of operation is ranked in this report through the use of seven different facility O&M indicators, as presented in Table 4.7.

Table 4.7: WASTEWATER TREATMENT TECHNOLOGY EASE OF OPERATION

WASTEWATER TREATMENT TECHNOLOGY	Mech. Equip.	Elec. & Inst.	Special Tools	Process Control	Staff Training	On-site Lab Testing	Steady Flow	Overall Level of Difficulty
Ext. Air (SOAF Plant)	5	5	5	5	5	5	5	35
Ext. Air (Ox-Ditch)	5	3	5	5	[illegible]	5	5	33
SFFR Type-2	2	2	4	2	2	3	3	18
Aerated Stab. Pond	2	2	2	2	1	3	2	14
Stabilization Pond	0	0	0	1	1	3	2	7

Note: Level of difficulty is rank ordered from 0-5 with five being the most difficult

Figure 4.1 illustrates the outcome of this ranking for each of the five technologies.

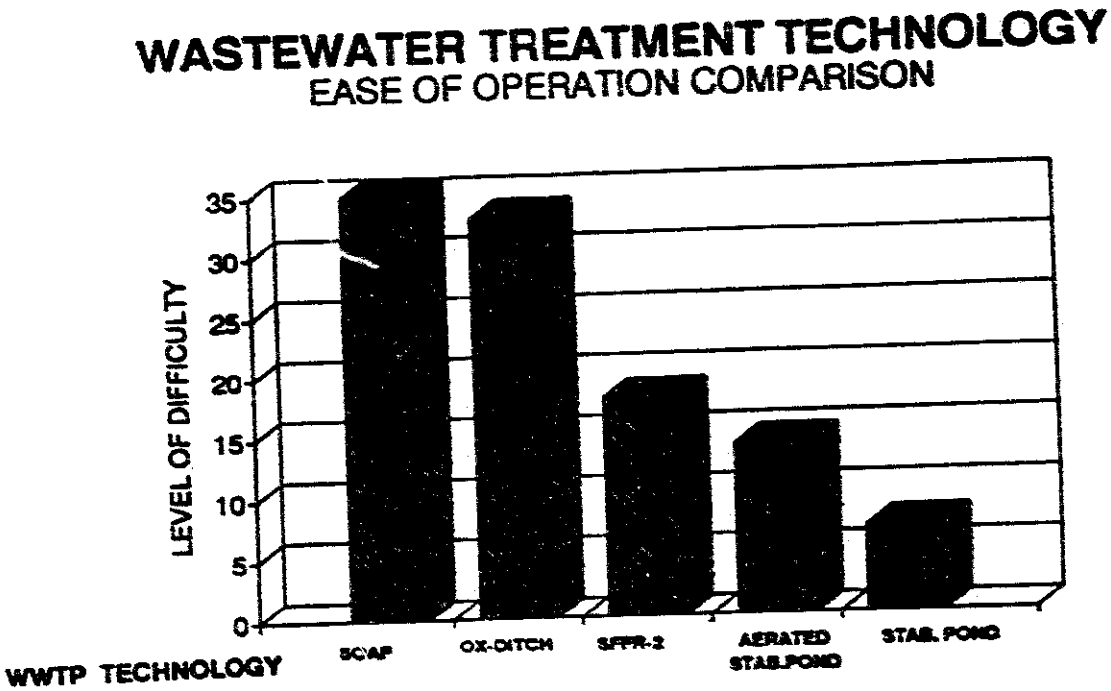

Figure 4.1

Wastewater Technology Operations and Maintenance Costs

Wastewater technology O&M costs have been determined on a monthly cost basis per family unit assuming a common daily average flow of 1100 m^3 for each four different treatment technologies (in this discussion, extended aeration technology includes both the oxidation ditch and SOAF plants). This comparison is applicable to a typical developed village with a population of 10,000 people and assumes a per capita wastewater flow of 110 liters per person (130 l/capita potable water), including sewer infiltration contributions. A typical family household is considered to include five people.

Table 4.8 shows the costs for staffing, electricity, and materials for the three cost centers (treatment plant, pumping station, and collection network) associated with each treatment technology. Sewage pumping station and sewer network O&M cost estimates are identical for each technology and are shown in the itemized listing for illustrative purposes only. In some cases village WW systems require two sewage pumping stations, which will result in higher overall costs to the consumer. In this report, however, a single sewage pumping station system has been assumed for comparison purposes.

Details of the estimating program used for determining each technology's staffing costs, electricity costs, and chlorine costs are included in Appendix G. In general, the total O&M costs shown in this table are considered minimum. Cost totals do not include any money budgeted for major capital replacements (sinking fund) or expensive remedial repairs, even though these are now required. In addition, the costs presented do not indicate the significant amount of money spent by USAID in providing technical assistance to the village operating staff. The methodology followed was to keep the costs estimates simple following current local government O&M budgeting practices.

A comparison of the total monthly O&M costs for each type of wastewater treatment technology, not including pumping and collection system costs, shows the extended aeration plants to be 10 times more expensive than the standard stabilization pond system and more then twice the cost of the SFFR and aerated stabilization pond systems. The major differences in costs is a result of the much higher power costs associated with the extended aeration technology. With electrical power costs expected to continue to increase (currently LE 0.16 per KW hour) the costs of electricity for the 1100 m^3/day extended aeration plants can easily reach LE 7,000 per month in the future.

Table 4.8 presents treatment technology total monthly O&M costs in two ways—with and without cost center staffing costs.

Table 4.8: WASTEWATER FACILITY RECURRENT COSTS SUMMARY / COMPARISON

	Cost Center/Line Items	Extended Aeration		SFFR Type-2		Aerated Stab. Pond		Stabilization Pond	
	Wastewater Plant:	Cost/Month	% of Tota	Cost/Mont	% of Tota	Cost/Mont	% of Tota	Cost/Mont	% of Tota
	Staffing	LE 2,200	15%	LE 1,400	17%	LE 1,400	17%	LE 6[illegible]	11%
W	Electricity	LE 4,948	34%	LE 1,244	15%	LE 1,521	18%	L[illegible]	0%
W	Materials/Spares	LE 2,000	14%	LE 500	6%	LE 500	6%	LE [illegible]	2%
T	Chlorine	LE 440	3%	LE 440	5%	LE 0	0%	LE [illegible]	0%
P	TOTAL WWTP COSTS/MONTH	LE 9,588	66%	LE 3,584	42%	LE 3,421	41%	LE 7[illegible]	13%
	TOTAL WWTP COSTS/YEAR	LE 115,056		LE 43,008		LE 41,052		LE 8,400	
	TOTAL WWTP COSTS /m3 FLOW	LE 0.29		LE 0.11		LE 0.10		LE 0.02	
P	SEWAGE PUMPING STATION:								
U	Staffing	LE 1,800	12%	LE 1,800	21%	LE 1,800	22%	LE 1,800	32%
M	Electricity	LE 500	3%	LE 500	6%	LE 500	6%	LE 500	9%
P	Materials/Spares	LE 1,000	7%	LE 1,000	12%	LE 1,000	12%	LE 1,000	18%
I	TOTAL P.S. COSTS/MONTH	LE 3,300	23%	LE 3,300	39%	LE 3,300	40%	LE 3,300	59%
N	TOTAL P.S. COSTS/YEAR	LE 39,600		LE 39,600		LE 39,600		LE 39,600	
G	TOTAL P.S. COSTS/m3 FLOW	LE 0.10		LE 0.10		LE 0.10		LE 0.10	
	SEWAGE COLLECTION NETWORK PIPING:								
S	Staffing	LE 1,400	10%	LE 1,400	17%	LE 1,400	17%	LE 1,400	25%
E	Equipment rental (contracting)	LE 100	1%	LE 100	1%	LE 100	1%	LE 100	2%
W	Materials/Spares	LE 100	1%	LE 100	1%	LE 100	1%	LE 100	2%
E	TOTAL COLL. SYS. COSTS/MONT	LE 1,600	11%	LE 1,600	19%	LE 1,600	19%	LE 1,600	29%
R	TOTAL COLL. SYS. COSTS/YEAR	LE 19,200		LE 19,200		LE 19,200		LE 19,200	
S	TOTAL COLL. SYS. COSTS/m3 FL	LE 0.05		LE 0.05		LE 0.05		LE 0.05	

TOTAL COSTS PER MONTH INCLUDING STAFFING				
Total costs per month:	LE 14,488	LE 8,484	LE 8,321	LE 5,600
Total costs per m3 flow:	LE 0.44	LE 0.26	LE 0.25	LE 0.17
Cost per person per month: (1)	LE 1.32	LE 0.77	LE 0.76	LE 0.51
Cost per family per month: (2)	LE 6.59	LE 3.86	LE 3.78	LE 2.55

TOTAL COSTS PER MONTH WITHOUT STAFFING				
Total costs per month:	LE 9,088	LE 3,884	LE 3,721	LE 1,800
Total costs per m3 flow:	LE 0.28	LE 0.12	LE 0.11	LE 0.05
Cost per person per month: (1)	LE 0.83	LE 0.35	LE 0.34	LE 0.16
Cost per family per month: (2)	LE 4.13	LE 1.77	LE 1.69	LE 0.82

(1): assumes 100 liters per capita.
(2): assumes 5 people per house:
(3): all costs based on a daily average flow of 1100 m3/day and include WWTP, pumping station, and collection system costs.
(4): extended aeration technology includes oxidation ditches and extended aeration package SCAF plants.

Village utilities staffing costs are presently being paid through the central government Bab I account and are not included as a recurrent cost item in village wastewater service delivery revenue plans. However, as illustrated in Figure 4.2, these staffing costs make up 40 to 70 percent of the total village wastewater system operating costs, depending on the selected technology. In general, actual village wastewater system staffing numbers (number of village staff actually working as a part of the wastewater utility) exceed the number required. Overstaffing of the village wastewater facilities is a common trait followed by most village managers. Although staff monthly salary costs are relatively low (LE 200/month per staff position, including fringe benefits), the potential cost savings per year can be as high as LE 10,000. The village does not feel these excessive staffing costs in their local operating budget and is not likely to change the situation until the time that they may be required to pay for these costs directly.

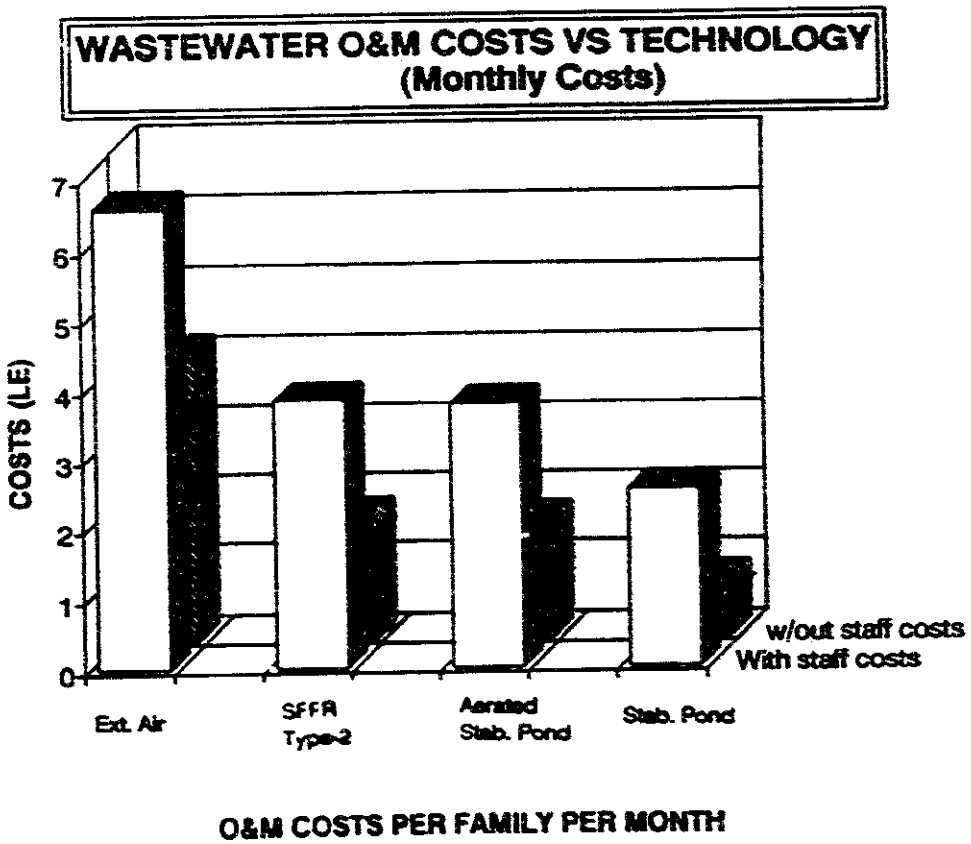

Figure 4.2: O&M Costs per Family per Month

GENERAL CONCLUSIONS REGARDING PERFORMANCE

This section summarizes and discusses some key O&M issues and wastewater facility performance-limiting items that should be considered in future village wastewater projects. The wastewater O&M problems encountered by the pilot program are not unique—many constraints and experiences that limit good O&M performance in developing countries have been thoroughly documented in the last 10 years and can be seen still taking place in rural Egyptian villages. Some of the most common constraints include difficulty in obtaining replacement parts from distant suppliers without adequate financial resources or foreign exchange, low salaries for O&M staff, burdensome electrical costs, shortage of previous O&M experience, undersized treatment unit processes for existing flows, and inappropriate materials and finishes chosen for items requiring trouble-free durability. Future projects should attempt to assure that the proposed technology can be supported by local financing and staff.

Also, it is important to realize that problems accumulated from previous stages of project implementation (such as design and construction) can seldom be addressed satisfactorily during the O&M phase. At best, patch-up solutions may keep the facility teetering along on the brink of disaster. At worst, whole parts of the treatment process may be abandoned and left to decay.

The Need to Design Out Problem Areas

The only way to prevent this situation is to design out problem areas and difficult maintenance activities and to ensure that the means are built-in to allow the remaining maintenance duties to be carried out effectively utilizing available resources. In some cases, this means choosing one treatment technology over another. A good example of this is the ongoing dilemma regarding the shortage of available land in agricultural areas for stabilization ponds, which is driving some decision makers to the selection of the more-difficult-to-maintain extended aeration treatment plants. Although the oxidation ditch and SOAF extended aeration plants reviewed in this report are all producing a quality effluent for the time being, each of these 12 operating facilities is currently plagued with design and construction problems, and heavy financial recurrent cost burdens. The question is: How long will the capital works investments made to these facilities be able to offer any kind of return in terms of wastewater treatment service delivery?

Village wastewater projects are a welcome addition to the beneficiary community and affordable wastewater service fees have been accepted by the people. However, these

communities feel cheated when the number of sewer house connections is limited because the plant was undersized for existing flows, or when the sewer collection system fails and floods their homes. Most recent construction of village wastewater facilities have been projects implemented for community convenience, to relieve the transport of sullage and frequent evacuation of saturated soak-away pits, rather than for environmental health reasons. The net improvement on the receiving drain quality is unnoticeable with the continuing practice of regular discharges from septic waste haulers into these same drains.

From a pure and practicable O&M forecast, choosing a high maintenance wastewater treatment technology which has a 95 percent removal efficiency rather than a simpler technology, which has perhaps a 70 percent removal efficiency, is a waste of scarce financial resources. The short-term gain is unmeasurable in terms of improved water resources and the long-term outlook is grim in terms of being able to keep this type of high technology in working order in the near future.

The most important lesson learned from the pilot village wastewater O&M experience is the importance of designing out problem areas and difficult maintenance activities.

Important Design Considerations

Functional plant design

Designing the plant to work sounds simple, but in many cases the designer's overzealousness to keep the construction costs low for the owner or funding arrangements takes precedence over the primary intent of building a plant that will function at normal and peak daily flow rates. Perhaps a simple analogy will help: If you are selling a new car to a buyer who cannot afford it, you do not offer it to him in a package without the doors. The decision to eliminate grit and scum removal as a preliminary treatment step in order to minimize construction costs of extended aeration facilities is false economy. The same can be said for the missing anaerobic pretreatment process for the Type 1 SFFR treatment systems. Frequent and difficult basin desludging and grit removal will probably cause the plant staff to quietly opt for a continuous plant flow by-pass.

Another example is the sludge drying bed process used in the extended aeration and SFFR treatment systems. Insufficient drying bed area results in the necessity of removing the sludge before it is completely dry to make room for more (a back-breaking and nasty job). There is more than one way to get the excess sludge out of the aeration process and village staff have already discovered how to accomplish midnight sludge spills to the receiving drains. Proper design of the

plant must come first, and the true costs of the different technologies should be explained to the facility owner.

Maintenance requirements

Designs and specifications should also target the reduction of maintenance requirements. Reliability cannot be guaranteed, but it can be pursued diligently in the design process. Each component of the process should be critically examined for its maintenance requirements.

This may promote the choice of options that entail higher capital costs. For example, the selection of stainless steel or fiberglass slide gates rather than one of mild steel will result in higher initial costs, but will provide longer life and better durability. Likewise, the cost savings obtained by leaving the plant wash water piping network out of the design are quickly lost when the unit processes are not regularly cleaned and must be shut down for maintenance. Sophisticated automatic controls and process instrumentation are often switched to manual or are not correctly calibrated, thus negating their usefulness.

In the case of pump stations, quality technology considerations include the dynamics of selecting pumps. Submersible pumps are more expensive and more difficult to maintain, but are still preferable to standard horizontal pump units because of their ability to provide a more even flow rate to the treatment plant and to minimize solids accumulations in the wet well. Sewage pump station wet well cleaning is a nasty and dangerous maintenance job that is rarely done satisfactorily. Thus, a pumping system that can minimize this activity is the better choice, especially when it has the added attraction of requiring a smaller, lower-cost, easier-to-build civil works structure.

The selection of aeration equipment has also proven to be a problem for some villages, as there are often no local agents for service and parts. Similar considerations exist for other equipment.

Ultimately, the questions that must be raised when considering maintenance requirements are: does the facility owner have the range of skills, equipment, and availability of spare parts to maintain the plant for its projected life?

Section 5

Conclusions and Recommendations

A number of valuable lessons can be drawn from the intensive implementation efforts expended over the last several years of the pilot program. Knowledge pertinent to the national wastewater sector was accrued through exposure to issues and constraints, many of which were outside the control of the BVS and LD II-P projects. However, these issues and constraints must be acknowledged, as they can have a profound affect on any national rural wastewater program.

This section discusses the lessons learned during the pilot program and uses these to formulate general recommendations that are aimed at refining the project implementation process for use within a framework for a sectorwide rural wastewater program. Some of the recommendations are augmented by more specific implementation strategies. Where appropriate, existing tools or aids for implementation are also discussed.

ACCOMPLISHMENTS OF THE PILOT PROGRAM

In addition to the general lessons learned, it is worthwhile noting several contributions made to Egypt's rural wastewater sector through the BVS and LD II-P wastewater pilot program, which were not directly related to the implementation of individual projects. These contributions, which stemmed from the eight-plus years of BVS and LD II-P project activity, are discussed below.

Assessment and Planning

The initial activities for the pilot program under BVS (beginning in 1984/85) ultimately did a great deal more for the rural wastewater sector than select villages for inclusion in the pilot program. One of the final products was a classification scheme for villages. Described in the rural wastewater project planning manual, the procedure classifies villages into "levels" of development, using parameters easily identified by village council staff and others employed by the marakez and governorates.[12] The classification

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1212*Manual: Rural WW Project Planning* (LD II-P publication EE5-09)

methodology provided a tool with which local governorate officials can identify the wastewater conveyance and disposal needs of villages in relation to other settlements. For example, well-developed villages with acute problems may require conventional water borne sewerage, while small satellites would receive lower cost options identified as suitable for rural areas and developing countries.

Work accomplished under the auspices of the LD II-P project regarding the disposal of sullage and use of small-bore sewers for less-developed villages should be useful in identifying suitable and appropriate solutions as the Egyptian rural wastewater program grows to include small satellite villages. Additional work in this arena was deleted from the LD II-P wastewater program, as the activities were deemed too research-oriented. However, continuation of the projects has been financed by USAID and implemented by the Egyptian Academy of Science and Technology. As a result, the techniques are now included in a project in Gharbiya Governorate through a research grant for Mansoura University.

In the absence of national policy for the rural wastewater sector, the classification system enables decision makers to identify priorities within their boundaries and ensure that appropriate solutions are utilized. As a result, sector development has not been totally handicapped by "having to wait" for national policy to be developed.

The program's role in overall sector development is well borne out by the many hours of advice and encouragement provided by BVS and LD II-P project staff to counterparts involved in program implementation for Egypt's rural sector, not to mention the numerous project publications. Many elements of the early work of the BVS project are reflected in programs sponsored by the governments of Finland, Denmark, Sweden, and the Netherlands.

Sustainability Issues

Prior to the publication of any of the manuals and guidelines developed by the project (see Appendix C), the BVS project, and to a greater extent, the LD II-P project, raised the consciousness of village, markaz and governorate personnel with regard to the sustainability of wastewater system facilities.

Sustainability requirements, that is the combined management, O&M and financing elements of systems operation, were discussed with local personnel from the earliest days of the pilot program. The key issue was to encourage village and other local officials to recognize that

they must start organizing for sustainability at the outset of project implementation, rather than waiting for the takeover period.

These promotional activities were instrumental as a basis for the design and preparation of many of the formal training programs on wastewater O&M provided to village, markaz, and governorate staffs. The project's concentration on O&M was a contributing factor to USAID's sponsorship of study tours for local personnel in India and the USA.

Further, the priority placed on sustainability was, in part, the basis for many improvements instituted by the LD II-P project for the implementation of individual pilot program projects. These included instituting a plan review process for project design drawings (later expanded to design review) and the insistence that contractors use graduate engineers, preferably recruited from the project area, for the supervision and inspection of ongoing construction work. Both were aimed at improving quality and thus improving sustainability.

DISCUSSION OF THE IMPLEMENTATION PROCESS

Integrity and Control of the Process

Errors made in the early steps of the wastewater project implementation process cannot be totally rectified at a later stage. Planning errors will affect design, poor design may cause below standard contract documents, and inadequate contracts will lead to below standard construction. Poor design and/or construction will invariably cause problems with facility O&M.

Thus, for the successful implementation of a single project or an entire program, each step in the implementation process should meet accepted standards. Inadequacy in any of the steps will damage the entire process and may lead to below standard products (facilities).

To ensure the necessary product quality, the process must be controlled from its inception. As the process progresses, the control exerted by the director of the process (that is, the village, markaz, or governorate) diminishes. This is perhaps easiest to envision when we consider the construction step in the process. As construction moves toward completion, the owner's control over the contractor lessens because payments have been made as work progressed and the normal retainage is not sufficient to influence contractors to correct problems.

In effect, the greater the level of control established at the start of the program, the more likely the process will produce a quality product. Thus, emphasis should be given to ensuring quality in the following:

- Plans at regional, markaz, and village levels
- Detailed designs, with well-examined specifications and thorough design reviews
- Contracts
- Construction supervision with materials testing and inspection
- Professional commissioning

Control of the implementation process is essential to ensure that quality products emerge from the process. Sufficient time must be expended in planning the overall program and program components. This means that the GOE, the governorates, and the villages must all recognize their responsibility for ensuring that the process will be based on appropriate standards and planning. Provision for human resources and training must be made as early in the process as possible.

Quality and Technology Considerations

This study showed that to be sustainable, not only must local entities be involved, but also infrastructure must be sustainable by the local economy. The existence of local desire and knowledge to sustain infrastructure is, in itself, not enough without the appropriate level of financial capability. Within the framework of the pilot program, stabilization pond technology proved the most sustainable technology; however, technologies other than those examined may prove easier to adapt to local materials, skills, and economic realities.

The pilot program has also illustrated that accepting compromises to quality may produce facilities that are nearly impossible to operate without enormous amounts of technical assistance. A national wastewater program simply cannot afford this extra expense either in cost expenditures or allocation of trained manpower.

Local facilities development and ownership can be accomplished without compromises to quality. Using the best inputs available for engineering design and tender preparation, and/or the facilities construction (including supervision) does not exclude capacity building and institutional development benefits accruing to local entities. In fact, the village councils who demand quality services be

provided (and in fact recognize the need to pay their higher costs for services) are enhancing their own quality levels, as these councils become self trained in recognizing the factors contributing to high quality services. Once trained, the councils can easily take the next step—applying these factors to all of their activities.

The amount of required land for stabilization pond facilities remains a controversial issue. The fact is that if all rural treatment systems were to utilize the stabilization pond technology (i.e. to service 35 million people), the required net loss would equate to less than 0.2 percent of Egypt's agricultural land.[13] This ignores:

- The probability that a significant portion of the facilities could be situated on non-agricultural land
- The use of effluent for reclamation of non-arable tracts
- The use of effluent for irrigation purposes to enhance the overall water balance of the country.

Consideration of these items should be integrated into future technology choices.

Financing

A definite policy regarding financing is an essential building block for GOE's rural sector wastewater program. The pilot program, and other LD II-P activities indicated that most villages do not have the capacity to raise the capital required for wastewater projects. A quick reading of tables 3.2 and 4.9 indicate that capital costs for wastewater collection and treatment (at year 1992 levels) could range from LE 1,200 to LE 2,500 per connection and LE 30 to LE 80 per year per connection for proper O&M costs. These are very substantial costs when one recognizes the cash incomes of rural household[14]

It is unlikely that more than a handful of villages could raise the capital costs required without outside help. Such help can only be provided by GOE either directly through its own funds or indirectly through the disbursement of funds obtained via bilateral donors or multilateral lenders. (The BVS and LD II-P projects contribution for the pilot program was approximately LE 100 million at 1992 price levels).

13R. L. Prosterman and Timothy, Egyptian Development and U.S. AID: A 25 Year Perspective, Rural Development Institute, Hanstad; March 1992.

14 LD II-P publication *Concept Paper: Rural Wastewater Financing—Egypt* (ENV-R-4), July, 1989.

The financial situation described above also points out the urgent requirement of developing low cost technologies for the rural wastewater sector. While payment of LE 2 to LE 3 per month is probably acceptable to most rural families as a tariff for wastewater service (O&M cost), any substantially higher value could meet with stiff opposition from the populace.

The establishment of a revolving loan system, which could be implemented to cover the future financing and operation and maintenance components for wastewater systems, may be the solution to these financial problems. Efforts are ongoing to encourage activity for adoption of such a system. In the revolving loan system described in a recent LD II-P publication, a range was set for user fees that were both affordable to the average village household and capable of sustaining the system.[15] This range, with a present observed ceiling of approximately LE 7 per household per month, also includes the financing of recurrent costs. It correlates to an individual project capital cost of LE 350 per household, and an operation, maintenance and replacement fee of LE 2 per household per month.

When applied to the replication of those technologies covered in the pilot program, the bottom line is that technology selection may be driven by economics. User fees that are above the range mentioned above could make a project unaffordable to many rural residents. The higher the net cost of a project, the less affordable the user fee and the less viable the revolving loan option becomes.

A proposed solution is the adoption of a revolving loan account system.[16] This proposed revolving loan account also provides a suggested framework for establishing individual governorate, markaz, and village fiscal autonomy.

In the pilot program, allocations were disbursed on a project-by-project basis. This resulted in the construction, in several cases, of individual treatment facilities that were in close proximity to one another. Future allocations should be approached on a sectorwide basis to examine the possibility of grouping villages together for a regional facility that could take advantage of economies of scale.

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[15] *Design of a Revolving Loan Fund for Local Capital Investments* (LD II-P publication LF4-01)

[16] See *Design of a Revolving Loan Fund for Local Capital Investments* (LD II-P publication LF4-01)

RECOMMENDATIONS PERTAINING TO THE IMPLEMENTATION PROCESS

Financing

Recommendation 1

Determine cost curves for the components of wastewater systems and require detailed cost estimates from contractors .

Implementation strategy 1.1: Develop cost curves. Cost curves that show the range of costs appropriate for the components of wastewater systems should be prepared for use by the governorates—perhaps as a new activity within LD II-P's ongoing wastewater program activities. Such cost ranges should be prepared in a format suitable for easy updating.

A survey of the industrial sector in Egypt should be conducted to determine the national capacity to produce standard items required for wastewater system construction. This could lead to use of standard, locally produced materials and/or equipment.

Implementation strategy 1.2: Require detailed cost estimates. The governorates should adopt contracting practices that allow them to require detailed submissions of cost estimates for various components of the work—including the basis of the estimates (such as quotes from suppliers). Adopting standards for various construction components of wastewater systems would allow for cost curve updates. Contractors could be required to construct standard components at the estimated cost.

Planning

Recommendation 2

Ensure that projects are planned in a manner that considers the pros and cons of the infrastructure to be provided.

Planning for wastewater facilities should consider alternatives, each of which is backed up by detailed analyses that consider technical and environmental benefits and drawbacks. Financial analyses should be prepared for each alternative to illustrate the level of investment and O&M costs that will be required and possible sources of financing. Means of providing for future expansion as the community's population increases should be considered. Village councils should review the alternatives and agree to the selected alternative only after reviewing the associated cost recovery requirements.

Implementation tools: Guidelines: Methodology and Terms of Reference to Conduct Rural WS/WW Needs Assessment and Strategic Planning (EE5-07)

Design

Recommendation 3

Provide detailed specifications that anticipate potential trouble areas in later steps of the implementation process.

Implementation strategy 3.1: Use proven criteria. Consulting firms should base their designs on proven criteria and parameters. This may necessitate treatability studies, and pilot testing in some cases. Although these services add extra cost, they will undoubtedly lead to improved design quality.

Implementation strategy 3.2. Design the plant to work. The proper and standard design of the plant must come first. Any decision to eliminate standard unit processes or to compromise materials is false economy. If the plant costs are found to be too expensive, another technology should be selected rather than modifying the first choice and removing unit processes until the capital costs meet the available funds.

Implementation strategy 3.3: Reduce the maintenance load. Appropriate materials and finishes should be chosen for lengthy, trouble-free durability. At the feasibility and design stage, reduced maintenance requirements may promote the choice of options that entail higher capital costs.

Implementation tools: Design Manual for Wastewater Treatment Works and *Design Manual for Sewerage Systems and Pump Stations* (training materials in Arabic)

Recommendation 4

Use qualified design consultants and perform adequate design reviews.

Implementation strategy 4.1: Adjust the consultant selection process and adequately compensate design firms. Evidence from other wastewater projects in Egypt indicates that there are Egyptian consultants with adequate levels of design expertise in sanitary engineering. The number of these firms within the sector is probably sufficient to handle most, if not all of the wastewater system designs for the rural sector, at least for the next several years. Most of these firms are in Cairo, however, they have performed services throughout Egypt.

The key to obtaining good design is to adjust the consultant selection system, perhaps by prequalifying consultants through the use of rigid standards developed by governorates, to ensure that the selected firm and staff have the proper experience with wastewater system design. Further, once a firm is selected it must be adequately compensated for its service. This is the only way of ensuring that a firm will dedicate its experienced staff and other resources required for proper design of such projects, and still make a profit.

Design quality will also improve if the general responsibilities and duties for the parties involved in the design process are more clearly delineated.

Implementation strategy 4.2: Increase the number of engineers who can effectively review designs. Steps should be taken by the governorates to increase the number of local engineers who can effectively review designs submitted by consulting companies. The current shortage of qualified engineers affects both the process of selecting consulting firms and the quality of the submitted designs. The plan and design reviews conducted under wastewater projects financed by LD II-P have helped provide on-the-job training to many local engineers. Ways of strengthening this growing capacity should be considered in future programs.

Implementation strategy 4.3: Enforce consultant design liability Consultant design liability is not enforced in Egypt; if it were unqualified companies might be eliminated and other consulting companies would be encouraged to revise their recruitment approach in order to select competent specialized engineers.

Implementation tools: Design Manual for Wastewater Treatment Works, Design Manual for Sewerage Systems and Pump Stations, and ***Manual on selecting consultants??***

Recommendation 5

Standardize designs, equipment, and spare parts.

Implementation strategy 5.1: Use standard specifications where possible. Efforts should be made to standardize designs, equipment, and spare parts used for wastewater treatment plants and pump stations. Standardization will help to minimize capital and recurrent project costs by encouraging economies of scale in procurement, and by minimizing purchasing and distribution delays. A list of standard elements should be developed and provided as part of the

contract documents. Standardization may also open avenues for local production of some required materials/components.

Implementation strategy 5.2: Encourage local manufacture of components, but ensure that components meet standards. Large-scale wastewater projects provide a widening market for Egyptian manufacturers. The GOE has recognized this opportunity and has brought pressure to bear on contractors to utilize locally manufactured products as much as possible.

However, not all local products are suitable for wastewater systems. This is especially true for those products needed for wastewater treatment facilities and pump stations. The use of non-suitable products should be avoided, even if it means utilizing imported goods. Legislation and financial incentives by the GOE could help promote local manufacture of foreign equipment under license.

As Egypt's national wastewater treatment program (both urban and rural) grows to meet the future demand, use of imported equipment might be avoided if standard specifications are developed for many common items. This may cause local manufacturers to recognize the new market potential and cause them to adjust their manufacturing processes to provide products to the higher standards and specifications required.

Implementation tools: Design Manual for Wastewater Treatment Works and *Design Manual for Sewerage Systems and Pump Stations.*

Construction

Recommendation 6

Use experienced contractors and pay them adequately.

As with design, construction expertise should be high-quality and provided by experienced contractors who are paid fairly. Systems must be established which will allow the resolution of disputes regarding interpretation of the plans or specification. Construction supervision and inspection services should be accomplished by experienced engineers and/or technicians, who are outside the contractor's organizations.

Contractors of proven capability should be prequalified by the governorates, who would need to develop suitable criteria for this purpose. The chief prequalification parameter should be proven experience on wastewater facilities projects. Contractors whose experience is limited to buildings, roads

and/or other civil projects should not be pre-qualified unless they are part of a consortium in which most of the members have the suitable experience.

Implementation tools: TOR for Sewerage System Contract Documents (EE5-02).

Recommendation 7

Ensure that construction supervision, inspection, and commissioning is performed by experienced engineers/technicians who are outside the contractor's organization.

A major achievement of the technical assistance program was instigating the use of private sector consultants, usually the consultant who performed the design, to supervise the contracts. This was intended to relieve the burden on the local engineers and ensure a better quality product. While improvements have been noted, the program was not as successful as first anticipated.

Two reasons can be cited for this. First, in most cases too little money was allocated for hiring engineers, the most significant impact of which was the lack of a proper office and equipment for the supervisor. Without an office plans cannot easily be consulted, nor proper files and records kept. Second, partly because of the lack of offices and partly because of the cultural aspects mentioned previously, consulting personnel tended to occupy the same offices as the contractor, an unsatisfactory situation. Neither of these problems can be resolved without the provision of additional funds for supervision.

RECOMMENDATIONS PERTAINING TO NATIONAL LEVEL POLICIES AND ISSUES

Recommendation 8

Establish policies for the rural wastewater sector at the national level.

As the rural wastewater program expands to become national in scope, the situation caused by the lack of national policy could become untenable and create chaos with regard to program implementation.

The potential for problems to occur in a sectorwide wastewater program is easily illustrated recognizing that six governorates have indicated their intentions to implement wastewater sector needs assessments by the third quarter of 1992. The number of villages in these governorates is

approximately 1400, and the situation could arise by late 1993 whereby these governorates could be ready to implement wastewater programs for several hundred villages.

GOE should take action through the appropriate ministries to formulate policy for the rural wastewater sector. The policy need not be final, but should be in sufficient detail to allow forward planning on a logical basis. Policy should cover:

- The level of service and coverage targets.
- Responsibility and breadth of jurisdiction of GOE ministries and other entities involved.
- The overall capital cost level of the program which will be supported by GOE, and the amount of financing GOE will provide under this program, to each local entity (including the terms of such financing).

National wastewater policy formulation is underway in Egypt, however no final determination has been made. Preliminary indications are that rural wastewater development may be delayed until urban needs are met. Even so, within the national policy parameters already adopted, the above criteria could still be formulated for rural development, at least on an interim basis.

Implementation tools: This assessment, *Report: Design of Revolving Fund for Local Capital Investments* (LF4-01), and *Guidelines: Methodology and Terms of Reference to Conduct Rural WS/WW Needs Assessment and Strategic Planning* (EE5-07).

Recommendation 9

Consider providing concurrent environmental health and solid waste programs.

As the rural wastewater program expands, providing concurrent environmental health programs should definitely be considered. Such interventions have often been included as components of infrastructure programs that focus on "educating" the beneficiary population as to how to utilize the infrastructure provided so that maximum public health benefits will accrue. Observations during the last several years of the pilot program and discussions with village council and governorate staff members, and Egyptian professionals in the public health fields all point to the benefits of such programs. Legislative and policy related decisions at the national level could ensure programs are integrated as part of overall health improvements.

Likewise, solid waste is a ubiquitous source of pollution in villages and complimentary programs should be instigated by villages.

Recommendation 10

Choose low-cost technologies for rural villages requiring piped collection wastewater treatment facilities.

The choice of appropriate technology for village wastewater systems and facilities ordinarily would be part of GOE's policy for the sector. Experience from the pilot program clearly indicates that choice of technology is an extremely difficult question to answer. Existing legal statutes regarding wastewater discharge, the great demand for agricultural land especially in the delta region, and the high expectations of the populace for applications of advanced technologies combine to make a strong argument for the provision of piped sewerage systems, with highly complex wastewater treatment as the sole solution for wastewater service provision. Assuming a "high technology" solution as the only available option, the estimated costs of a rural wastewater program would be so prohibitive that the development of policy and program may be seriously dampened.

The entire question of wastewater treatment technology choice for rural Egypt deserves serious consideration. Equivalent benefits may easily be derived by programs using less mechanically intensive technologies. The development of such programs, however, will probably require changes in the legal statutes, along with implementation of hygiene education programs. Additional research to determine low-cost, high-efficiency treatment systems applicable for Egypt is also in order.

Until such programs take hold, wastewater disposal technologies having the lowest cost are recommended. This does ***not*** imply that all villages require formal wastewater collection and treatment systems. However, for those which do, stabilization ponds or aerated stabilization ponds are recommended where sufficient land is available. If land is an absolute constraint, less expensive forms of secondary treatment should be used.

Implementation tools: Additional research and development is needed identify the most appropriate solutions for those villages that do not require conventional systems.

Recommendation 11

Consider staffing and training as integral factors in any rural wastewater program.

The availability of sufficient personnel with the requisite skills to operate the facilities provided is absolutely essential to the success of *any* rural infrastructure program. Because wastewater systems are somewhat more complex than other public works infrastructure, the training and management problem is magnified several times.

Employee training for the wastewater sector should be addressed as early as possible—even prior to the construction of any facilities. LD II-P programs training efforts in the wastewater sector and the pilot plant program O&M activities have left GOE with a wealth of material, from O&M manuals to detailed curricula. The application of this material to the sector will be essential for any infrastructure program in the sector to be effective and/or sustainable.

The wastewater pilot program under the BVS and LD II-P projects was implemented with training as a built-in element. This allowed thousands of hours of training to be provided under the technical assistance components of the LD II-P Project. Even with this assistance, there are many instances which illustrate the continuing need at all levels of the village administration.

The training effort required to bolster a national rural wastewater program could easily require intensive vocational training, over a one-to two-year period, to provide the several thousand technicians and administrators required. (Engineers and chemists would probably require less intensive training. However, this assumes such personnel will be available in the sector). This is an enormous need, and will require a tremendous expenditure of resources and a policy developed by the GOE regarding personnel resources and training. These resources are similar to those required in other sector, and thus, the competition for them will be intense.

Implementation tools: All LD II-P training material for this sub-sector.

APPENDIX A

LD II-P Wastewater Projects

LD II-P WASTEWATER PROJECTS

Project Location				Project Component			
Governorate	Markaz	Village/City	Sub-Village	FDS	CLS	PMS	WWTP
ASSYOUT	ASSYOUT	DERONKA		X			
BEHEIRA	GOVERN. PROJECT	GOVERN. PROJECT		W & WW SECTORIAL PLAN			
	DAMANHOUR	MARKAZ PROJECT			X		
	DAMANHOUR	EFLAKA			X	X	
	EL MAHMOUDIA	EL MAHMOUDIA CITY			X		
	ITAI EL BAROUD	NIKLA EL ENAB			X	X	X
	KOM HAMADA	WAQED			X	X	X
DAMIETTA	GOVERN. PROJECT	RAS EL BAR CITY			X		
	DAMIETTA	EL KAYATA			X	X	X
	DAMIETTA	EZAB EL NAHDA	ADLIYA		X	X	X
	DAMIETTA	GHEIT EL NASRA			X		
	EL ZARKA	SHIRMSAH			X	X	
	EL ZARKA	SEIF EL DEIN		X			
	EL ZARKA	DAQAHLLA			X	X	X
	EL ZARKA	EL SERW CITY			X	X	X
	FARASKOUR	EL GHONIMYA			X	X	X
	FARASKOUR	EL RAHAMNA			X	X	X
	FARASKOUR	EL RODA			X	X	X
	FARASKOUR	SHARABAS			X	X	X
	FARASKOUR	KAFR EL ARAB			X	X	X
	FARASKOUR	EL RODA CITY					
	KAFR SAAD	EL RIKABIYA		X			
	GOVERN. PROJECT	KAFR EL BATEIKH			X	X	X
	KAFR SAAD	KAFR EL GHAB					X
	KAFR SAAD	EL WESTANY			X	X	X
	KAFR SAAD	KAFR SAAD ELBALD			X	X	X
	KAFR SAAD	KAFR SLIMAN BAHARY			X	X	X
	KAFR SAAD	MEIT ABU GHALIB			X	X	X
DAQAHLIYA	AGA	MIET EL AMEL			X	X	
	EL MANZALAH	EL AZIZA			X	X	X
	EL SENBELAWEEN	EL MAQATAA		X			
	TALKHA	BATRA		X			
FAYOUM	ABSHEWAI	EL NAZLAH			X	X	X
	FAYOUM	MARKAZ PROJECT			X		
	FAYOUM	EL EDWA			X	X	X
	SENORES	SANHOUR			X	X	X
	SENORES	SENOURS CITY			X		
GHARBIYA	KAFR EL ZAYAT	EBIAR			X	X	

PROJECT COMPONENTS:

FDS	FEASIBILITY STUDY
CLS	COLLECTION SYSTEM
PMS	PUMPSET
WWTP	WASTEWATER TREATMENT PLANT

Printed On:
WWFUND3.WK1/ALL

LD II-P WASTEWATER PROJECTS

Project Location				Project Component			
Governorate	Markaz	Village/City	Sub-Village	FDS	CLS	PMS	WWTP
GIZA	KAFR EL ZAYAT	KAFR EL ZAYAT CITY			X		
	TANTA	MAHLT MARHOUM		X			
	EL BADRASHIN	SAQARA		X			
	EL SAF	MARKAZ PROJECT					X
	EL SAF	EL SAF CITY					
	ABU EL NOMROS	MARKAZ PROJECT			X		
	AWSIM	MARKAZ PROJECT			X		
	AWSIM	ABU RAWASH					
	AWSIM	EL BARAGEIL			X	X	
	AWSIM	KERDASA			X	X	
	ATFIEH	MARKAZ PROJECT			X		
	EL HAWAMDIYA	MARKAZ PROJECT					
KAFR EL SHEIKH	GOVERN. PROJECT	GOVERN PROJECT		W & WW SECTORIAL PLAN			
	KAFR EL SHEIKH	MASSEIR		X			
MATROUH	SEWAH	AGHORMY			X	X	X
MENUFIYA	EL BAGOUR	ASTANHA			X	X	X
	EL SHOHADA	SAHEL EL GAWABER			X	X	X
	SHEBIN EL KOM	MARKAZ PROJECT			X		
	SHEBIN EL KOM	EL MAI			X	X	
	SHEBIN EL KOM	EL KOM EL AKHDER			X	X	X
	SHEBIN EL KOM	EL BATANOUN			X	X	
	TALA	MEIT ABU EL KOM		X			
MINYA	GOVERN. PROJECT	GOVERN PROJECT		W & WW SECTORIAL PLAN			
	DAIR MAWAS	DELGA			X	X	X
	MINYA	TALA			X	X	
NEW VALLEY	EL KHARGA	BARIS			X	X	X
	EL KHARGA	BOULAQ			X	X	X
	EL DAKHLA	BALAT			X	X	X
	EL DAKHLA	EL GEDEEDA			X	X	X
	EL DAKHLA	EL QASR			X	X	X
	EL DAKHLA	EL RASHDA			X	X	X
QALUBIYA	BANHA	KAFR EL GAZZAR			X	X	
	BANHA	KAFR EL GAZZAR	BATA		X	X	
	BANHA	KAFR EL GAZZAR	WARWARA		X	X	
	BANHA	TAHLA	EL RAMLA		X	X	
	BANHA	BANHA CITY				X	
	EL KANATER EL KHAI	SHALGAN			X	X	X
	EL KHANKA	ABU ZAABAL			X	X	X

PROJECT COMPONENTS:

FDS	FEASIBILITY STUDY
CLS	COLLECTION SYSTEM
PMS	PUMPSET
WWTP	WASTEWATER TREATMENT PLANT

Printed On:
WWFUND3.WK1/ALL

LD II-P WASTEWATER PROJECTS

Project Location				Project Component			
Governorate	Markaz	Village/City	Sub-Village	FDS	CLS	PMS	WWTP
	QALYOUB	BELOS			X	X	
	SHEBEIN EL KHAN	KAFR SHEBEIN			X	X	
	TOUKH	MOSHTOHER			X	X	
SHARQIYA	ZAQAZEIQ	EL ZANKALOUN			X	X	X
	ZAQAZEIQ	SHEIBA EL NAKARIYA		X			
	ZAQAZEIQ	EL ZAQAZEQ CITY			X		
SOUTH SINAI	EL TOUR	EL TOUR CITY			X		
	SHARM EL SHIEKH	SHARM EL SHIEKH CITY			X	X	X
	NAWIBA	TABA			X	X	X
	EL AQABA	MARKAZ PROJECT					
	DAHAB	DAHAB CITY			X	X	X
		TOTAL		13	66	54	39

PROJECT COMPONENTS:

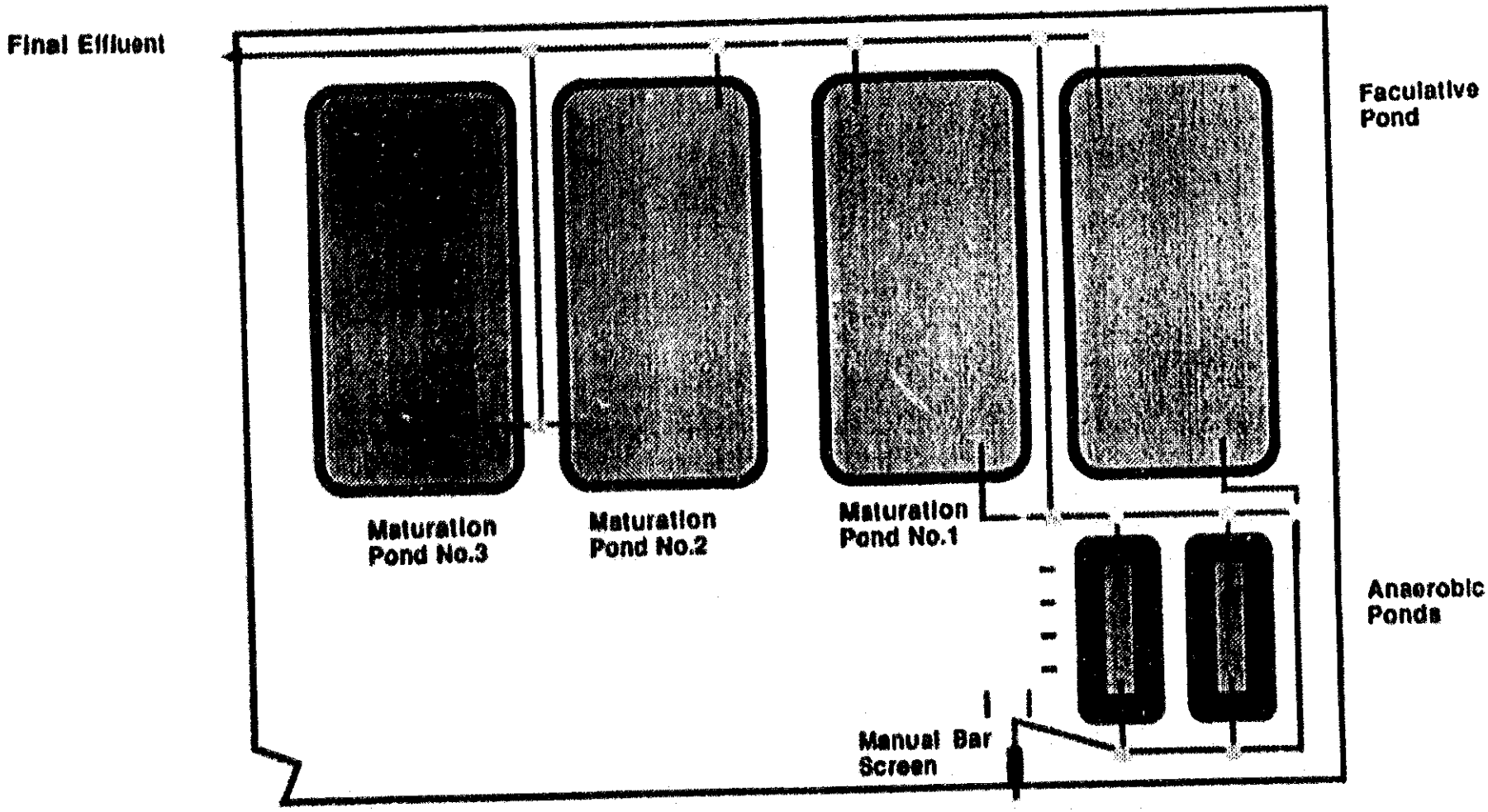
FDS	FEASIBILITY STUDY
CLS	COLLECTION SYSTEM
PMS	PUMPSET
WWTP	WASTEWATER TREATMENT PLANT

Printed On
WWFUND3 WK1/ALL

APPENDIX B

Description of the Wastewater Treatment Technologies Used in the Pilot Program

TYPICAL STABILIZATION POND

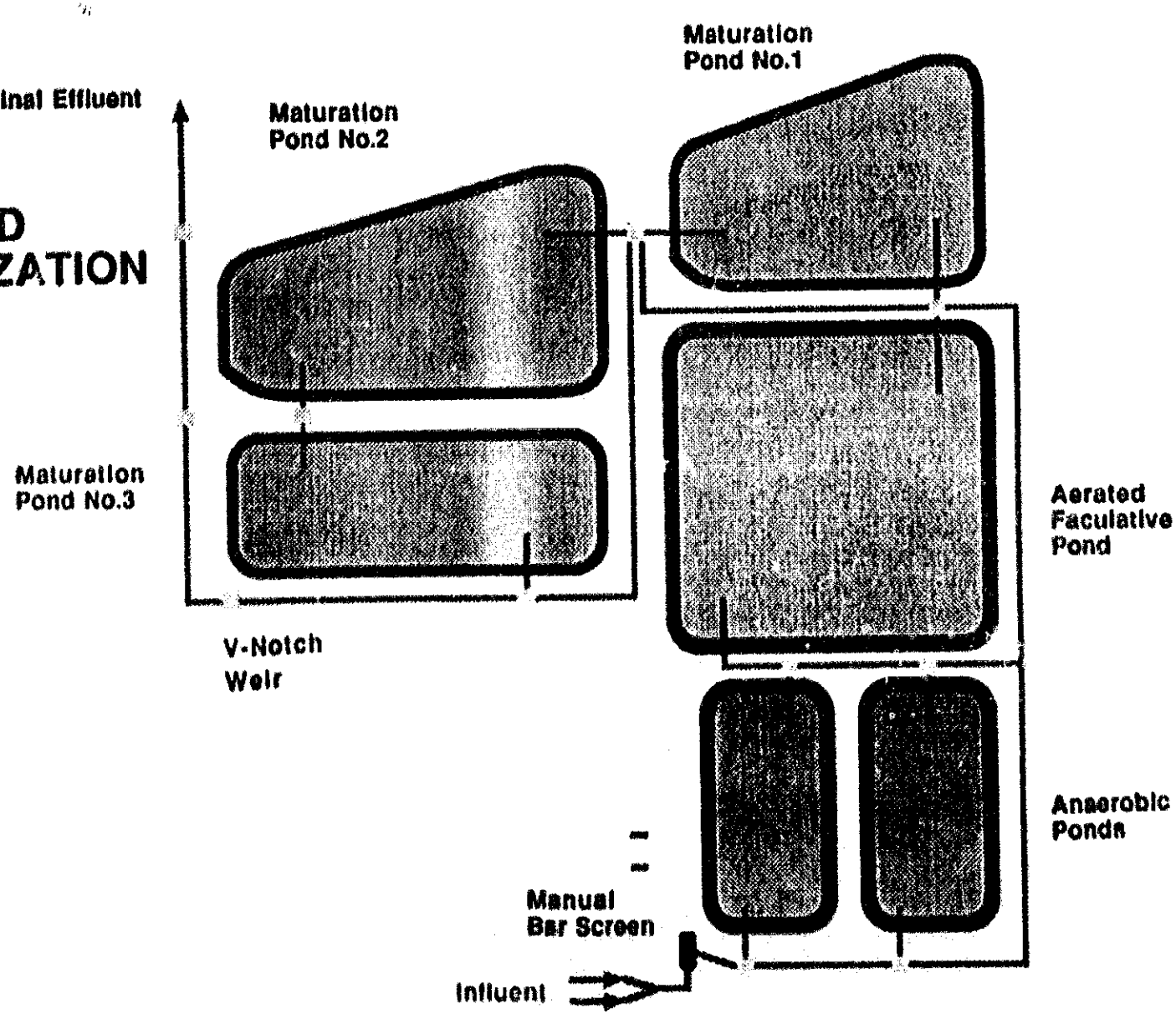


Stabilization Ponds

As shown in the on the opposite page, flow enters a stabilization pond facility from the pump station and passes through a manually cleaned bar screen to two anaerobic ponds that are operated in parallel. Flow then proceeds to the first of four ponds which operate in series; flow passes from one to the next, with effluent passing through a flow-measuring V-notch weir before discharging to the drain canal.

No mechanical equipment is used at this type of facility. Sludge must be removed from the anaerobic ponds (once every two years) by taking the pond off-line (bypassing it) and draining it; the sludge is then allowed to dry, for ease of handling, and is removed and disposed of off-site.

AERATED STABILIZATION POND

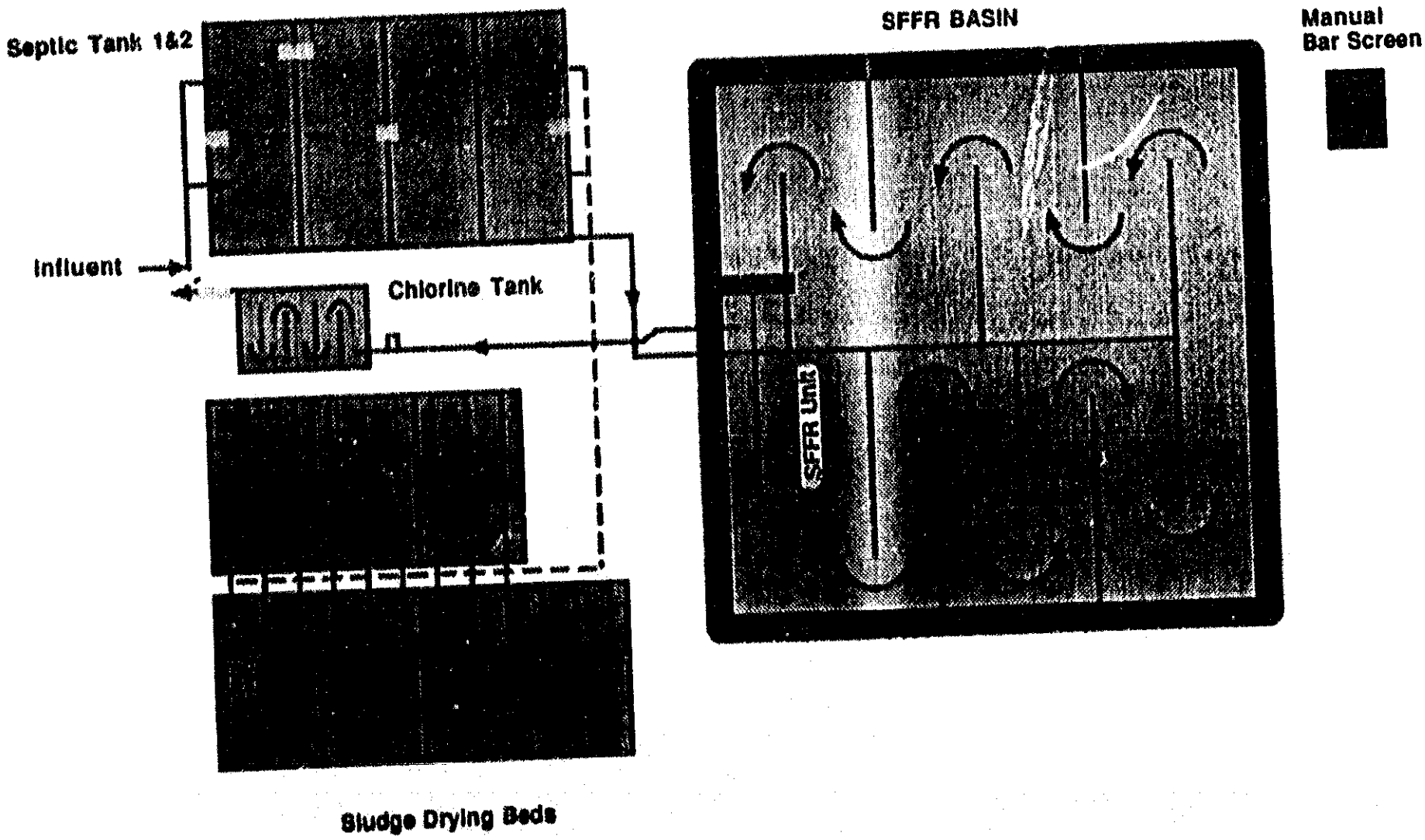


Stabilization Ponds with Aerated Facultative Cell

The figure on the opposite page shows how flow enters the aerated stabilization pond facility from the pump station and passes through the manually cleaned bar screens to two anaerobic ponds that are operated in parallel. Flow then proceeds to a series of four ponds, the first of which is aerated. After leaving the first pond, flow enters the maturation pond, then proceed through two "polishing" ponds in sequence. Effluent discharges to a drain canal through a flow-measuring V-notch weir.

Mechanical equipment consists of four floating surface aspirating aerators in the aerated pond. Sludge must be removed from the anaerobic ponds (once every two years) by taking the pond off-line (bypassing it) and draining it; the sludge is then allowed to dry for ease of handling and is removed from the pond and disposed of off-site.

SUBMERGED FIXED FILM REACTOR PROCESS

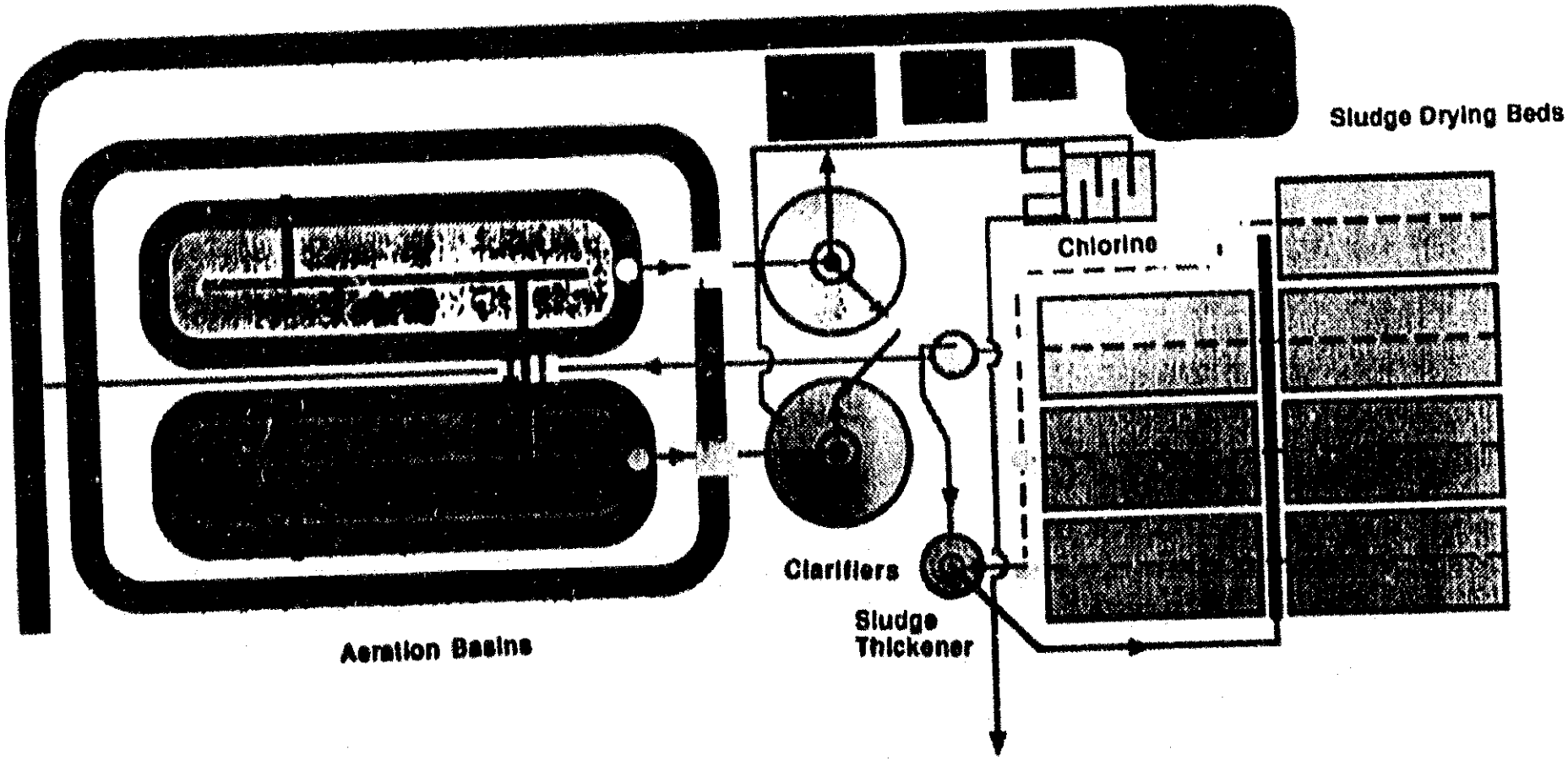


Submerged Fixed Film Reactor

As shown in the figure on the opposite page, flow enters the facility from a pump station and passes through a manually cleaned bar screen to two anaerobic tanks operated in parallel. (Note: the earlier submerged fixed film reactor facilities — referred to in this report as Type 1—do not have the anaerobic tanks.) Flow then proceeds to a lagoon with a set of internal baffle walls that establish a serpentine flow pattern. The inlet portion of the lagoon contains the submerged fixed film reactor, while the effluent end of the lagoon contains a recycle pump and a parallel plate separator. The recycle pump discharges through an aspirating venturi into the submerged fixed film reactor. Exiting the lagoon, flow proceeds by gravity over a small circular weir, which leads to a chlorine contact chamber for final discharge to a drain through a flow-measuring V-notch weir.

Mechanical equipment consists of one SFFR unit recycle pump, two undersized sludge pumps for removing settled solids from the anaerobic tanks, a hypochlorite day tank and small feed pump, and a stand-by generator. Once every six to twelve months, sludge pumped from the anaerobic tanks is discharged to a sludge drying bed, and final disposal of sludge is off-site.

TYPICAL OXIDATION DITCH

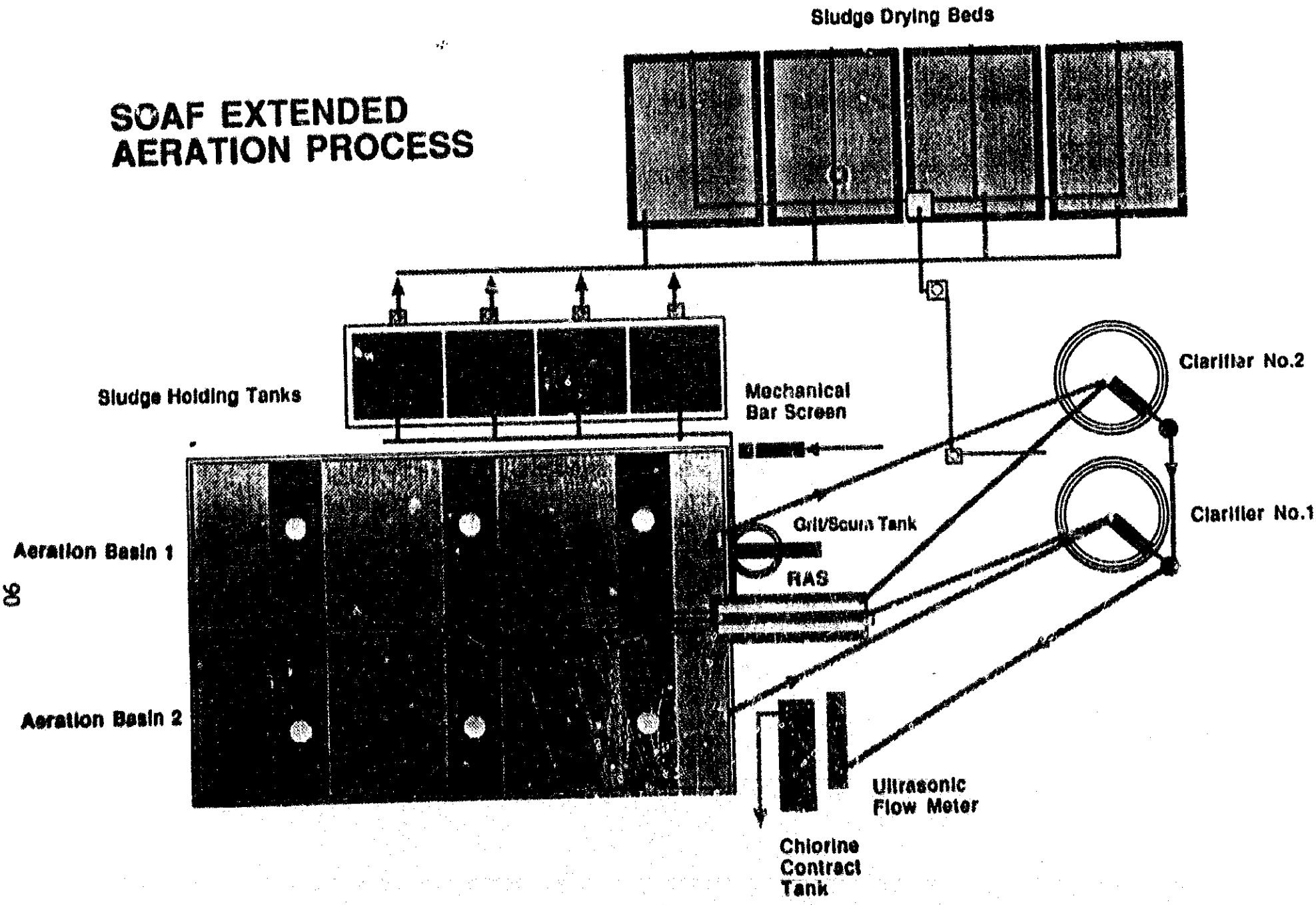


Extended Aeration (Oxidation Ditch)

Flow enters the facility from the pump station force main and passes through a bar screen to the oxidation ditches, as shown in the figure on the opposite page. Flow then proceeds to the clarifiers, where sludge is settled. Clarifier effluent is discharged to the chlorine contact chamber and then to the receiving drain. Sludge from the clarifiers is continuously pumped back to the oxidation ditches as return sludge. A portion of this sludge is removed each day as waste sludge to the thickener tank. From the sludge thickener, concentrated solids are sent to the sludge drying beds. When dry the sludge is removed and disposed of off-site. Filtrate from the sludge drying beds and supernate from the sludge thickener are returned to the aeration basins for additional treatment.

Mechanical equipment consists of aspirating aerators, clarifier and thickener drives, chlorine dilution water pumps, a chlorinator, and a stand-by generator.

SOAF EXTENDED AERATION PROCESS



Extended Aeration (Package Plant—SOAF)

The figure on the facing page shows how flow enters the SOAF package extended aeration facility from the pump station force main through a mechanically cleaned bar screen and proceeds through a scum-grit removal tank into the aeration basins. Flow then proceeds to the clarifiers, where sludge is settled. Clarifier effluent is discharged to the chlorine contact chamber and then to the receiving drain through a flow-measuring (ultrasonic-type) partial flume. Sludge from the clarifiers is continuously pumped back to the aeration basins as return sludge. A portion of this sludge is removed each day as waste sludge to the sludge holding tanks. From the sludge holding tanks, concentrated solids are sent to the sludge drying beds. When dry, the sludge is removed and disposed of off-site. Filtrate from the sludge drying beds and the supernate from the sludge holding tanks are returned to the aeration basins for additional treatment.

Mechanical equipment consists of a mechanically cleaned bar screen, grit pump, surface aerator, clarifier driver, chlorine dilution water system, and chlorinator. Stand-by power generators are now being installed at these facilities.

APPENDIX C

I.D II-P Project Publications Applicable to Planning, Design, and O&M of Village Wastewater Facilities

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Basic Training Course on the Planning of Wastewater Projects in Egyptian Villages (January 1989) **ENV-T-1(A)**

Introduction to different technologies of wastewater treatment suitable for Egyptian villages, presented to local engineers as an introduction to planning aspects of wastewater projects. 150pp.

Basic Training Program for Operation and Maintenance Personnel in Wastewater Treatment Plants in Villages (March 1989) **ENV-T-2(A)**

An introductory training course and quick reference book that includes natural biological treatments and techniques, disinfection, testing and sample collection, record keeping and safety and maintenance -- to be used by wastewater treatment plant operators and maintenance personnel.

Review and Questions Volume (March 1989) **ENV-T-2.1(A)**

Student workbook presented to those attending the Introductory O&M Training Course (see ENV-T-2A) 50pp.

Technical Guidelines for Wastewater Facility Operation (August 1989) **ENV-T-4(A)**

A training course book designed for operating technicians and managers of wastewater treatment plants, this manual presents information on how to operate facilities efficiently and effectively. The objectives of the book are to ensure that the student is able to identify basic components and the method of operation of main types of wastewater treatment technologies. The book is divided into eight sections: characteristics of sewage, sewage collection, preliminary treatment, primary treatment, trickling filters, final sedimentation, chlorination, and oxidation ponds. This manual is an adaptation of the United States Environmental Protection Agency manual titled *Operation and Maintenance of Wastewater Treatment Plants* (1976), prepared by the California State University Department of Civil Engineering. 112pp

Technical Guidelines for Wastewater Collection System Maintenance (August 1989) **ENV-T-5(A)**

This training course book is designed for maintenance technicians and managers of wastewater collection systems, and provides information on how to maintain these systems efficiently and effectively. The objectives of the book are to ensure that the student be able to identify basic components of a wastewater collection system maintenance program. Sections in the book include: collection system piping networks, construction supervision of sewage collection systems, pipeline cleaning and maintenance methods, inspection of sewer piping, methods for

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renewing and replacing sewer piping, and safety practices for the sewage collection system worker. This manual is adapted from the United States Environmental Protection Agency's publication entitled *Operation of Wastewater Collection Systems*, prepared by the California State University Department of Civil Engineering. (1980). 123pp

Technical Guidelines for Wastewater Facility Maintenance
(August 1989) **ENV-T-6(A)**

This training course book is designed for maintenance technicians and managers of wastewater treatment plants and provides information on maintaining these facilities efficiently and effectively. The objectives of the book are to ensure that the student is able to identify basic components of a wastewater facility maintenance program. Sections include: maintenance records, building maintenance, plant tanks and channels, and plant grounds. This manual is adapted from the United States Environmental Protection Agency's publication titled *Operation of Wastewater Treatment Plants*, prepared by the California State University Department of Civil Engineering (1980). 58pp

Management of Wastewater Project Design Stage
(January 1991; revised August 1991) **EE 4-01 (A)**

Analyzes and evaluates the results of two years of experience in implementing feasibility studies and designs by local consultants for wastewater projects in 35 villages (14 governorates). The document illustrates the design steps, from with TOR preparation through final design and submission of tender documents. Advantages and disadvantages of feasibility studies, emerging from two years of trial, are discussed for use in future studies. (65 pp not including 2 appendices)

Construction Supervision: A Manual for Technicians and Site Supervisors (September 1990) **EE 5-01 (A)**

Explains and simplifies the fundamentals of construction supervision and includes general guidelines for supervising the construction of a project. The manual discusses different construction phases in detail, lists and explains the symbols used in engineering drawings, and gives some calculations related to required site measurements. Also, it provides many illustrations and drawings and is a good reference for technicians and supervisors on site. (317 pp including appendix)

TOR for Sewage System Contract Documents EE 5-02 (A)
(November 1990; revised May 1991)

Prepared by the Chemonics EE Section to help concerned governorate departments in making complete contracts with the contractor who constructs wastewater projects. It demonstrates the legal and financial conditions for bidders and the rights and responsibilities of the contractor, and explains the specifications for the parts of the drain pipes, force mains, and pump stations. An alphabetical index at the end of the manual helps the user find the required article quickly. (266 pp including index)

Draft Guidelines for Village Wastewater Service Delivery EE5-03 (E&A)
(December 1990)

Based on field work and workshop experience, these guidelines explain the roles of the village/markaz, governorate, and national levels in village wastewater operations, and discuss the importance of preparing advance plans for operations and maintenance. The document presents considerations and recommendations for organizing and staffing the village engineering section, which includes the wastewater utility. One section describes the budget (operating) process and various methods for generating revenues at the local level. The final chapter deals with issues and processes related to contracting out O&M services. (62 pp including 4 appendices)

Technical Guidelines for the Operation and Maintenance of Wastewater Stabilization Ponds (June 1991; revised October 1991) EE 5-04 (A)

This training course manual is designed for technicians and managers of village wastewater stabilization pond treatment facilities. It is intended to be used as a student reference during classroom training, and is meant to help students identify and understand the basic components and methods of operating a stabilization pond system. The six sections address technical basics, calculations for stabilization ponds, laboratory experiments, O&M, stabilization pond problems, and safety concerns. (102 pp including 5 appendices)

Sampling Analysis and Process Control of Activated Sludge WWTPs for Technicians (October 91) EE5-05 (A)

Covers procedures and techniques for sample collection and analysis associated with the operation and process control of activated sludge treatment plants. It is meant to provide treatment plant technicians and engineers with technical instructions for sample collection and preservation, sampling program management, test procedures for measuring treatment process parameters and their applications, and quality control techniques associated with wastewater sampling programs. The manual, which consists of six chapters, can also be used as a student reference manual during on-site instruction sessions for sampling and

process control of activated sludge treatment facilities. (84 pp including one appendix).

Safety Considerations for Wastewater Employees **EE5-06(A)**
(Nov. 91)

The manual deals with safety considerations for public works employees who are working in the area of wastewater collection and treatment. It is meant to provide local engineers, supervisors, and technical staff with an understanding of the many hazards located in and around the work site. The manual covers common mechanical, electrical, chemical, biological, and confined space hazards. It identifies the procedures and activities for preventing accidents related to these hazards. The manual also describes the dangers associated with using chlorine gas and gives safety practices for protecting personnel. It discusses the causes of fires and ways to prevent them. The annexes include manual fire fighting equipment and first aid procedures in case of emergency. (95 pp including 2 annexes).

Guidelines: Methodology and Terms of Reference to Conduct Rural WS/WW Needs Assessment and Strategic Planning **EE5-07 (E)**
(Nov. 91; revised Jan. 1992)

Provides terms of reference and guidelines for a governorate-level water supply and wastewater sector needs assessment. Addresses the consultants interested in bidding on such an assessment, the consultant selected to perform the assessment, and to a lesser degree, the governorate requesting proposals. Section 1 provides an overview of the sector assessment process by briefly describing required outputs, the overall program, and sources of information. The work elements to be performed as part of the assessment are described in Section 2, with supporting technical details provided in various appendices. Section 3 reviews the requirements for proposals, and Section 4 gives a brief overview of some of the contractual requirements. (120 pp w/4 appendices).

Construction Supervision Procedures Manual for Engineers, 2nd Edition **EE5-08(A)**
(Nov. 91)

Outlines the criteria for successful construction supervision and describes the qualifications, duties, and responsibilities of the construction supervisor. It explains the legal aspects and the supervisor's interaction with the owner designer, contractor and other concerned parties. The manual also discusses quantity and cost estimates, project time and payment schedules, the use of specifications and contract drawings for project control, materials and equipment testing , and project delivery. The contents of a typical project tender document and a sample TOR for contracting a construction supervision consultant are included in the manual so that they may serve as guides in preparing similar documents. (150 pp including one annex).

Manual: Rural WW Project Planning EE5-09(A)
(December 1991)

Provides a methodology for defining the environmental problems experienced by rural Egyptian communities, and briefly describes the types of solutions and financial resources available to address these problems. The methodology for defining problems is described in terms of four basic indices—physical development, potable water service, social development, and environmental pollution. The method for calculating each of these indices is described and examples are provided for each index and for the combined rating as described by all four indices. (27 pp)

Instructors' Guide for Teaching Process Control of Activated of Activated Sludge Wastewater Treatment Plants EE5-10 (A)
(January 1992)

This document contains information on process control of the activated sludge wastewater treatment system. It is designed to be used primarily as an instructor's guide, but it also may be used as student reference during on-site training sessions. The four chapters of the document cover a discussion of the working concepts of the activated sludge system, including BOD vs COD and solids levels in the treatment system; process control by adjusting process variables; a discussion of return sludge and sludge wasting; and the dissolved oxygen requirements in the activated sludge system.

The five annexes include process control testing rates, loading rates for secondary clarifier, an activated sludge troubleshooting guide, case study data, and a course test. (103 pp with annexes)

Set of SOJPs for Sewage Pumping Station O&M EE5-11(A)
(January 1992)

This document cover procedures and techniques for operating sewage pumping station facilities. It is meant to provide pump station technicians and engineers with technical instructions for pump O&M, valve maintenance, sewage wet well cleaning, facility troubleshooting, and site safety. In addition, the document provides detailed schedules and record forms for sewage pumping station preventive maintenance activities. It is designed to be used as an on-site guide for operating the village sewage pumping stations. (69 pp)

Standard Operating Job Procedures Submerged Fixed Film Biological Wastewater Treatment Plant (January 1992) EE5-12(A)

This document covers procedures and techniques for operating the submerged fixed film biological (SFFB) wastewater treatment system and was prepared specifically to assist in the operation of the five village SFFB treatment facilities (three in Damietta Governorate and two in Menufiya Governorate). The technical content of this document is specific to the

facilities and equipment installed. The document can be used as an on-site guide for operating the village wastewater treatment plant or a training guide for new employees and refresher training for existing staff. (11 appendices)

Standard Operating Job Procedures Oxidation Ditch Wastewater Treatment Plant (January 1992) **EE5-13(A)**

This document provides technician and engineer procedures and techniques for operating the oxidation ditch wastewater treatment system. It was prepared specifically to assist in the operation of the four village oxidation ditch treatment facilities constructed in Damietta Governorate. The document is designed to be used as an on-site guide for operating the village oxidation ditch wastewater treatment plant and can be used as a training guide for new employees and refresher training for existing staff. (8 appendices)

Standard Operating Job Procedures Extended Aeration (SOAF) Wastewater Treatment Plant (January 1992) **EE5-14(A)**

This document was prepared specifically to assist in the operation of the eight village extended aeration (SOAF) treatment facilities constructed in Damietta Governorate. It is meant to provide extended aeration treatment plant technicians and engineers with technical instructions and procedures for operating treatment system unit processes and equipment, and provides detailed spare parts lists, schedules, and record forms for treatment plant equipment preventive maintenance activities. It can be used as an on-site guide for operating the village wastewater treatment plant of as a training guide for new employees and refresher training for existing staff. (8 appendices)

Model Contract Documents for Rural Infrastructure Projects **EE 5-15 (A)** *(February 1992)*

Intended as a guide for those who work in the field of administrative contracting. A properly prepared administrative contract will allow any administration to run its public utilities. the document includes a discussion of contracts and the contracting process, and the general conditions of contracts. Sample contracts and required forms are also included. (288 pp)

Construction Supervision Manual for Engineers and Technicians Vol. 2 (Implementation of Sewerage Systems) (March 1992) **EE 5-16 (A)**

Completes and supports a prior document prepared by Chemonics: *Construction Supervision - A Manual for Technicians and Site Supervisors.* While the first manual deals with construction in general, this manual discusses supervising construction of sewerage systems in particular. It provides engineers and site supervisors with guidelines for the

construction of each part of the sewerage system, to assure the completeness and quality of the system, and the adherence to standards and project specifications. (228 pp, including one annex)

Rural Water and Wastewater Assessment and Strategic Planning (March 1991) **EE8-01 (E)**

Proposes a method of strategic planning to enable governorates to develop their water and wastewater sectors. The paper outlines the features and characteristics of strategic planning; presents the elements and interrelationship of work included in the LD II-P strategic plan; describes the sector assessment, analysis of policy options, and detailed planning analyses that make up the plan; and discusses how the outputs can be used by other governorates. (25 pp)

TRAINING MATERIALS

Training Materials for the Planning Design and O&M of Village Wastewater Facilities

Design Manual for Wastewater Treatment Works (A)

Design Manual for Sewerage Systems and Pump Stations (A)

RELEVANT DOCUMENTS FROM OTHER LD II-P SECTIONS

Report: Design of Revolving Fund for Local Capital Investments (October 1991; revised December 1991) **LF 4-01 (E)**

Establishes the need for a cost recovery program in the wastewater sector discusses the major concepts and issues involved in defining a cost recovery model using a revolving loan fund system. Compares two mechanisms for recovering costs and recommends a variable-rate user fee. Shows how these systems (cost recovery and revolving loan) can be integrated into the existing system for wastewater project development in Egypt. (44 pp)

Wastewater Organization in Beheira Governorate, Preliminary Report (December 1991) . **HRD 4-04(E)**

This report analyses the organization of the Beheira wastewater department and makes recommendations for its future organizational structure and relationship to the Beheira Water Company. The discussion includes the development of independent water and wastewater companies in Egypt and cites the particular experience of the Kafr El-Sheikh Water and Sanitation Company. Recommendations include a strategy for developing the Beheira wastewater organization and recommended immediate and future actions by USAID. (42 pp)

Organizing for Wastewater Activities at the Governorate Level (March 1992) HRD 4-04a(E)

Experience has shown that any governorate wanting to expand its wastewater treatment capacity must consider how it should organize to effectively plan and oversee the wastewater disposal process. Five rural Egyptian governorates—Beheira, Damietta, Qalubiya, South Sinai, and Kafr El Sheikh—have taken steps to organize for more effective handling of wastewater facilities. This document outlines the mission and organizational issues pertinent to a governorate-level wastewater organization. Appendix A includes job descriptions of recommended positions, while Appendix B contains specific recommendations fro strengthening the Beheira Wastewater Department as it prepares to merge into the Beheira Water Company.

APPENDIX D

LD II-P Wastewater Training

Training Course	Location	No. of Events	No. of Participants	Type of Participant
Extended aeration SOAF process control training	on-site	2	29	engineers & technicians
Oxidation ditch WWTP process control training	on-site	2	28	engineers & technicians
Contracting procedures seminar	classroom	1	170	water & ww engineers from 22 governorates
Construction supervision for technicians	classroom with field trip	2	31	technicians
Construction supervision for engineers (orientation workshop)	classroom with field trip	3	60	engineers
Training needs assessment workshop	on-site	1	27	technicians & engineers
Establishing village wastewater utility department (workshop)	conference room	4	80	markaz & village chiefs & secretary generals
Design review of WWTPs	training center	2	63	engineers
Design review of sewage collection systems	training center	2	60	engineers
WWTP O&M	on-site	8	80	technicians
Stabilization pond O&M training	classroom with field trip	3	40	technicians & engineers
Introduction to WWTP O&M	classroom	3	90	technicians & engineers

APPENDIX E

Details Related to Design of Pilot Program Facilities

The following comments on specific wastewater treatment plant designs are the result of an examination of design documents, field visits to completed projects, and a review of relevant technical reports. Remarks are generalized for each technology; specific site conditions are not considered in this analysis. The intent is to highlight design elements that should be included or avoided in future projects.

STABILIZATION PONDS

Six stabilization ponds were included in the pilot study; one of these—Aadliya—was included in the performance monitoring study. The following comments pertain to the Aadliya facility.

The inadequate design layout for flow distribution to the two anaerobic ponds has resulted in one pond being overloaded.

The design of the plant does not provide flow distribution flexibility for pond dewatering and solids removal. The slide gates were constructed of materials that are subject to premature corrosion.

Industrial wastewater contributions were not considered in the design phase of the plant. A significant amount of the wastewater originates from two milk factories. These flows create organic and suspended solids shock loading, which adversely affects effluent quality.

No gauge was provided for the effluent flow measurement weir.

AERATED STABILIZATION PONDS

One aerated stabilization pond facility—Daqahla—is included in the pilot program.

As with the stabilization pond at Aadliya, inadequate design layout for flow distribution to the two anaerobic ponds has resulted in one pond being overloaded.

Inter-connecting pipes between the anaerobic pond and aerated lagoon are undersized, resulting in occasional flooding of the anaerobic pond. To avoid this, local engineers added a second pipe, allowing water removal from the surface of the anaerobic pond. This, in turn, resulted in moving scum from the anaerobic pond to the aerated local

lagoon, which is in direct conflict to the design intent of these unit processes.

Flow control chambers between the various ponds were not properly constructed as the design drawings did not provide adequate details. Slide gates provided are made of materials that are not corrosion-resistant which aggravate operational difficulties.

The effluent flow measurement weir is not provided with a scale to indicate flow rate. Design drawings did not provide this detail and the weir is not used for flow measurement.

SUBMERGED FIXED FILM REACTOR FACILITIES

The proprietary system components for these facilities were imported from an American company (Aqualife). Some modifications to the system were proposed and implemented by local consultants, the most important of which was to precede the SFFR unit with anaerobic ponds to improve the overall treatment efficiency. The anaerobic ponds were designed to remove at least 50 percent of suspended solids and about 35 percent of BOD_5.

The following specific remarks are related to the modified systems as provided in the pilot program.[1]

Design details did not indicate that SFFR units must be oriented with the ditch influent piping. Improper orientation of the unit caused inadequate distribution of air into the ditch.

The proposed method of sludge withdrawal, although conceptually correct is not functional because of the following two items.

- The design slope of the anaerobic tank was not sufficient to allow gravity sludge collection.
- The selected sludge-withdrawal pumps are not adequately specified for their function. Trial runs to remove sludge with these pumps failed.

Safety design considerations were inadequate. For example, there are no handrails or access platforms, and ladders are constructed of inadequate material.

Materials specified for the bar screens, drain plates, and gates are subject to premature corrosion.

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[1]Referred to as SFFR Type 2 in this assessment report.

OXIDATION DITCH PLANTS

Four oxidation ditch plants were constructed during the pilot program. Three of the plants these have equal capacities; the fourth is double this capacity. The following comments pertain to all plants.

Materials specified for bar screens, drain plates, and slide gates should be corrosion resistant.

Lack of design details for the attachment of the aerator bridges to the ditch embankments resulted in inadequate installation. The attachment method used for the bridge caused damage to the concrete base at all four facilities.

The aerator manufacturer specified stainless steel for the frame supporting the aerators on the bridge; however, locally produced mild steel was used. This frame, which is partly immersed in the oxidation ditch, is subject to premature corrosion.

Dissolved oxygen measurements in the oxidation ditch indicate that the aeration system has a lower transfer efficiency than required. This condition could have been avoided if field transfer performance tests had been specified.

The channel distributing the waste activated sludge to the drying beds is oversized. Precipitation of solids occurs in the channel, necessitating frequent cleaning. Also, the design did not include adequate access for dried sludge removal. Simplified solutions to these two problems have been recommended. The problems would not have occurred if the design had considered the required O&M functions.

Safety measures, including the provision of hand rails where appropriate, have not been addressed in the design of the facilities.

The inlet to the gravity sludge thickener is not properly designed, causing a turbulent short-circuit condition.

In summary, many construction details were missing in the design documents, including the method of connecting the access ladder to the final settling tanks, the routing of electric cables, and the steel frame supporting the aerators.

EXTENDED AERATION PACKAGE PLANTS (SOAF)

The design of the SOAF plants represents a mechanical proprietary treatment system. During the LD II-P project, eight plants of this type were constructed. The mechanical

and electrical design documents for these plants, including materials specifications and engineering drawings, were professionally prepared. These documents are considered a standard design that can be utilized by the contractor to suit any specific site requirements with few modifications. However, these facilities should be considered carefully for use in rural Egypt. They will be appropriate only if properly constructed and if a high quality of O&M is assured.

The following remarks pertain to the *five package SOAF* plants included in the performance monitoring program.????

Mechanically cleaned screens are inappropriate for villages or small communities where power outages are frequent, back-up generators are unavailable, and high levels of O&M must be provided. However, the stainless steel material used for the actual racks, gates, and frames is appropriate.

These plant designs must provide for adequate flow control devices (valves, gates, etc.) between the various treatment units to facilitate the separation of units for maintenance.

The selection of ultrasonic flow measurement elements as a flow measuring system was inappropriate because such devices require a high level of O&M and are difficult to calibrate without programming knowledge and experience. The devices installed in the five projects that were assessed do not operate. A float mechanism with a mechanical read out would be more appropriate.

Fences should be provided for all treatment facilities.

Although all plants have chlorinators, none are utilized because resupply is hindered by chlorine transportation difficulties and there problems inherent with the systems as installed. For example, the intermittent flow to the facilities is not compatible with the water dilution system as installed. At this point in time, the investment in chlorinators is not justified. In future plants, the necessity of providing chlorination disinfection should be examined thoroughly

APPENDIX F

Construction: Problems and Solutions

Issues presented in this appendix are the result of observations made during inspections and during the post-commissioning or warranty phase of the construction process. The first section deals with problems and suggestions according to the sequential activities that typically constitute the construction process. Subsequent sections deal with those construction issues that were specific to the type of facility under construction.

GENERAL DISCUSSION BY SEQUENTIAL ACTIVITY

Surveys & Cadastrals

Baseline layout

Application of uniform and accurate vertical and horizontal controls was not observed to be consistently applied by either setting permanent benches or by setting bounds for a site baseline. Typically, on treatment facility projects, permanent reference boundaries are set up to establish definitive reference lines for site layout. Standard procedures for both collection system and wastewater treatment facility projects call for establishing permanent bench marks to ensure elevation control. This standard procedure should be integrated into future pilot project replication efforts.

Reportedly, there is a national bench system administered by the Irrigation Department. Irrigation and drainage systems serve as the final effluent receptors and for this reason should be used as the initial design control points for the hydraulic profile of a treatment facility. If changes are made in the operating levels of the drainage systems, the discharge hydraulics of the treatment plant may be compromised.

Reviews of pilot project construction sites indicated that most benches used for design layout were arbitrary and not necessarily tied into this system. Occasionally elevation problems created the need for effluent pumping and resulted in marginal or inadequate hydraulic clearance among unit processes within the treatment facilities.

Through the construction technical assistance process consultants and contractors have been encouraged to include proper ground control systems. However, this has not yet been universally accepted at the local level.

Easements and rights-of-way

The normal course of action is to obtain all easements and right-of-ways for collection or treatment facility construction before work is started. This was not observed to be problematic in the pilot program.

Conflicts with water and sewer line locations occurred, which may indicate that the original cadastral work was not thorough. This may have resulted because standard terms of reference did not require the inclusion of utility locations;

because local as-built records did not exist; or because inadequate compensation was provided to locate these lines in the design phase.

Equipment and materials set down was not a problem in the pilot program.

Soil Investigation and Groundwater

Groundwater

The majority of the pilot subprojects were in areas with high or perched groundwater tables. The presence of a high groundwater table and cohesive soils affected compaction procedures and foundation selection. Although borings were taken, the result of any soils investigations was not translated to construction practice. Often the deeper sewers, pump station caissons, and foundations of structures for treatment facilities were laid in saturated conditions.

Dewatering

Specifications did not cover contractor dewatering requirements. Standard dewatering equipment, such as sheeting with submersible pumps or well point systems, was not installed; nor were standard dewatering measures implemented in any project.

These issues were consistently addressed with consultants, but remuneration for the design precluded the inclusion of these procedures and the contract values prevented contractors from operating expensive dewatering facilities Governorate engineers were instructed in the proper procedures for high ground water situations through training courses.

Excavation fill and spoil

The installation of specified pipe bedding or structural fill was not consistently practiced. Interim placement of excavation spoil was a problem in sewer construction.

Earthworks—Site Civil

Retaining walls

Rather than using true retaining walls, most designers applied standard dwelling wall construction techniques, an unsuitable substitute. The retaining walls were essentially a masonry fence, consisting of footings, columns spaced at about five meters, and a top tie beam for the columns. The open areas formed by the columns and beams were filled with brick.

The unsatisfactory nature of the walls were first addressed with consultants in 1988, but for cost reasons they could not be persuaded to alter their design, even though it is inherently unstable.

Engineers and technicians were alerted to these problems and to two possible solutions. One is to acquire more land area so that embankments can be sloped to grade thereby negating the need for a retaining wall. The second is to change the design of the wall to better fit its application, such as a counter foot retaining wall. In many cases, the costs of a true retaining wall may be approximately equal to the cost of additional land to run the outside toe of the embankment slope to grade.

Structural fill & compaction

The quality of construction fill was observed to be an issue.

Compaction of fill was questionable. Because no compaction tests were performed and no records were available, assessment was subjective. Observations indicated that compaction efforts were below acceptable standards. Again, this is cost-related, as compaction equipment and testing add to project cost although essential to provide minimum quality installations.

Structural Issues—Concrete

Given the fact that the majority of the capital expense associated with the pilot projects (other than stabilization ponds and aerated lagoons) was related to concrete, this item deserves special attention.

The enforcement of any degree of acceptable control over concrete quality was observed to be a major difficulty. This problem may be attributed primarily to two factors: the minimal experience of the contractors in constructing sanitary structures, and the attempt to minimize capital costs by using local techniques, which although suitable for residential dwelling construction, are inadequate for infrastructure construction.

For example, the building practice of using beams and columns with masonry fill was applied whenever possible for retaining walls, chlorine contact tanks, baffle walls, and sludge drying beds. While suitable for residential dwelling construction projects, these techniques did not provide the structural integrity required for the long-term durability necessary for water retaining structures.

Form work

Spacing between form boards was usually excessive, allowing the loss of cement paste. Paste loss would have been even greater if mechanical vibration had been properly employed. The use of pre-manufactured forms and snap ties was not typically practiced.

Forming procedures involved placement of reinforcing steel to the full height of the structure, followed by the installation of the

wooden-batten forms. This technique lacks vertical control. At all observed installations, migration of the reinforcing steel to the inside form has occurred; infrequently, the contractor attempted to use spacers to properly place the steel. Premature corrosion of reinforcing steel and spalling of concrete is expected at these sites.

Reinforcing steel

Designs using type 32 reinforcing steel (mild steel) typically ended up with spacing that rendered proper concrete placement a practical impossibility. This indicates a lack of designer familiarity with construction techniques. Type 57 steel was specified for some projects; the resultant steel spacing was compatible with aggregate size and good concrete placement. High strength reinforcing steel be used in any future projects to assure quality concrete work.

Mix & mixing

The cement and fine aggregate produced in Egypt is of good quality. Coarse aggregate can be of good quality, however, contractors typically purchase a lower grade coarse aggregate in which stone size is often greater than the spacing between the reinforcing steel. Segregation and honeycombing result.

Observations at pilot projects indicated a lack of quality control in concrete mixing. Typical mixes had very high slump, or high water-to-cement ratio. Cement, sand, and coarse aggregate were proportioned on a volumetric basis, which is acceptable.

Placing & consolidation

Placement of concrete—typically conducted with wheelbarrows or buckets—was observed to be poor. Incidents of segregation were high. Tramels were not used in situations where it would have been appropriate.

Because concrete mixing and placement was typically a hand operation and did not involve automated equipment, placement time was extended and the incidence of cold joints was high. Vibration to consolidate the concrete appeared to practiced only occasionally. Standard slab screeding, troweling, and floating methods were not practiced.

Curing

Proper concrete curing practices, including wetting procedures and the use of evaporation loss protection such as moisture barriers or spray sealants, were not observed. Concrete curing in the Arab Republic of Egypt should follow "hot weather concreting" practices throughout much of the year.

Testing

Neither slump cube, or core tests were performed, thus it is not possible to quantify concrete quality and definitively monitor contractor performance in this area.

Coatings

Coatings consist of mortar and bitumen. Use of proper form work eliminates the need for and expense of mortar coatings. Use of the correct type of cement eliminates the need for

bitumen coatings. As a result, these coatings and their associated costs should not be necessary.

Any mortar that was applied was cosmetic in nature, used to compensate for poor form work or to cover poor concrete work. Bitumen was not applied according to standard thickness build-up procedures and surface preparation (latence removal) was below acceptable standards.

Joints

Treatment of cold or construction joints was not consistently executed according to standard practice. Cold joints, aside from being excessive, were seldom cleaned properly and were covered with latence. Key ways were not utilized and water stops were not consistently installed.

Pipe penetrations

These were constructed by breaking a hole in a wall after the concrete pour, inserting the pipes, and applying mortar. It is unlikely that steel was correctly placed for the pipe penetration at all projects, or that a bonding agent, cement cream, or non-shrink grout was used consistently.

Although practiced widely, this method of constructing pipe penetrations is not considered correct. Pipe penetrations should be cast in place or should utilize sleeves for longevity and water tightness. Steel should be placed in a manner that reinforces the penetration area.

These comments regarding concrete were reiterated to governorate engineers and technicians both on site and in the classroom. Governorate staff are now much more aware of the need for good structural practices, but the specifications need to be improved and better construction techniques need to be employed, both of which may result in cost increases that reflect minimum quality requirements.

Mechanical

Screens, drain plates, slide gates and frames. Construction materials (mild steel) was such that frequent replacement will be required.

Valve pits. Installation of valve pits was not always required. Because there was no need for concern about freezing, pipes and valves could be installed at grade level. Covers and frames were constructed of materials that will require frequent replacement and frames were mounted incorrectly.

Pipes material type and miters. Where steel pipe was used, miters were often poorly fabricated and welds were of poor quality. Pipe alignment was often below acceptable standards. Thrust blocks were typically constructed and installed in a manner below acceptable standards. (They were usually

constructed with masonry units and contained no reinforcing steel or fixation.)

Weirs. Construction materials (mild steel) were such that frequent replacement is required. Weirs were often improperly dimensioned and/or installed, or were the wrong type for the application.

Aerator support, clarifier and thickener mechanisms. With the exception of the extended aeration facilities, construction materials were such that frequent replacement will be required. The mounting steel for oxidation ditch aerator support bridges was not installed properly. Tie rods from the concrete support columns were inadequately installed.

Ladders. With the exception of the oxidation ditches and extended aeration facilities, construction materials were below acceptable standards. Typically, an inadequate gauge of steel was used. In all cases, improvements in location and layout are recommended.

Chlorine Feed Systems. Chlorine gas piping consisted of mixed metals and is inadequate. Chlorine feed systems are substandard and require modification.

Electrical

In general, the installation of electrical equipment was very poor. Control boxes and cabinets are not dust resistant and were not correctly specified. Likewise, lighting fixtures were specified incorrectly—domestic grade units were installed when industrial grade units were warranted.

Materials were one of the first issues addressed by technical assistance staff in 1988. The described problems were anticipated, but local consultants could not be persuaded to alter their operations. Emphasis has been placed on inferior materials specifications and details in the design and construction course given to local staff, and improvement has been noted regarding details for new projects. However, although adding cost to projects, the use of materials suitable for an aggressive environment will satisfy minimum quality requirements.

COLLECTION SYSTEMS

This section provides a detailed discussion of observations concerning the construction of collection systems in the pilot program. Collection system projects consist of gravity sewers, pump stations, and force mains.

Sewer projects generally complied with the contractor's original schedule except where lines were located along narrow streets or drain crossing areas, both of which resulted in significant project delays. However, overall, sewer inspection was inadequate. Compaction test record logs were not kept, pipe bedding material was inconsistently installed, and as-built information was not consistently recorded.

Gravity Sewers

Sewer installation

Sewer construction typically utilized the open cut method. In deeper excavations, trench shoring consisted of wooden planks and cross braces. Exceptionally deep excavations utilized a benching approach so that the structural capacity of the shoring was not exceeded. The degree to which proper shoring techniques were used varied from contractor to contractor. There was no observed use of trench boxes or jacking techniques.

One documented death was attributed to inadequate shoring. In defense of the contractor, the design drawings specified the location of the sewer adjacent to a drainage channel and did not include requirements for sheeting or for a dewatering system.

Construction of deep sewers in areas of high groundwater, narrow streets, and marginal building foundations resulted in continued concern for building settlement and created sewer installation difficulties. Alternative systems that require shallow sewers (and would require more than one pump station) are not considered to be economical by local consultants. Decreasing excavation depths and providing multiple stations may, however, provide a cost-effective alternative. Small-bore sewerage systems, although easier to construct, were not considered.

House connections

House connections were generally made by laying plumbing from the dwellings to a clean-out box, combining the outlet pipes from these boxes (usually three to four dwellings), and connecting them to a manhole. The manhole connection procedure involves chiseling out a hole in the manhole wall (coring machines were not available). These holes were usually oversized, and grouting procedures for penetrating pipe installation were marginal. Each manhole had approximately four of these pipe penetrations.

This a questionable practice for several reasons. First, the penetrations weaken the manhole wall. Even if this issue is ignored, however, a second problem is that if an individual needs to enter the manhole for inspection or rod placement because of a sewerage blockage, he is faced with inundation from multiple live connections. This is the main reason that

the practice of connecting to manholes has been abandoned in the sanitary engineering industry. Third, this practice requires frequent placement of manholes and duplicate pipe runs (house connection piping parallels the sewer), which adds to the overall project cost.

Vertical control

In general, detailed attention to benchmarks was lacking. Benchmarks are not typically well marked nor is a permanent benchmark installed. No records of control loops were observed. At the onset of construction a rough bench line was sometimes, but not always, run for vertical control. In one of the replication projects, the contractor assumed ground elevations to be accurate and set inverts by measuring down from ground level. The result was sewers too shallow for gravity drainage of house connections in the upper reaches of the system.

Pipe inverts were typically set using two vertical wooden tees and a string line. The tees were positioned with a level and pipe inverts were set by measuring down from the connecting string line.

To check vertical and horizontal alignment a pig was drawn through a line between manholes. If the pig cleared the length of line, the line was considered acceptable. Although this method confirms the absence of blockage in the line, it does not locate horizontal and vertical misalignment that can aggravate solids accumulation and increase cleaning requirements.

High groundwater conditions

In the delta, groundwater is usually present at depths of one meter or less. In addition, sewer lines often parallel drainage canals where water levels are near ground elevation. Dewatering for sewer lines in these areas typically relies on submersible pumps and earth bulwarks that isolate sections of open trench. Trench bottoms are often saturated with free-standing water and boiling conditions occasionally occur.

Placement of pipe under these conditions was not as exact as the standard installation practice utilizing sheeting and well point systems. Pipe settlement can be expected to occur under these conditions, especially since placement of bedding material and compaction were inconsistently performed. No records of compaction tests were observed.

Trench excavation

A large portion of trench excavation was done by hand, both because labor was relatively inexpensive and because most village areas lacked the space for excavation equipment to work effectively. A situation commonly associated with rural villages in the delta is the combination of narrow streets and buildings with shallow or practically nonexistent foundations. In areas where excavations were deep, building

settlement was a concern, especially in view of the commonly practiced shoring techniques.

In addition, the placement area for excavated material was often inadequate. Excavated material was mounded against buildings, making pedestrian access difficult and unsafe. The safety issue was compounded by the fact that relatively long lengths of trench often remained open for periods of up to four weeks. Although there were no known pedestrian injuries resulting from this practice, the wisdom of designing deep excavations in areas of narrow streets is a questionable construction practice.

Manholes

With their relatively expensive covers, manholes represent a significant portion of the capital cost of installing sewers. From a construction point of view, future projects should consider the use of chimneys. Chimneys allow the use of clean-out boxes; however, they require fewer manholes and less pipe for house connections.

One drawback to the use of chimneys is that the saddles for chimney connections are not manufactured in Egypt. If the manufacture of saddles is not feasible, a possible solution is to use tees, which are presently manufactured for PVC, VC, and AC pipe.

Manholes were typically cast in place using steel forms that measure approximately one meter in height. Concrete was mixed by hand and placed with buckets. No measures were taken to prevent segregation during placement and the concrete typically had a high slump or water to cement ratio. Rodding or vibration was not a usual practice.

Although precast manholes and clean-out boxes are manufactured in Egypt, they were not employed in the pilot program. Given the low labor costs associated with cast-in-place units, the use of precast units may not be considered cost effective from the contractor's point of view. However, from a life-cycle cost point of view, the use of precast units should be investigated because the quality control measures utilized in their manufacture yields a more durable product than cast-in-place units.

There are two other main advantages to using precast units. One is that they can be specified with all the required openings for house connections. A second advantage relates to a common phenomena in Egypt—the increase in street elevations over what can be considered relatively short periods of time. In some projects manholes are constructed with the cone section protruding one quarter to one third meter above the finish grade surface elevation to accommodate this occurrence. Increases in street elevations

eventually bring the manhole cover level to ground elevation.

However, as the street level continues to rise, it becomes necessary to excavate the cone section, chisel it off, and recast a new barrel section and cone. If precast units were used this process would be simplified as the cone section could be removed without demolition, and a new barrel section installed. Alternatively, donut rings could be added to the top of the cone.

The questionable construction techniques described in this section were a result of cost-saving attempts by designer and contractor. For example, house connections were the responsibility of the home owner and thus were not included in the design, which resulted in unorthodox connections. Local contractors were not familiar with and could not afford the more expensive equipment and techniques that would result in improved system quality and longevity.

Technical assistance concentrated on these issues with contractors and governorate personnel during on-site visits, but to date change has been slow. Until increased project costs that will allow for minimal product quality levels are accepted, the installation of conventional sewerage systems will suffer.

Pump Stations

Types of Pump Stations. Earlier pump stations were constructed according to standard NOPWASD designs. Two problems frequently associated with these stations are wet well maintenance and pump priming. The LD II-P contractor is currently working on remedial designs to address these issues. Later pump stations utilized submersible pumps, thereby eliminating the priming problem, although wet well maintenance remains a problem.

Civil issues. To avoid multiple low-depth stations, designers provided one deep station and specified the use of caissons for pump station construction. However, the preferred procedure associated with caisson construction was implemented in only one replicate project.

Proper caisson construction techniques utilize slip forms so that installation of reinforcing steel and form work can proceed at ground level and groundwater removal can proceed as the caisson is sunk. Caisson boots were employed for these projects, but the use of slip forming and groundwater lowering was not practiced. Typically, the contractor excavated to a depth where groundwater was encountered and the boot was set and poured. When the caisson structure was eventually sunk to its design level, the presence of groundwater negatively impacted the quality of work of the floor and grouting operation. Design documents

should stipulate dewatering requirements to protect overall construction quality.

Structural issues. As practiced, the caisson boot was set in place and reinforcing steel was erected to the entire height of the caisson wall. The form work was then constructed to the length of the standard lumber dimensions (four meters). One result of this practice was migration of the steel to either the outside or inside of the wall. Not only does this change the intended design characteristics of the structure, it also exacerbates steel corrosion as there is no protective concrete cover. The use of spacers to position the form and steel is not effective from a practical standpoint, as the amount of pressure from the misaligned steel against the forms makes effective placement of biscuits impossible.

Some caisson designs specified mild steel. Mild steel decreases the spacing so that the aggregate cannot fit between the resultant interstitial openings. This results in severe segregation of the concrete and excessive honey-combing. Projects for which high-strength steel was specified were less susceptible to segregation, but the occurrence of steel migration was not diminished. Future projects should use high strength steel to control aggregate size and the contractor should be required to provide on-site screens for classifying the stone. Waste stone can be used in the grouting mat beneath the bottom slab.

The use of slip forms would mitigate the steel migration problem. With these forms, the steel can be erected in controllable one-meter lengths. Steel forms do not have openings as does the wooden form work, thus cement paste does not migrate and honey-combing is essentially eliminated. Because the steel form allows the contractor to work unencumbered on pours of up to one meter in depth, control is easier to maintain and proper steel coverage is assured. Slip forms are smooth, resulting in a smooth final finish, which eliminates the requirement for plastering and reduces capital costs. The shallower pour allows the contractor better control for consolidating the concrete (using manual rodders or mechanical vibrators if available).

Also, unlike concrete pours using a wooden form, the one-meter depth of the slip form allows access by the contractor to the cold joint for placement of water stop, construction of a key way, and cleaning of the joint surface. Slip forms also allow the contractor to concurrently excavate and sink the caisson as the wall height is constructed to design requirements. This allows ground level access and eliminates the need for the extensive scaffolding that is typically used. Finally, the slip form enhances concrete curing, provided it is left in place for the appropriate time period.

As mentioned earlier, one replicate project did use steel slip forms. This demonstrates that such forms are available in-country and their mandatory use can be specified.

Other construction materials included steel used for hatch covers, ladders, and railings. In all cases, mild steel was used. The frame for hatch covers was usually not embedded in the concrete properly and will quickly break away from the surrounding slab. Grout was substandard and did not bond to the surrounding concrete. Frames, covers, ladders, and rails are subject to early corrosion. Rail support penetrations were typically too close to the edge of the slab with insufficient surrounding concrete.

While there appears to be no indication of imminent structural catastrophic failure at any of the projects, premature functional failure should be expected. First indications of functional failure are loss of adhesion of the plaster stucco, spalling of concrete where reinforcing steel is insufficiently covered, failure of patched honey-combing where the surface was not properly prepared, and corrosion of exposed reinforcing steel.

These issues have been continuously addressed by the TA contractor in the regular field trips and were discussed with consultants at the design stage. But it is difficult to encourage change to the normal practice of rural contractors without increasing the cost of the project. Specifications would have to be altered. Governorate engineers are fully aware of the problems, but are constrained in addressing the situation because of contract price limitations.

Mechanical issues. Mechanical concerns were chiefly related to materials selection. For example, screens and screen slide rails were of mild steel and subject to premature corrosion. Often a screen was not aligned with the pipe opening, which limits the effectiveness of the screen. Such problems are mainly attributable to lack of attention to detail or substandard craftsmanship. The sumps of the wet wells were not properly filleted as is the standard in design. As a result solids build up and extra cleaning is required.

Where steel pipe was used, pipe alignment and supports were not usually up to standard. Thrust blocks were often constructed of masonry with a mortar coating. No reinforcing steel was provided nor were the blocks structurally tied to the supporting slab. Because of the material used for the thrust blocks and the manner in which they were installed, they are essentially nonfunctional.

In many instances, wiring was left exposed at junction boxes. The junction boxes and lighting fixtures were often of

residential quality, unsuitable for wet well installations. Future projects should specify the use of moisture-proof wiring hardware and fixtures, at a minimum. Explosion proof hardware and fixtures would be preferable.

Ventilation in pump stations was provided with vent pipes. No fans or blowers were installed. Standards usually require a minimum amount of air change volume per hour and specify mechanical equipment to do this. Future projects should provide some means of positive air movement to minimize condensate build up.

In some situations, drawings and specifications differed on ventilation components. In each case the contractor installed the least expensive alternative.

Many of the problems were a result not only of low bids, but of consultants' lack of understanding of the design requirements and contractors' lack of understanding of installation procedures. TA can help make consultants more aware of required design elements and contractors more aware of installation procedures, but the actual application of such items is tied to a willingness and ability to pay for them.

Force mains

Deficiencies associated with force main construction were related primarily to horizontal alignment and backfilling.

Alignment installation problems occurred where the contractor did not keep a true trench and installed pipe with excessive joint deflection.

When force mains were backfilled they were often covered in their entirety (including joints) before testing. Since leaks are most probable at joints, the joints should be left exposed so that any leaks are easy to observe and repair. Once the pipe joints are covered, re-excavation is required to repair leaks.

The above procedures are standard in construction. Technical advisors continuously emphasized their importance, but had difficulty integrating these concepts into actual practice.

CONSTRUCTION OF WASTEWATER TREATMENT FACILITIES

The following section discusses specific construction problems at wastewater treatment facilities as it relates specifically to the technology used. Problems relating to more general items discussed in previous sections will not be reiterated.

Stabilization Ponds and Aerated Stabilization Ponds

Lagoons

Lagoons were not lined, and resulting seepage will tend to keep the surrounding area wet. This affected construction quality.

In the delta region, where the groundwater table is high, most of the lagoon bottoms are below the water table. This will present dewatering difficulties in the future when desludging is required. It also results in direct contact between sewage and groundwater—with resultant groundwater contamination. The extent of the contaminated groundwater plume is unknown and may not be of concern since groundwater in Damietta governorate is saline and not used for drinking or irrigation purposes.

Anaerobic ponds

Some anaerobic ponds have flooded. A hydraulic analysis conducted by the TA contractor personnel demonstrated that flooding could be eliminated by installing the effluent pipe as originally shown on the contract drawings. Inherent flaws in the design concept for flow distribution piping were observed in the construction phase. The prime example is the piping to the anaerobic ponds: the piping layout was specified and designed such that one pond always receives a higher flow and loading than the next.

Submerged Fixed Film Reactors (Aqualife Systems)

This section presents specific additional construction observations related to the submerged fixed film reactor technology for treatment facilities.

Roadways

The concrete roadway exhibited several settlement cracks that indicate substandard subgrade preparation. The wearing surface exhibited chalking and spalling conditions consistent with lack of proper curing, screeding, floating, and troweling.

Sludge drying beds

At one facility, the underdrain system for the sludge drying beds was installed below the groundwater table. This necessitated the remedial installation of a peripheral drainage system that is expected to require pumping to be effective.

Anaerobic tanks

The bottom of the anaerobic tanks were constructed with internal floating slabs. Because of this approach, there is no way to guarantee water tightness of the tanks.

Also, the bottom slab of the tanks was not screeded, floated or troweled, and aggregate was exposed. The slope of the bottom slab did not appear steep enough for the intended method of sludge removal.

Efflorescence was observed in several areas around the outside of the tanks. Leaks were observed in the common wall between the two tanks.

Oxidation Ditches

This section presents specific construction observations related to the oxidation ditch technology.

The oxidation ditches utilized earthen embankments. The degree of stability of these embankments, as constructed, was not determined by testing. However, embankment settlement and a shift in the pitching was observed. Eventual functional failure of the berms, as constructed, can be expected.

From a construction point of view, it would be better to increase the top of berm width to allow compatibility with appropriate compaction equipment (the current settlement is due to improper compaction). This is an issue of the designer not being familiar with construction techniques or equipment.

Contractors were advised to build the berms wide enough to accept a compactor at the final elevation and then to cut away the compacted material to the design dimensions. However, this would require approximately twice as much fill material as well as off-site disposal of spoil. Therefore, technical advice was ignored.

Packaged Extended Aeration Facilities (SOAF)

Overall these facilities appear to be of acceptable construction quality. The universal problems with hydraulics, concrete finishing practices, pipe penetrations, and piping flexibility were observed. However, remedial action to correct these deficiencies at the extended aeration facilities is not of the order of magnitude as with the other technologies.

APPENDIX G

Facility Performance and O&M Considerations for Eight Pilot Plants

WASTEWATER FACILITY SAMPLING SUMMARY

Village Name	WWTP Type			SP*1	SP*2	SP*3	SP*4	Min	Max	Avg	% Removal
MET EL KHOLY	EXTENDED AERATION (SOAF)	INFLUENT	BOD	450	386	607	431	386	607	469	
			TSS	487	395	856	426	395	856	541	
			%VSS	80	68	57	86	57	86	73	
		EFFLUENT	BOD	7.5	18	46	27	8	46	25	98%
			TSS	8.3	37	30	20	8	37	24	98%
			%VSS	88	73	44	80	44	88	71	
EL SERW	EXTENDED AERATION (SOAF)	INFLUENT	BOD	464	450	458		450	464	457	
			TSS	398	546	464		398	546	469	
			%VSS	76		78		76	78	77	
		EFFLUENT	BOD	15	32	22		18	32	24	96%
			TSS	11	55	69		11	69	45	97%
			%VSS	73	83			73	83	78	
KAFR SOLIMAN	EXTENDED AERATION (OX-DITCH)	INFLUENT	BOD	415	205	347		205	415	322	
			TSS	565	179	356		179	565	367	
			%VSS	75	63	64		63	75	67	
		EFFLUENT	BOD	26	26	58		26	58	37	94%
			TSS	48	32	70		32	70	50	92%
			%VSS	75	61	57		57	75	64	
KOM ELAKHDER	SFFR TYPE - 1	INFLUENT	BOD	312	328			312	328	320	
			TSS	256	354			256	354	305	
			%VSS								
		EFFLUENT	BOD	128	131			128	131	130	59%
			TSS	92	131			92	131	112	64%
			%VSS								
KAFR SAAD	SFFR TYPE -2	INFLUENT	BOD	488	419	305	425	305	488	409	
			TSS	488	428	294	449	294	488	415	
			%VSS	71	82	70	82	70	82	76	

SP	Sampling period
BOD mg/l	Five day biochemical oxygen demand, mg/l
TSS mg/l	Total suspended solids, mg/l
VSS	Volatile suspended solids, percent

SFFR TYPE -1 Submerged Fixel Film Reacto (without Anaerbic Prestage)

SFFR TYPE -2 Submerged Fixel Film Reacto (with Anaerbic Prestage)

WASTEWATER FACILITY SAMPLING SUMMARY

		EFFLUENT	BOD	132	64	26	77	26	132	75	73
			TSS	95	67	23	83	23	95	67	81
			%VSS	58	75	70	79	58	79	71	
BARSHA	SFFR TYPE - 2	INFLUENT	BOD	432	480	395		395	480	436	
			TSS	468	459	400		400	468	442	
			%VSS	83	79	80		79	83	81	% Removal
		EFFLUENT	BOD	21	33	36		21	36	30	95%
			TSS	13	33	36		13	36	27	97%
			%VSS	73	72	73		72	73	73	
DAQHALA	STAB. POND (W/AERATED FACULATIVE)	INFLUENT	BOD	350	353	498		350	498	400	
			TSS	362	280	480		280	480	374	
			%VSS	81	64	74		64	81	73	% Removal
		EFFLUENT	BOD	6	35	35		6	35	25	98%
			TSS	21	48	26.5		21	48	32	94%
			%VSS	76	75	70		70	76	74	
ADLIYA	STAB. POND	INFLUENT	BOD	445	254	404	379	254	445	371	
			TSS	232	354	316	342	232	354	311	
			%VSS	86	78	84	75	75	86	81	% Removal
		EFFLUENT	BOD	98	66	126	104	66	126	99	78%
			TSS	76	62	82	67	62	82	72	67%
			%VSS	96	74	82	80	74	96	83	

SP	Sampling period
BOD mg/l	Five day biochemical oxygen demand, mg/l
TSS mg/l	Total suspended solids, mg/l
VSS	Volatile suspended solids, percent

SFFR TYPE -1 Submerged Fixel Film Reactc (without Anaerbic Prestage)

SFFR TYPE -2 Submerged Fixel Film Reactc (with Anaerbic Prestage)

WASTEWATER FACILITY STAFFING COSTS SUMMARY / COMPARISON

Note: Average monthly staff salary including fringe is:	LE 200

	Staff Positions	SOAF 1100 M3/DAY		SOAF 860 M3/DAY		OX-DITCH 2500 M3/DAY		OX-DITCH 1230 M3/DAY		SFFB 1190 m3/day		Aerated Lagoon 630 M3/D		Stab. Pond 33m3/DAY	
	Wastewater Plant	# Desired	# Actual	# Desired	# Actual	# Desired	# Actual	# Desired	# Actual	# Desired	# Actual	# Desired	# Actual	# Desired	# Actual
W	Engineer/Senior Supervisor	1	1	1	1	1	1	1	0	1	1	1	1	1	0
W	Supervisor/Technician	1	1	1	1	1	1	1	1	0	1	0	1	0	0
W	Technicians/Operators	6	7	6	8	6	5	6	7	5	5	5	3	1	1
T	Labors	3	4	3	2	3	5	3	2	1	4	1	1	1	1
P	TOTAL WWTP STAFFING COSTS PER MONTH	LE 2,800	LE 2,800	LE 2,800	LE 2,400	LE 2,[illegible]	LE 2,400	LE 2,800	LE 2,000	LE 1,400	LE 2,800	LE 1,400	LE 1,200	LE 600	LE 400
	TOTAL WWTP STAFFING COSTS PER YEAR	LE 33,600	LE 31,200	LE 33,600	LE 28,800	LE 28,800	LE 28,800	LE 33,600	LE 24,000	LE 16,800	LE 33,600	LE 16,800	LE 14,400	LE 7,200	LE 4,800
	TOTAL WWTP STAFFING COSTS PER m3 FLOW	LE 0.07	LE 0.08	LE 0.13	LE 0.15	LE 0.03	LE 0.03	LE 0.06	LE 0.05	LE 0.04	LE 0.06	LE 0.07	LE 0.06	LE 0.06	LE 0.04
P	Sewage Pumping Station														
U	Supervisor/Technician	1	1	1	1	1	0	1	1	1	1	1	1	1	
M	Technicians/Operators	6	4	6	5	6	5	6	3	6	4	6	7	6	
P	Labors	2	3	2	2	2	1	2	1	2	3	2	1	2	
I	TOTAL P.S. STAFFING COSTS PER MONTH	LE 1,800	LE 1,800	LE 1,800	LE 1,600	LE 1,800	LE 1,200	LE 1,800	LE 1,000	LE 1,800	LE 1,800	LE 1,800	LE 1,800	LE 1,800	
N	TOTAL P.S. STAFFING COSTS PER YEAR	LE 21,600	LE 19,200	LE 21,600	LE 19,200	LE 21,600	LE 14,400	LE 21,600	LE 12,000	LE 21,600	LE 19,200	LE 21,600	LE 21,600	LE 21,600	
G	TOTAL P.S. STAFFING COSTS PER m3 FLOW	LE 0.05	LE 0.05	LE 0.11	LE 0.10	LE 0.02	LE 0.02	LE 0.05	LE 0.03	LE 0.05	LE 0.04	LE 0.10	LE 0.10	LE 0.16	
S	Sewage Collection Nets & Piping														
E	Supervisor/Technician	1	1	1	0	1	1	1	1	1	1	1	1	1	
W	Technicians/Operators	2	2	2	0	2	1	2	2	2	3	2	0	2	
E	Labors	4	4	4	3	4	6	4	4	4	6	4	6	4	
R	TOTAL COLL. SYS. STAFF COSTS PER MONTH	LE 1,400	LE 1,400	LE 1,400	LE 600	LE 1,400	LE 1,600	LE 1,400	LE 1,400	LE 1,400	LE 2,000	LE 1,400	LE 1,400	LE 1,400	
S	TOTAL COLL. SYS. STAFF COSTS PER YEAR	LE 16,800	LE 16,800	LE 16,800	LE 7,200	LE 16,800	LE 19,200	LE 16,800	LE 16,800	LE 16,800	LE 24,000	LE 16,800	LE 16,800	LE 16,800	
	TOTAL COLL. SYS. STAFF COSTS PER m3 FLOW	LE 0.04	LE 0.04	LE 0.06	LE 0.04	LE 0.02	LE 0.02	LE 0.04	LE 0.04	LE 0.04	LE 0.06	LE 0.07	LE 0.07	LE 0.14	
	FINAL TOTAL STAFFING COSTS PER MONTH	LE 5,400	LE 5,000	LE 5,400	LE 4,000	LE 5,400	LE 5,200	LE 5,400	LE 4,400	LE 4,000	LE 5,800	LE 4,600	LE 4,400	LE 3,000	
	FINAL TOTAL STAFFING COSTS PER YEAR	LE 64,800	LE 61,200	LE 64,800	LE 48,000	LE 64,800	LE 62,400	LE 64,800	LE 52,800	LE 48,000	LE 69,600	LE 55,200	LE 52,800	LE 36,000	
	FINAL TOTAL STAFFING COSTS PER m3 FLOW	LE 0.16	LE 0.17	LE 0.33	LE 0.28	LE 0.07	LE 0.07	LE 0.15	LE 0.12	LE 0.13	LE 0.16	LE 0.24	LE 0.23	LE 0.36	
	VILLAGE NAME:	El Roda		El Wastany		Kafer Batikh		Rahamana		Kafer Saad		Daquala		Adliya	

Common O&M Problems with Stabilization Pond WWT Facilities

Unit Process	Problems Effecting O&M	Short Term Solutions	Issues for replication (Long Term Solutions)
Sewage Pumping Station	1. Pump discharge rates exceed the capacity of the facility inlet works. 2. Existing horizontal pumps are very difficult to prime.	Control pump running cycles. Install pump priming assist devices.	Replace pumps with submersible type pumps. (Same as above)
Sewage Flows	1. Existing daily flows exceed the design capacity of the pond system.		
Bar Screen	Early corrosion of bar screen material.	Scrape clean and repaint.	Replace bar material with aluminum alloy or stainless
Anaerobic Ponds	1. Difficult to desludge.		
Final Effluent Disinfection (for aerated lagoon only)	1. Installed chlorine feed system (hypochlorite) is too crude and not appropriate for normal flows. 2. Chlorine solution day tank (jerry can) is too small. 3. Wiring and housing for the installed peristaltic pump is crudely installed. 4. No drain line for the chlorine contact tank.		

Common O&M Problems with Submerged Fixed Film Reactor WWT Facilities

UNIT PROCESS	PROBLEMS EFFECTING O&M	SHORT TERM	ISSUES FOR REPLICATION (LONG TERM SOLUTIONS)
Sewage Pumping Station	1. Pump discharge rates exceed the capacity of the facility inlet works	Control Pump running cycles	Replace pumps with submersible type pumps.
	2. Existing horizontal pumps are very difficult to prime	Install pump priming assist devices.	(same as item #1 above)
Bar Screen	Early corrosion of bar screen material	Scrape clean and repaint.	Replaces bar material with aluminium alloy or stainless.
Pretreatment Septic Tanks	1. Tank outlet piping small for existing peak flows.	Control Sewage pumping station flows.	Increase pipe size.
	2. Entrance configuration of the tank outlet pipe does not allow for good liquid/scum separation.	No easy solution	Design and construct straight weir and effluent trough accross tank width at the effluent end.

Common O&M Problems with Submerged Fixed Film Reactor WWT Facilities

	3. Removal of bottom sludge is impossible due to the undersized sludge pumps and flat floor bottom.	* Install bigger pump	Reconstruct tank floor with steep benching. Use hydraulic head to feed drying beds without need of pumps.
	4. No access walkway has been provided (safety problem).	Install safety handrails.	
Treatment Basin (including SFFR Unit)	1. No course screen was installed on the inlet of the recirculation pump.	* install this screen.	
	2. Early corrosion of plate settlers	Remove plate settlers	
	3. Difficult to desludge treatment basin. Large amounts of raw sludge and grit accumulate in the treatment basin (for facilities without septic tank pretreatment).	Remove fence section provide access for backhoe or clamshell.	Design & Construct septic tanks.
	4. Periodic repair of submersible type pumps exceeds village staff capabilities.	Contract this maintenance to the private sector.	
	5. Accumulation of floating scum in the corners of the basin.	Remove scum with poor screen.	
	6. High alga (SS) concentration in basin effluent.		No solution. Limitation of treatment process

Common O&M Problems with Submerged Fixed Film Reactor WWT Facilities

	7. Effluent weir too short. High hydraulic approach velocity.		Increase length of weir.
Sludge Drying beds	1. Incorrect and insufficient drying bed media has been installed.	Install correct media.	Use better design specs. and closer construction supervision.
	2. Bed underdrain piping is not sloped correctly.	Reinstall underdrain piping.	Same as above.
	3. Application of raw primary sludge to the drying beds creates heavy foul odors.	No solution without high capital costs.	Design and construct sludge digestion facilities.
Final Effluent Disinfection	1. Chlorine feed system (hypochlorite is too crude and not adequate for normal flow rates.		
	2. Chlorine solution day tank (jerry can) is too small.		
	3. Wiring and housing for the installed peristaltic pump is crudely installed.		
	4. No drain line for the chlorine contact tank.		

Common O&M Problems with Oxidation Ditch WWT Facilities

Unit Process	Problems Effecting O&M	Short Term Solutions	Issues for replication (Long Term Solutions)
Sewage Pumping Station	1. Pump discharge rates exceed the capacity of the facility inlet works.	Control pump running cycles.	Replace pumps with submersible type pumps.
	2. Existing horizontal, suction lift pumps are very difficult to prime.	Install pump priming assist devices.	(Same as above)
Bar Screen	1. Early corrosion of bar screen material and screenings drip shelf.	Scrape clean and repaint.	Replace bar material with aluminum alloy or stainless
	2. Too large of spacing between bars (downstream aerators are sensitive to suspended debris which clog bearing lubrication holes)	Install fine screens behind existing course screens.	

Common O&M Problems with Oxidation Ditch WWT Facilities

Unit Process	Problems Effecting O&M	Short Term Solutions	Issues for replication (Long Term Solutions)
Aeration Process	1. Early wear of aspirating aerator unit's lower sleeve bearing and propellers.	* Adjust aerator angle of inclination and depth of submergence to reduce grit scouring.	Future designs should specify aerators which have a better working history of non fouling bearings. (also see item # 2 above)
	2. Early and dangerous wear of the non-weatherproof electrical control cabinets.	Cancel these panels and use MCC disconnect switches only.	Future designs should avoid outside control panels.
	3. Basin effluent outlet piping undersized for peak flows.	Try to control P.S. flows better.	Future designs should size piping better.
	4. Excessive vibration of aerator bridge mounts.	Weld bridge mounts.	
	5. Significant accumulation of settled grit in aeration ditches.	No short-term solution.	Include grit/scum pretreatment.
	6. Missing basin drain lines and valves.	No short-term solution.	Include drain lines for tanks and basins.
	7. Operators do not run enough aerators at one time to maintain minimum D.O. levels in the	Need better operator supervision.	

Common O&M Problems with Oxidation Ditch WWT Facilities

Unit Process	Problems Effecting O&M	Short Term Solutions	Issues for replication (Long Term Solutions)
Aeration basins Con'd.	8. Leaking basin inlet flow isolation valves. Gates are also highly corroded.	Replace with proper slide gates.	Future designs should specify proper slide gates.
	9. For Kafer Batikh village, basin inlet piping is too small for design flows. Two 8-inch force mains (one for infl. and one for RAS) feed two 6-inch gravity lines serving the basins.	Control P.S. flows better.	Future designs should be more careful with sizing piping correctly.

Common O&M Problems with Oxidation Ditch WWT Facilities

Unit Process	Problems Effecting O&M	Short Term Solutions	Issues for replication (Long Term Solutions)
Sludge Settling Process	1. Missing surface rake arm.	Use hand skimmer.	In general, activated sludge type WWTPs should include surface rake arms, fiberglass adjustable sections of weir, and scum baffles (especially if primary treatment has been omitted).
	2. Missing scum baffle and v-notch weir.	No short term solution.	
	3. Existing straight edge weir is not balanced. Adjusting bolts (soft iron) are corroded. Weir is in one piece.	*Instruct contractor to adjust this weir.	
	4. Tank inlet flow baffle (galvanized iron) shows signs of early wear and sever corrosion.	Replace with a fiberglass flow baffle.	Design should specify better materials.
	5. Bottom sludge scraper mechanism shows signs of early wear and sever corrosion.	Scrape and repaint.	Design should specify better materials.
	6. Missing high torque cut-out switch.	Install this switch.	High torque cut-out switches should be included in all designs.

Common O&M Problems with Oxidation Ditch WWT Facilities

Unit Process	Problems Effecting O&M	Short Term Solutions	Issues for replication (Long Term Solutions)
Return Sludge Pumping System	1. Difficult to control RAS withdrawal rate (gate valve control)	Install plug valves	Install telescoping valve and wetwell system.
	2. Wetwell overflow occurs during power failures.	Close RAS isolation valve during power failures.	(same as item # 1 above)
Sludge Thickening Process	1. Inlet flow pipe has been installed below the water level allowing a siphon to develop which begins to drain the tank.	* Cut this pipe above the water line or add elbow to extend pipe above water surface.	
	2. Inlet pipe has been installed without a surrounding flow distribution baffle.	* Install this flow baffle.	

Common O&M Problems with Oxidation Ditch WWT Facilities

Unit Process	Problems Effecting O&M	Short Term Solutions	Issues for replication (Long Term Solutions)
Sludge Drying beds	1. Incorrect and insufficient drying bed media has been installed.	Install proper media and at the required depth.	Use better design specs. and construction supervision in future WWT plants.
	2. Bed underdrain piping is not sloped correctly.	Reinstall this underdrain piping.	(Same as item # 1 above)
	3. Missing underdrain pipe end caps.	* Install pipe end caps.	
	4. Failure of village staff to empty the drying beds in a timely way.	* Improve WWTP operations management.	
	5. Insufficient drying bed area provided (.05-.08 m2 per capita only) problem especially during wet season.	Construct add'l drying bed area.	Use at least .09 m2/capita for drying bed area in future designs.
	6. Structural failure of drying bed's retaining walls and sludge feed channel.	Rebuild walls. Install plastic pipe in place of open sludge feed channel.	Future designs should <u>not</u> call for brick construction of sludge beds.

Common O&M Problems with Oxidation Ditch WWT Facilities

Unit Process	Problems Effecting O&M	Short Term Solutions	Issues for replication (Long Term Solutions)
	7. Bed's filtrate drain is connected to the same manhole as the thickener overflow piping. This manhole becomes surcharged and floods the drying beds.	Install separate drain line and manhole for the thickener overflow.	
Final Effluent Disinfection (Chlorine feed system)	1. Installation of improper chlorine gas piping (galvanized iron).	Replace with proper piping.	
	2. Undersized safety exhaust fans in chlorine room (simple kitchen exhaust type fans have been installed).	Replace with industrial type exhaust fans sized for the room dimensions.	
	3. Installation of cartridge type water pre-filter on chlorine dilution water supply (not suited for this application).	Remove this filter. Existing in-line Y-strainers are adequate.	
	2. Difficult to control chlorine feed rate (Manual only) with fluctuating flow rates.		
	3. No chlorine handling safety equipment has been provided. No room exhaust fans.		
	4. Short supply of chlorine gas in the market		

Common O&M Problems with Package (SOAF) Extended Aeration WWT Facilities

Unit Process	Problems Effecting O&M	Short Term Solutions	Issues for replication (Long Term Solutions)
Sewage Pumping Station	1. Pump discharge rates exceed the capacity of the facility inlet works.	Control pump running cycles.	Replace pumps with submersible type pumps. (Same as above)
	2. Existing horizontal pumps are very difficult to prime.	Install pump priming assist devices.	
SOAF Bar Screen	1. Bar screen unit requires realitively difficult maintenance and adjustment (mechanical and electrical).	If major breakdown occures in the future do not replace or repair. Use Manual mode of operation instead.	* Future WWTP designs should not include mechanical bar screens for village systems.
SOAF Grit/ Scum separation tank	1. Scum beach plate bar spacings are too close together.	Remove every other bar.	
	2. Grit pump and air pump (submersible type) require a special workshop for periodic repairs.	Contract this maintenance with a specialty workshop.	Submersible pumps should only be purchased from suppliers who also provide maintenance services.
	3. High torque limit switch has not been provided.	Install this switch.	All tank drives should include high torque limit switches.
	4. Process can not handle existing peak flows.	Control P.S. pumping cycles better.	Package type WWT plants need influent flow surge tanks to help handle peak flows.

Common O&M Problems with Package (SOAF) Extended Aeration WWT Facilities

Unit Process	Problems Effecting O&M	Short Term Solutions	Issues for replication (Long Term Solutions)
SOAF Aeration Process	1. Thickener supernatant return line discharges at mid point and effluent end of one aeration basin.	Extend piping to influent end of the aeration tanks.	Need better design review.
	2. Aerator drive gear oil seal damage.	Replace damaged seals.	
	3. Aerator splash protection needs improvement.	Install plastic covers.	
	4. Basin outlet piping restricts peak flows.	Control P.S. flows better.	Use higher per capita WW flow value in future designs.
	5. Frequent Start/Stop operation of aerator units (48 ON/OFF cycles per day).	* Operate aerators in MANUAL mode. Control ON/OFF based on dissolved oxygen levels.	No not include automatic controls for aeration systems in future designs.
	6. Basin inlet flow isolation slide gates leak.	Repair these gate's installation	Need beter construction supervision.
	7. Aerator units are oversized for design flows.	(Same as item # 5 above)	Need better design review.

Common O&M Problems with Package (SOAF) Extended Aeration WWT Facilities

Unit Process	Problems Effecting O&M	Short Term Solutions	Issues for replication (Long Term Solutions)
SOAF Sludge settling/clarification process	1. Short clarifier sidewall depths. Sludge blankets are easiely disturbed by hydraulic fluctuations.	* Maintain minimum sludge blankets. Control P.S. flows. Turn RAS OFF during peak flows.	Future designs should require sidewall depths of 3-4 meters minimum.
	2. No flow isolation valves between clarifier bottom sludge pipe and RAS wetwell.	Install these valves.	Isolation valves should be included on all inter-connecting piping between tanks.
	3. No interconnection piping/valves between the two clarifier units.	Install this piping and valves.	(same as item # 2 above)
	4. No high torque cut-out switch installed.	Install this cut-out switch.	High torque shutdown controls should be required on all tank drive units.
	5. High surface overflow rate (greater than 32 m3/m2/day) during peak flows with RAS pump running.	(Same as item # 1 above)	Future designs should antisipate super peak flows from villages.
	6. Clarifier launder outlet piping restricts flow and floods weirs during daily peak	Control P.S. flows better.	(Same as item # 5 above)

Common O&M Problems with Package (SOAF) Extended Aeration WWT Facilities

Unit Process	Problems Effecting O&M	Short Term Solutions	Issues for replication (Long Term Solutions)
	7. Bottom sludge scraper early and excessive wear of concrete tank floor (deep groves).	Chip away bad area of floor and place concrete repair material.	Use better concrete specification and better construction supervision in future WWT plants.
SOAF Return Sludge Pump System (RAS)	1. Difficult access to screw pump bottom bearing for maintenance and inspection.	(No short-term solution)	Use centrifical pumps in future designs.
	2. RAS flow overflows back into wetwell during peak flow periods.	* Turn RAS pumps OFF during peak flow periods.	(Note: existing flows are above design limits)
	3. RAS wetwell flow isolation valves have not been provided.	Install these valves.	Isolation valves should be included on all inter-connecting piping between tanks.
Sludge Holding & Thickening Process	1. Unadjustable (fixed in place) piping for supernatant withdrawal.	Install adjustable sludge withdrawl (goose neck piping or multiple fixed ports.	Use conventional sludge thickeners in future WWT plant designs (as used in the oxidation ditches).

Common O&M Problems with Package (SOAF) Extended Aeration WWT Facilities

Unit Process	Problems Effecting O&M	Short Term Solutions	Issues for replication (Long Term Solutions)
SOAF Sludge Drying beds	1. Incorrect and insufficient drying bed media has been installed.	Install proper media and at the equired depth.	Use better design specs. and construction supervision in future WWT plants.
	2. Bed underdrain piping is not sloped correctly.	Reinstall this underdrain piping.	(Same as item # 1 above)
	3. Missing underdrain pipe end caps.	* Install pipe end caps.	
	4. Failure of village staff to empty the drying beds in a timely way.	* Improve WWTP operations management.	
	5. Insufficient (.02 m2/capita) amount of drying bed area provided (especially during wet season).	Construct add'l drying bed area.	Use at least .09 m2/capita for drying bed area in future designs.
SOAF Chlorine feed system	1. Failure of chlorine injection water pump.	Do not try to add chlorine at this time.	
	2. Difficult Auto control of chlorine feed.	Operate in MANUAL mode.	
	3. No chlorine handling safety equipment has been provided. No room exhaust fans.	* Order and purchase this equipment.	
	4. Short supply of chlorine gas in the market.		