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LIFE Integrated Water Resources Management
Task Order No. 802
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Task 6: Improving Water Reuse Practices

Environmental Monitoring Plan

Report No. 22

November 2005

International Resources Group
In association with EPIQ II Consortium

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Prepared by ECODIT, Inc.

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Acknowledgements

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Acronyms and Abbreviations

AAU	Agricultural Administrative Unit
AED	Academy for Educational Development (a US-based entity providing USAID-funded assistance regarding environmental education and awareness)
APRP	Agricultural Policy Reform Program
BCWUA	Branch Canal Water User Association
BOD	Biological Oxygen Demand
CAD	Computer aided design
CD	Central Directorate
CDA	Community Development Association
CLAC	Central Lab for Agricultural Climate
CLEQM	Central Laboratory for Environmental Quality Monitoring (MWRI)
COD	Chemical oxygen demand
CTO	Cognizant Technical Officer (the USAID person responsible for supervising a technical assistance contractor)
CY	Calendar Year
DAI	Development Alternatives, Inc. (a Washington DC-based consulting firm working with IRG to implement the project)
EEAA	Egyptian Environmental Affairs Agency
EEPP	Egyptian Environmental Policy Program (a USAID-funded program aimed at achieving environmental policy reform)
EMP	Environmental Monitoring Plan
EPADP	Egyptian Public Authority for Drainage Projects (MWRI)
EPIQ	Environmental Policy and Institutional Strengthening Indefinite Quantity Contract
ET	Evapotranspiration
FC	Field Capacity
GB	Gigabyte
GIS	Geographic Information System
GOE	Government of Egypt
GPS	Global Positioning System
GW	Groundwater
GWS	Groundwater Sector
HD	(Aswan) High Dam
IAS	Irrigation Advisory Service
IBRD	International Bank for Reconstruction and Development or World Bank
ID	Irrigation Department
IDS	Irrigation and Drainage System
IIIMP	Integrated Irrigation Improvement and Management Project
IIP	Irrigation Improvement Project

IRG	International Resources Group (a Washington DC-based consulting firm that is prime contractor for the IWRMP)
IRMU	Integrated Water Management Unit
IRs	Intermediate Results
IRU	MWRI Institutional Reform Unit
IS	Information Systems
IT	Information Technology
IWMD	Integrated Water Management District
IWMU	Integrated Water Management Unit (A unit of MWRI)
IWRM	Integrated Water Resources Management
IWRMP	Integrated Water Resource Management Project
jpg, jpeg	Joint Photographic Expert Group (computing)
KB	Kilobyte
LAN	Local Area Network
LIFE	Livelihood and Income from the Environment (project)
LOE	Level of Effort
M&E	Monitoring and Evaluation
MALR	Ministry of Agriculture and Land Reclamation
MED	MWRI Mechanical & Electrical Department
mg/l	milligrams per liter
MIC	MWRI Ministry Information Center
MISD	Matching Irrigation Supply and Demand
MOE	Ministry of Education
MOH	Ministry of Health
MOU	Memorandum of Understanding
MSEA	Ministry of Sate for Environmental Affairs
MWH	Montgomery Watson Harza
MWRI	Ministry of Water Resources and Irrigation
NASA	(United States) National Aeronautics and Space Administration
NGO	Non-governmental Organization
NSCE	North South Consultants Exchange
NWRC	(MWRI) National Water Research Center
O&M	Operation and Maintenance
OJT	On-the-Job Training
PC	Personal Computer
pH	Potential of Hydrogen ions (measure of acidity or alkalinity)
PM&E	Performance Monitoring and Evaluation
ppm	Parts per Million
PWP	Permanent Wilting Point
RSC/WP	Red Sea Coastal/Water Project (short name for USAID-funded Red Sea Coastal and Improved Water Resource Management Project)
RWS	Relative Water Supply
SIRs	Sub-Intermediate Results
SOs	Strategic Objectives
SS	Suspended Solids
STTA	Short-term Technical Assistance
SWERI	Soils, Water, and Environment Research Institute (MALR)
TA	Technical assistance

TDS	Total Dissolved Solids
TOR	Terms of Reference
TRG	Training Resources Group
TS	Transition State (chemical)
TSS	Total Suspended Solids
TWW	Treated Wastewater
UPS	Uninterruptible Power Supply Device
USAID	United States Agency for International Development
USB	Universal Serial Bus (computing)
WCU	MWRI Water Communication Unit
WDC	MWRI Central Water Distribution Center
WPRP	Water Resources Results Package
WQU	MWRI Water Quality Unit
WUA	Water User Association
WWTP	Wastewater Treatment Plant

Executive Summary

Egypt has been using treated wastewater to produce wood and other industrial products since the early 1990s. The Ministry of Agriculture and Land Reclamation (MALR) has established 23 water-reuse projects across the country, including one in Luxor where they grow African Mahogany (*Khaya senegalensis*), mulberry (*Morus spp*), and Physic Nut (*Jatropha curcas*). So far, these projects have been exclusively government driven and private sector participation is absent. An inter-ministerial committee recently approved the Egyptian Water Reuse Code and the Ministerial Decree was issued in April 2005.

Task 6 under the Integrated Water Resources Management (IWRM) Project will demonstrate the technical feasibility of water reuse in a manner that is environmentally safe and compliant. In particular, the project will manage a 10-feddan water reuse site in Luxor, near the new wastewater treatment plant. The site will receive treated wastewater from the nearest maturation pond and grow a number of commercial crops including jojoba, jatropha, sorghum, flax, cut flowers, and ornamental plants.

This report presents an Environmental Monitoring Plan (EMP) made up of five monitoring groups:

1. Treated wastewater (physical, chemical and biological parameters)
2. Soil
3. Groundwater
4. Crops
5. Health and safety.

For each monitoring groups, the plan defines monitoring parameters, frequency, responsibility, and laboratory. Treated wastewater and groundwater will be tested at the Central Laboratory for Environmental Quality Management (CLEQM); soil and crops will be tested at the Soil, Water, Environmental Resources Institute (SWERI).

The EMP proposes six measures to reduce occupational hazards associated with reused water, including training, information/warning signs, pre-employment medical check-up and vaccination, protective clothing, and record keeping. These measures are critical to project sustainability and replication.

The report also reviews pertinent sections of the Egyptian Water Reuse Code as they relate to the Luxor demonstration site and describes the baseline environment

including soil and water quality. Water test results were compliant across all parameters except chemical oxygen demand (COD) and total suspended solids (TSS). Soil tests showed moderate alkalinity (pH about 8.4) and a sandy to loamy-sand soil type (more than 90 percent sand).

To complete the baseline, the project will collect and analyze groundwater samples from three ground water wells, one is inside the demonstration site and the other are surrounding the site, during Quarter 1 of Year 2. The project will use the one inside the site to serve as observation well. Finally, the baseline biodiversity assessment will be conducted in coordination with the biodiversity unit at the Egyptian Environmental Affairs Agency (EEAA).

1. Introduction

Background

Egypt has been using treated wastewater to produce wood and other industrial products since the early 1990s. The MALR and the MSEA have established 24 water-reuse projects across the country including one in Luxor where they grow African mahogany (Khaya senegalensis), mulberry (Morus spp), and physic nut (Jatropha curcas). So far, these projects have been exclusively government driven and private sector participation is absent. An inter-ministerial committee approved the Egyptian Water Reuse Code (Ministerial Decree No. 171/2005) in April 2005.

Task 6 under the IWRM Project will demonstrate the technical feasibility of water reuse in a manner that is environmentally safe and compliant. In particular, the project will manage a 10-feddan water reuse site in Luxor, near the new wastewater treatment plant. The site will receive treated wastewater from the nearest maturation pond and grow a number of commercial crops including jojoba, jatropha, sorghum, flax, cut flowers, and ornamental plants.

Purpose

The purpose of this report is to identify and outline the environmental monitoring requirements related to the water reuse demonstration site in Luxor. These monitoring requirements aim to help the project team assess the environmental performance of the demonstration site and prevent adverse impacts on the local environment.

Methodology

To prepare this report, the project team:

- Reviewed the Water Reuse Code to determine which monitoring groups and parameters would be relevant to the demonstration site.
- Conducted several site visits to Luxor to become familiar with the site characteristics, sources of pressure, and state of the environment in general.

- Collected soil, wastewater, and groundwater samples for analysis at the MWRI central lab in Cairo and received test results from the local laboratory at the treatment plant.
- Consulted with MSEA, MWRI, and MARL staff to discuss opportunities and constraints for environmental monitoring and to seek advice regarding the baseline assessment.
- Presented and discussed a draft version of the EMP with senior representatives from MSEA, MALR, MWRI, presenting key findings and recommendations. The minutes of that meeting are contained in appendix A.

Report Organization

This report is organized into five chapters:

1. Introduction
2. Review of the Egyptian Water Reuse Code
3. Baseline Assessment
4. Monitoring Requirements
5. Reporting Requirements
6. Three appendices:
   A. Minutes of Coordination Meeting at EEAA (27/09/2005)
   B. Classification of Plants and Crops Irrigated with Treated Wastewater
   C. Baseline Test Results

2. Review of the Egyptian Water Reuse Code

The proposed EMP was based on the Egyptian Water Reuse Code. The Code outlines monitoring requirements in relation to water reuse and divides monitoring parameters into four groups:

1. Group 1: Physical and chemical tests for treated wastewater
2. Group 2: Bacteriological tests for treated wastewater
3. Group 3: Soil, plants, and groundwater
4. Group 4: Medical check-up

The Code stipulates two levels of monitoring:

1. Self-monitoring, conducted by the agency responsible for the reuse site
2. Inspection, conducted by the relevant agencies including the Ministry of Health (MOH).

The following sections describe in more details key articles of the Code, relevant to the EMP.

Article 4: Treated Wastewater

The Code classifies treated wastewater (TWW) into three grades (denoted A, B and C) depending on the level of treatment:

1. “A” is advanced
2. “B” is secondary
3. “C” is preliminary.

The Luxor demonstration site has been designed to meet Grade B requirements. For each grade, the Code defines limit values for biological oxygen demand (BOD), suspended solids (SS) and fecal coliform (see table 1). The Code also defines limit values for other chemical parameters (including total dissolved solids [TDS]) in two groups:

1. Long-term use (reusing water for an unlimited period and on any soil type)
2. Short-term use (reusing water for a period not exceeding 20 years).

Limit values for long and short-term use are the same for all three grades (see table 2). At the 27/09/2005 coordination meeting at EEAA, all project stakeholders agreed to adopt the limit values for short-term use.

Table 1 Limit Values for Treated Municipal Wastewater Reused in Agriculture (mg/l)

Treatment Grade Requirements		A	B	C
Effluent limit values for BOD and SS	BODs	< 20	< 60	< 400
	SS	< 20	< 50	< 250
Effluent limit value for fecal coliform and Nematode cells or eggs (per liter)	Fecal coliform count [(2)] in 100 cm^3	< 1000	< 5000	Unspecified
	Count of Nematode cells or eggs per liter	< 1	< 1	Unspecified

Table 2 Chemical Limit Values for Treated Municipal Wastewater Reused in Agriculture

Component	Long term use [(1)] Maximum Concentration Mg/liter	Short-term use [(2)] Maximum Concentration Mg/liter
Al	5.00	20.0
As	0.10	2.0
Be	0.10	0.5
Cu	0.20	5.0
F	1.50	15.0
Fe	5.00	20.0
Li	2.25	2.5
Mn	0.20	10.0
Ni	0.20	2.0
Pb	5.00	10.0
Se	0.02	0.02
Cd	0.01	0.05
Zn	5.00	10.00
Cr	0.10	1.00
Hg	0.002	0.002
V	0.05	1.00
Co	0.05	5.00
B	1.0	2.0
M o	0.01	0.05
Phenol	0.002	0.002
TDS	2000	2000
Total PO_4	30	30
Cl Ions	400	400

Component	Long term use (1) Maximum Concentration Mg/liter	Short-term use (2) Maximum Concentration Mg/liter
SO4 Ions	500	500
HCO_3	400	400
Sodium Adsorption Rate	6-9	6-9
Sodium Cation (Na)	230	230
Mg Cations	100	100
Calcium Cations	230	230

Article 5: Water Reuse Crops

The Code bans the use of treated wastewater in the production of:

- Vegetables, whether eaten raw or cooked
- Fruits that are eaten raw and have no epicarp (rind or peel) such as grapes and guavas
- Export-oriented crops such as cotton, rice, onions, potatoes, medicinal and aromatic plants, and citrus.
- Other strategic crops may be added in the future.

The Code defines water reuse crops according to the treatment level (Grade A, B and C). The Luxor demonstration site has selected crops listed or compliant with Grade B, including jatropha, jojoba, flax, sorghum, cut flowers, and ornamental plants. Appendix B presents the full list of reuse crops divided by treatment level.

Article 6: Irrigation Methods for Reuse Crops

According to the Code, the following irrigation methods are permitted when using treated wastewater:

- Flood irrigation (furrow irrigation), wetting almost all the soil surface
- Basin irrigation, using irrigation pipes to deliver water to the basins
- Strip irrigation, where water covers only part of the soil surface
- Drip irrigation, which ensures the least contact of the treated municipal wastewater with the irrigated plants and the agricultural laborers
- Sub-surface irrigation, which minimizes contact with the treated municipal wastewater used in irrigation
- Pressurized irrigation, which is controlled by valves regulating the flow of treated municipal wastewater.
- Pop-up sprinklers, characterized by low pressure and high discharge at an angle of 11° with the horizontal plane.

The Luxor demonstration site will be using “spaghetti” lines, a form of drip irrigation or drippers. Compared to conventional drip irrigation that uses pressure-regulated nozzles, discharge from spaghetti lines is not affected by pressure; this results in lower coefficients of uniformity of distribution and higher incidence of standing water (see figures 1 and 2). For drip irrigation methods, the Code stipulates:

1. Adequate on-farm training for good system operation
2. Measures to reduce clogging (nozzles and pipes)
3. Measures to eliminate salt build-up.

Figure 1 Close-up of Spaghetti Line on Lateral

Figure 2 Standing Water in Plantations Irrigated with Spaghetti Lines

Article 7: Occupational Health and Safety

The Code describes health and safety measures to reduce public hazards related to water reuse in agriculture and recognizes five target groups:

1. Farm workers
2. Harvesters and processors (workers)
3. Consumers
4. Public and other users of open spaces and gardens
5. Passers-by and residents who live near the reuse sites.

The target groups in Luxor are (1), (2) and (3). The treated wastewater is not used to irrigate public gardens and the demonstration site is too remote to represent a risk to passers-by or local residents. The Code has defined mandatory safety measures for farm workers and harvesters. It is recommended to be particularly vigilant on health and safety issues in the production of cut flowers because they require extensive management and care during growth that will inevitably increase worker exposure to treated wastewater.

3. Baseline Assessment

To properly implement an environmental monitoring activity, a baseline assessment must be made of the environment as it exists. The project team collected most of the baseline data (including soil and wastewater quality) but residual data (such as groundwater and biodiversity) will need to be collected and presented as part of the first progress report on environmental monitoring.

Site Description

The selected site covers 10 feddans. It is adjacent to the wastewater treatment plant maturation ponds. Several important features are located within a 1-km radius from the site, including vast jatropha plantations, at least three private wells (figure 3), kaya plantations, and other units of the treatment plant, including facultative ponds and sludge drying beds. The site proper has never been cultivated and slopes gently to the east (see figures 4, 5, and 6).

Figure 3 Production Well about 500 m South of Demonstration Site

Figure 4 Demonstration Site Looking East (dike structure in the foreground)

Figure 5 Demonstration Site Looking South (Kaya plantation in the background)

Treated Wastewater

The quality of the treated wastewater in the maturation (and polishing) lagoons is reportedly high in comparison to the treated wastewater in the old plant, or the mixed water. The wastewater treatment plant (WWTP) environmental laboratory conducts routine sampling and analysis of the influent and effluent water, including effluent from the aeration and maturation ponds in the new plant. Standard tests include pH, alkalinity, TSS, total dissolved solids (TDS), transition state (TS), BOD, coliform, and Chlorophyll A. Table 3 presents a selection of test results for effluent water quality during summer and winter, provided by the WWTP lab.

Figure 6 General Map of the Demonstration Site and Surrounding Features

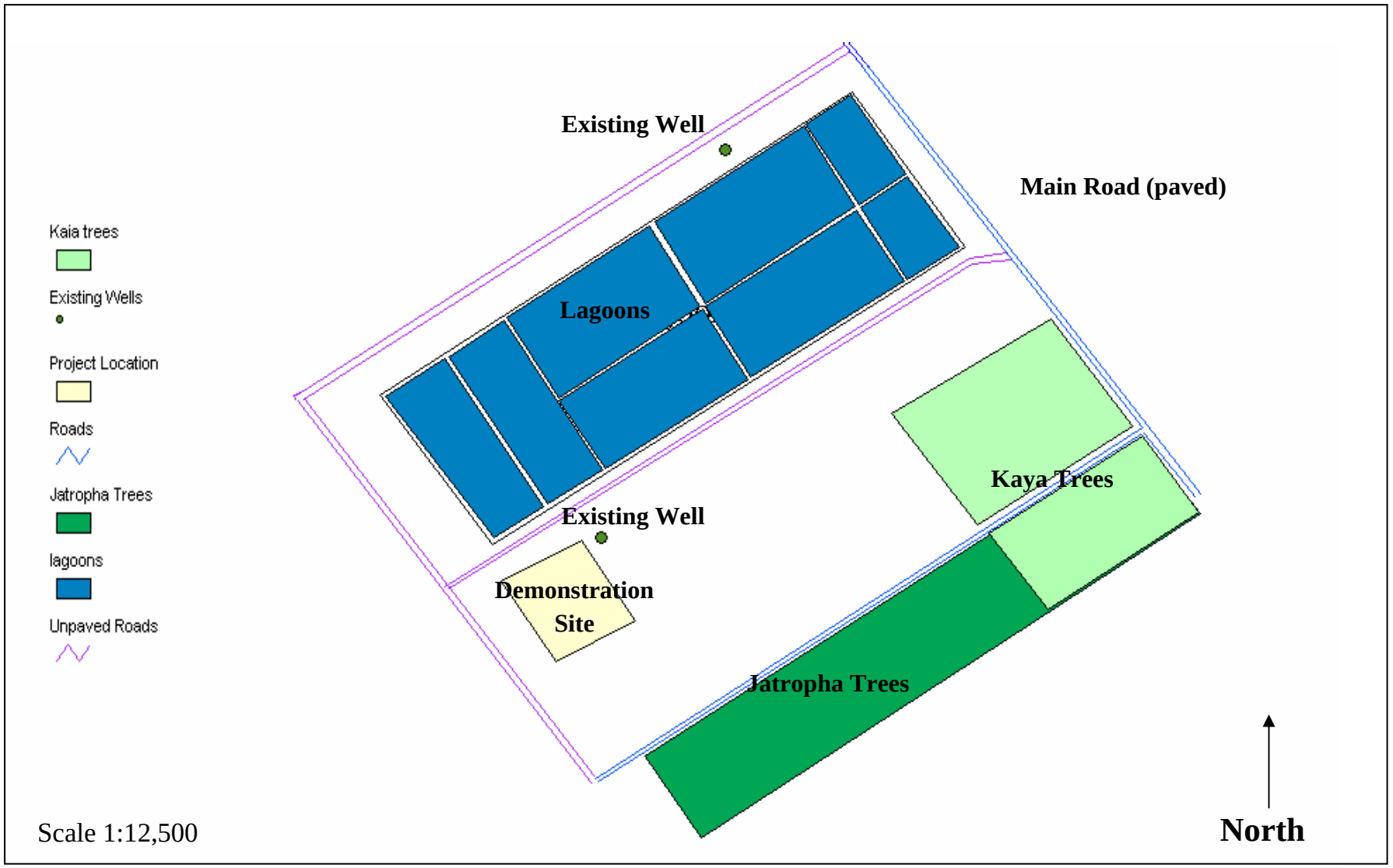

Table 3 Selection of Monthly Average Effluent Test Results in Luxor

Month	PH	Alkalinity (mg/l)	TSS (mg/l)	TS (mg/l)	BOD_5 (mg/l)	Total Coliform (mg/l)	Chlorophyll A (mg/l)
Dec 2003	8.0	NA	22	502	22	18,792	0.120
Jun 2004	8.4	NA	35	552	37	1,482	0.390
Sep 2004	8.2	238	37	579	33	3,838	0.225
Oct 2004	8.1	239	36	555	29	2,092	0.188

Source: Data provided by Luxor laboratory to LIFE Project Team, Nov 2004

To determine the quality of the effluent that will be used in the project, the WWTP laboratory agreed to collect and analyze samples from the candidate lagoon over a period of 7 days. Those test results are summarized in Table 4.

Table 4 Effluent Test Results from Lagoon over a 1-Week Period

	Temp	pH	BOD	COD	DO	TDS	TSS	Coliform Count
Day 1	30	7.8	25	31	7.5	454	30	2,400
Day 2	31	8.05	28	40	8.3	486	32	3,000
Day 3	30	8	25	31	6.2	476	28	3,000
Day 4	30	8.5	28	31	8	450	25	3,400
Day 5	30	8.5	23	31	7.9	466	30	3,500
Average	**30.2**	**8.17**	**25.8**	**32.8**	**7.58**	**466.4**	**29**	**3,060**
Std*	35	6-9	60	80	>4	2000	50	5,000

* Egyptian Water Reuse Code (Grade B)
Source: Data provided by Luxor laboratory to LIFE Project Team, September 2005

To verify the Luxor test results, the project team collected two treated wastewater samples from the lagoons on 26/09/2005 and sent them to the CLEQM laboratory in Cairo for complete analysis. Appendix C presents the CLEQM test results. TSS and COD were slightly above the corresponding standard; and BOD was higher compared to the test results in Luxor, but compliant. Heavy metals concentrations were all below their limit values.

Soil Quality

The project team collected 24 soil samples from eight locations inside the demonstration site and from three different depths (0–30, 30–60, and 60–90). The samples were analyzed at the MARL lab in Cairo: physical tests were conducted on all 24 samples (8 locations) and chemical tests were conducted on 9 samples (3 locations).[1] Physical tests include particle size distribution (to determine texture), and chemical tests including pH, electrical conductivity, anions and cations, $CaCO_3$, organic matter, and macro and micro nutrients. The test results are presented in appendix C and summarized below:

- Alkalinity: high, pH ranges from 8.05–8.45
- Electrical Conductivity: moderate, EC ranges from 3.5–7.4 dS/m
- Organic matter: very low (expected), OM ranges from 0.03–0.53 percent
- Texture: ranges from loamy sand to sandy (>90 percent sand).

Groundwater

Many factors can lead to groundwater contamination from water reuse. It is therefore important to assess groundwater vulnerability prior to application of treated wastewater. It is recommended that his assessment cover:

- Overview of local geology
- Soil profile and rate of infiltration in root zone (1-m)
- Depth to water table
- Direction of groundwater flow
- Hydraulic conductivity
- Groundwater quality.

Based on observations from nearby production wells, the depth to water table is about 18–20 meters. Nitrate (NO_3) tests conducted on-site using a nitrate meter (as shown in figure 7) showed very low nitrate values in the 5–15 parts per million (ppm) range.

On 28/02/2005, the project team collected a groundwater sample from a 20-meter deep (production) well located 1-km west of the demonstration site, near the forested area. The sample was analyzed at CLEQM at the MWRI. Test results indicated no contamination (test results are presented in appendix C). It is recommended that more extensive groundwater tests be conducted to establish a firm and representative baseline.

[1] Ministry of Agriculture/Agricultural Research Centre/Soils, Water & Environment Research Institute (SWERI)/Unit of Analysis & Studies. Giza, Cairo.

Figure 7 Nitrate Tester Used in Luxor for Baseline Assessment

Recommendation—The project team will collect groundwater samples from three observation wells. One of them will be built inside the demonstration site. The Groundwater specialist on LIFE will determine the most suitable location to drill the well based on available hydrological data, including depth to water table, groundwater flow direction and geological profile.[2] The other two observation well are out side the site and the three wells has triangle location shape.

Biodiversity

Although plant cover is scarce in open deserts, desert ecosystems can host significant biodiversity in the form of reptiles. The demonstration site in question is part of a larger area that has been significantly altered from years of water reuse and forest cultivation.

Recommendation—It is highly recommended that the project conduct a rapid biodiversity assessment to determine the occurrence and density of major plant, reptile, and bird species in the area. The specialist would have previous experience in the identification and classification of species in Upper Egypt. The survey should provide species lists including common names in English and Arabic.

[2] Dr. Sherif El Didi is a Professor in the Department of Irrigation & Hydraulics, at the University of Cairo

Workers' Health

Water reuse can seriously impact public health including workers who are directly exposed to treated wastewater, harvesters, fruit handlers, and consumers. Because the Luxor Manmade Forest will provide the workers needed to implement the demonstration site, these workers should be screened before joining the project.

Recommendation—MALR will provide the workers and graduates a medical check-up at the local government hospital in Luxor. The results of the medical check-up will provide a baseline on workers' health.

4. Monitoring Groups

This chapter presents environmental monitoring parameters, including frequencies and responsibility. Whereas the Water Reuse Code presented four monitoring groups, this plan proposes to reorganize the same parameters into six groups:

Water Reuse Code	Luxor Environmental Monitoring Plan
Group 1: TWW (physical & chemical)	Group 1: TWW (physical, chemical and biological)
Group 2: TWW (biological)	Group 2: Soil
Group 3: Soil, Plants and Groundwater	Group 3: Groundwater
Group 4: Health & Safety	Group 4: Crops
	Group 5: Health & Safety
	Group 6: Biodiversity

Treated Wastewater

The demonstration site will pump water from one of two maturation ponds that receive treated wastewater from the new plant, as seen in figure 8. The water in these ponds is reportedly good (better than water from other locations in the plant)—standing water in the ponds receives significant radiation over a large surface area providing an additional "polishing" effect. The water column in the ponds is about 1 meter, plus about 0.5 meters freeboard. Figure 9 shows water samples being collected from one of the maturation ponds.

Figure 8 Maturation Pond Adjacent to Demonstration Site

Figure 9 Collecting Water Samples from a Maturation Pond

The Project will collect water samples from the pond to monitor quality fluctuations and trends, if any, and analyze them at the CLEQM lab in Cairo. Monitoring parameters, frequency and responsibility are summarized in table 5.

Table 5 Treated Wastewater Monitoring Protocol

Parameters	Turbidity, pH, BOD, COD, SS, DO, TSS, residual Cl, oil and grease, heavy metals, nematode cells/eggs, *E. coli* and/or fecal coliform	
Frequency	Every month as the Egyptian Code states.	
Responsibility	LIFE	**Laboratory**: CLEQM (Cairo)

Soil and Groundwater

The application of treated wastewater can alter certain physical and chemical soil properties. For example, higher soil alkalinity can reduce the availability of certain essential plant nutrients and may warrant the application of acidifying fertilizers; crop cover will (moderately) increase soil organic matter and therefore have a favorable effect on soil moisture retention. Soil monitoring parameters, frequency, and responsibility are summarized in table 6.

Table 6 Soil Monitoring Protocol

Parameters	Organic matter, macro & micro-nutrients, EC, alkalinity, heavy metals	
Frequency	Every year	**Responsibility**: LIFE
Laboratory	Soils, Water and Environment Research Institute (SWERI)	

Irrigation can alter the water table. The project must therefore monitor groundwater level and quality. It is recommended that at least two observation wells are drilled and several piezometers installed to monitor and prevent water logging. Groundwater monitoring parameters, frequency, and responsibilities are summarized in table 7.

Table 7 Groundwater Monitoring Protocol

Parameters	Depth to water table, pH, EC, nitrates and fecal coliform
Frequency	Every Year
Responsibility	LIFE/MWRI
Laboratory	Central Laboratory for Environmental Quality Management (CLEQM)

Crops

Several contaminants including heavy metals, if present in treated wastewater, can accumulate in crop tissue such as roots, seeds, foliage, and/or fruits and seeds. Crop monitoring parameters of interest include the common nutrients (N, P, and K), heavy metals and fecal coliform. It is unnecessary to conduct heavy metal tests on reuse crops if heavy metal concentrations in treated wastewater are negligible (significantly lower than corresponding limit value). If, however, appreciable amounts of heavy metals were detected in the water, then heavy metals tests become important.

As indicated in the Code, it is recommended that plant tissue from every crop at the end of each growing season (at harvest) be sampled and analyzed. Sampling should be limited to plant parts that will be harvested and commercialized such as seeds (jojoba, jatropha, flax), stems (flowers), and stalks (flax and sorghum), as summarized in table 8.

Table 8 Plant Tissue Monitoring Protocol

Crop	Jatropha	Jojoba	Sorghum	Flax	Flowers
Plant part to be tested	Seeds	Seeds	Stalk	Stalk/Seeds	Stem/Flower
Frequency Timing	At harvest In about 2 yrs	At harvest In about 2 yrs	At harvest Every 6 months	At harvest Every 6 months	At harvest (continuous)
Responsibility	LIFE				
Laboratory	SWERI				

Health and Safety

Workers and graduates will be exposed to water reuse. Pursuant to the Code, they should be vaccinated against common communicable diseases that may be transmitted through contact with treated water. They must wear protective clothing such as rubber boots and gloves at all times. MALR should provide medical check-ups every 6 months the first year, and once a year thereafter (the medical check-up should comply with MOH requirements for people working in sanitation, including treatment plants and networks). The project should install information signs to caution workers and visitors and keep record of all health and safety measures. Table 9 provides a summary of health and safety measures for workers and crop handlers (harvesters and processors). Pursuant to the Code, irrigation must stop 2 weeks before harvest to minimize contaminant exposure by crop harvesters.

Table 9 Risk Reduction Measures for Farm Workers, Crop Handlers, and Graduates

Measures	Implementation in Luxor	Responsibility
1. Training	Organize targeted training program to sensitize farm workers on water reuse hazards and best protection measures	LIFE
2. Information signs	Install information/warning signs at suitable locations to caution farm workers and remind them of safety measures	LIFE
3. Vaccination	Vaccinate farm workers according to MOH requirements for sanitation workers involved in treatment plants and networks	MALR
4. Protective boots and gloves	Provide workers with adequate protective boots and gloves, as well as first aid kit and a dedicated wash room	LIFE
5. Supervision	Project supervisor should make sure that safety measures are implemented and water reuse guidelines are followed	LIFE
6. Medical Check-ups	Conduct regular medical check-up and lab tests to detect potential infectious diseases related to water reuse (every 6 months)	MALR
7. Record keeping	Keep record of all safety measures described above and disease incidents, if any	LIFE

Source: Adapted from the Water Reuse Code

Biodiversity

Following the baseline evaluation, a follow-up assessment of biodiversity in and around the demonstration site at the end of the project should be made. This assessment should be conducted in the spring to be able to observe the highest number

of flowering plants. It should also identify reptiles and potential agricultural pests including the black rat and field mice, commonly associated with water reuse projects.

Summary of Monitoring Requirements

Table 10 summarizes the environmental monitoring program at the Luxor demonstration site (Group 1–5).

Table 10 Summary of Environmental Monitoring Plan in Luxor

Group	Parameters	Frequency	Laboratory	Responsibility
Group 1: TWW	Turbidity, BOD, COD, SS, DO, residual chlorine, oil and grease, heavy metals, nematode cells or eggs, *E. Coli* and/or total coliform	One sample monthly	CLEQM	LIFE/EEAA
Group 2: Soil	Organic matter, macro and micro-nutrients, *E. Coli*, alkalinity, heavy metals	One sample every Year	SWERI	LIFE
Group 3: Groundwater	Depth to water table, pH, *E. Coli*, nitrates and fecal coliform	One sample every Year	CLEQM	LIFE/MWRI
Group 4: Crops	Basis nutrients (N, P, K), total coliform and heavy metals	At harvest (crop specific)	SWERI	LIFE
Group 5: Health and Safety	Training on Health and Safety Information/ warning signs Medical check-up Vaccination Protective clothing Record keeping	Year One-time (replace if necessary) Pre-employment Pre-employment Daily Weekly		LIFE

5. Reporting Requirements

The LIFE project team will be responsible for collecting all samples, and for interpreting and keeping track of all test results. The project will prepare an environmental monitoring report every 6 months and submit it to MSEA, MALR, and USAID for comments and approval.

Appendix A Minutes of Task #6 Coordination Meeting to Review Draft EMP

Task 6 Water Reuse
Coordination Meeting
MSEA/EEAA
September 27, 2005 – 13h00-15h00

Key discussion points regarding EMP

Baseline

- Treated Wastewater: The Project cannot solely rely on the test results produced at the WWTP laboratory. It should conduct its own tests at the MWRI lab in Cairo.
- Groundwater: The Project must sample and analyze groundwater from the monitoring wells and/or nearby wells to develop a solid baseline.
- Workers' Health: The Project should request all the workers and the graduates who will be involved in the demonstration site to do a regular medical check-up at Luxor Hospital. Dr. Mawaheb explained that this would be considered a standard "pre-employment" medical check up. Mr. Mohamed Mustafa agreed to follow-up directly with Mr. Awad Chafiq. The medical check-up should comply with regulations set by the Ministry of Public Health, if any.
- Biodiversity: The area surrounding the demonstration site is already affected by years of water reuse and forest cultivation. Dr. Mawaheb suggested that we conduct a biodiversity survey a few km away from the demonstration site and consider those results as baseline.

Monitoring Considerations

- Monitoring frequency: Dr. Mawaheb explained that self-monitoring and inspection, as stipulated in the Code, are not paramount to the demonstration site but would be required from future water reuse practitioners in the private sector. Therefore, it was agreed to design a monitoring plan that would be flexible and responsive to project needs. For example, the Project Team could intensify the frequency of sampling and analysis (every month) during the

first quarter and then relax the sampling frequency during later stages of the project if the test results show compliance.

- Monitoring period: It was agreed that the EMP would extend until the end of the LIFE project (i.e., 3 years)
- Monitoring Standards: It was agreed to adopt Grade B water reuse standards and guidelines for shot-term use (i.e., using treated wastewater for up to 20 years on soft-textured soils whether neutral or alkaline).

Monitoring Parameters

- Treated wastewater: It was reiterated that the Project should monitor heavy metals closely though it is generally recognized that there are no significant industries in Luxor. Minor industrial effluents may nevertheless find their way to the treatment plant (and remain in treated wastewater) through the municipal sewage system. In addition to routine testing conducted by the WWTP lab in Luxor, the Project should initially monitor treated wastewater on a monthly basis for at least 3 months and thereafter every quarter if test results show compliance. The MWRI lab was highly praised for its technical services and cost-effectiveness.
- Plants: In addition to monitoring key parameters in seeds and leaves, Mr. Moustafa El Hakeem encouraged the Project to also monitor the physiologic/agronomic performance of the crops (i.e., plant vigor, growth, flowering, shedding) and to assess plant growth in relation to soil and water test results. Dr. El Hakeem agreed to design a crop monitoring form to be used by the Project team.
- Groundwater: It was agreed to conduct a complete groundwater quality test every 6 months. The Project will install two observation wells near/inside the demonstration site. Dr. Mawaheb encouraged the Project team to consult the relevant department at MWRI for groundwater information.
- Irrigation Scheduling: The Project team should manage irrigation scheduling carefully to prevent water percolation. The project will install one bulk meter and five subsidiary water meters (one meter per plot) to monitor water consumption. Dr. Mohamed Moustafa requested to closely monitor the uniformity of distribution in case the irrigation design uses “spaghetti” drippers.
- Occupational safety: The Project should provide basic protective clothing (boots and gloves) to all the workers and graduates participating in the demonstration site. The team should also consult the Ministry of Public Health to determine whether or not they need to be vaccinated.

Appendix B: Classification of Plants and Crops Irrigated with Treated Wastewater

Table 11 Classification of Plants and Crops Irrigation with Treated Wastewater

Grade	Agricultural Group	Recommendations
A	G1-1: Plants and trees grown for greenery at tourist villages and hotels	Grass, Saint Augustine grass, cactus plants, ornamental palm trees, climbing plants, fencing bushes and trees, wood trees and shade trees
	G1-2: Plants and trees grown for greenery inside residential areas at the new cities	Grass, Saint Augustine grass, cactus plants, ornamental palm trees, climbing plants, fencing bushes and trees, wood trees and shade trees
B	G2-1: Fodder/Feed Crops	Sorghum sp
	G2-2: Trees producing fruits with epicarp	On condition that they are produced for processing purposes such as lemons, mangoes, date palms and almonds
	G2-3: Trees used for green belts around cities and afforestation of highways or roads	*Casuarina*, *camphor*, *Athel tamarix* (salt tree), oleander, fruit-producing trees, date palms, and olive trees
	G2-4: Nursery plants	Nursery plants of wood trees, ornamental plants, and fruit trees
	G2-5: Roses and cut flowers	Local roses, eagle roses, onions (e.g. *gladiolus*)
	G2-6: Fiber crops	Flax, jute, hibiscus, sisal
	G2-7: Mulberry for the production of silk	Japanese mulberry
C	G3-1: Industrial oil crops	Jojoba and Jatropha
	G3-2: Wood trees	Caya, camphor, and other wood trees

Source: Egyptian Water Reuse Code (Ministerial Decree No. 171/2005), unofficial translation.

Appendix C: Treated Wastewater, Soil, and Groundwater Baseline Test Results

Treated Wastewater Test Results

FROM :CLEQM FAX NO. :022174663 Oct. 24 2005 11:42AM P1

وزارة الموارد المائية و الري
المركز القومي لبحوث المياه
المعامل المركزية للرصد البيئي

Central Laboratory for Environmental Quality Monitoring
LEQM
ICC
Internationally accredited
CAFAL member ship # 3409
حائزه على الاعتماد الدولي
الاتحاد الكندي لمعامل التحاليل البيئية

Final Results Sheet

Client Name: Integrated Water Resources Management Project

Water Samples from Polishing Lagoon

Nature of Sample: Water

Serial			1	2
Sample code			من حوض المعالجة النهائى A1	من شبكة الرى A2
Date of Arrival			26/09/2005	
Physicochemical Parameters				
pH		-----	8.34	8.35
Carbonate	CO_3	mg/l	7.3	8.1
Bicarbonate	HCO_3	mg/l	255.6	271.3
Total Alkalinity		mg/l	282.9	279.4
Electrical Conductivity (EC)		mg/l	0.710	0.707
Total Suspended Solids (TSS)		mmhos/cm	68	74
Total Hardness		mg/l	204	176
Turbidity		mg/l	35.8	37.4
Total Dissolved Solids (TDS)		NTU	454	452
Biochemical Oxygen Demand (BOD)		mg/l	48	45
Chemical Oxygen Demand (COD)		mg/l	123	120
Ammonia	NH3	mg/l	5.7	6.5
Total Nitrogen	(T.N)	mg/l	9.8	9.8
TOC		mg/l	30.32	22.84
Oil&Grease		mg/l	385.75	227.5
Major Cations				
Calcium	Ca	mg/l	45	43
Potassium	K	mg/l	22	21
Magnesium	Mg	mg/l	27	23
Sodium	Na	mg/l	57.4	56.1
Major Anions				
Chloride	Cl	mg/l	63.1	62.3
Nitrite	NO_2	mg/l	<0.2	<0.2
Nitrate	NO_3	mg/l	15	12.4
Phashate	PO_4	mg/l	<0.2	<0.2
Sulfate	SO_4	mg/l	35	31
Trace Metals				
Aluminum	Al	mg/l	0.097	0.423
Arsenic	As	mg/l	<0.01	<0.01
Barium	Ba	mg/l	0.108	0.071
Cadmium	Cd	mg/l	0.002	0.005
Cobalt	Co	mg/l	<0.005	<0.005
Chromium	Cr	mg/l	<0.002	<0.002
Copper	Cu	mg/l	0.011	<0.002
Iron	Fe	mg/l	<0.01	<0.01
Manganese	Mn	mg/l	0.075	0.012
Nickel	Ni	mg/l	<0.005	<0.005
Lead	Pb	mg/l	<0.005	<0.005
Antimony	Sb	mg/l	<0.03	<0.03
Selenium	Se	mg/l	<0.03	<0.03
Tin	Sn	mg/l	<0.03	<0.03
Strontium	Sr	mg/l	0.302	0.274
Vanadium	V	mg/l	<0.005	<0.005
Zinc	Zn	mg/l	<0.005	0.03
Microbiological Parameters				
Total Coliform		CFU/100ml	4800	3000
Fecal Coliform		CFU/100ml	1600	600

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حاصلة على الاعتماد الدولى رقم العضوية 3409

ICC

المركز القومى لبحوث المياه

المعامل المركزية للرصد البيئى

القناطر الخيرية، ص.ب:١٣٦٢١،٦١
القليوبية، جمهورية مصر العربية.
ت: (٢٠٢)-٢١٧-٣٦٦٣/٤/٥، (٢٠١)-٢١٨-٣٥٨١.
فاكس: (٢٠٢)-٢١٧-٤٦٦٣

Final Results Sheet

Client Name: Integrated Water Resources Management Project

Nature of Sample: Water

Water Sample from Polishing Lagoon

Serial			1	2	3
Sample code			محطة الخلط الخاصة بإعادة الأستخدام A1	من مخرج برك الأكسدة A2	الخزان الخاص بالغابة الشجرية A3
Date of Arrival			07/05/2005		
Physicochemical Parameters					
pH		-----	7.29	7.83	8.13
Carbonate	CO_3	mg/l	0.0	0.0	0.0
Bicarbonate	HCO_3	mg/l	268.4	279.8	311.34
Total Alkalinity		mg/l	268.4	279.8	311.3
Electrical Conductivity (EC)		mg/l	0.740	0.688	0.753
Total Suspended Solids (TSS)		mmhos/cm	66.0	76.0	36.0
Total Hardness		mg/l	178.000	180.000	181.000
Turbidity		mg/l	28.800	35.500	17.900
Total Dissolved Solids (TDS)		NTU	474.0	440.0	482.0
Biochemical Oxygen Demand (BOD)		mg/l	48	46	30
Chemical Oxygen Demand (COD)		mg/l	192	202	125
Ammonia	NH3	mg/l	8.6	9.6	3.4
Total Nitrogen	(T.N)	mg/l	14.0	16.8	8.4
TOC		mg/l	10.97	11.41	14.63
Major Cations					
Calcium	Ca	mg/l	35	32	38
Potassium	K	mg/l	31.15	28.4	34.71
Magnesium	Mg	mg/l	31	27.5	31.2
Sodium	Na	mg/l	58.2	56.2	61.44
Major Anions					
Chloride	Cl	mg/l	72.15	65.7	79.07
Nitrite	NO_2	mg/l	<0.2	<0.2	<0.2
Nitrate	NO_3	mg/l	35.84	27.25	50.01
Phoshate	PO_4	mg/l	<0.2	<0.2	<0.2
Sulfate	SO_4	mg/l	29.51	25.58	30.5
Trace Metals					
Aluminum	Al	mg/l	0.324	0.217	0.424
Arsenic	As	mg/l	<0.01	<0.01	<0.01
Barium	Ba	mg/l	0.035	0.007	0.034
Cadmium	Cd	mg/l	<0.0005	<0.0005	0.002
Cobalt	Co	mg/l	0.019	0.037	0.027
Chromium	Cr	mg/l	0.008	0.022	0.005
Copper	Cu	mg/l	0.03	0.047	0.042
Iron	Fe	mg/l	<0.01	<0.01	<0.01
Manganese	Mn	mg/l	<0.01	0.006	0.006
Nickel	Ni	mg/l	0.043	0.041	0.04
Lead	Pb	mg/l	0.005	0.059	0.079
Antimony	Sb	mg/l	<0.03	<0.03	<0.03
Selenium	Se	mg/l	<0.03	<0.03	<0.03
Tin	Sn	mg/l	<0.03	<0.03	<0.03
Strontium	Sr	mg/l	0.521	0.501	0.607
Vanadium	V	mg/l	0.0221	0.02	0.009
Zinc	Zn	mg/l	0.007	0.006	0.005
Microbiological Parameters					
Total Coliform		CFU/100ml	$33x10^3$	32	$6x10^3$
Fecal Coliform		CFU/100ml	$18x10^3$	17	$1x10^3$

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مدينة الأقصر

ادارة مياه الشرب والصرف الصحى

معمل تحاليل الصرف الصحى

نتيجة تحليل عينة مياه صرف صحى من مدخل ومخرج محطة برك التثنيت (البوند)

تاريخ اخذ العينة 2005/9/14

م	عنصر التحليل	الوحدة	مدخل المحطة	مخرج المحطة	الحد المسموح
1	درجة الحرارة	درجة مئوية	37	30	35
2	PHالأس الهيدروجيني		6.5	7.8	من 6 الى 9
3	الأكسجين الحيوي الممتص BOD	مج/ل	220	25	40
4	الأكسجين الكيماوي المستهلك COD	مج/ل	265	31	80
5	DOالأكسجين الذائب	مج/ل	0	7.5	لا يقل عن 4
6	TSالمواد الصلبة الكلية	مج/ل	634	454	2000
7	TSSالمواد العالقة الكلية	مج/ل	215	30	40
8	العد الاحتمالي للمجموعة القلونية فى 100 سم^3	فى 100سم^3	1000000	2400	5000

العينة مطابقة للمعايير طبقا لقرار وزير الاسكان رقم 44 لسنة 2000

مدينة الأقصر

ادارة مياه الشرب والصرف الصحى

معمل تحاليل الصرف الصحى

نتيجة تحليل عينة مياه صرف صحى من مدخل ومخرج محطة برك التثنيت (البوند)

تاريخ اخذ العينة 2005/9/15

م	عنصر التحليل	الوحدة	مدخل المحطة	مخرج المحطة	الحد المسموح
1	درجة الحرارة	درجة مئوية	39	31	35
2	PHالأس الهيدروجيني		6.3	8.05	من 6 الى 9
3	الأكسجين الحيوي الممتص BOD	مج/ل	205	28	40
4	الأكسجين الكيماوي المستهلكCOD	مج/ل	245	40	80
5	DOالأكسجين الذائب	مج/ل	0	8.3	لا يقل عن 4
6	TSالمواد الصلبة الكلية	مج/ل	633	486	2000
7	TSSالمواد العالقة الكلية	مج/ل	210	32	40
8	العد الاحتمالي للمجموعة القلونية فى 100 سم^3	فى 100سم^3	1000000	3000	5000

العينة مطابقة للمعايير طبقا لقرار وزير الاسكان رقم 44 لسنة 2000

مدينة الأقصر

ادارة مياه الشرب والصرف الصحى

معمل تحاليل الصرف الصحى

نتيجة تحليل عينة مياه صرف صحى من مدخل ومخرج محطة برك التثنيت (البوند)

تاريخ اخذ العينة 2005/9/17

م	عنصر التحليل	الوحدة	مدخل المحطة	مخرج المحطة	الحد المسموح
1	درجة الحرارة	درجة مئوية	37	30	35
2	PHالأس الهيدروجيني		6.5	8	من 6 الى 9
3	الأكسجين الحيوي الممتص BOD	مج/ل	220	25	40
4	الأكسجين الكيماوي CODالمستهلك	مج/ل	265	31	80
5	DOالأكسجين الذائب	مج/ل	0	6.2	لا يقل عن 4
6	TSالمواد الصلبة الكلية	مج/ل	634	476	2000
7	TSSالمواد العالقة الكلية	مج/ل	215	28	40
8	العد الاحتمالي للمجموعة القلونية فى 100 سم^3	فى 100سم^3	1000000	3000	5000

العينة مطابقة للمعايير طبقا لقرار وزير الاسكان رقم 44 لسنة 2000

مدينة الأقصر

ادارة مياه الشرب والصرف الصحى

معمل تحاليل الصرف الصحى

نتيجة تحليل عينة مياه صرف صحى من مدخل ومخرج محطة برك التثنيت (البوند)

تاريخ اخذ العينة 2005/9/18

م	عنصر التحليل	الوحدة	مدخل المحطة	مخرج المحطة	الحد المسموح
1	درجة الحرارة	درجة مئوية	37	30	35
2	PHالأس الهيدروجيني		6.5	8.5	من 6 الى 9
3	الأكسجين الحيوي الممتص BOD	مج/ل	205	28	40
4	الأكسجين الكيماوي المستهلكCOD	مج/ل	265	31	80
5	DOالأكسجين الذائب	مج/ل	0	8	لا يقل عن 4
6	TSالمواد الصلبة الكلية	مج/ل	634	450	2000
7	TSSالمواد العالقة الكلية	مج/ل	215	25	40
8	العد الاحتمالي للمجموعة القلونية فى 100 سم^3	فى 100سم^3	1000000	3400	5000

العينة مطابقة للمعايير طبقا لقرار وزير الاسكان رقم 44 لسنة 2000

مدينة الأقصر

ادارة مياه الشرب والصرف الصحى

معمل تحاليل الصرف الصحى

نتيجة تحليل عينة مياه صرف صحى من مدخل ومخرج محطة برك التثنيت (البوند)

تاريخ اخذ العينة 2005/9/19

م	عنصر التحليل	الوحدة	مدخل المحطة	مخرج المحطة	الحد المسموح
1	درجة الحرارة	درجة مئوية	37	30	35
2	PHالأس الهيدروجيني		6.5	8.5	من 6 الى 9
3	الأكسجين الحيوي الممتص BOD	مج/ل	190	25	40
4	الأكسجين الكيماوي المستهلكCOD	مج/ل	265	31	80
5	DOالأكسجين الذائب	مج/ل	0	7.5	لا يقل عن 4
6	TSالمواد الصلبة الكلية	مج/ل	634	454	2000
7	TSSالمواد العالقة الكلية	مج/ل	215	30	40
8	العد الاحتمالي للمجموعة القلونية في 100 سم^3	فى 100سم^3	1000000	2400	5000

العينة مطابقة للمعايير طبقا لقرار وزير الاسكان رقم 44 لسنة 2000

Soil Test Results

Table 12 Locations of Soil Samples

	N 25^0 37.882'		**N 25^0 37.772'**	
	E 032^0 40.773'		**E 032^0 40.844'**	
	(0,200)		(220,200)	
	M.A		M.A	C.A
●	●	●	●	●
C-1	**C-2**	**C-3**	**C-4**	**C-5**
N 25^0 37.841'	N 25^0 37.812'	N 25^0 37.781'	N 25^0 37.766'	N 25^0 37.747'
E 032^0 40.762'	E 032^0 40.781'	E 032^0 40.785'	E 032^0 40.806'	E 032^0 40.816'
M.A		C.A		M.A
●	●	●	●	●
B-1	**B-2**	**B-3**	**B-4**	**B-5**
N 25^0 37.828'	N 25^0 37.799'	N 25^0 37.774'	N 25^0 37.756'	N 25^0 37.746'
E 032^0 40.737'	E 032^0 40.758'	E 032^0 40.773'	E 032^0 40.782'	E 032^0 40.798'
C.A			M.A	
●	●	●	●	●
A-1	A-2	A-3	A-4	A-5
N 250 37.817'	N 250 37.783'	N 250 37.756'	N 250 37.740'	N 250 37.722'
E 0320 40.709'	E 0320 40.728'	E 0320 40.745'	E 0320 40.754'	E 0320 40.762'
	(0,0)		(220,0)	
	N 25^0 37.827'		**N 25^0 37.724'**	
	E 032^0 40.669'		**E 032^0 40.739'**	

Key: ●	Sites of collected analysis
☐	Location of samples for analysis
C.A	Complete analysis
M.A	Mechanical analysis only

Table 13 Macro and Micro Nutrient Concentration in Soil Samples (CA)

S. No.	Soil Profile No.	Depth (cm)	mg/kg soil							
			N	P	K	Cu	Fe	Mn	Zn	B
1	A1	0-30	120.4	4.65	130.3	0.37	2.21	1.08	0.31	0.88
2		30-60	80.0	3.64	97.5	0.31	2.22	0.81	0.32	0.94
3		60-90	58.6	3.26	81.9	0.29	1.83	0.72	0.28	0.87
4	B2	0-30	77.3	1.41	171.6	0.41	2.23	0.57	0.27	1.34
5		30-60	88.0	1.25	124.8	0.46	2.25	0.06	0.32	1.38
6		60-90	92.3	1.25	106.9	0.41	2.16	0.06	0.31	1.20
7	C5	0-30	63.9	1.96	116.2	0.28	2.03	0.54	0.22	0.87
8		30-60	82.5	1.97	124.8	0.27	1.92	0.58	0.26	0.88
9		60-90	65.0	2.08	89.7	0.30	2.02	0.44	0.22	1.00

Table 14 Particle Size Distribution and Texture of Soil Samples

Soil Profile No.	Depth (cm)	Particle size distribution (%)				Texture
		Clay	Silt	Sand		
				Fine	Coarse	
A1	0-30	2.4	6.98	4.62	86.0	Sandy
	30-60	2.34	7.15	4.41	86.1	Sandy
	60-90	4.51	15.2	2.89	77.4	Loamy Sand
A4	0-30	27.3	63.6	3.46	5.55	Silty Loamy
	30-60	5738	31.6	8.92	1.68	Clay
	60-90	11.7	2.38	8.02	77.4	Loamy Sand
B1	0-30	1.06	1.67	7.21	90.1	Sandy
	30-60	2.07	5.52	6.31	86.1	Sandy
	60-90	1.04	4.08	4.18	90.7	Sandy
B5	0-30	1.94	9.27	1.49	87.3	Loamy Sand
	30-60	2.1	3.1	6.9	87.9	Sandy
	60-90	1.01	1.59	10.5	86.9	Sandy
B3	0-30	4.6	9.7	3.9	82.2	Loamy Sand
	30-60	0.97	3.86	6.67	88.5	Sandy
	60-90	1.93	5.21	7.56	85.3	Sandy

Soil Profile No.	Depth (cm)	Particle size distribution (%)				Texture
		Clay	Silt	Sand		
				Fine	Coarse	
C2	0-30	2.77	7.77	12.2	77.3	Sandy
	30-60	4.9	10.2	10.00	74.9	Loamy Sand
	60-90	1.7	9.2	1.8	87.3	Loamy Sand
C4	0-30	1.71	4.67	1.92	91.7	Sandy
	30-60	1.74	4.96	2.8	90.5	Sandy
	60-90	1.07	11.4	4.93	82.6	Loamy Sand
C5	0-30	2.58	6.9	2.02	88.5	Sandy
	30-60	4.75	2.38	5.17	87.7	Sandy
	60-90	0.9	3.79	4.21	91.1	Sandy

Table 15 Chemical Analysis of Saturated Soil Paste Extract (CA)

Sample No.	Soil profile	Depth (cm)	pH	SP	EC (dS/m)	Anions (meq./l)				Cations (meq./l)				$CaCo_3$ (%)	O.M (%)
						Co^{--}_3	HCO^{-}_3	Cl^{-}	So^{--}_4	Ca^{++}	Mg^{++}	Na^{+}	K^{+}		
1	A1	0-30	8.1	23	5	-	1.93	18.54	33.33	25.41	7.71	18.37	2.31	1.6	0.2
2		30-60	8	22	4.8	-	1.65	12.36	37.65	26.18	9.1	14.52	1.86	0.8	0.16
3		60-90	7.95	22	4.8	-	1.65	14.42	35.65	26.95	9.77	13.97	1.25	0.8	0.45
4	B3	0-30	8.45	29	7	-	1.1	25.75	48.37	26.18	17.02	30.16	1.86	1.2	0.53
5		30-60	8.05	25	6.7	-	1.1	28.84	40.56	28.49	11.11	26.25	1.65	0.8	0.43
6		60-90	8.1	25	7.4	-	1.38	30.9	49.56	29.26	14.13	36.8	1.65	0.8	0.51
7	C5	0-30	8.45	25	3.5	-	1.38	15.45	18.75	9.63	5.13	19.28	1.54	1.2	0.03
8		30-60	8.45	25	4.3	-	3.58	16.48	24.32	15.79	6.53	20.25	1.81	1.2	0.03
9		60-90	8.35	24	3.8	-	1.93	15.45	21.68	13.86	7.38	16.48	1.34	1.2	0.03

Groundwater Test Results

Central Laboratory for Environmental Quality Monitoring
ICC

وزارة الموارد المائية و الري
المركز القومى لبحوث المياه
المعامل المركزية للرصد البيئى
القناطر الخيرية، ص.ب.:٦،١٣٦٢١،
القليوبية، جمهورية مصر العربية.
ت: ٢١٨-٣٥٨١-(٢٠٢)، ٢١٧-٣٦٦٣/٤/٥-(٢٠٢)
فاكس: ٢١٧-٤٦٦٣-(٢٠٢)

Final Results Sheet

Client Name: Integrated Water Resources Mana
Nature of Sample: Water

Water Sample from Shallow Well

Serial			1	2
Sample code			A1	A2
Date of Arrival			26/02/2005	
Physicochemical Parameters				
pH		-----	7.44	7.19
Total Hardness		mg/l	210	372
Carbonate	CO_3	mg/l	0	0
Bicarbonate	HCO_3	mg/l	363	431
Total Alkalinity		mg/l	363	431
Electrical Conductivity (EC)		mmhos/cm	0.771	0.972
Total Dissolved Solids (TDS)		mg/l	500	630
Total Solids (TS)		mg/l	552	632
Total Suspended Solids (TSS)		mg/l	52	2
Turbidity		NTU	47	0.5
Chemical Oxygen Demand (COD)		mg/l	154	12
Biochemical Oxygen Demand (BOD)		mg/l	100	1.0
Oil&Grease		mg/l	18.5	1.2
Ammonia	NH3	mg/l	24.74	<0.2
Total Nitrogen	(T.N)	mg/l	40.6	<2
Organic Nitrogen		mg/l	15.86	<2
TOC		mg/l	25.8	2.1
Major Cations				
Calcium	Ca	mg/l	21	57
Potassium	K	mg/l	25.5	22.1
Magnesium	Mg	mg/l	30.6	40.2
Sodium	Na	mg/l	87.15	94.5
Major Anions				
Chloride	Cl	mg/l	54.5	68.9
Nitrite	NO_2	mg/l	<0.2	<0.2
Nitrate	NO_3	mg/l	13.7	7.2
Phoshate	PO_4	mg/l	<0.2	<0.2
Sulfate	SO_4	mg/l	20	47.56
Trace Metals				
Aluminum	Al	mg/l	<0.01	<0.01
Arsenic	As	mg/l	<0.01	<0.01
Barium	Ba	mg/l	0.021	0.204
Cadmium	Cd	mg/l	<0.0005	<0.0005
Cobalt	Co	mg/l	<0.005	<0.005
Chromium	Cr	mg/l	<0.002	<0.002
Copper	Cu	mg/l	0.004	0.004
Iron	Fe	mg/l	0.217	0.456
Manganese	Mn	mg/l	0.076	0.015
Nickel	Ni	mg/l	<0.005	<0.005
Lead	Pb	mg/l	<0.005	<0.005
Antimony	Sb	mg/l	<0.03	<0.03
Selenium	Se	mg/l	<0.03	<0.03
Tin	Sn	mg/l	<0.03	<0.03
Strontium	Sr	mg/l	0.291	4.536
Vanadium	V	mg/l	<0.005	<0.005
Zinc	Zn	mg/l	1.31	1.32
Microbiological Parameters				
Total Coliform		CFU/100ml	$525x10^4$	0
Fecal Coliform		CFU/100ml	$171x10^4$	0

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