PN-ADJ-345

FY 1993- 3 - Jordan

SHORT-TERM IMPROVEMENTS TO THE AS-SAMRA WASTEWATER STABILIZATION POND SYSTEM

ENVIRONMENTAL ASSESSMENT REPORT

MARCH 31, 1993

(REVISED JULY 18, 1993)

DRAFT - REV. 7/18/93

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SECTION 1

INTRODUCTION

Camp Dresser & McKee International Inc. (CDM) undertook conceptual design of the As-Samra Wastewater Stabilization Pond (WSP) System under an agreement between the United States Agency for International Development (USAID) and CDM, dated December 1, 1992. Two documents were prepared during the conceptual design of the project, including the Design Report and this Environmental Assessment Report.

A description of the system and historical background to the project are provided in Section 2.

1.1 Contract Language

The agreement states that under this task, a review of the environmental assessment presented in the Draft Feasibility Study (Ref. 1) will be made to ensure that the assessment covers the emergency short-term improvements program, including the following activities:

a) Review of the environmental impacts;

b) Environmental scoping statement;

c) Agriculture water use impacts;

d) Public health impacts;

e) Odor and other air quality impacts;

f) Land use and biological impacts;

g) Environmental impact mitigation concepts;

h) Assessment of archaeological remains which might be encountered in implementing the short-term improvements program, along with a plan for damage mitigation.

The agreement further states that comments generated from this review will be discussed with USAID and a separate Environmental Assessment Report will be prepared to cover the short-term emergency program. The focus of this report is the assessment of environmental impacts resulting from the conditions (i.e. design criteria) established by the Water Authority of Jordan (WAJ), USAID, and CDM. The original version of the report was submitted to USAID at the Design Report completion stage.

The full text of the Statement of Work is attached hereto as Appendix A.

1.2 Review of the Environmental Scoping Statement of March 1992

As part of the conceptual study for upgrading and expansion of the wastewater stabilization pond system at As-Samra, performed in 1992, an Environmental Scoping Session was conducted on 28 March, 1992. The purpose of the meeting was to begin the process of identifying significant issues relating to the proposed action and determining their scope. The document resulting from this meeting is the Environmental Scoping Statement (Ref. 2). For convenience, this document is attached hereto as Appendix E.

Attendees to the scoping session included USAID; WAJ; Jordan Valley Authority; representatives from numerous relevant other ministries; representatives from Amman and Zarqa Governorates and from the villages of Ruseifa, Sukhna, Hashimiya, Abu Sallih, Guiyesha, and Khirbet As-Samra; the Royal Scientific Society; the Amman Council of Industry; the Royal Society for Preservation of Nature; the American Center for Oriental Research; and the consulting engineers.

Environmental issues identified as being of primary concern are as follows:

a) Maintenance and protection of public health for irrigators, rural communities, and irrigated crop consumers.

b) Protection of the surface water and irrigation resources of the Zarqa Basin and the Jordan Valley.

c) Protection of groundwater resources from contamination by wastewater, sludge disposal and effluent, especially in the Wadi Dulheil.

d) Improvement and minimization of nuisances, odors, appearance and effluent color, and insects.

e) Improvement of water quality of the King Talal Reservoir.

f) Control and minimization of salts, boron, foam-causing chemicals, and metals in the effluent.

g) Protection and preservation of antiquities at Ain Ghazal, along the wadis, and at the As-Samra site.

h) Conservation of water and power in delivery and treatment.

i) Reduction of risks of uncontrolled or accidental by-passing, leakage, and release of raw sewage or poorly-treated effluent.

Issues considered of secondary rank were:

a) Odors and nuisances from surface water in the Wadi Dulheil and Wadi Zarqa.

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b) Conservation of resources.

c) Protection and improvement of biotic resources of the Zarqa Basin.

d) Mitigation and rehabilitation of areas disturbed by construction.

e) Support for and avoidance of interference with existing land uses.

For each of these the Scoping Statement gives a brief discussion of why the proposed work will cause negligible adverse impact or provide a benefit.

As presented at the scoping session, the statement briefly reviews the effects of the existing system on the environment and those anticipated from the various alternative concepts for upgraded and expanded delivery and treatment facilities.

The Scoping Statement then cites the environmental evaluations to be prepared in the course of the 1992 work:

- Environmental Assessment of existing facilities, as part of the Survey Report;
- The Environmental Scoping Session and Statement;
- Evaluation and ranking of conceptual alternatives, as part of the Conceptual Study Report;
- Environmental Assessment of the Proposed Project, as part of the Feasibility Study Report.

1.3 Review of the 1992 Environmental Assessment Report

Review of the Environmental Assessment presented in Section 9 of the Draft Feasibility Study by Engineering Science (Ref. 2 and Appendix F) showed it to be generally adequate in matters relevant to the proposed short-term improvements, with the following qualifications:

a) No discussion is made of the matter of the disposal of screenings and grit from the Ain Ghazal Treatment Plant (AGTP).

b) Although there is a routine environmental analysis of the siphon from AGTP to As-Samra which provides some interesting geographical and cultural information, the perilous situation of the siphon due to erosion in Seil Zarqa is hardly treated at all therein.

c) There is essentially no discussion of the environmental impact of the sludge-removal operation or of sludge disposal.

Aside from these issues, which are addressed thoroughly in the present report, the Environmental Assessment by Engineering Science contains much useful information, is complementary to the present report, is incorporated here by reference (and reproduced herein as Appendix F), and endorsed, insofar as issues related to the Short-Term Improvements are concerned.

1.4 Format and Approach of this Environmental Assessment Report

1.4.1 Environmental parameters

The list of environmental parameters to be considered in the present report is as follows:

a) Use of sewage effluent in agriculture;

b) Use of sludge on agricultural land;

c) Public health impacts;

d) Biological impacts;

e) Land use impacts;

f) Archaeological assessment;

g) Flooding;

h) Power consumption;

i) Odor and other nuisances; and

j) Seismicity concerns.

These parameters will be discussed in Section 3.

1.4.2 Short-term improvements to be made

The short-term emergency improvements can be categorized by sub-system as follows:

a) Ain Ghazal Treatment Plant
   - i) New headworks (ie, the Pretreatment Facility)
   - ii) Rehabilitation of existing headworks
     [Note: Siphon bypass arrangements at AGTP are dealt with below]

b) Siphon
   - i) Short-term siphon protection measures
   - ii) Longer-term siphon protection measures
   - iii) Siphon bypass arrangements at AGTP
   - iv) Measures at the emergency pond

c) As-Samra Wastewater Stabilization Ponds (WSP)
   i) Reconfigured and enlarged inlet works
   ii) Provisicn of mechanical aerators
   iii) Rehabilitation of disinfection system
   iv) Removal of accumulated sludge from ponds

The AGTP, the siphon, and the As-Samra WSP subsystems will be discussed in Sections 4, 5, and 6 respectively.

1.4.3 Screening matrix format

There are at least three settings in which environmental impacts may be considered:

N: Normal, everyday operation of a facility.

C: Construction impacts, sustained during a limited construction period.

E: Emergency conditions, and perhaps for a limited recovery period following an emergency.

The environmental assessment can thus be conducted by systematically considering each cell of a three-dimensional matrix: "Short-term measure" x "Impact Type" x "Setting". Screening matrices will be used in Sections 4, 5, and 6, and in the environmental evaluations of alternative actions presented for each sub-system in Section III of the Design Report.

SECTION 2

BACKGROUND

2.1 GENERAL

The United States Agency for International Development (USAID) entered into an agreement with Camp Dresser & McKee International Inc (CDM) to provide engineering services for conceptual and final design and preparation of tender documents for the Emergency Short Term Improvements of the As-Samra Wastewater Stabilization Pond (WSP) System.

The Emergency Short Term Improvements Project was conceived as a result of the termination of the consulting engineering agreement between the Water Authority of Jordan (WAJ) and the association of Engineering Science Inc. (an American firm) and Consulting Engineering Center (a Jordanian firm). Under the terminated agreement, the consultants were to prepare a "Technical and Economic Feasibility Study and Final Design of Upgrading and Expansion of the As-Samra WSP System". Upon conclusion of the consultant-terminated work, three reports were submitted to the WAJ; these are:

- Final Report - Survey of Existing As-Samra WSP System dated March 1992,
- Final Conceptual Study, dated June 1992, and
- Draft Feasibility Study, dated August 1992 (submitted October 1992).

The scope of work of the Emergency Short Term Improvements program was identified and adopted by the WAJ to address the urgently needed improvements to the As-Samra WSP System. Under this Emergency Short Term Improvements Project, an assessment of the performance of the existing facilities at the Ain Ghazal Treatment Plant (AGTP)and As-Samra WSP Sites was assessed and conceptual and final designs of facilities for the short-term needs (i.e.through Year 1997) was prepared. Where the short-term needs require expansion of facilities, they were designed to accommodate the long-term (i.e. Year 2005) needs. Also, when designing treatment improvements to meet the short-term needs, verification of the suitability of the treatment process and provision for the long-term expansion were made.

The existing As-Samra System collects, treats and disposes of wastewater from areas in Amman, Zarqa, Ruseifa, and Hashimiya (refer to Figure 2.1 - Project Location Map). This system handles sewage from an estimated connected service area population (Year 1990) of 1.14 million people; the population is projected to grow to approximately 2.6 million people by the year 2005.

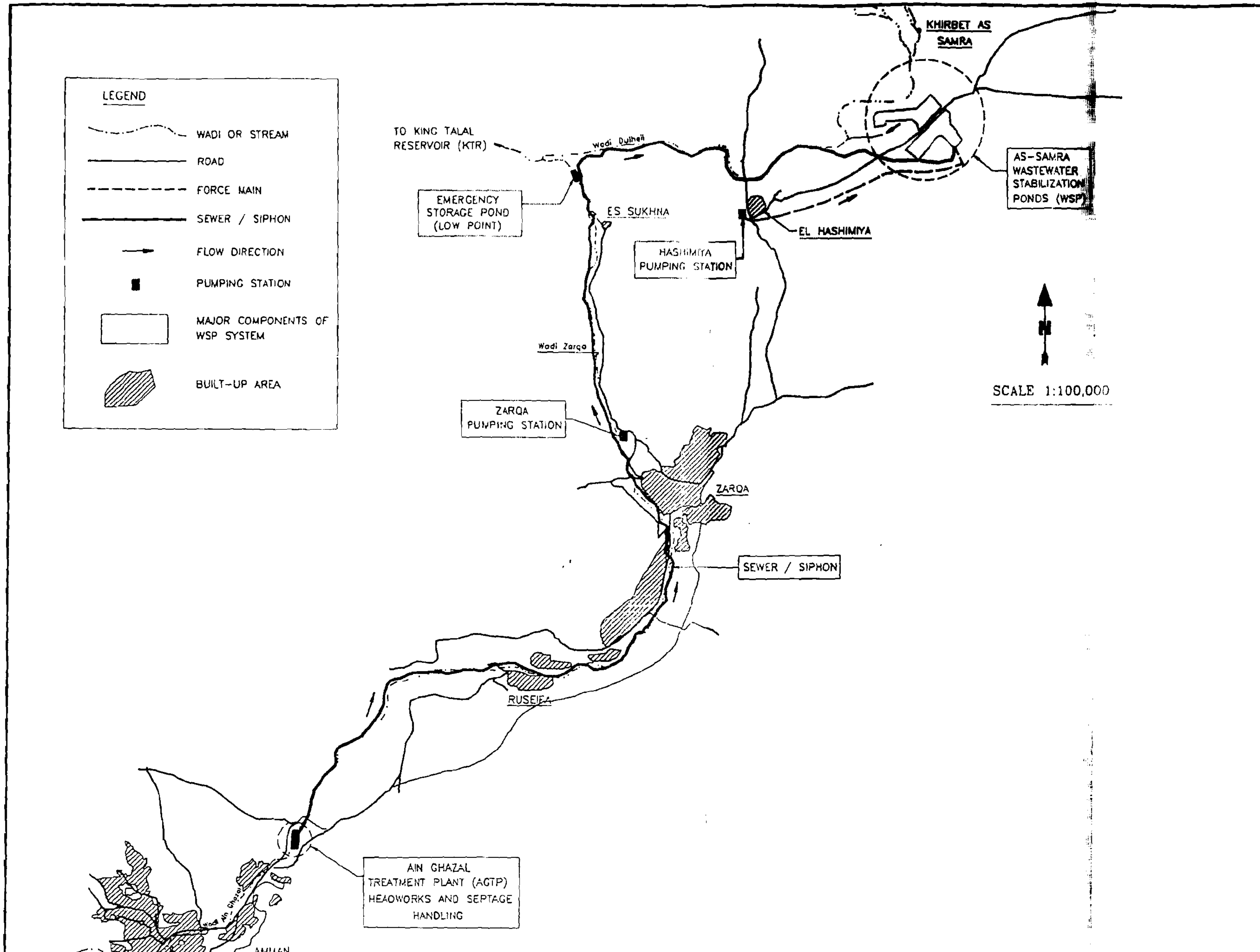

FIGURE 2.1

PROJECT LOCATION MAP

CAMP DRESSER & McKEE INTERNATIONAL, INC.
ENVIRONMENTAL ENGINEERS, SCIENTISTS, PLANNERS & MANAGEMENT CONSULTANTS, MASSACHUSETTS-USA

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The existing As-Samra WSP System consists of: (1) Headworks and septage handling facilities at the Ain Ghazal Treatment Plant site, which receives wastewater flow from the Amman area; (2) 39.6 km long sewer/siphon, which conveys wastewater from AGTP to the As-Samra WSP site; (3) Zarqa Pumping Station and preliminary treatment facilities discharging into the siphon; (4) Hashimiya Pumping Station which discharges directly to the inlet structure at the As-Samra WSP site; and (5) As-Samra WSP Facility which consists of an inlet structure, three trains of stabilization ponds each consisting of two anaerobic, four facultative and four maturation ponds, and disinfection facilities.

2.2 Description of the System

The As-Samra Wastewater Stabilization Pond System is an extensive infrastructure which collects, treats and disposes of a major portion of the wastewater generated by the people, commercial establishments and industries in Amman, Jordan. The system also handles and treats wastewater from Zarqa, Ruseifa, and Hashimiya.

The As-Samra WSP collection system is a combined sanitary and storm runoff system. During dry weather periods, it receives mainly household, commercial and industrial wastewater and a small base flow from the groundwater table. During wet weather, considerable amounts of surface runoff are also directed to the sewer system for treatment and disposal. The system was designed to hydraulically handle the incoming wet-weather flow and to treat the dry-weather pollution load it receives.

The initial facility for treatment of wastewater in the Amman area is the Ain Ghazal Treatment Plant, which was built and commissioned in the early 1970's. The plant was designed to provide secondary treatment for 60,000 cu m/d dry weather flow. The system was designed for a pollution load of 300 mg/l BOD. When the plant was placed in operation, the incoming BOD load was found to be about double the design load and the plant capacity for adequate secondary treatment turned out to be on the order of 30,000 cu m/d. The plant was operated for several years with increasing overload and with increasing operation and maintenance costs.

The 1982 Master Plan for the Wastewater Disposal in the Greater Amman Area recommended expansion of the AGTP. It also recommended wastewater stabilization ponds at As-Samra to provide for wastewater treatment on a temporary basis during the AGTP expansion and to relieve overloaded conditions at the expanded AGTP during wet weather. These changes were implemented under the Immediate Relief Project (IRP) between 1983 and 1985.

The IRP treatment system consisted of pretreatment using screening and grit removal, and a series of wastewater stabilization ponds located at Khirbet As-Samra. The wastewater is pretreated at the Ain Ghazal site and then conveyed through 39.6 km of 1228 mm pipe to the As-Samra site, where it is metered and distributed to three trains of stabilization ponds for treatment, disinfection by chlorination and discharge. The effluent flows in a natural channel for about one km and discharges into Wadi Dulheil, which is tributary to the King Talal Reservoir (KTR).

The IRP also included facilities at the AGTP to receive and handle septage and sludge trucked from other plants to the Ain Ghazal site for disposal. Small amounts of septage had been received at a manhole upstream of the AGTP prior to the IRP. The new IRP septage facility provided improved facilities for receiving and draining septage trucks, two manually-cleaned bar screens, an aerated grit chamber and a large septage storage tank. The septage screens and grit chamber are housed in buildings to contain odors and an odor control system was provided to control odors from these buildings, as well as from the grit storage tank. The screened and degritted septage is gravity-piped for disposal to the As-Samra Ponds via the inverted siphon.

As indicated above, the IRP system was initially conceived to handle and treat Amman's wastewater flow while the existing AGTP was out of service for expansion and maintenance. The plan was to construct the IRP system for full service until the new AGTP was returned to service. After the AGTP was returned to service, the inverted siphon and treatment ponds were to be used for wet weather flow in excess of the AGTP capacity. This would likely have resulted in reduced organic loadings, with runoff-diluted wastewater in the winter months and virtually no loading during the summer months. It is probable that during normal rainfall years there would have been no effluent for discharge, the water having evaporated during the summer.

After the IRP construction was started, the decision was made to change the overall plan, to abandon the expansion and maintenance of the existing AGTP process units and send all wastewater to the WSP for treatment and disposal to the wadi. Thus, the WSP was transformed into a full-time system. Moreover, loads and flows have increased significantly since As-Samra was commissioned in 1985. The WSP system is now being subjected to loadings considerably in excess of those for which it was designed and is performing reasonably well under the circumstances. In 1991, hydraulic load averaged about 100,000 cu m/d, compared with a design flow of 68,000 cu m/d. Similarly, organic load is excessive. The BOD load in 1991 was about 67,000 kg/d, up from the design BOD load about 38,000 kg/d. And, in 1992, flows and loads were higher than in 1991. With these excessive loads, the effluent from the ponds often does not meet the original design standards for fecal coliforms. Effluent BOD is of the order of 120 mg/l.

2.3 Existing Conditions

The investigation and assessment of the capacity and performance of the existing As-Samra WSP System under this Emergency Short Term Improvements project were limited to the (1) headworks and

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septage handling facility at the AGTP site, (2) erosion and corrosion of the siphon which transports wastewater flows from the AGTP site to the As-Samra ponds site, and (3) WSP facility near the village of Khirbet As-Samra.

At Ain Ghazal, the headworks are hydraulically overloaded and wet-weather wastewater flows in excess of the siphon capacity are diverted to the wadi. Furthermore, due to the deteriorated conditions of the existing wastewater and septage screening and grit facilities and the difficult O&M environment, wastewater flows, including septage, are frequently bypassed to the WSP without treatment. In addition, odors from the AGTP headworks reach residential areas up to several kilometers away. High levels of hydrogen sulfide in the septage screen and grit buildings prohibit proper O&M of these facilities.

At the 38.6 km long siphon, one of the four existing cathodic protection transformer/rectifier stations is completely inoperative. Several anodes in the remaining three stations are no longer working and require replacement. In addition, the portion of the siphon pipeline situated in the wadi has been severely exposed by the meandering action of the stream at several locations and threatens to expose it at several other locations.

The waste stabilization ponds at As-Samra are situated on a gently sloping, relatively large plot of land in a sparsely settled area east of Hashimiya, northeast of Amman. Flow through the three trains is by gravity, generally by means of weir and open channel structures from pond to pond. Piping is used only to distribute the flow from the siphon and headworks to the first anaerobic ponds, across the oil pipeline which bisects the site and from the M-4 ponds to the chlorine contact pond. The detention period in the ponds depends on the rates of flow and evaporation, but generally it is less than 25 days. This is far fewer days than is generally provided for an unaided waste stabilization pond installation. Losses of water to evaporation and seepage vary from nearly zero in the winter to as much as 26 percent during the summer. There is no evidence of seepage from the ponds, and it is believed seepage from the ponds is minimal.

In addition to receiving flows from Amman, the ponds also receive flows from Zarqa, Ruseifa and other communities. The organic loading to the pond system is excessive and the effluent from the ponds often cannot meet the IRP design standards for BOD and fecal coliforms. Also, H_2S odors from the ponds reach residential areas up to several kilometers away. Sources of highly concentrated odors are the inlet structure, the outlet structures at the anaerobic ponds, and the distribution chamber between the anaerobic and facultative ponds.

In addition, sludge deposition in the anaerobic ponds has reached a point where it should be removed. The depth of sludge in the first set of anaerobic ponds, for example, has accumulated to 4.7 meters in some locations. If not removed, the sludge will

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continue to decrease the volume of the ponds to such an extent that their effectiveness will be further impacted.

The WSP facility is described further in Section 2.5.

2.4 Project Design

According to the Agreement between USAID and CDM, the following five (5) tasks are to be performed:

Task 1 - Field Investigations and Data Collection. Under this task, the following are to be completed during this conceptual design phase:

Task 1.1- Topographic Survey
Task 1.2- Geotechnical Investigation
Task 1.3- Laboratory Sampling and Testing
Task 1.4- Air Quality Field Measurement
Task 1.5- Pond Sludge Quantification and Characterization
Task 1.6- Siphon Cathodic Protection and Cover Erosion Survey

Task 2 - Conceptual (Preliminary) Design. Under this task, the following are to be prepared:

- Emergency Short Term Improvement Program/ Assessment Report,
- Environmental Assessment Report, and
- Project Design Report

Under this conceptual design phase, preliminary design for the Short Term Improvements is to be performed. This includes:

1. Improvements to grit and screenings systems,
2. Control of emissions at the AGTP headworks and septage facilities and at the As-Samra WSP site,
3. Improvements to the inlet and distribution system at As-Samra,
4. Addition of aeration to selected ponds in the As-Samra ponds, and
5. Study of the As-Samra chlorination facilities.

Task 3 - Detailed Design and Preparation of Tender Documents. Under this task, comments generated from the review of the conceptual design documents will be incorporated in the final design. Tender documents (i.e. drawings and specifications) will be prepared for bid by American contractors. In addition, a probable construction cost estimate for the Emergency Short Term Improvements will be prepared.

Task 4 - Project Reviews. Under this task, Quality Assurance, Quality Control (QA/QC) reviews will be provided during the conceptual and final design phases of the project. Also, reviews of the deliverables of the conceptual and final design phases (i.e. Emergency Short Term Assessment Report, Environmental Assessment Report, Project Design Report, and Tender Documents) will be made by the WAJ and USAID.

Task 5 - Project Management. Under this task, mobilization of the project teams (i.e. Sigma and CDM) and CDM's visiting specialists is to be accomplished. In addition, this task is to provide for the liaison with the WAJ and USAID.

The Statement of Work is attached in Appendix A.

2.5 As-Samra Wastewater Stabilization Pond Facility

The WSP facility was built under the IRP and consists of three trains, as shown in Figure 2.2. Details of pond sizes, volumes, surface area and weirs are contained in Table 2.1. The ponds include two anaerobic, four facultative and four maturation ponds in each train and are operated in series. The only intra-train interchange of flow can occur in the central mixing chamber situated between the second anaerobic ponds and the first facultative ponds where flows from the three trains are brought to the mixing chamber for redistribution to the first set of facultative ponds. Actually, it is observed that the mixing afforded in this chamber is not considerable and much of the flow from one train is returned to the same train downstream. This chamber, however, affords the redistribution of unequal flow from the three trains, up to the carrying capacity of the pipeline from the chamber. This is described in more detail under System Hydraulics, below.

1. Inlet Facility

The incoming flow to the WSP system is received by pipelines from Amman and Zarqa, and Hashimiya. The flows are combined in an inlet flume, pass through a critical-depth type open channel meter and are distributed through a gated distribution structure to the first anaerobic pond of each of the three trains.

2. Pond Treatment

The flow into and through WSP system is by gravity afforded by a gradual slope across the entire site. The normal treatment functions of pond systems of this type are described as follows:

(a) Anaerobic Ponds

The anaerobic ponds are essentially settling basins wherein the settleable suspended solids in the wastewater settle to the bottom, where they remain. The biodegradable organic matter in these solids digest, leaving about one-half of the settled mass to accumulate. The degraded products are mostly in soluble form and are returned over time to the water flowing through the ponds. These soluble constituents still exert a significant loading in downstream ponds but, overall, about 50 to 60% of the pollution load is removed in the anaerobic ponds. Periodically, these ponds will fill up with residue (sludge) which must be removed if the effectiveness of the ponds is to be maintained.

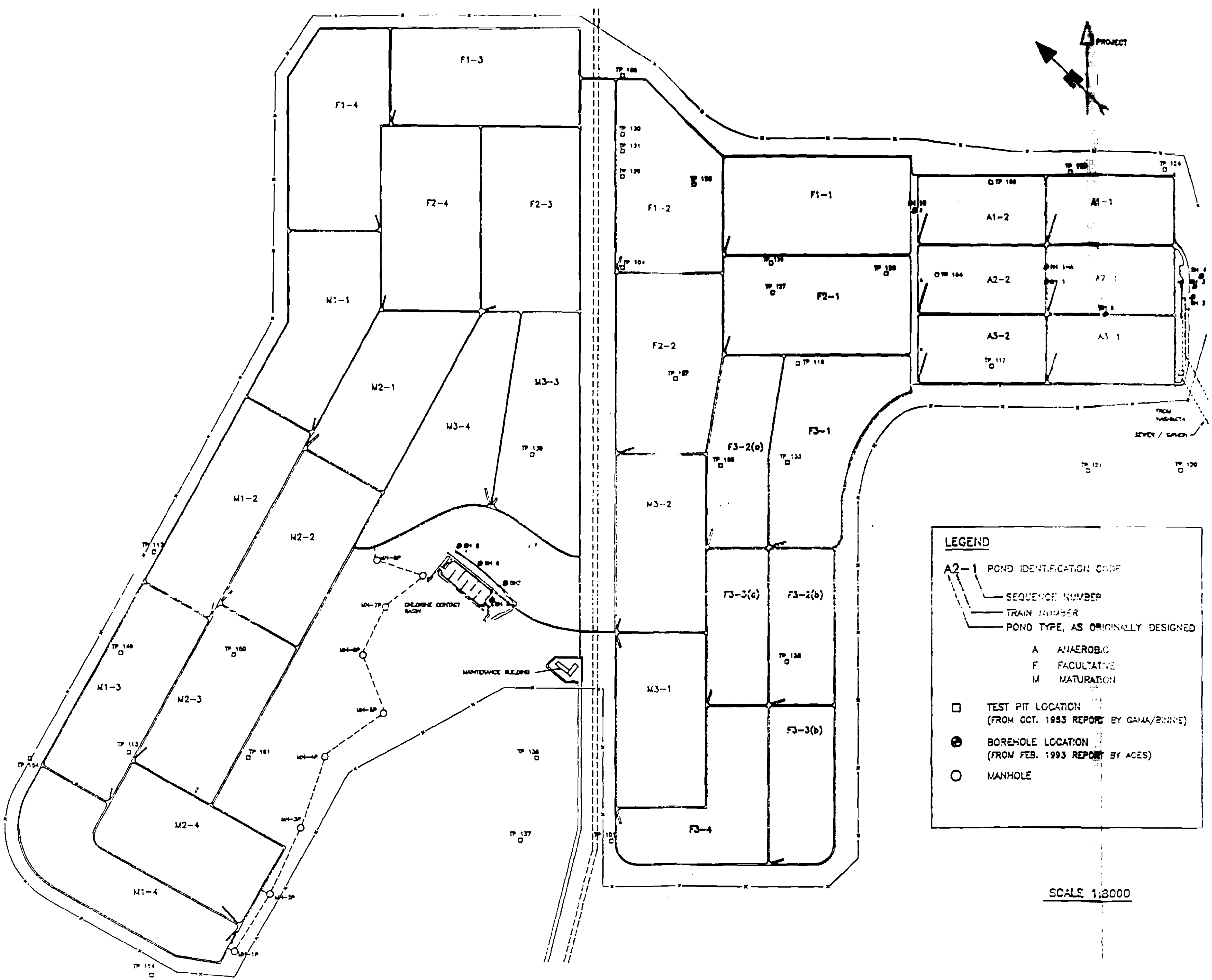

FIGURE 2.2

AS-SAMRA WASTEWATER STABILIZATION PONDS
EXISTING SITE PLAN

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ENVIRONMENTAL ENGINEERS, SCIENTISTS, PLANNERS & MANAGEMENT CONSULTANTS
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see Table 2.2, p. 2-12

TABLE 2.1 IMMEDIATE RELIEF PROJECT
Pond Information

Pond No.	elev. bottom	elev weir	Depth below weir m	Surface area weir height m^2	Area at Bottom m^2	Surface area adf m^2	Surface area peak m^2	Volume at adf m^3	Volume at peak m^3	Detention Time ADF days
1 A1-1	573.90	578.79	4.89 (3.16 left)	36789	26395	37211	37329	161336	163254	3.34
2 A1-2	570.90	575.59	4.89	36789	26395	37206	37319	161243	163084	3.34
3 F1-1	569.75	571.89	2.14	75652	68753	76261	76427	168507	172336	3.49
4 F1-2	568.60	570.49	1.89	75437	69147	76045	76211	150565	154378	3.12
5 F1-3	565.10	566.49	1.39	74419	69938	75023	75187	114086	117850	2.36
6 F1-4	563.80	565.19	1.39	74419	69938	70526	70681	110617	114145	2.29
7 M1-1	563.45	564.59	1.14	63903	60491	64462	64615	82721	85955	1.71
8 M1-2	562.85	563.99	1.14	63903	60491	64462	64615	82721	85955	1.71
9 M1-3	561.35	562.49	1.14	63903	60491	64462	64615	82721	85935	1.71
10 M1-4	559.35	560.49	1.14	63903	60491	64462	64615	82721	85955	1.71
11 A2-1	573.90	578.79	4.89	36789	26395	37211	37329	161336	163254	3.34
12 A2-2	570.90	575.59	4.89	36789	26395	37206	37319	161243	163084	3.34
13 F2-1	568.75	570.89	2.14	75652	68753	76261	76427	168507	172336	3.49
14 F2-2	565.50	567.39	1.89	75437	69147	76045	76211	150565	154378	3.12
15 F2-3	565.10	566.49	1.39	74419	69938	75023	75187	114086	117850	2.36
16 F2-4	563.30	564.69	1.39	74419	69938	75026	75185	144160	117801	2.36
17 M2-1	562.55	563.69	1.14	63903	60491	64465	64613	82785	85913	1.72
18 M2-2	561.95	563.09	1.14	63903	60491	64465	64613	82785	85913	1.71
19 M2-3	560.45	561.59	1.14	63903	60491	64465	64613	82785	85913	1.71
20 M2-4	558.05	559.19	1.14	63903	60491	64462	64613	82721	85913	1.71
21 A3-3	573.90	578.79	4.89	36789	26395	37211	37329	161336	162254	3.34
22 A3-2	570.90	575.59	4.89	36789	26395	37206	37319	161243	163084	3.34
23 F3-1	569.75	571.89	1.89	69213	62622	69798	69952	153940	157330	3.19
24 F3-2A	566.60	568.49	1.39	45730	41009	46206	46331	90486	92732	3.74
25 F3-2B	568.10	569.99	1.39	45730	41009	46206	46331	90486	92732	3.77
26 F3-3A	564.80	566.19	1.39	45091	41619	45564	45688	68657	70870	2.84
27 F3-3B	654.80	566.19	1.39	45091	41619	45564	45688	68657	70870	2.84
28 F3-4	564.20	565.59	1.39	55455	51596	55979	56117	84716	87434	1.75
29 M3-1	563.85	564.99	1.14	63903	60491	64465	64613	82785	85913	1.71
30 M3-2	563.25	564.39	1.14	63903	60491	64462	64613	82721	85913	1.71
31 M3-3	561.55	562.69	1.14	63903	60491	64462	64613	82721	8513	1.71
32 M3-4	558.85	559.99	1.14 (3.74 ft)	63903	60431	64462	64613	82721	85913	1.71

ADF -145,000 m^3/d
PEAK FLOW- 210,000 m^3/d

(b) Facultative Ponds

The facultative ponds are intended to operate with two levels of activity. The lower level, up to about one-half of the pond depth, is intended to be anaerobic (i.e. devoid of dissolved oxygen, DO). Solid matter and anaerobic organism bodies which escape from the anaerobic ponds settle to the bottom and are further degraded anaerobically, generally by organisms which can live with or without DO. The upper layer of the facultative ponds is intended to be aerobic, where DO is present. The source of this DO is the atmosphere. The transfer of oxygen from the atmosphere depends upon the rapidity with which the air-water interface is changed, upon temperature and upon DO deficit in the water. Rapid changes in the air-water interface are enhanced by winds creating waves and causing mixing in the pond. Floating material, scum and/or oily layers on the surface decrease significantly the transfer of oxygen from the atmosphere.

Facultative ponds which are overloaded to the point where there is no DO in the upper layer, such as at As-Samra, are only extensions of the anaerobic ponds. In order for them to carry out their function, to provide the initial aerobic decomposition of the waste materials, facultative ponds must be loaded lightly enough so that the oxygen demand in the pond water can be satisfied by oxygen transferred from the atmosphere. When the loading to such ponds has more oxygen demand than can be transferred from the atmosphere, artificial or mechanical aeration and/or mixing devices must be installed to supply the deficit.

In most pond systems employing facultative ponds, the facultative ponds are large in area and provide long detention times (as many as 80-120 days). The As-Samra WSP facultative ponds afford far fewer days detention time than normally are designed and are overloaded to the extent that little or no DO is present in the upper levels. Therefore, these facultative ponds must either be increased in area and volume, be more lightly loaded, have their efficiency maximized, or be given outside help by way of an additional oxygen supply. Their efficiency can be aided somewhat by installation of baffles to reduce the dead or stagnant areas. The series configuration of the As-Samra WSP design is a benefit in this regard but the present design can be improved only to a limited extent by properly placed baffles in the unaerated ponds.

(c) Maturation Ponds

The maturation ponds are usually called "polishing" ponds in the USA because their function is to ready the effluent for final disposal. This is accomplished by providing an environment wherein stabilized solids and organism bodies can settle, predators can feed on bacteria and algae, the final oxidation of nearly stabilized organics can take place and the DO levels can be brought up to saturation. Effluent disinfection is often not necessary for properly sized and operated maturation ponds.

Oxygen transfer is not so important in maturation ponds as are clarity for penetration of sunlight and quiescence for settling, either upward or downward, of debris. Detention time in maturation ponds of 10-12 days is effective in killing nematode eggs, required of As-Samra WSP effluent.

(d) Sludge Quantity and Quality

The WSP influent deposits much of its suspended solids contents in the anaerobic ponds. There has been no sludge removed from these ponds since the system was commissioned in 1986. It has been reported that measurements of sludge depth in early 1989 in Pond A2-1 showed an average depth of 1.8 meters (i.e deposition rate of approximately 0.6 meter per year). Sludge depth in the middle portion of the pond was much higher than at the sides.

Based on the estimated rate of sludge deposition in the anaerobic ponds, it is projected that the sludge has reached a point where it should be removed (i.e. more than the design limit average of 2.0 meters).

When sludge is removed, the overall hydraulic retention time in the system will be increased, sludge will not be swept into subsequent ponds during wet-weather flow, and organic loading on the facultative ponds will be reduced. Thus, the average final effluent quality should improve. Accordingly, the desludging of the ponds was included under the scope of work of this Emergency Short Term Improvements Project.

To investigate the desludging, processing and disposal options for sludge and to provide recommendation for sludge handling under the short term program, it was necessary to implement a field investigation program to (1) estimate the amounts of sludge in these ponds, and (2) provide information on the physical, chemical and biological characteristics of the sludge.

A sludge field investigation program was implemented in January-February 1993. A detailed description of the program methodology, sludge depth measurements and laboratory testing results are included in Appendix B of the Design Report.

A limited sludge depth measurement effort in the first facultative pond of the middle train, Pond F2-1, was made. The results indicated roughly 0.30 meter of light sludge . It was therefore concluded that only negligible amounts of sludge are deposited in the ponds downstream of the six anaerobic ponds.

Also, a very thick layer of scum covers large areas of the first anaerobic ponds of the three trains. From one third to half of the pond surface area is covered with such scum. This layer moves in the direction of wind and continuously changes its location. The presence of the scum layer impeded the sludge depth measurement effort and caused delays. Also, a sample of the surface floating material from Pond A2-1 was tested at the RSS laboratory. The test result showed a total volatile solids (TVS) of 66%.

Sludge depth variations, solids content and volumes in the anaerobic ponds are summarized in Table 2.2.

Table 2.2
Sludge Quantity and Quality
Anaerobic Ponds

No.	Pond Sludge Depth (m) Min.	Max.	Solids Content (%) Top	Bottom	Avg.	Sludge Volume (cu m) Wet Basis	Dry Basis
A1-1	0	3.8	12.3	20.0	16.1	46,758	7,528
A2-1	0.7	4.7	11.8	22.0	16.9	79,314	13,404
A3-1	0	3.7	12.4	19.0	15.7	59,011	9,265
A1-2	0.6	1.0	12.4	---	12.4	18,369	2,278
A2-2	1.5	2.7	12.0	18.0	15.0	50,986	7,648
A3-2	1.4	1.7	10.4	14.0	12.2	40,920	4,992
TOTAL						295,358	45,992

The average solids concentration of the anaerobic ponds sludge is estimated at approximately 15%.

The measured total volatile solid content (TVS) of the sludge in the anaerobic ponds ranges between 47 to 73% of the total solids (TS). The top layers of the sludge are less digested than the bottom layers.

Sludge samples taken from the anaerobic ponds have been analyzed also for heavy metals concentrations. The measured heavy metal concentration in the anaerobic pond sludge is an indication of the industrial wastewater discharge to the system. Consideration of the heavy metals concentrations is necessary to develop alternatives for the disposal of sludge to be removed from the anaerobic ponds.

These concentrations are within acceptable limits for both the U.S EPA pollutant concentration limits and the European Community (EC) Agricultural Use limits.

The results of sludge biological and pathogen analysis (i.e. fecal coliforms and streptococci, salmonella sp., and nematode eggs) show levels in excess of the levels considered acceptable for sludge applied in bulk to agricultural land, forest, public contact site, reclamation site, lawn, or home garden (Class A and Class B Regulations). The sludge would therefore have to undergo a process to significantly reduce pathogens (PFRP) before it can safely be applied to agricultural land or used as a soil amendment.

Refer to the detailed discussion of use of sludge on agricultural land in Sections 3 and 6.

3. Disinfection Facility

The final treatment process at As-Samra WSP is disinfection through chlorination for the purpose of reducing bacteria levels in the wastewater. Chlorine is a substance which is toxic to wastewater organisms in relatively low concentrations.

The chlorination basin at As-Samra is a small pond, approximately 1.6m deep, with earthen bottom and sides on a slope of 3 horizontal to 1 vertical. The volume is approximately 5400 m^3, depending upon the head over the overflow weir. Detention times (theoretical) are 121.5 minutes at 60,000 cu m/d flow rate and 34.7 minutes at 240,000 cu m/d. Transverse baffles are installed to decrease short circuiting.

Chlorine is supplied in 1 tonne containers from which liquid is evaporated and metered under vacuum for safety. The chlorine solution is fed upstream of a metering flume which provides the necessary mixing and can also be used to pace the feedrate. The chlorine feedrate, however, is generally varied manually in response to changes in pathogen levels, as determined through regular effluent sampling, and when there are changes in flow.

The existing chlorine building consists of a room containing stored and on-line cylinders of liquid chlorine and evaporator equipment, and a separate room containing chlorinators. The building is provided with roof fans for air supply and wall fans mounted low with a high discharge for exhaust. The design ventilation rate in both the chlorination room and the storage room is 15 air changes per hour. Control of the systems is manual from the control room. Chlorine detectors are installed and provide automatic start for the fans. The system is manually operated on an intermittent basis.

The chlorinator room has one supply fan with 100% standby and one exhaust fan with 100% standby which provide a total capacity of 30 air changes per hour.

The storage room has three supply fans, one of which acts as standby, and six exhaust fans, two of which act as standby, to provide a total capacity of 22.5 air changes per hour.

4. System Operation

At present the As-Samra WSP system is considerably overloaded, although the anaerobic ponds are doing a superb job of removing solids and BOD. Operating data for the period 1989 through 1992 show that these ponds, on average, decrease the BOD_5 concentration from 687.6 mg/l to 264.6 mg/l, a reduction of 62%. However, the remaining 264.6 mg/l means a mass BOD loading of 34,400 kg/day (based upon a flow rate of 120,000 cu m/d, roughly today's average flow) to the facultative ponds. This 62% BOD reduction by anaerobic ponds cannot be sustained for long because these ponds are rapidly becoming full of sludge and their efficiency will (or has started to) decrease. These ponds must be cleaned of sludge.

The loading of 34,400 kg/day of BOD to the first facultative ponds is at the rate of 1548 kg/ha/d. The normally suggested design rate is 45 kg/ha/d. The facultative ponds operate as extended anaerobic ponds as is confirmed by zero DO readings in these ponds, even to the last one in each train.

One of the factors which must be contributing to the occurrence of zero DO in the facultative ponds is the observed existence of an oily covering floating on the water surface. It was observed, on January 6, 1993, that under a wind speed estimated conservatively at 20-25 km/hr, the F1-1 pond surface was unruffled-- there were no waves. The surface was covered by a multi-colored sheen indicative of floating oil. The pond was being deprived of its best source of oxygen, not only by effective blocking of the air-water interface, but also by eliminating the water surface interchange through wave action and pond mixing induced by wind shear. Further observation revealed that all the ponds of the system were covered with an oily substance. Samples of this oil, upon analysis, showed the fat, oil and grease (FOG) content to be 14 mg/l in Pond F2-1, 17 mg/l in Pond F2-4, and 10 mg/l in Pond M2-4. This surface coating of oil must be eliminated if the ponds are to function as intended.

A summary of operating data for the WSP system is included as Table 2.3. The effluent BOD values are for unfiltered samples. The effluent quality as represented by these data show that the system does not meet the required design standards for effluent goals as shown below.

The design effluent goals for the original pond system were as follows:

Average filtered BOD_5 (60 samples)	20 mg/l
Mean effluent filtered BOD_5 (60 samples)	30 mg/l
Maximum fecal coliform count (80% or more of samples)	100 mg/l

5. System Hydraulics

Details of the individual ponds as to depth, surface area, volume and detention time are contained in Table 2.1. The layout of the pond system is shown on Figure 2.2. The wastewater flows from pond to pond by gravity, either by connecting concrete open channel structures with weirs to control pond levels and rates of flow between ponds, through or pipelines (also with weirs and gates) to control flow. In general , there is no means to cause or allow flow between trains, except between the second anaerobic and first facultative ponds.

TABLE 2.3

AS-SAMRA WSP SYSTEM
EXISTING FLOW AND LOADING CONDITIONS*

YEAR	1986	1987	1988	1989	1990	1991	1992
A. AS-SAMRA POND FACILITY							
AVG FLOW, IN cu.m/d	56801	68463	80890	90500	96500	97300	127992
AVG FLOW, OUT cu.m/d	46830	56282	67187	72560	82340	83130	107750
PEAK FLOW, IN cu.m/d	135000	149000	140910	169600	169440	194590	189635
PEAK FLOW, OUT cu.m/d	145000	131590	111180	111630	111340	112260	119920
BOD5, mg/l	625	678.7	856.7	736.5	704.5	706.7	505.3
TSS, mg/l	704.8	728.9	584.3	617	621.8	619.3	389.2
WATER TEMP, HIGH	22.4	22.3	23.7	22.5	20.3	21.3 **	-
WATER TEMP, LOW	20.8	20.2	19.9	19.5	18	18.3 **	-
RAINFALL,mm ANNUAL	139	89.7	61	37	48	108	123
BOD5 ANAEROBIC OUT				285	234.2	236.9	302.3
BOD5 FACULTATIVE OUT				173.3	163.1	141.5	199.8
BOD5 MATURATION OUT	115	110		128.8	155.3	112.7	126.3
TSS ANAEROBIC OUT				156	-	-	-
TSS FACULTATIVE OUT				166.4	-	-	-
TSS MATURATION OUT				173.3	-	186.8	168.6
% RED. BOD ANAEROBIC PONDS				61.3	66.8	66.5	40.2
ORGANIC LOAD BOD5, kg/d	35380	49220	69000	67800	67820	68110	
COD,mg/l EFFLUENT	385	406	352	330	298	310	
NH4, mg/l EFFLUENT	86	72	88	85	82	90	
B. AIN GHAZAL HEADWORKS							
AVG. FLOW cu.m/d				70560	69930	70085	97770
PEAK MONTH FLOW cu.m/d				78846	79752	86440	125995
PEAK DAY FLOW cu.m/d							172730

* PLANT OPERATING DATA
** 8 MONTHS AVERAGE

A hydraulic analysis has been made to estimate the flow rate capacity of all WSP structures. The details of the analysis are described below. A computer model has also been prepared which affords quick determination of pond volumes, surface areas, detention time, heads on weirs, and losses to evaporation and gains by rainfall. This model is very useful in tracking various rates of flow through the system.

Wastewater is received at the WSP by pipeline flow into the headworks structure, which is a rectangular open channel in which a critical depth type primary element for metering is constructed. The rate of flow is sensed by an electronic device which measures the depths of water in the channel. The measuring signal is transmitted to an electronic receiver at the Operations Building where it is converted to flow rate. Downstream of the meter, the channel diverges to accommodate three flow controlling sluice gates, one for each pond train. The shape of the channel greatly favors the middle outlet and tends to direct considerably more than one-third of the flow to pond Train 2. This unbalance can be corrected somewhat by adjusting the gate settings, but for accuracy an adjustment would have to be made for each change in the incoming flow rate. Therefore, the gates are adjusted infrequently and the unbalance in flow to the ponds is accepted.

Detailed hydraulic calculations show the headworks has a maximum capacity of 255,000 cu m/d before the channel wall upstream of the meter is overtopped. If the three gates in the structure are closed too much, in an attempt to equally distribute the flow, the walls of the structure could be overtopped at a somewhat lower incoming flow rate.

The pipelines from the inlet structure to the three first anaerobic ponds have an estimated capacity of 103,500 cu m/d, 156,900 cu m/d and 100,600 cu m/d to Trains 1,2 and 3 respectively. At greater rates of flow, the inlet structure downstream of the gates will overflow to the ground.

Where the hydraulic structure between ponds is an open channel with a flow controlling weir or multiple weirs, the rate of flow will not be limited for reasonable rates of flow, as long as the weir and flow channel are not blocked. Therefore, the capacity of these structures is adequate for any reasonable rate of flow. These weirs have been rated (in conjunction with preparation of the hydraulic model) to show the relationship between head, H, on the weir and rate of flow, Q, over the weir. This relationship is $H = 0.000145\ Q^{0.662}$ for anaerobic ponds and $H = 0.000166^{0.650}$ for all other ponds. These formulas are for an overflow structure made up of 2-2 m wide weirs. For weir structures made up of a 1-2 m wide weir, $H = 0.000327\ Q^{0.628}$ (H is in meters and Q is in cu m/d). The outlet weirs from the second anaerobic ponds, of different design, are rated as $H = 0.000170\ Q^{0.646}$.

Pipelines are also used between Ponds F1-2 and F1-3 ; F2-2 and F2-3; and M3-2 and M3-3 where the Jordan Petroleum Corp. pipeline passes through the pond site. Estimates of the capacities of these pipelines are : from F1-2 to F1-3, 92,700 cu m/d; from F2-2 to F2-3, 42,400 cu m/d; and from M3-2 to M3-3, 118,400 cu m/d. All these pipelines will be too small to handle the long term flow rates expected at As-Samra WSP system.

Pipelines are also used to convey the flows from the M-4 ponds to the chlorine contact chamber inlet flume. It is predicted, based upon hydraulic analysis, that the pipeline from the metering flume to Manhole 2P, handling flow from the Trains 1 and 2, will be surcharged at flows in excess of 140,000 cu m/d and manhole 5P will overflow its top at more than about 260,000 cu m/d. The pipeline from M3-4 is short and steep and has capacity well in excess of 240,000 cu m/d.

Visual inspection of the pond layout indicates that there is considerable hydraulic short-ciruiting within most of the ponds. Furthermore, among the anaerobic ponds there is short-circuiting in the additional sense that flow has been poorly distributed among the three trains, with a greater amount being directed to Train 2. Accordingly, sludge deposits in that train are greater, so retention time is least. Therefore, the mean residence time in th anaerobic ponds is less than if flows and volumes did not vary from pond to pond.

Lastly, the analysis of the capacity in the metering flume at the chlorine contact pond, indicates the walls of the flume upstream of the meter element will be overtopped at a flow rate of about 230,000 cu m/d.

6. Odor Survey at As-Samra

An odor survey was performed at the As-Samra wastewater stabilization ponds on January 21, 1993. The same instrument as was used in the Ain Ghazal survey was again used to measure hydrogen sulfide at this site. Hydrogen sulfide measurements taken at As-Samra are summarized in Table 2.4.

On the day of the survey, moderate to high hydrogen sulfide levels were recorded at the inlet structure. Hydrogen sulfide is generated as a result of the anaerobic condition of the wastewater in the siphon. Specifically, hydrogen sulfide is produced by the reduction of sulfate species by bacteria under anaerobic conditions. It is reported by WAJ personnel that during warm weather, hydrogen sulfide levels at the inlet structure are much higher. This is expected because the rate of microbial activity increases markedly with temperature. Also, the solubility of oxygen decreases with temperature. The wastewater is likely depleted of oxygen before it enters the siphon.

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Table 2.4

Hydrogen Sulfide (H_2S) Measurements at As-Samra

Source Location	Hydrogen Sulfide Concentration (ppm) (1/93)	(3/93)
1. Inlet Structure		
A. Outlet of siphon, about 1.2 m above liquid level	10	5
B. Above Hashimiya inlet, about 1.2 m above liquid level	15-20	9
C. Above Parshall flume, about 0.1 m above liquid level	1.5-7.5	3
D. Upstream of inlet gates at end of structure, about 1 m above liquid level	0.5-1.0	4-16
E. Outlet of gate to Train 1, after gates, about 0.5 m above liquid level	10-20	
2. Anaerobic Ponds		
A. Outlet of Pond A2-1, downstream of weir, about 3.5 m above liquid level	9-10	25-30
B. Inlet of Pond A2-2, a downstream end of channel, near liquid surface	90	
C. Outlet of Pond A2-2, about 1 m above effluent weir	65	130
D. Splitter box, about 1m above weir	>100	350
E. Inlet of Pond F2-1, at liquid surface	100	190

The anaerobic ponds have accumulated vast quantities of sludge. This sludge undergoes anaerobic decomposition (digestion) and in the process releases hydrogen sulfide and other reduced compounds. Some hydrogen sulfide is released at the surface of the anaerobic ponds. This quantity is presumed to be small, since only slight hydrogen sulfide odors were detected coming from the quiescent ponds. As winds increase, there will be greater releases of hydrogen sulfide from the ponds surfaces as turbulence is induced at the air/water interface.

When turbulence is induced into the wastewater, by flowing over weirs and in channels and other transitions, significantly greater amounts of hydrogen sulfide (and other gases) are released. The weirs at the outlet of the first anaerobic pond in each train are quite high (3.5 m), and hence considerable splashing occurs downstream of the weirs. Hydrogen sulfide measurements of 9 to 10 ppm were recorded at this point, but were probably many times greater closer to the liquid surface. Levels of 65 ppm and more than 100 ppm were recorded at the outlet of Pond A2-2 and at the distribution box, respectively.

Since odor levels exceeded the range of the H_2S analyzer used in the initial survey, a follow-up survey was conducted on March 13, 1993 using an instrument with a higher range. On that day winds were very strong and gusting. Odor levels above the quiescent pond surfaces were relatively low (less than 1 ppm H_2S). H_2S levels above and adjacent to areas of turbulence were very high. The highest levels were again recorded above the weir between the anaerobic and facultative ponds. The maximum concentration measured was 350 ppm. Follow up survey results are reported in Table 2.4 along with initial survey results.

Equally high levels of hydrogen sulfide were found at the inlet of anaerobic pond A2-2 and at the inlet of the first facultative pond, F2-1.

High hydrogen sulfide levels were also sensed at the weir structures between facultative ponds.

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SECTION 3

ENVIRONMENTAL PARAMETERS

In this section, the environmental parameters to be considered will be introduced and discussed. Since the As-Samra effluent flows primarily through agricultural lands and is used almost entirely for irrigation, and because a prominently considered means of residuals disposal is the use of sludge on agricultural lands, the environmental parameters associated with these practices will be discussed in detail in this section (see Subsections 3.1 and 3.2).

In considering the application of effluent or sludge to agriculture, it is understood that there are four populations potentially at risk: a) the consumers of the agricultural products; b) the farm workers; c) human neighbors of the farm who are not direct participants in agriculture; and d) neighboring flora and fauna, including migratory birds and other animals.

By adopting guidelines of practice that have been developed with these four populations in mind, one effectively has taken care of nearly all public health, biological and land use issues, as well. Any exceptions will be presented and discussed separately.

3.1 Use of Sewage Effluent in Agriculture

This is an issue of major commercial importance, as effluent from As-Samra forms the prime source of water for irrigated agriculture along the Wadi Dulheil, which in turn is a major tributary to the King Talal Reservoir, which in turn is a major source of water for irrigated agriculture in the Jordan Valley. The WAJ is presently observing the following guideline:

> For irrigation of crops likely to be eaten uncooked, sports fields or public parks, in which the exposed group is workers, consumers and the public: No more than 1 intestinal nematode egg per litre, and no more than 1,000 fecal coliforms per 100 ml (geometric mean during the irrigation period).

This is based on the WHO Effluent Quality Guidelines for Agriculture. A useful discussion of the most recent effluent guidelines for agriculture developed by the World Health Organization (WHO) and adopted by Jordan, is presented in WHO Technical Report Series 778 (Ref. 3). Excerpts from this report are quoted below.

Standards or guidelines for the quality of wastewater to be used for unrestricted crop irrigation, including that of salad and vegetable crops eaten raw as developed over the past 50 years have tended to be very strict, as they were based on a theoretical evaluation of the potential health risks associated

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with pathogen survival in wastewater and soil and on crops, rather than on firm epidemiological evidence of actual risk. To some extent, those early standards were based on a "zero risk" concept, with the aim of achieving an "antiseptic" or pathogen-free environment. At that time, the method of choice for pathogen removal, as judged by coliform removal, was secondary biological treatment followed by carefully controlled effluent chlorination. Since this could, at least theoretically, achieve very low residual coliform concentrations, the maximum permissible number of coliforms was set correspondingly low.

In 1971, a WHO meeting of experts on the reuse of effluents (Ref. 4) recognized that the extremely strict California standards for effluent reuse were not justified by the available epidemiological evidence and recommended a microbial guideline for the unrestricted irrigation of vegetables eaten cooked of not more than 100 total coliform per 100 ml, which was in effect a significant liberalization. It was felt in that meeting that there was a need for wastewater irrigation guidelines to be given a sounder epidemiological basis, and it was recommended that this matter be fully investigated.

Since that time, extensive new epidemiological evidence has been accumulated and earlier studies and reports have been evaluated. The findings of these studies have been carefully reviewed by leading public health experts, environmental scientists and epidemiologists at meetings in Engelberg (Ref. 5) and Adelboden (Ref. 6) in 1985 and 1987, respectively, and at numerous national and international meetings and consultations. The consensus view of the epidemiologist and public health experts who have reviewed these data is that the actual risk associated with irrigation with treated wastewater is much lower than previously estimated and that the early microbial standards and guidelines for effluent to be used for unrestricted irrigation of vegetables and salad crops normally consumed uncooked were unjustifiably restrictive, particularly in respect of bacterial pathogens.

On the basis of this new evidence, the Engelberg report recommended new guidelines containing less stringent standards for fecal coliform than those previously suggested. However, they were stricter than previous standards in respect of numbers of helminth eggs, which were recognized to be the main actual public health risk associated with wastewater irrigation in those areas where helminthic diseases are endemic. The Engelberg recommendations were subsequently reviewed and confirmed at the Adelboden meeting.

After consideration of this preparatory work and the epidemiological evidence currently available, the Scientific Group (Ref. 3) now recommends the guidelines shown in Table 3.1.

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Table 3.1 Microbiological Quality Guidelines for Wastewater Use in Agriculture[a] as Recommended by WHO

Category	Reuse conditions	Exposed Group	Intestinal nematodes[b] (arithmetic mean no. of eggs per liter[c])	Fecal coliform (geometric mean no. per 100ml)	Wastewater treatment expected to achieve the required microbiological quality
A	Irrigation of crops likely to be eaten uncooked, sports fields, public parks	Workers, consumers, public	< 1	< 1000	A series of stabilization ponds designed to achieve the the microbiological equality indicated, or equivalent treatment
B	Irrigation of cereal crops, industrial crops, fodder crops, pasture and trees[e]	Workers	< 1	No standard recommended	Retention in stabilization ponds for 8-10 days or equivalent helminth and fecal coliform removal
C	Localized irrigation of crops in category B if exposure of workers and the public does not occur	None	Not applicable	Not applicable	Pretreatment as required by the irrigation technology, but not less than primary sedimentation

[a] In specific cases, local epidemiological, sociocultural and environmental factors should be taken into account, and the guidelines modified accordingly.
[b] Ascaris and Trichuris species and hookworms.
[c] During the irrigation period.
[d] A more stringent guideline (<200 fecal coliforms per 100ml) is appropriate for public lawns, such as hotel lawns, with which the public may come into direct contact.
[e] In the case of fruit trees, irrigation should cease two weeks before fruit is picked, and no fruit should be picked off the ground. Sprinkler irrigation should not be used.

These are based on the fact that in many developing countries the main actual health risks, as pointed out above, are associated with helminthic diseases and that the safe use of wastewater in agriculture or aquaculture will therefore require a high degree of helminth removal. Thus, these guidelines introduce a new, stricter approach concerning the need to reduce numbers of helminth eggs (*Ascaris* and *Trichuris* species and hookworms) in effluents to a level of one or less per liter. This means that some 99.9% of helminth eggs must be removed by appropriate treatment processes in areas where helminthic diseases are endemic and present actual health risks (field studies indicate that helminth concentrations are rarely greater than 1000 per liter, even in endemic areas).

Stabilization ponds with a retention time of 8-10 days are particularly effective in achieving this, but other technologies are also available. While not all helminths and protozoa of public health importance are referred to specifically in the guidelines (for example, *Amoeba* and *Giardia* species are not mentioned), the intestinal nematodes covered should serve as indicator organisms for all of the large settleable pathogens(including amoebic cysts); other pathogens of interest apparently become non-viable in long-retention pond systems. It is thus implied by the guidelines that all helminth eggs and protozoan cysts will be removed to the same extent.

Based on current epidemiological evidence, a *bacterial guideline* of a geometric mean of 1000 fecal coliform per 100 ml for unrestricted irrigation of all crops is recommended. This is considered to be technically feasible. The Scientific Group concluded that no bacterial guideline need be recommended in cases where farm workers are the only exposed population, since there is little or no evidence indicating a risk to such workers from bacteria; nevertheless, some degree of reduction in bacterial concentration is desirable in wastewater used for any purpose.

The natural die-off of pathogens in the field constitutes a valuable additional safety factor in reducing potential health risks. Pathogen inactivation by ultraviolet irradiation, by desiccation and by natural biological predators when effluent is applied to crops and soil can often provide an additional 90-99% reduction of pathogens within a few days after application. In addition to this important factor, field and laboratory studies, which indicated that wastewater effluent with 1000 fecal coliform per 100 ml contained few, if any, detectable pathogens, were taken into account by the Scientific Group in formulating the guidelines.

3.2 Use of Sludge on Agricultural Land

3.2.1 Introduction

Sewage sludge has not traditionally been used in Jordanian agriculture. Yet given the large quantities that will be made available with the desludging of the As-Samra waste stabilization ponds, it is reasonable to consider using the sludge as a soil conditioner, or soil builder, due to its physical characteristics and its nutrient content. Such practice is becoming increasingly widespread in the world and without ill effects, as long as practice conforms to certain guidelines.

A most useful reference on this subject is <u>Sludge Parasites and Other Pathogens</u> by Robert Lewis-Jones and Michael Winkler, Ellis Horwood Ltd, UK, 1991. It describes parasites found in sludge and means to nullify their ill effects when applying sludge to agricultural lands, or to gardens or municipal parkland.

<u>3.2.2 Examples of guidelines and regulations</u>

The two examples of official guidelines and regulations that will be relied upon herein are:

a) The United States Environmental Protection Agency's Subchapter O in Chapter I of Title 40 of the Code of Federal Regulations, recently amended (November 1992) by adding Part 503, "Standards for the Use or Disposal of Sewage Sludge" (Ref. 7).

b) The European Community's "Council Directive on the Protection of the Environment, and in Particular the Soil, When Sewage Sludge Is Used in Agriculture," 86/278/EEC, 121 June 1986, appearing in the Official Journal of the European Communities, L181, v 29 (4 July), pp 6-12 (Ref. 8).

<u>USEPA "Section 503"</u>

The USEPA Section 503 standards describe the conditions under which sewage sludge may be applied to farmland. (The following brief description is an attempt to capture the essential points only. The interested reader is referred to the full document cited.) Aside from general requirements, specified management practices, and reporting requirements, there are quality standards for the sludge itself with respect to three categories of impact: heavy metals, pathogens, and vector attraction.

<u>Heavy metals.</u> For a list of ten elements, there are four sets of numerical standards (Table 3.2). Two sets are concentration values (mg/kg) for metals in the sludge itself, while the other two sets pertain to loading rates for the metals on agricultural land (kg/ha/year, and kg/ha cumulative). The pollutant concentrations in Column (a) are not to be exceeded if the sludge is to be applied to agricultural land, lawns or gardens, or if it is sold or given away in bags or other containers. If the sludge is to be applied to land other than agricultural, lawn, or garden or, provided that one can be sure that the cumulative pollutant loading rates of Column (d) are not exceeded where the sludge is applied, the less restrictive "ceiling concentrations" of Column (b) may be observed. Column (c) is a maximum permissible annual loading rate to land for sludge given away/sold in bags or other containers. Column (d) is a maximum

TABLE 3.2 HEAVY METAL GUIDELINES FOR SLUDGE APPLIED TO LAND (USEPA)				
Pollutant	(a) Pollutant Concentrations, mg/kg dry wt basis	(b) Ceiling Concentrations, mg/kg dry wt basis	(c) Annual Pollutant Loading Rates, kg/ha/365-day period	(d) Cumulative Pollutant Loading Rates, kg/ha
Arsenic	41	75	2.0	41
Cadmium	39	85	1.9	39
Chromium	1200	3000	150	3000
Copper	1500	4300	75	1500
Lead	300	840	15	300
Mercury	17	57	0.85	17
Molybdenum	18	75	0.90	18
Nickel	420	420	21	420
Selenium	36	100	5.0	100
Zinc	2800	7500	140	2800

permissible cumulative loading rate to agricultural land, forest, etc. (For exact specifications and conditions, please see the cited document.)

Pathogens. The regulations present "Class A" and "Class B" pathogen requirements. Sludge meeting "Class A" requirements must be met for sludge applied in bulk to agricultural land, forest, public contact site, reclamation site, lawn, or home garden; or if the sludge is to be sold or given away in bags or other containers. The less restrictive "Class B" is for bulk application to land where food crops meet various criteria, e.g. of time and distance between sludge application and crop harvest.

There are several versions of "Class A" requirements, all versions requiring:

> Fecal coliforms MPN less than 1,000 per gram of total solids (dry weight basis), OR the density of Salmonella sp. bacteria in the sewage sludge be less than 3 MPN per 4 grams of total solids (dry weight basis), and varying means to test or act to ensure adequately low concentrations of enteric viruses and helminth ova.

Appendix C of the document briefly describes processes that may be used to significantly reduce pathogens (PSRP):

- Aerobic digestion
- Air drying
- Anaerobic digestion
- Composting
- Lime stabilization

Appendix C of the document also briefly describes processes to further reduce pathogens (PFRP):

- Composting
- Heat drying
- Heat treatment
- Thermophilic aerobic digestion
- Beta ray irradiation
- Gamma ray irradiation
- Pasteurization

There are several versions of "Class B" requirements. One of these is that the fecal coliform density, as indicated by the geometric mean of seven samples, be less than 2,000,000 MPN per gram of total solids (dry weight basis), or less than 2,000,000 Colony Forming Units per gram of total solids (dry weight basis). This criterion seems to be easily met; from Tables B.7 and B.8 in Appendix B, the fecal coliform concentration (TFCC) is consistently reported to be of the order of 10^6 to 10^7 MPN/100 ml. This is 10^4 to 10^5 MPN/1 ml. Assuming a sludge density on the order of 10 percent solids, divide once more by 10 to obtain a range of the order of 10^3 to 10^4 MPN/gram dry solids, well within the limit of 2,000,000 MPN per gram of total dry weight solids.

For sludge meeting such Class B pathogen requirements, site restrictions apply, all in one way or another specifying a time buffer between the time of sludge application and the time of crop harvesting or other land use. (A copy of these restrictions may be found in Appendix D).

<u>Vector attraction.</u> The third category of criterion for sludge application to land refers to measures to reduce the attractiveness of the sludge to flies or other vectors that can spread disease. Such measures and criteria include reduction of volatile solids content, aerobic digestion, pH elevation for specific durations, sufficiently low percentage of unstabilized solids, and injection of the sludge below the land surface or other burial.

The regulations also have a section on incineration of sludges.

European Community "Council Directive"

The European Community "Council Directive of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture" establishes the limit values for concentrations of heavy metals shown in Table 3.3.

The directive specifies that sludge to be applied to agricultural lands should be treated, except for some subsoil injection or ploughing-in techniques as member states may exempt. Forage shall not be permitted on grassland until a period of at least three weeks, or greater as member states may specify, has passed since application. Sludge is not to be applied on lands where fruits and vegetables are grown, with the exception of fruit trees. If sludge is to be applied to land for growing fruits and vegetables normally in contact with the soil and normally eaten raw, there must be a waiting period of at least 10 months preceding the harvest and during the harvest itself. Sludge is to be used in such a way that takes into account the nutrient needs of the plants. The soil pH is to be monitored because of its effect on the availability and mobility of the heavy metals. Specifications are given for sampling techniques and reporting procedures.

No mention is made in this 1986 directive regarding nematode eggs or other parasites.

TABLE 3.3 HEAVY-METAL LIMIT VALUES (EUROPEAN COMMUNITY)

Element	Concentrations in Soil (mg/kg)	Concentrations in Sludge for Agricultural Use (mg/kg)	Loading rate to Agricultural Land, 10-yr avg (kg/ha/yr)
Cadmium	1 to 3	20 to 40	0.15
Copper	50 to 140	1000 to 1750	12
Nickel	30 to 75	300 to 400	3
Lead	50 to 300	750 to 1200	15
Zinc	150 to 300	2300 to 4000	30
Mercury	1 to 1.5	16 to 25	0.1
Chromium	(n/a in 1986)	(n/a in 1986)	(n/a in 1986)

3.2.3 Other pathogens in sludge

Salmonella spp. are Gram-negative, flagellate and motile rods, and are facultative anaerobes. Infection occurs by ingestion of food or water contaminated by feces from an infected creature, and perhaps by inhaling contaminated aerosols.

Salmonella spp. are the bacteria that traditionally have been of most concern in the utilization of sewage sludge in agriculture, and were responsible for 26 percent of identified causes of gastro-intestinal infection in the UK in 1989. However, that was before adoption there of guidelines for the use of sewage sludge in agriculture; it is considered that the health risks from *Salmonella* in sludge are small if the guidelines are followed.

3.2.4 Types of agriculture

The acceptable limits for sludge quantity parameters depend significantly on the type of agriculture considered, e.g. leafy vegetables, tubers, fruit, fruit trees, grains, or pasture. Jordanian agriculture includes all such types, and it should be assumed that sludge may be applied to all types--unless specific restictions need to be imposed with respect to any type.

3.3 Other Public Health Issues

While most public health impacts of effluent from the proposed works have been addressed in Section 3.1, we include here a discussion of schistosomiasis, based on Ref. 9:

Schistosomiasis

This disease, also known as Bilharzia, is an important disease whose vector is an aquatic snail. It has not been a problem at the As-Samra ponds and is not found in Jordan in general. Nevertheless, a short discussion is in order.

Schistosomiasis in man is caused mainly by one of four species of trematode worms, two of which are found in the Middle East: *Schistosoma mansoni*, infecting man and some animals, and *Schistosoma haematobium*, rarely infecting animals.

The cycle. Man excretes eggs of *S. mansoni* in his feces, of *S. haematobium* in his urine. These eggs must find water where they will hatch into miracidia. These tiny swimming organisms will locate and infect an aquatic snail of a particular species. *S. mansoni* mainly infects snails of the genus Biomphalaria, and *S. haematobium* mainly infect snails of the genus Bulinus.

The different snail species prefer different habitats but, very roughly speaking, Bulinus species prefer still or very slowly moving water and are often found in small pools and water holes. Biomphalaria can live in gently flowing water and tend to occur in streams and irrigation systems.

Some time after infection the snail will shed many cercariae which will reinfect man through his skin when he is in the water or, less commonly, when he drinks infected water.

Time element of the cycle. The eggs excreted from human beings must reach fresh water within three weeks of excretion to survive, and may not even survive until then. The miracidia that hatch from the eggs must find a snail host within 24 hours or even less, or the cycle will be broken. Development within the snail host takes about four to eight weeks.

Sewage treatment as a barrier to schistosomiasis transmission. While intense schistosomiasis transmission may result from the discharge of effluents to streams and lakes, correct sewage treatment can prevent this. Different sewage-treatment processes have different effects upon the survival of eggs and miracidia:

- o In primary sedimentation some, but not all, of the eggs will settle out. (Eggs are unlikely to hatch in sedimentation tanks, but if they are carried to another, more favorable environment within 24 hours, they may hatch there.)

- o Trickling filters and activated-sludge plants provide a relatively favorable environment for eggs. Many will pass through, and many will hatch. (In an activated sludge plant, most eggs will hatch within a few hours; this is good in that the miracidia must immediately find a snail within 24 hours, which usually is difficult).

- o Waste stabilization ponds with an adequate total retention time (at least 20 days) will provide a total barrier to schistosomes. Anaerobic ponds strongly inhibit hatching of eggs, while facultative and aerobic ponds do not. Miracidia die within six hours in anaerobic ponds, and within 10 hours in facultative ponds. In anaerobic ponds snails cannot reproduce and will die within a few weeks, whereas they can live and breed in facultative and maturation ponds. If a viable egg enters a facultative pond in a three-pond system, it may hatch and infect a snail; but any cercariae shed by the snail will still have to pass through two maturation ponds and will die long before they reach the treatment plant outlet.

3.4 The Other Parameters

Biological issues not covered under the agricultural use or public health categories, such as uncultivated plant and animal life, migratory birds, or the impact of aerosols on the olive plantation, will be discussed.

The land use category will include the landfilling of screenings and grit from AGTP, and of sludge from As-Samra. It will also cover the creation of new buildings, drying beds, or ponds, and the disposal of material excavated during construction.

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Odors are a major perceived impact of the present As-Samra ponds. Under certain conditions of still air and temperature inversion, odors attributed to the As-Samra WSP can be offensive even many km away. The need for effective odor control, at Ain Ghazal and at As-Samra, is a major reason for this project.

Archaeological considerations are of particular importance in Jordan, where artifacts from hundreds of centuries of civilization abound. The project team has been in contact with the American Center of Oriental Research (ACOR), Amman.

As for archaeological impacts of construction or construction activities at the As-Samra WSP, we have held preliminary discussions of the proposed measures with Dr. Gaetano Palumbo, Cultural Resources Management Archaeologist of ACOR. Dr. Palumbo indicated that it appears that the proposed work will be limited to areas already heavily modified, and that the likelihood of encountering any significant archaeological remains is very small. To be certain of this, however, a modest archaeological survey should be undertaken, at the initial construction stages, of the lands to be affected.

Flooding is a category relevant to the siphon, not so much in the case of its own rupture and spillage of sewage to Wadi Ain Ghazal and to Seil Zarqa--though that would be a significant water quality impact--but in the case of sudden failure of the emergency pond when full. This will be discussed in Section 4.

Power consumption is discussed with respect to the As-Samra Ponds, where a significant increase in power is required for the aerators proposed in the short-term measures.

Seismicity is an appropriate concern, given the long design life of these facilities, the major 1927 earthquake in Jordan, and the recent earthquakes in Cairo. It is of particular relevance to the structural integrity of the siphon.

SECTION 4

AIN GHAZAL TREATMENT PLANT HEADWORKS

4.1 Introduction

The short-term emergency measures at Ain Ghazal Treatment Plant are limited to designing a new headworks and rehabilitating the existing headworks. The expansion will allow for a far greater ultimate tributary flow, as well as continue to accept septage as at present. Grit and screenings collection will be greatly improved, and odor control will be improved. The new design average flow is 148,500 cu m/day and the design peak flow is 327,000 cu m/day.

As detailed in Section III.B of the Design Report, the following four alternatives were considered, representing varying degrees of rehabilitation of existing facilities and construction of new facilities:

- o Alternative No. 1: Rehabilitate the existing wastewater and septage facilities and use them on a regular basis. Provide a new pretreatment facility capable of handling Year 2005 wastewater flows in excess of the existing wastewater facility's capacity;

- o Alternative No. 2: Rehabilitate the existing wastewater pretreatment units and use them for standby capacity. Abandon the existing septage pretreatment facility and pump septage to the new pretreatment facility. Provide a new pretreatment facility to handle septage flow and Year 2005 flows,with standby capacity furnished by rehabilitated existing units;

- o Alternative No. 3: Abandon both the existing wastewater and septage pretreatment facilities. Provide a new pretreatment facility to handle (a) septage flow through pumping, and (b) Year 2005 wastewater flows; and

- o Alternative No. 3A: This is identical to Alternative No. 3 except that the new pretreatment facility is lowered just enough to (a) enable gravity flow of septage into the new facility, and (b) eliminate a considerable amount of the existing surcharge upstream of the existing pretreatment facilities.

Alternative 3A is recommended.

The environmental impacts for these alternatives vary insignificantly from one to the next in kind or degree, with a minor exception regarding odor control, discussed below. Otherwise, the following discussion applies to all the alternatives.

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In the course of these improvements, provision will be made to permit emergency bypass of all flows to the Wadi Ain Ghazal should the siphon need to be taken out of service. The environmental impacts to be considered therewith are discussed in Section 5.

Table 4.1 is an impact matrix in which the impact categories (left column) are ranged against the proposed activities for the AGTP (top row). In the matrix cells, the impact type (N, C, E, or "-" for "not applicable") are denoted. As shown in the matrix, matters concerning biological impacts or impacts of effluent or residuals on agricultural land are _a priori_ not considered relevant to the short-term emergency measures proposed for AGTP.

The measures at AGTP, rehabilitation of existing headworks together with construction of new facilities, will be discussed as one set of activities.

TABLE 4.1 IMPACT MATRIX FOR AIN GHAZAL TREATMENT PLANT

	Rehab'd Headworks	New Headworks
Agricultural Water Use	-	-
Agricultural Residuals Use	-	-
Public Health	N	C,N
Biological	-	-
Land Use	-	C,N
Odor, Other Air	N	N
Archaeological	-	C
Seismicity	C	C

Legend:
- \- Not applicable
- N Impact during normal operation
- C Impact during construction
- E Impact during and/or following emergency

Note: Siphon bypass at AGTP is considered in the next table

4.2 Public Health

During construction of the new headworks, there would be a negative impact if sewage had to be bypassed to the Wadi Ain Ghazal at any time, such as switch-over from using the old system to using the new headworks. Such an impact would be comparable to that which now occurs, and will in the future occur, whenever sewage inflows exceed the capacity of the siphon due to rainfall. This can be mitigated by proper design and planning for the switch-over process.

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Grit and screenings should be kept covered as they are removed from the wastewater stream. They should be promptly loaded onto covered trucks, and transported to the landfill.

Daily cover of grit and screenings disposed at the landfill is essential to effectively control odor and disease vectors.

With these qualifications, adverse public health impacts during construction of the new headworks, and during operation of the new and rehabilitated headworks, will be nil.

4.3 Land Use

During construction, land use issues for the new headworks will be nil, since the limited amount of new construction will be contained within the existing site.

During normal operation of the new and rehabilitated headworks, grit and screenings removal will be much more effective than at present. The present practice of trucking grit and screenings to the Ruseifa sanitary landfill is expected to continue, but the volume rate of such material to be disposed will increase by an order of magnitude, to several tons per day. This is still a modest landfilling rate, compared with the total daily load of all material brought to that landfill; the land use impact is therefore considered minor.

4.4 Dust

During construction, there is a slight possibility of dust being generated at the site, or of dust blowing from trucks driving from the site with, say, excavated soil. A major problem is not anticipated, since the proposed construction of new civil works, hence associated earthworks, is small. However, if dust is poorly controlled, this could be troublesome to facilities such as the adjacent abattoir. Dust at the site can be mitigated as needed by sprays, and in trucks by sprays or tarpaulin covering.

4.5 Odor

A major objective of the short-term emergency measures is to improve odor control at AGTP. It appears that this can be achieved without difficulty, provided that odor control facilities can be operated as designed and specified. For example, odor control presently is only partially effective. One probable cause for impaired effectiveness is clogging of chemical feed lines due to scale deposits, as a result of chemical interaction with the alkalinity of the water supply. Presuming that the short-term measures will likewise provide appropriate odor-control hardware to the new headworks, the rehabilitated headworks, and the septage receiving facilities, the remaining challenge will be to keep the system operating and maintained as designed.

In general, a design that minimizes the amount of free surface and turbulent, air-entraining overfalls is a design that best mitigates odor release, and should be sought at AGTP. Wherever possible, closed-channel flow is, in this regard, preferable to open-channel flow.

Among the several rehabilitation/new facility alternatives considered, Alternatives 3 and 3A have the minor environmental advantage of requiring fewer odor control units, to keep operating properly. These alternatives call for one pretreatment facility to handle septage and wastewater in an enclosed building.

The odor associated with the removal, handling, transport, and disposal of grit and screenings is small provided the material is handled promptly and promptly buried at the landfill.

4.6 Archaeology

Practically speaking, it is extremely unlikely that there will be any archaeological impacts during excavation for the new AGTP headworks, as the land on the site has been determined to be relatively recent fill.

The downstream end of the new headworks will provide a stub-out for a future second siphon. While it is expected that there will be archaeological studies for the second siphon route, no such studies are needed for the new headworks, which terminate well within a well-disturbed area of the existing AGTP site.

4.7 Seismicity

An appropriate earthquake design code should be adopted and followed for all structures at AGTP.

4.8 Environmental Impact Summary for AGTP

Significant environmental benefit will be provided by the new headworks in terms of odor control and reduction in frequency of overflows.

The most significant environmental impact issues for short-term emergency measures at AGTP concern odor and the handling and disposal of screenings and grit, both during normal operations.

Odor will be mitigated with provision of works that facilitate capture of odorous air, and proper treatment of it. Provision of such facilities, and the electrical power to operate them, is expected. The challenge lies in ensuring a steady supply of sufficient appropriate chemical reagents to keep the odor control facilities operating as designed.

Issues of odor and public health related to handling and disposal of screenings and grit are best addressed by prompt handling of this material, moving it directly from its point of removal from the flow into a covered truck to transport it to a sanitary landfill where daily cover is applied.

Any dust problems should be mitigated by water sprays or by cover, as appropriate.

The degree of noise will be little different from present conditions, either during construction or subsequent operations. Issues of agricultural criteria for effluent or residuals disposal, or of biological impact, or of archaeology, are not relevant at AGTP.

SECTION 5

PROTECTION OF THE CONVEYANCE SIPHON FROM AGTP TO AS-SAMRA

5.1 Introduction

As part of preparing this Environmental Assessment Report, the team inspected the siphon along most of its path from AGTP to As-Samra. The team found that to avoid a major adverse environmental impact, namely rupture of the siphon due to soil erosion in the wadi in which it is carried, immediate measures should be taken to ensure its protection in several critical areas, and that a program of longer-term protection measures for a number of reaches should be studied (Figure 5.1). Such measures are presented and discussed in the Design Report and its Appendix D.

This section of the environmental assessment report deals not with the adverse impact of a ruptured siphon, but with the proposed short-term emergency measures to protect the siphon. They consist of:

a) Specific short-term measures to ensure enduring protection to the pipeline in identified critical areas that require immediate attention;

b) Recommendations towards a longer-term study of additional measures to provide better long-term strategic protection;

c) Provision of capability at AGTP for complete bypass of the siphon should that be necessary to effect repairs of the siphon; and

d) Recommendations concerning the emergency pond at the siphon's lowest elevation.

Table 5.1 is an impact matrix in which the impact categories (left column) are ranged against the proposed activities for the siphon (top row). In the matrix cells, the impact type (N, C, E, or "-" for "not applicable") are denoted.

5.2 Short-Term Emergency Measures

No significant environmental impacts associated with short-term immediate remedial measures are indicated in the matrix. These activities will be limited to specified placements of graded stone and rock at critical points along the pipeline, as specified in Section III.C (and Appendix D) of the Design Report. These activities will entail a number of truck loads of this material being brought over highways and the pipeline access road to the site, and placed as specified. Machinery such as bulldozers and front-end loaders will have to operate in the bed

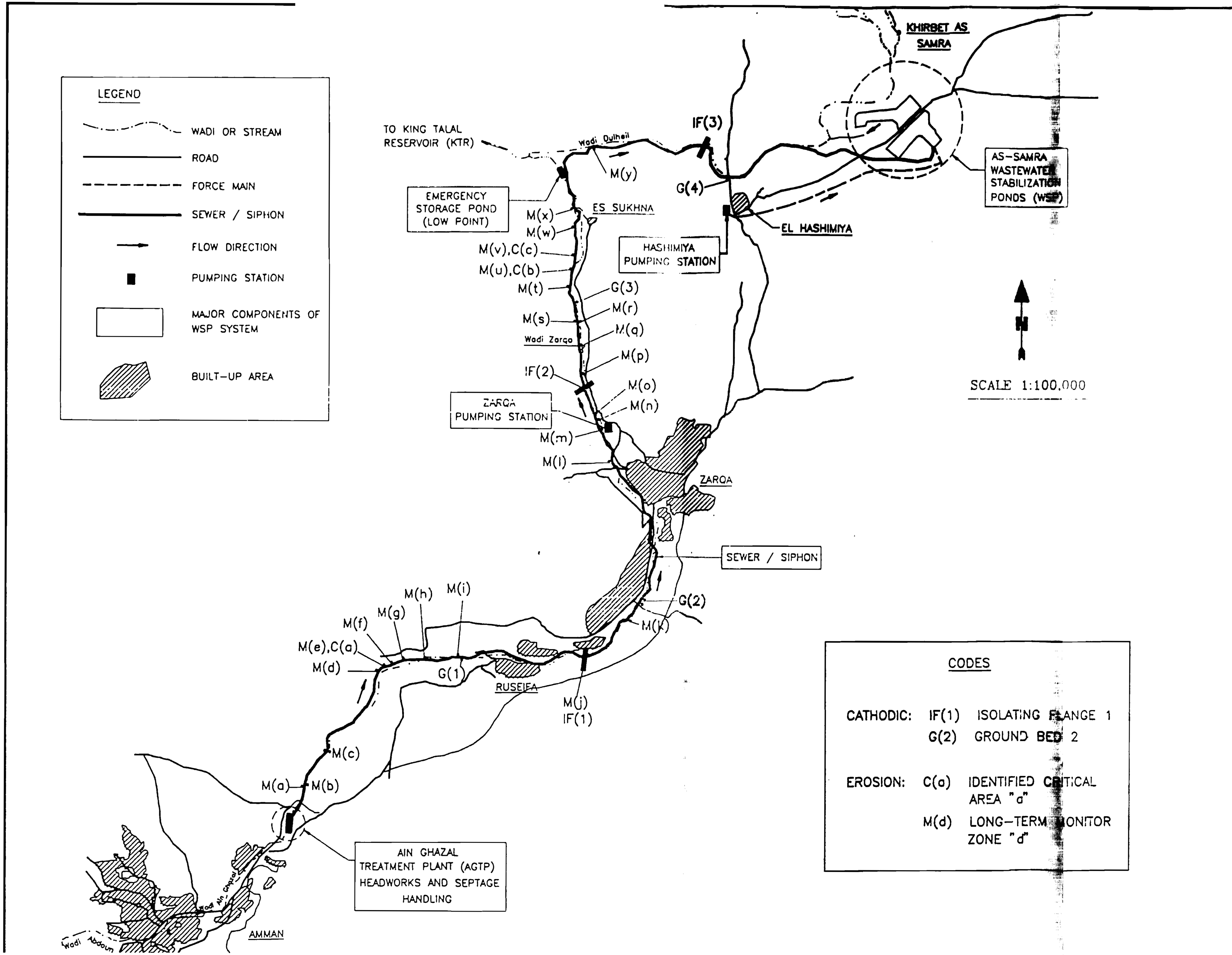

FIGURE 5.1

PLAN OF SIPHON ROUTE SHOWING CATHODIC PROTECTION, ZONES OF CRITICAL EROSION, AND EROSION MONITORING

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ENVIRONMENTAL ENGINEERS, SCIENTISTS, PLANNERS & MANAGEMENT CONSULTANTS, MASSACHUSETTS-USA
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of the wadi. If trucks keep to roads, there should be no adverse impacts on adjacent farmlands.

Downstream of Horizontal Inflection Point (HIP) 74, the encased pipeline where it crosses the wadi is regularly used by local vehicles. While there is no evidence to the casual eye that the traffic of cars or pickup trucks has yet damaged the pipeline there, traffic of laden dumptrucks and heavy earthmoving equipment should not take this route to Identified Critical Area (b) between HIP 71 and HIP 72, or Identified Critical Area (c) at HIP 73. Heavy traffic fording the wadi in this way would possibly endanger the pipeline, as well as generate turbidity in the wadi flow. Instead, vehicles should use the access road to these areas from the south.

Construction materials for remedial work at all three Identified Critical Areas will consist of ballast stone and armor rock. These materials should not be gathered from the bed of the wadi nearby, but imported from conventional quarries. To gather materials from the wadi bed would abet further erosion in the wadi, as well as generate turbidity.

TABLE 5.1 IMPACT MATRIX FOR SIPHON FROM AGTP TO AS-SAMRA

	Short-term Measures on Pipeline	Longer-term Measures on Pipeline	Bypass at AGTP	Emergency Pond
Agricultural Water Use	-	-	E	E
Public Health	-	-	E	E
Biological	-	-	E	E
Land Use	-	C,N	-	-
Odor, other air	-	-	-	--
Archaeology	-	C	-	-
Flooding	-	-	E	E

Legend:
- \- Not applicable
- N Impact during normal operation
- C Impact during construction
- E Impact during and/or following emergency

5.3 Longer-Term Measures to Protect the Siphon Pipeline

In addition to the short-term specification of measures in identified critical areas, the design report section on siphon protection also specifies 25 zones that should be monitored for onset of erosion problems, with tactical erosion control measures to be taken as needed. The design report also sets out suggestions for studies towards longer-term strategic measures to protect the pipeline over considerably greater reaches than just the identified critical areas.

The tactical measures, to be taken in advance of erosion problems reaching a critical condition, would likely be of the same nature as the short-term emergency measures: placement of stone and rock in limited areas. The same environmental mitigation measures would apply.

The longer-term strategic measures could involve relocating entire sections of the pipeline that are in perilous areas, systematically dissipating the wadi stream energy by a series of dams, and/or other major structural measures. As such the plans for these measures must anticipate and mitigate land-use impacts such as taking or working on farmland, and need to avoid or evaluate impact on archaeological sites, during construction. Another major consideration is the avoidance of damage due to a major earthquake.

Furthermore, one must anticipate and mitigate serious land-use impacts after construction: if barrages are built to dissipate stream energy, the resulting upstream pools could inundate farmland and buildings with more frequent runoff events than at present. (This may be an acceptable impact, if farmland is thereby not lost as rapidly to erosion.)

5.4 Provision of Siphon Bypass Capability at Ain Ghazal Treatment Plant

5.4.1 Introduction

At present, the siphon is the only means to convey Amman's wastewater flows from their point of collection at AGTP to their point of treatment at As-Samra, 39 km away. The siphon has but one barrel. It is a pressure pipeline that in many sections is under an internal head of between 100 and 200 m. As noted in previous sections, much of the pipeline is laid in the structurally perilous wadi of the Seil Zarqa.

Although short-term emergency measures and longer-term strategic protection measures are proposed, it is also judicious to anticipate that the pipeline could fail at some section.

In the event of an emergency discharge of sewage, there would be an impact to agricultural lands, in that water drawn from the wadi to irrigate adjacent farmland, or to wash off harvested produce such as carrots and turnips, would doubtless not meet the fecal coliform standards listed in Section 3.1. The nematode egg criterion would likely be violated. Similarly, the public health of farm workers might be compromised. There may be other biological impacts, as well.

Therefore it is essential to provide means for the quickest possible repair of the pipeline and its return to service. Given the high internal pressures of normal service, there is an obvious need to be able to isolate the pipeline of any flows for such duration as needed to repair the break completely, so that the pipeline can once more be put into high-pressure service for an indefinite period.

Accordingly, a capability for emergency bypass of the siphon, with all flow being diverted to the adjacent Wadi Ain Ghazal, should be provided. This capability is physically available under present conditions, in the sense that flow to the existing headworks could be diverted from the siphon and through the old existing treatment works; and then, by closing the conduit to the siphon from the old chlorine contact tank, the diverted flow would all pass to the wadi. All that is needed to put this capability in place is to ensure that the appropriate sluice gates are operational (some after several years of inactivity), that institutional arrangements for rapid communication/rapid response are in place, and that local staff are drilled on the procedures. Similar institutional arrangements should be coordinated with the authorities operating the Zarqa Pump Station.

The proposed new headworks will specifically be designed to provide the capability of total bypass to the wadi.

5.4.2 Discussion of impacts

To bypass to the wadi will cause the impacts described above; but by allowing the pipeline to be dewatered and quickly repaired, bypass to the wadi will be of far shorter duration than would be leakage to the wadi from a ruptured pipeline that could not be dewatered.

5.4.3 Frequency of discharge to Wadi Ain Ghazal

Since in its eight years of service there has never been a total bypass of the siphon, it may seem that specific provision of bypass capability at AGTP is an "invitation to use it", and that raw sewage discharge to the wadi will become more frequent. However, the fact is that sewage overflow to the Wadi Ain Ghazal already occurs several times a year, in the wet season, whenever stormwater infiltration and inflow increase the influent rate to more than the capacity of the pipeline (or the hydraulic capacity of the bar screens). Residents of the wadi plain are therefore accustomed to occasional sewage discharges lasting a few hours each. The impact of a discharge to the wadi due to siphon bypass lasting perhaps several days until the pipeline can be repaired should therefore be acceptable. In any case, the probability of such an event is far less than the probability of an overflow to the wadi. With the advent of the new headworks, the net frequency of overflow/bypass will be reduced.

5.4.4 Routing bypass through abandoned AGTP

To provide some measure of storage and treatment to siphon bypass flow before discharging it to the wadi, the bypassed flow could simply be routed through the tanks, presently empty, of the abandoned AGTP. The time needed to fill the tanks, and the ability of all these tanks--clarifiers, aeration basins, and the chlorine contact tank--to settle some of the sewage solids will provide at least a small degree improvement to the flow before discharge to the wadi.

5.5 Emergency Pond Capacity and Lack of Overflow Spillway

The capacity of the emergency pond is 56,000 cu m. This is slightly in excess of the pipeline's volume of about 40,000 cu m, and so it will be an appropriate emergency pond volume once there is a means to isolate the siphon at its upper end at the AGTP, as described in the previous section.

Currently:

- o There is no way to prevent substantial flow from entering the siphon.
- o A typical average daily flow of about 100,000 cu m will fill the pond within half a day.
- o It is inconceivable that any emergency requiring use of the emergency pond would be solved within half a day's time. (In fact, the time required to properly open and close the gate valves to the pond is of the order of 3 hours each way, in order, certainly, to avoid waterhammer.)
- o Except for two culverts about 200 mm in diameter, there is no outlet or overflow spillway from the pond situated on the bank of the wadi.

Therefore, unless and until provision is made in the short-term emergency program to provide for emergency isolation of the siphon at its upper end:

- o Any genuine emergency use of this pond is almost certain to result in the pond overflowing its banks, and to a degree that may result in sudden failure of the pond, as well as the sudden release of the 56,000 cu m of sewage to the Wadi Zarqa.

The environmental impact of this catastrophe will be in the volume of this sudden flood, and only secondarily in that it is sewage. Farms, herds, people, and buildings may be at risk.

WAJ policy should be to not use the emergency pond under any circumstances until siphon bypass capability at Ain Ghazal is provided.

5.6 Environmental Impact Summary for the Siphon

Short-term emergency measures should be implemented in several identified critical areas along the pipeline in Seil Zarqa where erosion in the wadi has seriously threatened the integrity of the pipeline. In most of these areas the WAJ has already taken important remedial action, but further erosion protection is warranted. These critical areas and the recommended measures are detailed in the Design Report.

The environmental impacts of undertaking such remedial actions are minor, and in any event are far less an impact than allowing the situation to deteriorate to the point where the siphon ruptures and a major sewage spill to the wadi would occur.

A range of longer-term measures is suggested for future study. The nature of some of these measures is to significantly modify the dynamics of the wadi; accordingly, significant environmental impacts may be associated, and must be assessed as part of the long-term study. Seismicity concerns should be fully addressed.

It is recommended that, as soon as possible, structural, operational, and institutional changes be made at the Ain Ghazal Treatment Plant, and with respect to the Zarqa Pumping Station, to enable flows to be immediately diverted from entering the siphon, and bypassed to the neighboring wadi, in the event of a siphon rupture. There will be no significant environmental impact in making such changes. There is an environmental impact to discharge raw sewage to the wadi, but this (a) normally occurs anyway during many rainstorms in a year, and (b) permits quick and effective repair of the siphon so it can be returned to service in the shortest possible time.

The emergency pond should not be used until there is siphon bypass capability. An emergency spillway for the pond should be considered in the longer term.

SECTION 6

AS-SAMRA WASTEWATER STABILIZATION PONDS

6.1 Introduction

For the As-Samra WSP facility, the design criteria were as follows:

Inlet Structure:

Peak Flow, cu m/day	462,000

Pond Treatment and Disinfection

Average Daily Flow, cu m/day	145,000
Peak Daily Flow, cu m/day	210,000
Total BOD_5	30-60 mg/l
Fecal Coliform	100 MPN/100 ml
Nematode Eggs	<1/100 ml

As shown in Table 6.1, the proposed short-term activities consist of replacing the existing inlet works with an enlarged and improved inlet works; installing three odor control facilities; providing mechanical aerators in several of the maturation ponds; installing baffles in the facultative and maturation ponds of each train; rehabilitating chlorination facilities; removing, processing and disposing of over eight years' accumulation (275,500+ cu m) of sludge from the six anaerobic ponds; and constructing electrical switchgear and motor control facilities.

The environmental impact matrix for the short-term improvements at the As-Samra Wastewater Stabilization Ponds is shown in Table 6.1. The perceived beneficial and potentially adverse impacts of the four proposed measures are discussed below.

6.2 Inlet

For the inlet structure, the two alternatives considered were:

- o Alternative No. 1: Rehabilitate the existing inlet structure and provide a new structure sized to augment the capacity of the rehabilitated inlet structure in order to meet Year 2005 flows; and

- o Alternative No. 2: Abandon the existing inlet structure and provide a new inlet structure to accommodate Year 2005 peak flow.

Alternative No.2 is recommended.

TABLE 6.1 IMPACT MATRIX FOR AS-SAMRA WSP					
	Inlet Works	Aeration	Baffles in F, M ponds	Disin-fection	Sludge Removal, Process'g and Disposal
Agricultural Water Use	-	N	N	N	-
Agricultural Residuals Use	-	-	-	-	N
Public Health	-	N	N	N	N
Biological	-	N	N	N	N
Land Use	C	-	-	-	C,N
Odor, Other Air	N	N	N	N	N
Archaeological	C	-	-	-	C
Seismicity	C	-	-	-	C

Legend:
- \- Not applicable
- N Impact during normal operation
- C Impact during construction
- E Impact during and/or following emergency

Benefits

A new inlet structure will provide an environmental benefit in its greater hydraulic capacity to accept increased flow via the existing siphon and from a second siphon; in its improved ability to distribute flow equally among the trains in service; and in its design to facilitate control of odors from the sewage at that point.

Adverse impacts

During construction, any adverse impacts on land use or archaeology will be negligible since the structure is small and will be sited near the existing inlet works. This location is on WAJ property, far from any boundary, and in an area which has already been well disturbed. The only odor impacts will be positive ones, resulting from improved control of odors. No particular mitigation measures are deemed necessary beyond conventional measures for dust control and keeping site disturbance within reasonable bounds during construction.

Seismicity

A seismicity study for the area should be written, and an appropriate earthquake design code adopted for the structure.

6.3 Aeration

For the WSP aeration, five alternatives were considered, including:

- o Alternative No. 1: Raise the weir crest elevation in Ponds F1-1, F2-1 and F3-1 by 0.4 m and in Ponds F2-1, F2-2, F3-2a and F3-2b by 0.65 m and provide electrically-driven floating mechanical surface aerators;
- o Alternative No. 1A: Construct three new ponds having a depth of 5 m each, in the area east of the existing Ponds A1-1 and F1-1 and provide electrically-driven floating mechanical surface aerators;
- o Alternative No.2: Deepen ponds M1-3, M2-3 and M3-3 to a depth of 3.0 m below the pond effluent weir (ie, 1.86 m excavation) and install two baffle walls to form three cells in each pond. Provide electrically-driven floating mechanical surface aerators. Also, divide each Mx-4 pond lengthwise to provide two sludge settling sub-ponds and improve flow-through characteristics.
- o Alternative 2A: Provide facilities in Ponds M3-3 and M3-4 identical to those described under Alternative No.2 above. Provide three new ponds north of the existing Pond M1-4 to form three cells to accommodate the combined flow from Trains 1 and 2. Provide interpond structures to convey flow, and subdivide each Mx-4 pond lengthwise to provide two sludge settling sub-ponds and improve flow-through characteristics; and
- o Alternative No. 2B: Provide a supplemental treatment system downstream of the maturation ponds involving the conveyance of the effluent from the Mx-4 pond of each train to an aeration tank where it would be mixed with return activated sludge (RAS). Provide electrically-driven floating mechanical surface aerators. Also, provide a battery of rectangular clarifiers for solid settlement.

Alternative No.2 is recommended.

Benefits

The provision of aeration is intended to provide the major environmental benefit to public health, generally, and to agricultural workers, in particular, through improved effluent quality, reduced the BOD and ammonia concentrations and higher DO levels. A beneficial consequence of reduction of organic constituents (as indicated by BOD) is an improvement in the effectiveness of the subsequent disinfection process, and a reduction in the likelihood and amount of trihalomethane (THM) formation as an unwanted byproduct of the disinfection process.

Potential adverse impacts

During construction. The installation of mechanical aerators will require that the water depth be of the order of 3 to 4 m in the ponds where they are installed.

Five locations have been considered (see Section III.D of the Design Report):

1. In the first two sets of facultative ponds;

2. In new ponds between the anaerobic and facultative ponds;

3. In the third set of maturation ponds;

4. In new ponds between the third and fourth sets of the maturation ponds (Trains 1 and 2 only); and

5. In a conventional waste-activated sludge facility at the end of the three existing trains.

Option 1 would cause the least environmental impact, as the required depth for aeration can be achieved merely by raising the weirs and adding revetment farther up the banks of the ponds involved. No pond would have to be taken out of service.

Options 2, 4 and 5 need not involve taking any existing ponds out of service. There would be the customary concerns such as dust and traffic to be mitigated during construction. As noted in Section 6.6 following, archaeological concerns adjacent to the existing ponds are expected to be nil, although a survey should be conducted early in the construction phase. There would be a need to dispose of excavated material, to the extent that this material would not be used in constructing the embankments forming the ponds. The material would presumably be of conventional soil quality and present no particular problems.

Option 3 would require taking ponds out of service for deepening. This would result in a minor reduction in WSP system performance, and could be mitigated by taking only one pond out of service at a time. There would be the additional impact of disposal of the excavated material, which to some extent would include sludge fines from eight years of operation. This could be buried on WAJ property at the As-Samra WSP site, with the similar care and concerns as noted for burial or landfilling of sludge, discussed in Section 6.6.

During operation. The use of aerators will generate large quantities of aerosols containing detergent chemicals and, conceivably, viruses. Wind would carry these aerosols a considerable distance. The detergent aerosols may have an adverse impact on nearby flora, in changing the capillary hydrodynamics of plant leaves. In particular, the condition of the olive trees planted nearby should be monitored.

As for viruses, studies conducted over many years have failed to show any epidemiological peril to sewage plant workers or other populations due to aerosols from stabilization pond aeration or activated sludge plants.

At present, overfalls in the pond trains that provide energetic air entrainment also generate considerable amounts of foam, with the amount of foam seen increasing as one moves downstream through the pond trains. The aerators, particularly if located far downstream in the pond trains, can be expected to generate very large volumes of foam. Wind can carry the foam out of the ponds.

The adverse impact of wind-driven foam is relatively minor; it would not reach beyond the WAJ site. At most, it might affect the on-site olive plantation. It can be mitigated by plantings of cypress, casuarina, or other evergreen border trees close around the pond where the aerators are located, to keep foam from blowing far from that pond.

The beneficial impact of generating foam in the As-Samra ponds is that foaming potential downstream in the Wadi Dulheil may be reduced. This would be an aesthetic benefit, for the flow in the wadi does generate and carry foam. Therefore, no measures to control foam in the aeration basins are recommended.

Foaming is expected to decrease over time as household and industrial/commercial detergents are gradually replaced by detergents that foam less, a presently ongoing process.

As for odor, aeration should have the positive impact of rendering the water aerobic, which will eliminate the possibility of a hydrogen sulfide odor from that part of the pond system. There is an odor commonly associated with sewage aeration. While it can be identified as being of sewage origin, and while it is not practicable to control such odor when it is generated by a large installation of surface aerators on a large outdoor pond, it is an odor far fainter and far less disagreeable than hydrogen sulfide odor. It is very unlikely to be sensed in inhabited areas.

The addition of mechanical electric aerators will increase the power consumption on the site by roughly 5 megawatts, an increase that will require the construction of new power lines to and about the WSP site, with several substations and motor control centers. The impact of these new installations will be very minor. The 5 MW will result in a marginal increase in heat and exhaust at the principal Jordan Electric Company generating station a few kilometers away.

6.4 Provision of Baffles

Internal baffle walls are recommended for the facultative ponds of each train and for essentially all of the maturation ponds. These around-the-end baffles will greatly reduce short-circuiting in each pond so equipped by training the flow from its influent point to the pond outlet along a path roughly three times the pond length, but one-third the pond width.

Not having to withstand any but very mild lateral forces, the baffles will be of simple, lightweight construction, such as post-and-wiremesh (e.g. "cyclone") fencing installed in the pond bottoms and extending to just below the water surface (8 cm below weir level), and made impermeable by lining the fencing with durable plastic sheeting.

Benefits

In theory, the roughly 3,600,000 cu m of pond volume should give a retention time of 25 days to the projected average daily flow of 145,000 cmd, and a retention time of 17 days to the peak flow of 210,000 cmd. However, this is not attained at present, with significant (although unquantified) short-circuiting within the ponds. The baffles would ensure essentially complete use of the pond volume and allow for the continuous achievement of 8 to 10 days' retention time, as required in a stabilization pond system to achieve good pathogen reduction. By reducing or eliminating the need for disinfection by chlorination, the cost of chlorine is reduced, and the possibility of THM formation is accordingly reduced. This will benefit agriculture and public health. Furthermore, there will be greater reduction of BOD and possibly of odor in the effluent, as well.

Potential adverse impacts

To install the baffles in the pond, the pond will have to be taken out of service for the few days required for installation. Otherwise, there are no evident adverse effects of baffling. The slender construction will take up negligible pond volume. By keeping the top of the baffle just below the water surface, oily slicks and other floating material can still be wind-driven to the banks of the pond for removal.

6.5 Odor Control

Odors at As-Samra are generated wherever the effluent meets the atmosphere, which is to say everywhere over the 184-hectare free surface of the pond system. However, odor generation is by far the most intense in areas of high-energy activity at the free surface, meaning at the plant inlet structure and at the weirs where the water falls from one pond level to another. Most such weir flows are presently simple waterfalls, with no engineering attempt to minimize off-gassing of odors.

While it is not at all practical to control emissions from the entire pond area, it is feasible to consider odor control at the inlet and drop structures. Accordingly, the inlet and drop structures are to be hooded, and the contaminated air ducted to two-stage packed-tower scrubbers for treatment.

An attractive strategic alternative to be tested is the replacement of the simple aerated weirs between ponds with appropriately sized siphon spillways that move effluent from one pond to the next, dissipating as much as 3.2 meters of head simply by turbulent headloss within the piping, and at its submerged entrance and exit, without major sustained mingling with air. The simple siphon design requires minimal maintenance and does not involve moving parts or chemical feeds.

6.6 Disinfection

For the disinfection facility, it is recommended:

- Not to expand the chlorine contact basin;
- Not to expand the chlorination facility and associated equipment; and
- To rehabilitate the disinfection facility (i.e, provide miscellaneous repair and replacement of existing chlorination system components) and replenish the system's spare parts inventory.

Benefits

The short-term improvements for As-Samra will provide improved disinfection performance and reliability. This will result from the rehabilitation or replacement of existing chlorination equipment, as well as modifications to the original system. In addition, disinfection performance will improve as a result of the reduction in chlorine-demanding BOD and organic material upstream during the aeration process. This will reduce the amount of chlorine required over what is currently necessary in order to achieve the same level of disinfection. These improvements will not only provide an effluent that will more consistently meet adopted microbiological standards, but one that will be less odorous, as well.

Impact issues of agricultural use of the effluent water are relevant to the normal aeration and disinfection operations, which are explicitly introduced to improve the agricultural water quality. Presently, the effluent meets the fecal coliform and nematode standards most of the time. The proposed short-term improvements are designed to provide consistent compliance with the WHO standards presented in Section 3.1.

Potential adverse impacts

The adverse impacts attributable to short-term improvements for disinfection at As-Samra consist of the possible contamination of the effluent with trihalomethanes (THMs). THMs are suspected carcinogens and can form when the chlorine dosed to inactivate pathogenic bacteria and viruses combines with certain organic compounds which may be present in the wastewater.

Field tests were recently conducted at the outlet from the chlorination basin to determine the levels of THM formation through a wide range of chlorine doses. Total THM levels in all cases were found to be much lower than the USEPA drinking water standard of 0.10 mg/l. THMs are expected to be even less of a concern after the implementation of the short-term improvements, since a smaller chlorine dose than that currently required will be needed to meet disinfection standards. Even the small concentrations of THMs formed by chlorination will decrease before the effluent reaches the user downstream. This decrease occurs because THMs are volatile and are released to atmosphere through turbulence in the wadi. Section III of the Design Report contains further details regarding the field tests performed for THMs.

In balance, the effluent should be chlorinated only as needed to meet fecal coliform criteria. Chlorination requirements for a given flowrate may be expected to decrease as a result of desludging and baffling, in addition to the aeration process.

6.7 Sludge Removal, Processing and Disposal

Of the four short-term measures proposed for the As-Samra WSP, sludge removal, processing and disposal have the greatest potential environmental impacts, both positive and negative. Environmental considerations, as discussed in Section III of the Design Report, play a particularly prominent role in selecting a strategy for sludge removal, processing and disposal. The environmental considerations are reviewed here.

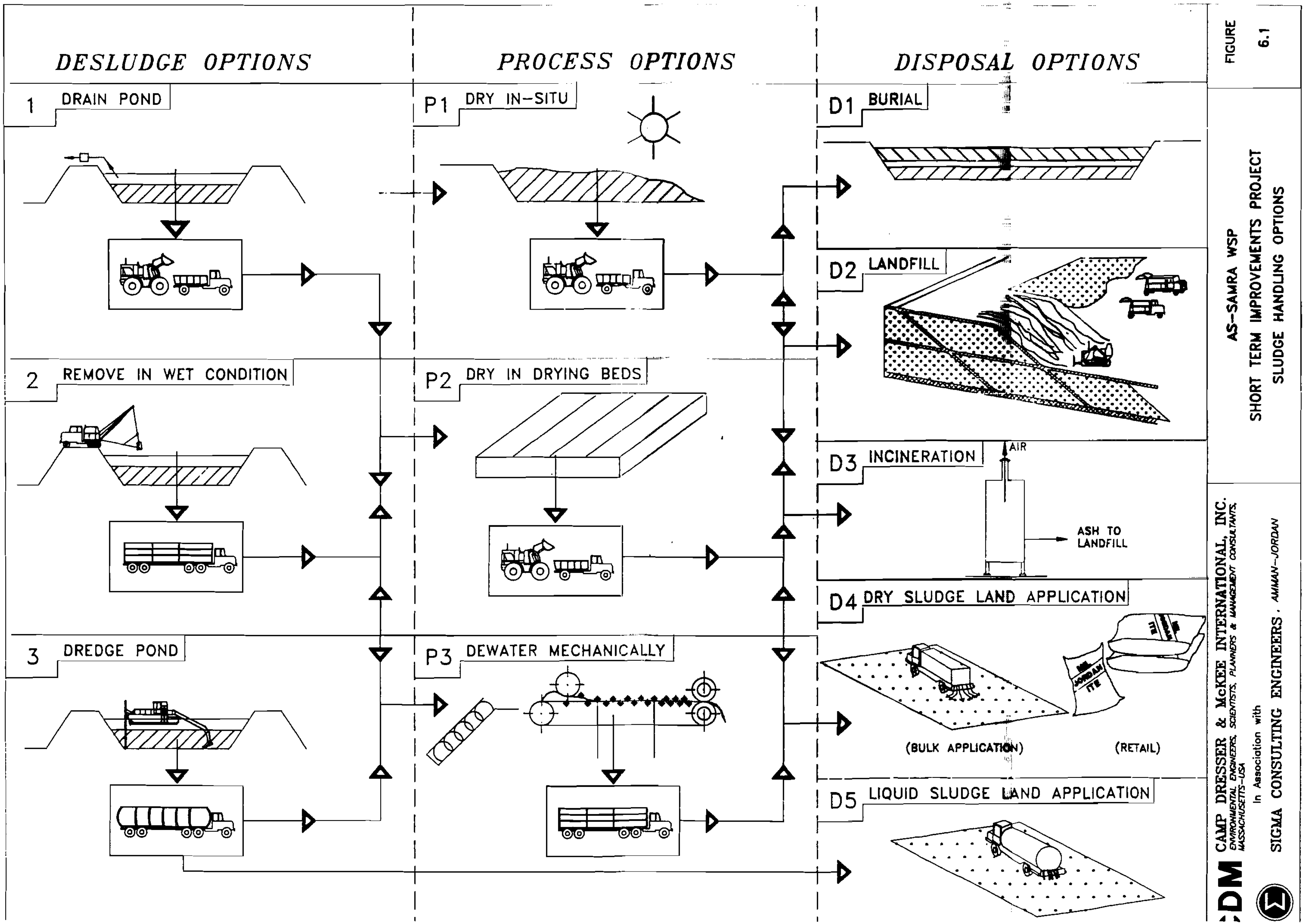
Benefits

The removal of nearly 300,000 cu m of sludge from the anaerobic ponds will restore the significant fraction (over 30 percent) of anaerobic pond volume now occupied by the sludge. This will increase retention time in the anaerobic ponds and in the treatment plant overall. It will increase retention time pond-by-pond, by restoring active volume to each pond. Together with the improvement in equitable flow distribution at the inlet, desludging will also increase retention time by eliminating the current situation where nearly half the influent is directed to the pond train with the least remaining active volume, a form of systematic short-circuiting.

Possible beneficial uses for the removed sludge, as well as the environmental aspects of the range of options considered for the short and long terms, as illustrated in Figure 6.1, are discussed further below.

Desludge options

1. Drain pond. Drain each pond and excavate the sludge using conventional earth-moving equipment such as front-end loaders and dump trucks. During the several months required for this task in each pond, the sludge deposit will be exposed to the atmosphere. The deposit may be odorous, and it may attract vectors (e.g. disease-carrying insects). For those ponds where



DESLUDGE OPTIONS
PROCESS OPTIONS
DISPOSAL OPTIONS
1 DRAIN POND
2 REMOVE IN WET CONDITION
3 DREDGE POND
P1 DRY IN-SITU
P2 DRY IN DRYING BEDS
P3 DEWATER MECHANICALLY
D1 BURIAL
D2 LANDFILL
D3 INCINERATION
AIR
ASH TO LANDFILL
D4 DRY SLUDGE LAND APPLICATION
(BULK APPLICATION)
(RETAIL)
D5 LIQUID SLUDGE LAND APPLICATION
FIGURE 6.1
AS-SAMRA WSP
SHORT TERM IMPROVEMENTS PROJECT
SLUDGE HANDLING OPTIONS
CDM CAMP DRESSER & McKEE INTERNATIONAL, INC.
ENVIRONMENTAL ENGINEERS, SCIENTISTS, PLANNERS & MANAGEMENT CONSULTANTS
MASSACHUSETTS-USA
In Association with
SIGMA CONSULTING ENGINEERS. AMMAN-JORDAN

the sludge deposit is sufficiently shallow (up to 1 m) that a tilling machine such as a "Brown Bear" can traverse it, odors and insects can be controlled by rabbling the surface and mixing in suitable conditioning chemicals. However, for the four anaerobic ponds where the sludge deposit has become so deep that no vehicle can safely traverse it, there is no feasible way to condition it for odor and insect control, or to rabble the surface to enhance drying and insect control, until the excavating machinery can work its way entirely through the deposit.

It was therefore recommended that a different scheme be employed for the removal of the existing sludge deposits under the Short Term Improvements construction contract. In this regard, two new anaerobic ponds ("Ponds A0-1 and A0-2") will be provided as part of the Short Term Improvements facilities (refer to Section III and Folio 1 Drawings of the Design Report). The accumulated sludge in Ponds A1-1, A1-2 and A3-1, A3-2 will be conveyed into Ponds A2-1 and A2-2 where large amounts of sludge deposits already exist. When Ponds A2-1 and A2-2 are filled with sludge, the ponds will be abandoned for a lengthy period of time (approximately five or six years) until the sludge is dried and can be removed using conventional excavating machinery. When the sludge is removed, Ponds A2-1 and A2-2 can then be put back in operation.

<u>2. Remove sludge in wet condition.</u> In this option, the pond is kept full of water to its normal depth, and so presents no more of an environmental impact than when in service. Excavation would be by dragline to dump truck, thence to drying beds or other dewatering. There is opportunity for odors to escape during this open operation.

<u>3. Dredge the pond.</u> In this option also, the pond is kept full of water to its normal depth. However, sludge removed from its deposit by the cutter-suction dredge can be transported from the pond in an entirely enclosed pipeline, discharging to a tank truck, or conveyed by pipeline the entire way to a drying bed, if a drying bed can be built sufficiently near. If conditioning chemicals are needed, they can be metered into the sludge line and thus be efficiently mixed throughout the sludge before it reaches the drying bed or other dewatering step. For these several reasons, dredging/pumping is by far the most environmentally attractive desludging option.

<u>Common adverse impact.</u> For all the desludging options, there will be an adverse impact in the system's capacity to treat, if no new anaerobic ponds are first constructed, due to the need for taking ponds out of service; but taking an anaerobic pond out of service is judged to have a relatively minor impact, sufficiently small that in the consultants' judgement no additional anaerobic ponds need be constructed to replace the capacity of a pond out of service for desludging.

Process options

P1. Dry in-situ. The same concerns apply as in Desludging Option 1, Drain the Pond. This option is environmentally manageable if the deposit can be worked throughout by a Brown Bear or equivalent tiller, but otherwise is unmanageable, because odors and vectors cannot be controlled.

P2. Dry in drying beds. Odors and insects are a concern but can be controlled provided the sludge deposit in the beds is kept to half a meter or less, so that it can be mechanically tilled and chemically conditioned, just as in in-situ drying. The inherent advantage of drying beds to which sludge is brought, as opposed to drying in-situ, is that the depth in a drying bed is controlled by the process design engineer and the desludging operator.

P3. Dewater mechanically. This class of options, including filter presses, belt presses, and centrifuges, is the most environmentally sound with respect to insects and odor control, because odorous gases can be ducted to scrubbers and incinerators. Of the options mentioned, centrifuges are the best for this purpose because of their continuous and closed-flow configuration. Mechanical dewatering will consume more power than drying bed operations.

In sum, all three of the process options can be environmentally acceptable if certain conditions are observed.

Disposal options

The five disposal options to be considered are burial, landfill, incineration, reuse as a soil conditioner/fertilizer in bags or bulk cake form, and discharge to land in liquid form.

To prepare for discussion of these options it is appropriate to examine the quality of the As-Samra sludge deposits, in terms of the USEPA and EC criteria presented and discussed in Section 3.2. Analyses for heavy metals content, total and volatile solids content, and concentration of total and fecal coliform, fecal streptococci, salmonella, and the eggs of several species of nematodes are provided in Appendix B. The results are discussed below.

Heavy metals. The heavy-metals results for the As-Samra sludge are presented in Table 6.2, showing an average value and the maximum value for each element. This is derived from Table B.6 in Appendix B. Also shown in the table are the USEPA pollutant concentration limits from Columns (a) and (d) of Table 3.2 and the European Community limit values for metal concentrations in sludge for use in agriculture.

Miqdadi earlier (Ref 10) reported a set of heavy metals analyses for As-Samra sludge. These values, expressed as ranges, are also presented in Table 6.2.

TABLE 6.2 AVERAGE AND MAXIMUM HEAVY METAL VALUES FOUND IN AS-SAMRA SLUDGE (mg/kg)						
ELEMENT	As-Samra Geometric Average	As-Samra Max Value	Miqdadi 1989	USEPA Poll'nt Conc.	USEPA Ceiling Conc.	EC Agric. Limit
Al	7,800	13,207	3242-12,227			
As	1.316	2.9		41	75	
Ag	1.493	23.5				
Ba			177.3-307.6			
Cd	3.653	8.1	3.94-7.84	39	85	20 to 40
Co	4.626	50.7	1.67-113.26			
Cr	222.085	669	42.73-181.97	1200	3000	
Cu	231.339	362	181.97-307.0	500	4300	1000 to 1750
Fe	436.141	23,676	10,023-21,470			
Hg	2.489	5.3		17	57	16 to 25
Li	2.901	5.6	1.52-3.64			
Mn	127.430	175	80.8-162.1			
Ni	46.627	68.4	28.4-109.8	420	420	300 to 400
Pb	151.767	211	97.7-365.9	300	840	750 to 1200
Se	1.462	6.3		36	100	
Si	1.148	1028				
Sn	0.190	0.6				
Ti	78.832	316				
V	22.139	141	30.4-37.7			
Zn	2163.076	3850	974.2-2222	2800	7500	2300 to 4000
B	33.628	88.8				
Mo			5.00-53.86	18	75	

Table 6.2 shows that:

- The USEPA pollutant concentration limits and the EC Agricultural Use Limits are of comparable value.

- The As-Samra sludge concentrations measured in the present study are less than both the USEPA Pollutant Concentrations and the EC Agricultural Limits for all metals except zinc. The maximum zinc level is less than the USEPA ceiling concentration.

- Miqdadi's range for lead included at least one sample exceeding the USEPA pollutant concentration, but not the USEPA ceiling concentration or the EC limit.

- Molybdenum (Mo) sampling was requested for the present study, but could not be analyzed at this time. Miqdadi's range for Mo exceeds the USEPA pollutant concentration, but not the USEPA ceiling concentration. (No EC limit for Mo is given.)

The implications of these results for agricultural use of As-Samra sludge are given below.

Pathogens. The results of sludge analysis by the Royal Scientific Society and by M. Hindiyeh are presented in Tables B.7 and B.8, respectively, in Appendix B. In summary:

Fecal coliforms and Streptococci. Both the RSS data and Hindiyeh's data indicate fecal coliform concentrations of the order of 10^6 to 3×10^7 per 100 ml of sludge; dividing by a typical sludge solids content of 150 g/l, or 15 g/100 ml, this range becomes 70,000 to 2,000,000 MPN per gram dry solids, well in excess of the "Class A" criterion described in Section 3.2.

M. Hindiyeh's data indicate fecal streptococci concentrations in the range of zero to 500,000 colony-forming units (CFU) per 100 ml.

Salmonella sp. concentrations in the range of 10^6 to 10^8 CFU per 100 ml are reported by Hindiyeh; on the basis of about 15 percent solids content, this translates to 300,000 to 30,000,000 CFU per 4 grams of dry solids, far in excess of the "Class A" criterion of 3 plaque-forming units (PFU) per 4 g dry solids.

Nematode eggs. The RSS data show 20 to 50 *Ascaris lumbricoides* eggs per 10 gm of sludge; many samples also show several *Trichuris trichiura* eggs per 10 gm of sludge, as well. Dr. Hindiyeh's data indicate concentrations an order of magnitude greater, between 20 and 140 helminth eggs per 1 gram of sludge solids. These levels are far in excess of the levels considered acceptable (less than 1 per four grams of total solids, dry weight basis).

We now return to Figure 6.1, to discuss the disposal options.

D1. Burial. This method of disposal can easily be made environmentally sound against odors and vectors by providing adequate daily cover. Groundwater contamination will not be a problem, certainly not greater than at present, because:

- o In the case of sludge burial nearby on the WAJ site, any leachate from sludge that has been accumulating in the As-Samra ponds will not likely create an impact different from that of seepage from the ponds themselves. In other words, this is not material new to the site, merely material that is removed from a pond site to a burial site nearby.

- o Burial will effectively prevent the release of nematode eggs, bacteria, and viruses. Even if there is leachate to groundwater, the ground will act as a slow sand filter. Sand filtration is an effective barrier to the passage of viruses, bacteria, and all larger particles.

- o In any case, the fact that the sludge meets the less stringent USEPA metals criteria for disposal to land other than agricultural land (Column (b) of Table 3.2) indicates that there will not be a significant impact on groundwater, no matter whether the sludge is buried near the existing ponds, or elsewhere on or off of the WAJ site.

As is standard practice, if the sludge is buried it should not be in a wadi where it would eventually be subject to excavation and washout. Nor should it be buried in an area which is below the groundwater table or which could be saturated by a rising groundwater table.

A variant of "burial" or "landfill" is to remove anaerobic ponds A2-1 and A2-2 from service for the forseeable future, and use them as receptacles for sludge excavated or dredged from the other four anaerobic ponds. Pond A2-1 is already more than half full of sludge; Pond A2-2 is about one-third full. The A2-1 and A2-2 ponds (or "A2" ponds) contain approximately 45% of the total existing sludge volume of the anaerobic ponds. Therefore, this option would obviate the need to move the sludge now in the two most laden ponds. This method would apply to the short-term program only (i.e. handling of existing sludge). The sludge would be allowed to dewater unassisted with time. Additional pond capacity must be constructed to replace the converted pond volume.

A new two-pond anaerobic train would be constructed to the north or south of the existing three trains. None of the recommended inlet piping modifications would be made to the A2 ponds, although convenient stubout piping would be provided in the event that the A2 ponds are excavated and put back into service, once the sludge has dried completely.

After the new anaerobic train (A0) is commissioned for service, the A2 ponds would be drained sufficiently to provide volume to accommodate sludge conveyed from the A1 and A3 ponds. A free water surface supply should be allowed to exist above the sludge in the A2 ponds for odor control. Sludge would then be dredged from either the A1 or A3 trains, and pumped to the A2 ponds. When the A2 ponds fill, dredging would cease, and the sludge allowed to settle. Liquid would be decanted off and the dredging operation continued until the A1 and A3 ponds are desludged.

When the desludging operation has been completed, the free liquid is decanted off of the A2 ponds. The A2 ponds would act as a landfill for the wasted sludge.

The A2 ponds would be allowed to dewater through natural percolation and evaporation in the years following the short term program. If expansion of the anaerobic pond system is required in the future, the sludge could be removed from the A2 ponds and returned to service. A certain degree of composting would be anticipated to take place in the A2 ponds over time, and the sludge deposits may be suitable for reuse after one to two years of burial.

Of all the feasible options, this is likely to generate the least odors, if undertaken by dredge.

The long term program, in subsequent years, would utilize one of the other sludge management alternatives being evaluated in this section.

D2. Landfill. Landfilling can be described as a systematic, carefully planned burial process, with daily cover of the sludge or other material placed, and a final cover with a soil chosen for its low permeability. The discussion given above for the environmental acceptability of burial applies also to landfill.

D3. Incineration. This option is sometimes adopted for sludge disposal by very large municipalities that have few other options due to lack of space. Combustion process and stack emissions must be closely monitored to ensure that products of combustion are not toxic, and that odoriferous compounds are destroyed.

Given (a) a risk of non-optimal performance and resulting toxic and/or odorous emissions, particularly in the region of Hashimiya and Khirbet As-Samra where atmospheric temperature inversions can inhibit effective dispersion of emissions from the region for several hours a day, and (b) the significant fuel consumption necessary to burn well-digested sludge, incineration must be given an unfavorable environmental rating.

D4. Dry sludge land application and/or reuse as a soil amendment or conditioner; and D5. Liquid sludge land application. These options deserve considerable study because of the environmental benefit that dry sludge as a soil amendment, appropriately applied, could bring to plantations, farms, pastureland, and parkland. A sandy soil can be unsuitable for growing grasses or other crops because of its inability to retain water, and because of its lack of nutrients. Treated sewage sludge can add the lacking physical properties, and provide much of the desired nutrient content (some additional fertilizer is usually desirable). Use of sewage sludge for such purposes in an environmentally sound manner has long been practiced in some areas of the Americas, Europe, and Asia, and is rapidly being adapted more widely and intensively.

For desludging, the recommendations are as follows:

1. Under the Short Term Improvements construction contract, based on environmental impact and cost reasons associated with the desludging of the existing deep layers of sludge in Ponds A2-1 and A2-2, the following recommendations were made:

- o Provide two new anaerobic ponds in series to match the other three anaerobic trains ("Ponds A0-1 and A0-2");
- o Dredge or pump the deposited material in Ponds A1-1, A1-2, A3-1, and A3-2 into Ponds A2-1 and A2-2 until these two middle anaerobic ponds are full; and
- o Abandon Ponds A2-1 and A2-2 until sometime in the future (approximately five or six years) when the sludge has dried and can more easily be removed.

2. Immediately after the completion of construction of the Short Term Improvements, and for the long term, a set of the anaerobic ponds (three ponds initially and four ponds when Ponds A2-1 and A2-2 are back in operation) will be taken out of service to allow for annual routine desludging. Sludge deposits depths would be in the range of 0.5-0.8 m and the Dry-in-Situ method would be the most cost effective and environmentally acceptable solution. The set of three or four anaerobic ponds will be drained, sludge will be allowed to dry (for approximately two or three months), and dried sludge will be disposed of by landfill burial on the WAJ property, or, with appropriate monitoring for pathogens and metals, sold as a conditioner for agricultural soil.

Heavy metals. As presented in Table 6.2, most of the sample results obtained in this study, and in 1989 by Miqdadi, do not exceed the USEPA Pollutant Concentration values for unrestricted application of sludge to agricultural land. No results exceed the USEPA ceiling concentration values or EC Agricultural Limit values, indicating that there is no heavy-metal restriction to use of As-Samra sludge in agricluture, provided that the USEPA and EC guidelines regarding permissible annual and cummulative metals loadings per hectare (Tables 3.2 and 3.3) are observed.

Pathogens. The results of analyses of the As-Samra sludge described above clearly indicate that to be designated a Class A sludge, it would have to undergo one of the processes to further reduce pathogens (PFRP, see Appendix C), which is not practical in this situation without incurring significant costs. However, the sludge analyses for fecal coliform show that the sludge can be designated as a Class B sludge, in which case a waiting period is imposed after application to agricultural land (see Appendix D).

6.8 Archaeological Impacts

As for archaeological impacts of construction or construction activities at the As-Samra WSP, we have held preliminary discussions of the proposed measures with Dr. Gaetano Palumbo, Cultural Resources Management Archaeologist of the American Center of Oriental Research, Amman. Dr. Palumbo indicated that it appears that the proposed work will be limited to areas already heavily modified, and that the likelihood of encountering any significant archaeological remains is very small. To be certain of this, however, a modest archaeological survey should be undertaken, at the initial construction stages, of the lands to be affected.

6.9 Seismicity

The adopted seismic design code should be followed in the design of new structures, and if there is any major structural alteration of the ponds.

6.10 Environmental Impact Summary for the As-Samra WSP

The proposed measures are specifically intended to reduce present environmental impacts from As-Samra with respect to agricultural use, public health, and biological aspects of effluent quality. The measures are also specifically to reduce odors from the plant. The danger of the WSP facility being conducive to the transmittal of schistosomiasis is nil; in fact, stabilization pond systems are well known for their effectiveness in interrupting the disease cycle where it is found.

The several options considered for removing sludge from the ponds are all environmentally acceptable, except for the drain-and-excavate option when the sludge is too deep to be accessed as necessary for odor and vector control. The process options are acceptable, again excepting drying in-situ when the sludge is too deep for odor and vector control. To mitigate the negative environmental impact associated with the in-situ drying of sludge under the construction contract, additional anaerobic ponds will be provided as part of the short term improvements facilities (see Section III of the Design Report). This will allow leaving the existing deep sludge deposits in place, as described earlier under Section 6.7.

As for final disposal, analyses of sludge samples in the anaerobic ponds show heavy metal concentrations that are within the guideline values published by the USEPA and the EC, for all metals but zinc, for which some samples slightly exceeded the guideline values. Fecal coliform, fecal streptococcus, and nematode concentrations greatly exceeded the concentrations deemed acceptable by the USEPA guidelines for disposal to agricultural land.

There are several measures outlined in Ref. 8 and Appendix C for reducing pathogens, some of which appear feasible for use at As-Samra. The zinc issue may not itself prevent the use of sludge on agricultural land, provided that certain related constraints are observed. With further treatment and under certain conditions, therefore, it may well be feasible to use As-Samra sludge safely on agricultural land.

Because of the very limited extent of new construction contemplated, and the already extensively disturbed nature of the WAJ site, it is very unlikely that proposed activities at As-Samra will adversely impact any archaeological sites. Nevertheless, an archaeological survey of the specific sites proposed to be disturbed is recommended as an early task during the construction stage.

Structural design should follow an appropriate seismic design code.

SECTION 7

SUMMARY AND CONCLUSIONS

Environmental Impact Summary for Ain Ghazal Treatment Plant

Significant benefit will be provided by odor control and reduction in frequency of overflows.

The significant adverse impact issues for short-term emergency measures at AGTP concern odor and the handling and disposal of screenings and grit, both during normal operations. Odor will be mitigated with provision of works that facilitate capture of odorous air, and proper treatment of it. However, there must be a steady supply of sufficient appropriate chemical reagents to keep the odor control facilities operating as designed.

Screenings and grit are best disposed of by prompt transport of these materials from their point of removal into a covered truck to a sanitary landfill where daily cover is applied.

Any dust problems should be mitigated by water sprays or by cover. Noise will be essentially the same as at present, either during construction or subsequent operations. Issues of agricultural criteria for effluent or residuals disposal, or of biological impact, or of archaeology, are not relevant at AGTP.

Environmental Impact Summary for the Siphon

Short-term emergency measures should be implemented in identified critical areas where erosion has threatened the pipeline. WAJ has already taken important remedial action, but further erosion protection is warranted.

A range of longer-term measures is suggested for future study. Significant environmental impacts may be associated and must be assessed as part of that study. Seismicity concerns should be fully addressed.

Structural, operational, and institutional changes should be made at the AGTP, and with respect to the Zarqa Pumping Station, so that in the event of a siphon rupture flows can be immediately diverted from entering the siphon and bypassed to the neighboring wadi. Bypassing will enable a quick siphon repair, thus justifying the short-term impact to the wadi.

The emergency pond should not be used until there is siphon bypass capability. An emergency spillway for the pond should be considered in the longer term.

Environmental Impact Summary for the As-Samra WSP

The proposed measures will reduce environmental impacts on the agricultural use, public health, and biological aspects of effluent quality. The measures will also reduce odors generated at specific points at the plant.

The several options considered for removing and processing sludge are all environmentally acceptable, except for the drain-and-excavate option and the dry in-situ process option, when the sludge is too deep to be accessed for odor and vector control. In this regard, recommendations are made (refer to Section III of the Design Report) to leave the deep sludge deposits in place, abandon the middle anaerobic train ponds when full with sludge, and provide two additional ponds to replace the abandoned ones.

Heavy metal concentrations are within the USEPA and EC guideline values for all metals but zinc, which slightly exceeds the guideline values. Fecal coliform, fecal streptococcus, and nematode concentrations greatly exceed the USEPA guidelines. Therefore, short-term emergency measures should be to landfill or bury the sludge. Means to render the sludge acceptable for agricultural applications are encouraged for the long term.

It is not likely that proposed activities at As-Samra will adversely impact any archaeological sites, but an archaeological survey of specific proposed construction sites is recommended.

This report was prepared by Jonathan A. French of Camp Dresser & McKee International Inc.

SECTION 8

REFERENCES

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APPENDIX A

STATEMENT OF WORK

As-Samra Wastewater Stabilization Ponds
Emergency Short Term Improvements Program

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Statement of Work

I. BACKGROUND

In 1985, wastewater stabilization ponds were commissioned at As-Samra to relieve overloaded conditions at the Ain Ghazal Wastewater Treatment Plant (AGWP). At that time, it was anticipated that diversion of dry-weather flow to the ponds would end when the AGTP expansion was completed. With the AGTP expanded, the ponds would be used only to treat wet-weather flows. But, except for its headworks, the AGTP has been abandoned, and flow from the Greater Amman Municipality is diverted to the stabilization ponds at As-Samra Wastewater Treatment Plant (AWP).

Besides receiving flows from Amman, the ponds now also receive flows from Zarqa, Ruseifa, and other communities. With all these sources of wastewater, the capacity of the ponds is now exceeded. In 1991, hydraulic load averaged about 100,000 cu m/d, compared with a design flow of 68,000 cu m/d. Similarly, organic load is excessive. The BOD load in 1991 was about 67,000 kg/d, up from the design BOD load of about 38,000 kg/d. And, in 1992, flows and loads are higher than in 1991. With these excessive loads, the effluent from the ponds does not meet design standards, in terms of BOD and of fecal coliform. Also, odors from the ponds reach areas seven to eight kilometers away.

Sludge deposition in the anaerobic ponds is thought to have reached a point where it should be removed. If not removed, the sludge will decrease the volume of the ponds to such an extent that the effectiveness of the ponds will decrease.

There are problems also at the headworks at the AGTP. The headworks are overloaded hydraulically and from the load of screenings and grit in the influent wastewater. Odors from the AGTP headworks can reach residents several kilometers away.

II. OVERVIEW OF EXISTING CONDITIONS

This section summarizes the information dealing with the emergency short-term improvements program. Issues related to longer-term programs are included only as necessary for understanding the short-term program.

AIN GHAZAL TREATMENT PLANT

Processes

The Ain Ghazal Treatment Plant (AGTP) was constructed as a conventional activated sludge treatment plant, with sludge processing by anaerobic digestion followed by dewatering on belt filter presses. The plant has been abandoned except for the headworks, septate facilities, and diversion structure.

In the mid 1980s, supplementary headworks, septate facilities, and a diversion structure were constructed south of the treatment plant. The new facilities were built to protect the siphon to As-Samra, which, at that time, was to be used only during wet weather. However, all facilities at Ain Ghazal have since been abandoned, except for the supplementary facilities (headworks, septate facilities, and diversion structure).

The headworks include structures for removal of screenings and grit. For screenings removal, bar screens with 25-mm openings are provided. (Originally, the plant included comminutors. These were removed because of problems with plugging). Screenings removal is followed by grit removal in aerated grit chambers.

Septate facilities include manually raked bar screens and an aerated grit chamber. The screens and the grit chamber are housed in separate buildings.

The grit from both the wastewater and septate flows to a grit sump, from which it is pumped to a grit cyclone. In the grit cyclone, grit is separated from the wastewater liquid. The separated grit then falls into a sandwheel, to separate organics.

Physical Condition of Equipment

Operating problems begin at the manhole structures entering the plant. At these structures, wastewater overflows to the Wadi during high flows.

After this, grit and stones accumulate in the distribution channel ahead of the screens. Besides clogging the channel, the grit and stones prevent slide gates provided to isolate the screens from seating. Indeed, the gates have been damaged by operators attempting to force the gates shut.

Stones that reach the bar screens cause them to jam. When this occurs, the flow to the jammed screen can completely be halted only with difficulty, because of partly open slide gates, both upstream and downstream.

It is reported that both grit chambers are out of service and are bypassed. The right-hand grit chamber had been drained, and buckets are used to remove grit from hoppers. The header to the diffusers is broken. Also, the Survey Report by Engineering Science notes that the air-lift pumps clog frequently. The clogging could be from grit or from other materials that pass the screens.

The two screens for septate flow are hand raked and are kept free from screenings. The grit chamber for septate is being bypassed.

The grit transfer pump, cyclone and grit washer are not in operation. The operators report that they are not large enough to process all the grit.

Odor Evaluation

Air from the grit and screenings buildings is treated in two packed-tower scrubbers in series. The scrubbing chemical is sodium hydroxide, although the operation and maintenance manual calls for sodium hypochlorite. During the day, the pH of the recirculating solution is monitored with test paper to maintain a pH of 11. It appears that the pH drops at night, so that the scrubbing is less effective.

With sodium hydroxide as the scrubbing liquid, hydrogen sulfide dissolves in the scrubbing liquid. However, when the scrubbing liquid is discharged to the wastewater flow, the pH drops and hydrogen sulfide is released.

Foaming is evident in the viewing port, and bubbles of foam are released from the scrubber exhaust. Operators report that foaming began recently, when the supplier of sodium hydroxide was changed.

Odors in the grit and the screenings buildings vary in severity, but, because of opening the doors to both buildings, the effectiveness of the odor control system is compromised. During warm weather, odors in the buildings are said to be so intense that operators have to wear self-contained breathing equipment, even with the doors open. With the doors open, the severe odors from these buildings are probably the source of odor complaint from local residents.

Process Considerations

Flow to the existing AGTP headworks exceeds design capacity. The headworks were designed for an average daily flow of 68,000 cu m/d and a peak hydraulic flow of 148,000 cu m/d. The average flow to the As-Samra plant in 1991 was about 100,000 cu m/d, and peak flow exceeded 200,000 cu m/d.

When flow exceeds peak hydraulic capacity, excess wastewater is bypassed directly to Wadi Ain Ghazal. The Survey Report states that rags and other materials pass through the screens. Of course, when the screens are inoperable, all the screenings reach the siphon, except for wet-weather overflows that are sent to Wadi Ain Ghazal.

Inadequate grit removal capacity poses a potential severe problem to the siphon. Accumulation of grit at the low point will significantly decrease its capacity.

Assessment of Needs

The purposes of the Ain Ghazal headworks facility are to protect the siphon to the Wastewater Stabilization Ponds and to minimize the impact of overflows to Wadi Ain Ghazal. Also, the construction of a second siphon has been strongly recommended in the draft feasibility study prepared by Engineering Sciences Inc. So, improvements to the headworks must include additional capacity to accommodate the flow to be carried by the second siphon and a provision for headwork - siphon connection. At the same time, odors need to be addressed, both for the comfort of local residents and for safety of the workers.

To protect the siphon and minimize the impact of overflows, and to prepare for the construction of a second siphon with other donor support, reliable processes need to be maintained that will assure efficient removal of grit and screenings. To prevent odors from reaching the residents, effective and reliable odor control needs to be provided. To provide a safe environment for workers, adequate ventilation needs to be assured.

At Ain Ghazal, the emergency short-term programs needs, which are discussed further in the Section III, are as follows:

- Provide reliable removal of grit and screenings
- Control odorous emissions

WASTEWATER STABILIZATION PONDS

Initially constructed to relieve the Ain Ghazal Treatment Plant, the Wastewater Stabilization Ponds at the As-Samra soon replaced the AGTP. They also have flows and loads higher than the design levels.

Processes

The ponds consist of three trains each consisting of two anaerobic ponds, four facultative ponds, and four maturation ponds. Parallel operation of some of the ponds is possible, but it is reported that this flow scheme does not materially improve treatment. Flow can be recirculated from the last facultative pond in train 2 and from maturation ponds in trains 1 and 3 to the distribution structure at the head of the facultative ponds.

Physical Condition of Equipment

Except for corrosion of some metal, the equipment at the Wastewater Stabilization Pond appears to be in good condition.

Odor Evaluation

It is reported that odors from the ponds can reach up to seven or eight kilometers from the lagoons. The major source of odors is the influent structure at the exit of the siphon. Secondary sources of odors include the first anaerobic ponds and distribution structures after each anaerobic pond.

Process Considerations

The effluent goals for the pond system were as follows:

Design average filtered five-day BOD	20 mg/L
Mean effluent filtered BOD	30 mg/L
Maximum fecal coliform count	100 MPN/100 mL.

However, because the ponds are overloaded, effluent from the ponds does not meet the goals. Monthly averages for effluent filtered BOD are somewhat less than 50 mg/L in the summer. In the winter, monthly averages for filtered BOD reach up to about 120 mg/L.

Stabilization-pond effluent is now chlorinated to decrease coliform concentrations. It is reported that 10 mg/L of chlorine are adequate during the summer to decrease fecal coliform concentrations to less than 1000/100 mL. In the winter, about 25 mg/L are required to meet the standards. Because chlorination capacity is a dosage of 25 mg/L at average design flows, chlorination capacity is insufficient for high winter flows.

Besides being overloaded, the ponds also suffer from short circuiting. With short circuiting, much of the flow is not held for the design detention time.

Although the plant supervisor believes that sludge accumulation in the anaerobic lagoons has not yet adversely impacted performance of the ponds, this sludge should be removed because about 2 meters of sludge have accumulated.

In the past, foaming has been a problem in the stabilization ponds. However, as biodegradable detergents replace the non-biodegradable detergents formerly used, foaming is apparently becoming less of a problem.

Assessment of Long-term Alternatives

In evaluating improvements to the Wastewater Stabilization Ponds, planning for long-term improvements needs to be considered. In the Conceptual Study, four alternatives were developed to improve effluent reaching Wadi Dhuleil. The alternatives are:

Additional waste stabilization ponds
Adding aeration equipment to the ponds
Conventional secondary treatment
Treatment of Zarqa flows separately.

The Conceptual Study recommended that aeration equipment be added to the second anaerobic pond and first and second facultative pond in each train.

Assessment of Needs

The emergency short-term program needs at As-Samra ponds, which are discussed further in Section III, can be summarized as follows:

- o Control emissions
- o Desludge anaerobic ponds
- o Improve operation of stabilization ponds
- o Improve chlorination facilities

III. SCOPE OF SHORT-TERM IMPROVEMENTS

The short-term improvements are as follows:

A. For the Ain Ghazal Treatment Plant

Provide Reliable Removal of Grit and Screenings Improved removal of grit and screenings must consider three factors:

One, if retained as part of the short-term program, the existing equipment needs to be repaired and modified to improve reliability.

Two, redundancy must be provided, so that a unit is always in service. For example, because there is only one grit chamber for septate, septate flow must be bypassed when the grit chamber is bypassed. Operators report that this grit chamber is out of service about once every two months, for at least a week each time.

Three, increased capacity is needed. The screens should be able to process all flows reaching the Ain Ghazal plant, including flows exceeding the capacity of the siphon.

These needs hold not only for the wastewater stream, but also for grit storage, grit classification, and grit washing.

Control Emissions. Odorous emissions to the neighborhood and odor levels inside working areas must be controlled. To control odors to the neighborhood, all emissions from the septate works must be collected (none must be allowed to exit through doors and windows) and properly treated. To protect workers, ventilation rates must be high enough to decrease room level concentrations of pollutants. Some segregation of volumes, such as by placing a cover on grit chambers, can be achieved.

A lower priority can be set on emissions from the headworks for the wastewater stream. These have less of an odor level, but control is desirable.

B. For the Wastewater Stabilization Ponds at As-Samra

Control emissions. Controlling fugitive emissions from the anaerobic lagoons themselves would likely be too expensive. But the emissions from influent and distribution structures can be controlled. For this, the structures would be covered and the emissions treated to remove the odors.

Desludge anaerobic ponds. The anaerobic ponds should be desludged. Whether the sludge is or is not impacting current effluent quality, the sludge will eventually have to be removed. To assure that sludge in the ponds does not impede the treatment process, the sludge in the ponds should be removed now. Careful attention needs to be given to the procedures for removing the sludge, for processing the sludge, and alternatives for disposal or reuse need to be analyzed in coordination with WAJ.

Improve operation of stabilization ponds. Operation of the stabilization ponds can be improved by improving flow through the ponds so that more of the available volume will be available for treatment and by adding aeration. Flow patterns can be improved by modifications in headworks and influent distribution and by decreasing short circuiting. Short circuiting can be decreased, for example, by addition of baffles in the ponds. Some baffles could consist of dikes or walls. These baffles would affect the entire flow stream. Other baffles could float on the surface. Flooding baffles would decrease the effect of wind action. The addition of aerators fits with the improvement program recommended in the Conceptual and Feasibility Studies.

The improvement of headworks and distribution flow shall include additional capacity to accommodate the flow to be carried by the second siphon and a provision for headwork - siphon connection, as recommended by the draft feasibility study and as planned in the near future by the GOJ in cooperation with other donors.

Improve chlorination facilities. For increased pathogen destruction, increased detention time or increased chlorination capacity (or both) will be required.

IV. ENGINEERING DESIGN SERVICES

This section provides (1) a description of the project work plan, (2) staffing level and strategy, and (3) project implementation schedule.

A. Project Work Plan

The project work plan shall include the following tasks:

Task 1 - Field Investigation and Data Collection

Under this Task, the following will be performed:

Task 1.1 - Topographic Survey: This shall include verification of ground spot elevations, top of structure and sewer invert elevations as required for the design of the emergency short-term facilities at the AGTP Headworks and at the As-Samra WSP.

Task 1.2 - Geotechnical Investigation: This shall include review of the available existing geotechnical information for the location of the AGTP Headworks and As-Samra WSP facilities. Additional soil borings and laboratory testing will be provided as required for the design of the headwork expansion and odor control facilities at AGTP site and the odor control facilities, inlet distribution structures and chlorination facilities at As-Samra WSP site. It is anticipated that a total of 160 - 240 linear meter borings will be required.

Task 1.3 - Laboratory Sampling and Testing: This shall include the review of the available laboratory analyses data on wastewater effluent and effluent at the AGTP headworks and As-Samra WSP facilities. This shall include (1) the AGTP and As-Samra WSP plant operating data, (2) 1989 - 1990 Annual Report of the Environmental Research Center of the Royal Scientific Society of Jordan regarding the study of the As-Samra treatment plant (to be made available through the WAJ), and (3) any other relevant data.

Additional laboratory wastewater sampling and testing shall be performed as required to provide data for the design of the short-term emergency improvements.

Task 1.4 - Air Quality Field Measurement: This shall include field measurement of the air-borne hydrogen sulfide (H_2S) levels at the AGTP and As-Samra Headworks and at the locations of the inlet/outlet structures of the ponds. The measurements will be used in the development of the design criteria for the proposed odor facilities of the short-term emergency improvement.

Task 1.5 - Pond Sludge Quantification and Characterization: This shall include field measurement of the sludge quantities deposited in the As-Samra anaerobic and facultative Ponds. It shall also include an evaluation of the sludge characteristics, such as concentration, volatile hydrogen sulfide concentration, and metal concentration.

Sludge quantities to be removed from the anaerobic and proposed aerated facultative ponds will be estimated. In addition, the amount of excavated material resulting from the conversion of the first and second sets of the facultative ponds will be estimated. These estimated quantities will be used in the design of the sludge and spoil disposal scheme.

In cooperation with WAJ, alternatives for sludge reuse will be analyzed and recommendations on sludge disposal and resuse will be presented.

Task 2 - Design Report and Environmental Assessment Statement

Under this task, a review of the reports generated by other consultants will be made. This will include:

(1) The Final Report for the survey of Existing As-Samra Wastewater Stabilization Pond System, dated March 1992.

(2) Final Conceptual Study Upgrading and Expansion of the Wastewater Stabilization Pond System at As-Samra, dated June 1992.

(3) Draft Feasibility Study, dated August 1992.

The consultant will prepare a report and provide its independent assessment of the needs of a short-term emergency program.

Environmental Assessment

Under this task, a review of the environmental assessment presented in the Draft Feasibility Study will be made to ensure that the assessment covers the emergency short-term improvements program, including the following activities:

(a) Review of the environmental impacts,
(b) Environmental scoping statement,
(c) Agriculture water use impacts,
(d) Public health impacts,
(e) Odor and other air quality impacts,
(f) Land use and biological impacts,

(g) Environmental impact mitigation concepts.
(h) Assessment of the archaeological remains which might be encountered in implementing the short-term improvements program along with a plan for damage mitigation.

Comments generated from this review will be discussed with USAID and a separate Environmental Assessment Report will be prepared to cover the short-term emergency program. This report will be submitted to USAID at the Design Report completion stage.

Preliminary Design

Based on the recommendations of the Draft Feasibility Study for the short-term improvements program, a review of the plants' operating data and results of the supplemental laboratory testing, a preliminary process design of the short-term improvements will be performed. The identification and extent of alternatives to be evaluated as part of this preliminary design will depend on the extent of alternative evaluation performed under the Draft Feasibility Study phase by other consultants. The evaluation and development of alternatives for the Design Report will include the following:

(a) Improvements to grit and screenings systems

- Provide for flow measurement upstream of the preliminary treatment facilities at AGTP. Study the effect of sludge resulting from other treatment plants disposal on AGTP headwork and siphon.

- Estimate flow, and quantities of grit and screenings.

- Set goals for grit and screenings removal (e.g. flows to be treated, grit and screenings to be removed, redundancy required)

- Determine capacity of existing units.

- Examine grit and screenings systems, and determine need for rehabilitation and suitability for future use.

- List alternatives, including use or abandonment of existing structures. Alternatives will include entirely new facilities, repairing and expanding existing facilities, and treating septate flows with wastewater flows. Also, alternative equipment types, such as vortex grit chambers and finer screens will be considered. For these alternatives, provide for preliminary treatment of all flows, including flows exceeding the capacity of the siphons.

- Evaluate alternatives, considering costs, reliability, efficiency and other factors.
- Select concepts for design.
- Develop concepts, including system hydraulics.

(b) Control of emissions at AGTP headworks and septate facilities

- Analyze results of field sampling program, to determine odor intensity.
- Identify alternatives for collecting odorous air, considering worker safety and odor complaints from local residents. For wastewater screens and grit chambers, consider covering units. For septate screens and chambers, consider covering units (within their buildings).
- Determine air flows required.
- Estimate odor reduction required.
- Determine capacity of existing odor-control equipment.
- Identify alternatives for treating collected odorous air.
- Evaluate alternatives for collecting air and for treating odors.
- Select concepts for design.
- Develop concepts.

(c) Investigate the siphon cathodic protection system and provide for replacement of anodes if required. Evaluate the critical zones of the siphon as determined by external forces such as erosion, and provide measures needed for its protection.

(d) Control of emissions at Wastewater Stabilization Ponds

- Analyze results of field sampling program, to determine odor intensity.
- Determine critical odorous sources.

- Identify alternatives for decreasing emissions and for collecting odorous air.
- Determine air flows required.
- Estimate odor reduction required.
- Evaluate alternatives for decreasing emissions, for collecting air and for treating odors.
- Select concepts for design.
- Develop concepts.

(e) Inlet and distribution improvements at the ponds

- Study the hydraulics of inlet works at As-Samra WSP (parshal flume, ultra sonic flow sensor, distribution gates pipe feeding to first set of ponds).
- Identify alternatives to improve headworks and inlet conditions and distribution and to decrease short circuiting. Consider diffuser arrangement and baffles to control entire flow and to decrease wind effects.
- Evaluate alternatives.
- Select concepts for design.
- Develop concepts.

(f) Addition of aeration to ponds

- Develop effluent goals in consultation with USAID and WAJ.
- Review previous work related to addition of aerators in ponds.
- Assess relationship between aeration in the short-term program and requirements for long-term program.
- Review alternative locations for oxygen addition, considering possible growth of algae in subsequent ponds.
- Estimate oxygen requirement.

- Identify alternative methods of aeration.
- Estimate oxygen transfer efficiency of alternative methods of aeration and determine power requirements.
- Evaluate alternatives for adding oxygen. In evaluation, consider life-cycle costs. Also consider desirability of flexibility required for repositioning aerators and requirement for excavation required for installation of aerators.
- Pilot testing of pond aeration. This optional task may be recommended pending the results of investigations during the preliminary design phase.
- Select concept for design.
- Develop concept.

(g) Desludging anaerobic and facultative ponds

- From results of field program, estimate volume of sludge and scum to be removed.
- Identify alternative procedures for desludging ponds.
- Identify alternatives for transporting, processing and disposing of sludge.
- Evaluate alternatives for desludging ponds and for transporting processing and disposing of sludge, considering costs, odor generation, potential for reuse, and environmental impact.
- Select concepts for design.
- Develop concepts.

(h) Improvements to chlorination facilities

- Evaluate current chlorination practice.
- Identify alternatives for improving disinfection, including providing more chlorine, more detention time, or both.
- Review potential modifications to decrease short circuiting in chlorine contact tanks.

- Evaluate formation of chloroform and other trihalomethanes, and their impact on the environment. (Perform laboratory analysis to measure trihalomethane concentration in chlorinated effluent.)

- Conduct test program to optimize chlorine dose and detention time, and evaluate results.

- Evaluate alternatives for improving chlorination practice, including life-cycle costs.

- Select concept for design.

- Develop concept.

Upon completion of the preliminary process design, a Project Design Report will be prepared; this report shall include:

(1) Overview of existing conditions.

(2) Evaluation of Alternatives.

(3) Description of the recommended short-term improvements.

(4) As-Samra System flow schematic and hydraulic profile.

(5) Conceptual layouts and details of the expanded preliminary treatment (i.e. screening and grit removal) facilities including odor control at AGTP and the odor control, improved headwork and inlet pond distribution, aeration and expanded chlorination facilities at the As-Samra WSP.

(6) Project functional design criteria; this shall include the following functions:

- Process/Mechanical
- Civil/site
- Architectural
- Structural
- Heating ventilation and air conditioning (HVAC)
- Plumbing
- Electrical
- Instrumentation and control (I&C)

(7) Nominated list of equipment manufacturers including manufacturer catalogue data (i.e. odor control and pond aeration equipment).

(8) Operation and maintenance needs of the As-Samra upgraded

facilities (i.e. scope, budget, spare parts, chemicals for the odor control and chlorination facilities).

(9) Probable construction cost estimate at the preliminary stage of design.

(10) Recommended construction packaging, sequence of construction including temporary measures during construction, and construction schedule.

(11) Outline of the tender documents specifications and a list of the contract drawings.

The completed Environmental Assessment and the Project Design Report will be reviewed by the Water Authority of Jordan (WAJ) and USAID. All comments will be reviewed, resolved and incorporated into the Design Report and the Environmental Assessment Report.

Task 3 - Detailed Design and Preparation of Tender documents

Upon completion of USAID and WAJ reviews of the Design Report, work will start on the detailed design and tender documents for the emergency short-term improvements. This shall include the following tasks:

Task 3.1 - Functional Design: Under this task, the conceptual design calculations, design criteria, equipment sizing and selection will be finalized. Detailed design calculations will be prepared and be available for transmittal to USAID at the closeout of the project.

Task 3.2 - Contract Specifications: Under this task, the tender document specification will be prepared to conform to USAID direct procurement requirements; this will include the following:

- Contract Forms and General Requirements. This shall include the contract Bill of Quantities as coordinated with the WAJ.
- General Conditions (latest edition of FIDIC)
- Detailed contract specifications in CSI Format (Division 0 thru 16).

Task 3.3 - Contract Drawings - Under this task, detailed contract drawings will be prepared. These shall include civil/site structural, process/mechanical, HVAC, electrical and I&C drawings. CADD facilities will be used in the preparation of contract drawings. Electronic drawing files will be submitted to WAJ through USAID for their use in the development of "Record" drawings.

Task 3.4 - Probable Construction Cost Estimate: Under this task, the preliminary design phase construction cost estimate will be upgraded to reflect the details of the Final Design. The

Engineer's detailed probable construction cost estimate shall be submitted to USAID for budgeting purposes and for use in the evaluation of the bids received from contractors.

Project Reviews

This shall include the consultant, WAJ and USAID reviews of the project technical deliverables at different phases of the program. These reviews shall be as follows:

(a) Consultant Reviews - Consultant senior staff who are not involved in the design of the emergency short-term improvements will provide technical reviews of the project deliverables as follows:

1. Technical review of the draft project Design Report.

2. Quality Assurance, Quality Control (QA/QC) reviews of the detailed design and tender documents. These reviews shall be made at 50% and 90% completion stages of the tender documents respectively.

(b) WAJ and USAID Reviews - These official reviews shall be made at two stages: (1) at the completion of the Project Design and Environmental Assessment Reports, and (2) at the completion of the detailed design and tender documents.

For the purpose of these reviews, the Consultant shall submit ten (10) copies of the design report and tender documents to USAID for distribution. Upon completion of the reviews comments will be evaluated, resolved and incorporated in the final tender documents (i.e. design report, drawings and specifications).

Project Management

The Consultant shall provide a project leader to be stationed in Amman, Jordan, for a nine-month period (November 1992 - July 1993), who will provide full-time project management services; these services will include:

1. Mobilization of the expatriate and local project team members.

2. Arrange for and hold a kick-off workshop to be attended by the Consultant team, the local subconsultant team, and representatives of WAJ and USAID.

3. Arrange for and conduct reviews of the project deliverables by the Consultant, WAJ and USAID.

4. Arrange for consultant specialists visits to provide expert reviews and consultation as required.

5. Prepare and submit to USAID milestone progress reports as required. These progress reports will identify work completed, work to be performed during the next reporting period, major issues, problems and recommended solutions.

6. Provide liaison with USAID and representatives of the WAJ.

7. Provide management of the consultant and subconsultant teams.

8. Provide home office support.

9. Provide for demobilization of the project team, and an orderly closeout of the project. This shall include assembly and delivery to USAID of the project records, deliverables and other pertinent technical material.

The project leader provided by the consultant will work closely with the GOJ and USAID project managers and the GOJ technical advisory committee. To ensure close coordination among all concerned parties, a regular coordination meeting will be held every two weeks.

Duration of the Study: The duration of the study is anticipated to be approximately 8 months of intensive field work, and one additional month to finalize the report. Work is anticipated to start o/a December 1, 1992 and be completed o/a September 30, 1993.

Implementation Schedule:

The following is a summary of the major actions and deliverables, as reflected in the attached Implementation Schedule:

12/1/92 - 12/12/1992	Mobilization of Field Staff
12/15/92 - 3/31/93	Tasks 1 and 2
2/28/93	Submit Short-term Improvement Assessment Report
3/31/93	Submit Design Report and Environmental Assessment

4/1/93 - 4/15/93	Review of the Design and Environmental Assessment by GOJ and USAID
3/31/93 - 8/31/93	Task 3
9/1/93	Final Detailed Design and Tender Documents
9/2/93 - 9/15/93	Review by GOJ and A.I.D. of the Detailed Design and Tender Documents
9/30/93	Fifty (50) Copies of Final Detailed Design and Tender Documents

APPENDIX B

ANALYSES FOR QUALITY OF SLUDGE IN THE AS-SAMRA ANAEROBIC STABILIZATION PONDS:

SELECTED TABLES FROM APPENDIX B OF THE DESIGN REPORT

TABLE B.6 RESULTS OF HEAVY-METALS ANALYSIS OF SLUDGE SAMPLES

SAMPLE NO.

ELEMENT	UNITS (a)	1.0	2.0	4	5	6	7	8	9A	11	19	25	31	38	39	40	42	43
Al	gm/kg	2.0	4.8	8.4	8.7	8.1	8.4	7.8	13.2	6.6	8.510	10.9	12.3	8.0	8.550	8.960	9.0	7.1
Ag	mg/kg	(b)	(b)	9.1	(b)	(b)	4.6	1.5	(b)	22.3	23.5	2.7	8.7	1.9	1.1	2.0	4.8	5.9
As	mg/kg	0.6	(b)	1.1	1.7	1.5	1.3	0.9	1.8	1.4	1.5	1.6	1.0	2.6	2.6	2.4	1.8	2.9
Cd	mg/kg	0.9	(b)	3.8	4.5	4.4	3.3	3.7	5.6	5.4	6.9	8.1	7.1	5.7	5.3	5.1	5.6	4.5
Co	mg/kg	1.7	50.7	7.6	5.4	8.8	9.2	8.3	11.3	1.7	1.9	3.2	3.8	3.0	3.4	2.1	3.0	3.0
Cr	mg/kg	83.1	190.0	200.0	170.0	167.0	258.0	137.0	395.0	482.0	669.0	579.0	236.0	120.0	113.0	189.0	181.0	304.0
Cu	mg/kg	64.9	152.0	226.0	207.0	224.0	199.0	260.0	269.0	248.0	312.0	362.0	339.0	300.0	247.0	266.0	274.0	211.0
Fe	mg/kg	8590.0	13950.0	21218.0	16319.0	19328.0	20849.0	23676.0	18738.0	14.7	18.2	21.4	20.9	15.0	15.8	16.7	16.0	13.3
Hg	mg/kg	0.4	1.3	1.8	3.9	1.8	1.0	1.5	2.9	4.0	4.1	4.0	4.2	5.3	3.9	3.4	3.5	3.2
Li	mg/kg	1.7	(b)	3.8	3.6	3.5	3.9	3.4	5.6	4.1	4.9	5.6	4.8	3.0	3.1	3.1	3.0	2.6
Mn	mg/kg	39.8	101.0	124.0	135.0	151.0	143.0	141.0	148.0	129.0	154.0	175.0	165.0	139.0	142.0	129.0	130.0	107.0
Ni	mg/kg	13.8	50.7	52.5	37.0	58.3	50.1	60.8	55.3	37.3	47.1	50.6	59.0	66.8	68.4	50.1	46.7	31.1
Pb	mg/kg	58.0	114.0	185.0	133.0	172.0	141	151.0	191.0	150.0	189.0	209.0	211.0	163.0	160.0	157.0	160.0	129.0
Se	mg/kg	0.8	6.3	1.3	2.4	3.1	2.1	1.3	2.9	2.0	1.7	2.2	1.3	0.6	0.6	0.6	0.9	0.9
Si	mg/kg	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	1028.0	467.0	298.0	189.0	388.0
Sn	mg/kg	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	0.5	0.3	0.3	(b)	0.5	0.2	0.5	0.4	0.6
Ti	mg/kg	(b)	(b)	236.0	234.0	212.0	224.0	255.0	316.0	256.0	136.0	227.0	287.0	137.0	140.0	163.0	141.0	83.0
V	mg/kg	(b)	(b)	48.7	38.8	46.8	31.7	(b)	38.4	91.0	119.0	141.0	113.0	95.0	89.0	86.0	84.0	65.0
Zn	mg/kg	433.0	1395.0	1863.0	1983.0	1730.0	1814.0	1921	2641.0	2470.0	3100.0	3850.0	3000.0	2810.0	2670	2670.0	3120.0	2530.0
B	mg/kg	11.3	88.8	32.7	27.9	37.1	34.3	32.8	33.9	33.8	38.9	37.5	39.5	35.0	33.0	32.7	32.1	29.4

(a) Dry Weight Basis

(b) Concentration is below the detection limit of the element in the final digested solution

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TABLE B-7
ANAEROBIC POND SLUDGE
PHYSICAL AND BIOLOGICAL ANALYSIS

SAMPLE NO.	TS		TVS		TCC (MPN/100ml)	TFCC (MPN/100ml)	FOG (mg/l)	NEMATODES* (Eggs/10 gm of wet sludge)
	gm/kg	%	gm/kg	% of TS				
1	112.354	11.24	81.515	72.51	x	x		
2	7.798	0.78	4.818	61.54	x	x		
4	126.676	12.67	70.240	55.41	1.7E+08	1.7E+07		20(A.1)
5	105.633	10.56	56.659	53.69	5.0E+08	2.3E+07		20(A.1)
6	109.262	10.93	71.678	65.60	5.0E+08	1.7E+07		20(A.1)
7	146.868	14.69	91.803	62.49	x	x		
8	186.304	18.63	90.779	48.74	x	x		
9A	87.366	8.74	50.270	57.55	x	x		
10	87.077	8.71	45.849	52.58	x	X		
11	98.681	9.87	53.989	54.71	1.3E+07	4.0E+06		
12	115.776	11.58	63.770	55.09	x	X		
13	93.920	9.39	51.744	55.06	5.0E+07	4.0E+06		30(A.1)
14	117.333	11.73	63.940	54.48	x	X		
15	110.112	11.01	60.386	54.86	x	X		
16	129.085	12.91	74.293	57.55	5.0E+06	2.0E+06		39(A.1)
17	114.083	11.41	62.990	55.21	x	X		
18	116.381	11.64	64.076	55.07	x	X		

* Nematode species : A.1 = Ascaris lumbricoides, T.t = Trichuris trichiura

TABLE B-7
ANAEROBIC POND SLUDGE
PHYSICAL AND BIOLOGICAL ANALYSIS (CONTINUED)

SAMPLE NO.	TS		TVS		TCC (MPN/100ml)	TFCC (MPN/100ml)	FOG (mg/l)	NEMATODES* (eggs/10 gm of wet sludge)
	gm/kg	%	gm/kg	% of TS				
19	116.433	11.64	64.716	55.58	2.3E+07	2.0E+06		30 (A.l)
20	118.818	11.88	68.729	57.83	X	X		
21	126.073	12.61	73.988	58.68	X	X		
22	137.627	13.76	74.089	53.85	X	X		
23	137.327	13.73	74.612	54.33	X	X		
24	126.930	12.69	69.051	54.45	X	X		
25	120.446	12.04	62.813	52.16	8.0E+06	2.0E+06		10(A.l)
26	110.734	11.07	57.255	51.76	X	X		
27	108.364	10.84	58.870	54.34	1.1E+07	2.0E+06		25(A.l) 10(T.t)
28	104.357	10.44	64.178	61.49	X	X		
29	101.298	10.13	64.433	63.57	X	X		
30	106.131	10.61	63.374	59.75	X	X		
31	158.518	15.85	75.473	47.63	5.0E+07	1.1E+07		13(A.l) 6(T.t)
32	137.812	13.78	73.056	53.05	5.0E+07	1.3E+07		8(A.l) 8(T.t)
33	127.713	12.77	70.278	55.05	X	X		

* Nematode species : A.l = Ascaris lumbricoides, T.t = Trichuris trichiura

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SAMPLE NO.	TS		TVS		TCC (MPN/100ml)	TFCC (MPN/100ml)	FOG (mg/l)	NEMATODES * eggs/10 gm of wet sludge)
	gm/kg	%	gm/kg	% of TS				
34	118.513	11.85	66.098	55.77	X	X		
35	124.395	12.44	70.222	56.45	X	X		
36	113.560	11.36	62.793	55.29	X	X		
37	109.150	10.92	58.523	53.57	X	X		
38	191.474	19.15	92.955	48.55	5.00E+06	2.00E+05		20(A.l)
39	219.315	21.93	103.889	47.37	3.00E+06	4.00E+05		15(T.t)
40	200.693	20.07	99.292	49.47	3.00E+07	1.70E+06		13(T.t)
42	184.771	18.48	93.529	50.62	1.10E+06	2.00E+05		16(A.l) 16(T.t)
43	139.684	13.97	73.099	52.33	3.00E+07	1.70E+06		80(A.l) 32(T.t)

TABLE B-7
ANAEROBIC POND SLUDGE
PHYSICAL AND BIOLOGICAL ANALYSIS (CONCLUDED)

* Nematode species : A.l = Ascaris lumbricoides, T.t = Trichuris trichiura

TABLE B.8 BIOLOGICAL ANALYSIS OF
SLUDGE BY M. HINDIYEH

		MPN/100 ML	MPN/100 ML	CFU*/100 ML	CFU/100 ML	EGGS/G	EGGS/G	EGGS/G	EGGS/G	EGGS/G		
SAMPLE NO.**	SAMPLE SITE	TCC	TECC	FECAL STREPTOCOCCI	SALMONELLA sp.	TOTAL HELMINTHS	ASCARIS	TRICHURIS	HYMENOLOPIS	TAENIA	% VIABILITY	PH
POND A 1-1												
28	8	8.0×10^{7}	1.4×10^{7}	4×10^{3}	2.2×10^{7}	40.5	34.5	1.5	3	1.5	29	6.7
29	14	2.2×10^{8}	3.0×10^{7}	5×10^{5}	1.1×10^{7}	28.0	8.0	0	12	8.0	ZERO	6.7
31	20	3.0×10^{8}	2.0×10^{6}	ZERO	2.0×10^{6}	22.7	22.7	0	0	0	5.7	7.0
32	23	5.0×10^{7}	1.3×10^{7}									
D 40	27	3.0×10^{7}	1.7×10^{6}	ZERO	1.4×10^{6}	40.4	40.4	0	0	0	26.8	7.0
POND A 1-2												
22	25	5.0×10^{6}	1.3×10^{6}	4.0×10^{4}	4.0×10^{5}	72	72	0	0	0	22.2	6.8
25	18	8.0×10^{6}	2.0×10^{6}	2.0×10^{4}	8.0×10^{5}	20	20	0	0	0	20	6.7
26	9	8.0×10^{7}	1.3×10^{7}	2.0×10^{3}	7.0×10^{6}	15	13.8	0	0.6	0.6	28	6.8
27	11	1.1×10^{7}	2.0×10^{6}									
POND A 2-1												
3	2	4.4×10^{8}	5.0×10^{7}	5.5×10^{5}	9.0×10^{7}	14.7	11.7	2.3	0.7	0	18.4	6.6
4	4 ***	1.7×10^{8}	1.7×10^{7}	1.9×10^{5}	3.0×10^{7}	5.25	4.5	0	0.75	0	ZERO	6.5
D 39	23	3.0×10^{6}	4.0×10^{5}	ZERO	1.4×10^{5}	23.3	23.3	0	0	0	16.7	7.6

NOTES:
* "CFU" = Colony Forming Units
** Prefix "D" denotes sample from the bottom of the sludge deposit
*** Redox petential for Sample Site 4 was -300.

TABLE B.8 BIOLOGICAL ANALYSIS OF
SLUDGE BY M. HINDIYEH (CONCLUDED)

		MPN/100 ML	MPN/100 ML	CFU*/100 ML	CFU/100 ML	EGGS/G	EGGS/G	EGGS/G	EGGS/G	EGGS/G		
SAMPLE NO.	SAMPLE SITE	TCC	TFCC	FECAL STREPTOCOCCI	SALMONELLA sp.	TOTAL HELMINTHS	ASCARIS	TRICHURIS	HYMENOLOPIS	TAENIA	% VIABILITY	PH
POND A 2-2												
16	25	5.0X10^7	2.0X10^6	1.0X10^3	1.1X10^6	130.6	101.3	0	21.3	3	21.1	6.8
19	11	4.4X10^7	7.1X10^6	2.4X10^5	5.0X10^6	26	16	0	6	4	12.5	6.8
20	10 ***	2.3X10^7	2.0X10^5	2.7X10^5	4.0X10^6	49	91	0	7	0	35.5	6.8
D 42	17	3.0X10^6	8.0X10^5	ZERO	1.0X10^4	90	90	0	0	0	13.3	7.7
POND A 3-1												
5	29	5.0X10^8	2.3X10^7									
6	10	5.0X10^9	1.7X10^7									
8	18	3.0X10^8	2.3X10^8	3.5X10^5	1.3X10^7	23.5	18.5	1.5	3.5	0	17	6.9
9	19	8.0X10^8	2.0X10^7	3.5X10^5	5.0X10^7	64	56	1.6	6.4	0	27.5	7.3
D 36	23	5.0X10^6	2.0X10^5	1.0X10^2	3.5X10^7	6.8	3.4	3.4	3.4	0	ZERO	8.4
POND A 3-2												
10	1	4.0X10^7	1.6X10^6	6.0X10^7	6.5X10^7	32	26.7		2.0	3.3	43	6.7
11	10	1.3X10^7	4.0X10^6			51	39	1.7	10	0	35	6.6
13	18	4.1X10^7	6.6X10^6	4.0X10^5	2.7X10^6	9.6	5.8	0	3.8	0	0	6.8
D 43	21	3.0X10^7	1.7X10^6	ZERO	7.8X10^6							7.5

NOTE:

*** Redox potential for Sample Site 10 was -257.

APPENDIX C

PROCESSES TO SIGNIFICANTLY REDUCE PATHOGENS AND TO FURTHER REDUCE PATHOGENS

This appendix is a copy of Appendix B - Pathogen Treatment Processes, from Reference 8 of this Environmental Assessment Report.

A. PROCESSES TO SIGNIFICANTLY REDUCE PATHOGENS (PSRP)

1. Aerobic Digestion

   Sewage sludge is agitated with air or oxygen to maintain aerobic conditions for a specific mean cell residence time at a specific temperature. Values for the mean cell residence time and temperature shall be between 40 days at 20 degrees Celsius and 60 days at 15 degrees Celsius.

2. Air Drying

   Sewage sludge is dried on sand beds or on paved or unpaved basins. The sewage sludge dries for a minimum of three months. During two of the three months, the ambient average daily temperature is above zero degrees Celsius.

3. Anaerobic Digestion

   Sewage sludge is treated in the absence of air for a specific mean cell residence time at a specific temperature. Values for the mean cell residence time and temperature shall be between 15 days at 35 to 55 degrees Celsius and 60 days at 20 degrees Celsius.

4. Composting

   Using either the within-vessel, static aerated pile, or windrow composting methods, the temperature of the sewage sludge is raised to 40 degrees Celsius or higher and remains at 40 degrees Celsius or higher for 5 days. For four hours during the five days, the temperature in the compost pile exceeds 55 degrees Celsius.

5. Lime Stabilization

   Sufficient lime is added to the sewage sludge to raise the pH of the sewage sludge to 12 after two hours of contact.

B. PROCESSES TO FURTHER REDUCE PATHOGENS (PFRP)

1. Composting

   Using either the within-vessel composting method or the static aerated pile composting method, the temperature of the sewage sludge is maintained at 55 degrees Celsius or higher for 3 days.

   Using the windrow composting method, the temperature of the sewage sludge is maintained at 55 degrees or higher for 15 days or longer.

During the period when the compost is maintained at 55 degrees or higher, there shall be a minimum of five turnings of the windrow.

2. Heat Drying

Sewage sludge is dried by direct or indirect contact with hot gases to reduce the moisture content of the sewage sludge to 10 percent or lower. Either the temperature of the sewage sludge particles exceeds 80 degrees Celsius or the wet bulb* temperature of the gas in contact with the sewage sludge as the sewage sludge leaves the dryer exceeds 80 degrees Celsius.

*[CDM cautions that in their experience with heat drying, use of the wet bulb temperature is very likely to lead to overheating and fire danger. Use of the dry bulb temperature is appropriate and far safer.

3. Heat Treatment

Liquid sewage sludge is heated to a temperature of 180 degrees Celsius or higher for 30 minutes.

4. Thermophilic Aerobic Digestion

Liquid sewage sludge is agitated with air or oxygen to maintain aerobic conditions and the mean cell residence time of the sewage sludge is 10 days at 55 to 60 degrees Celsius.

5. Beta Ray Irradiation

Sewage sludge is irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad at room temperature (ca. 20 degrees Celsius).

6. Gamma Ray Irradiation

Sewage sludge is irradiated with gamma rays from certain isotopes, such as Cobalt 60 and Cesium 137, at room temperature (ca. 20 degrees Celsius).

7. Pasteurization

The temperature of the sewage sludge is maintained at 67 degrees Celsius or higher for 30 minutes or longer.

APPENDIX D

SITE RESTRICTIONS FOR LAND APPLIED WITH SEWAGE SLUDGE

The following site restrictions for land applied with sewage sludge are taken from the latest USEPA Sludge Regulations (Chapter 40 CFR Part 503) and apply to Class B sewage sludge:

(1) Food crops with harvested parts that touch the sewage sludge/soil mixture and are totally above the land surface shall not be harvested for 14 months after application of sewage sludge.

(2) Food crops with harvested parts below the surface of the land shallnot be harvested for 20 months after application of sewage sludge when the sewage sludge remains on the land surface for four months or longer prior to incorporation into the soil.

(3) Food crops with harvested parts below the surface of the land shall not be harvested for 38 months after application of sewage sludge when the sewage sludge remains on the land for less than four months prior to incorporation into the soil.

(4) Food crops, feed crops, and fiber crops shall not be harvested for 30 days after application of sewage sludge.

(5) Animals shall not be allowed to graze on the land for 30 days after application of sewage sludge.

(6) Turf grown on land where sewage sludge is applied shall not be harvested for one year after application of the sewage sludge when the harvested turf is placed on either land with a high potential for public exposure or a lawn, unless otherwise specified by the permitting authority.

(7) Public access to land with a high potential for public exposure shall be restricted for one year after application of sewage sludge.

(8) Public access to land with a low potential for public exposure shall be restricted for 30 days after application of sewage sludge.

APPENDIX E

"ENVIRONMENTAL SCOPING STATEMENT: UPGRADING AND EXPANSION OF THE WASTEWATER STABILIZATION POND SYSTEM AT AS-SAMRA"

Transmitted by Engineering Science Inc. to the Secretary General, Water Authority of Jordan, 27 April 1992.

Consulting Engineering Center

C.E.C. (Sajdi & Partners)

مركز الاستشارات الهندسية
(سجدي وشركاه)

Ref. : 195/130
Date : 27/04/1992

The Secretary General
Water Authority of Jordan
Amman,
Jordan

Project : Upgrading and Expansion of the Wastewater Stabilization Pond System at As-Samra

Subject : Transmittal Of Final Scoping Statement

Dear Sir,

Returned herewith is the Scoping Statement modified to incorporate the comments contained in your letter. We have included additional material to answer your comments 1.2 and 3. Foam was already mentioned as an issue of environmental concern. Measures to mitigate adverse impacts will be included in the "Environmental Assessment " which will be prepared and included in the Feasibility Report.

If you are satisfied with the Scoping Statement as modified, please direct a copy as soon as possible to USAID for their review.

Very Truly Yours,

Richard Deussen
Project Manager

C : USAID
C : File
RD/rj

BEST AVAILABLE COPY

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ENVIRONMENTAL SCOPING STATEMENT

UPGRADING AND EXPANSION OF
THE WASTEWATER STABILIZATION POND SYSTEM
AT AS-SAMRA, JORDAN

(A.I.D. LETTER OF COMMITMENT NO.)

In conformance with the requirements of 22 CFR Part 216, "A.I.D. Environmental Procedures" as published in the Federal Register of 9 October 1980, an Environmental Scoping Session was held in the offices of the Water Authority of Jordan (WAJ, Ministry of Irrigation and Water), Amman, Jordan at 10:00 AM on 26 March 1992.

The purpose of the meeting was to initiate the process of identifying significant issues relating to the proposed action and determining the scope of issues to be addressed in the Environmental Assessment and design of the proposed activity.

In order to assure adequate input from pertinent sources, individuals having expertise and interests relevant to the environmental aspects of the proposed actions were invited by WAJ to attend and submit their concerns and interests. In addition, representatives of the planning and design consultants, Engineering-Science, Inc. (ES) of Pasadena, California (USA) in association with Consulting Engineering Center (CEC) of Amman, Jordan were present to discuss the scope and schedule of work for the project. The attendees were as follows:

U.S.A.I.D.
Ministry of Water and Irrigation
    Water Authority of Jordan
    Jordan Valley Authority
Ministry of Planning (National Planning Council)
Ministry of Agriculture
Ministry of Health
Ministry of Municipal, Rural Affairs and the Environment
Ministry of Industry, Trade, and Supplies
Ministry of Energy and Mineral Resources
    Natural Resources Authority
Ministry of Tourism and Antiquities **
Amman Governorate
Zarqa Governorate
Villages of Ruseifa, Sukhna, Hashimiyeh, Abu Salllh,
    Guiyesha, and Khirbet es-Samra

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Royal Scientific Society (Chemical Department)
Amman Council of Industry
Royal Society for Preservation of Nature
Amercian Center for Oriental Research
Consultants - ES and CEC
Those invited but not attending were as follows:

(None)

Those submitting written statements are indicated by ** whether they attended or not.

As a result of these discussions and others, the environmental concerns of potential significance have been identified and are discussed as follows.

The meeting presented a brief review of the environmental effects of the existing system and its operation and the anticipated effects of the various delivery and treatment alternatives being considered. Discussions regarding these aspects and others allowed a full presentation on the part of the attendees as to their concerns, issues, and significance of effects related to the environment.

AREAS OF ENVIRONMENTAL CONCERN

In the project area (Amman, Zarqa, and As-Samra) and the effluent-related areas of the Zarqa basin, King Talal Reservoir, and the Jordan Valley), the most significant sectors of environmental concern were:

a) Maintenance and protection of public health for irrigators, rural communities, and irrigated crop consumers.

b) Protection of the surface water and irrigation resources of the Zarqa basin and the Jordan Valley.

c) Protection of groundwater resources from contamination by wastewater, sludge disposal and effluent especially in the Wadi Dhuleil.

d) Improvement and minimization of nuisances, odors,appearance and effluent color, and insects.

e) Improvement of water quality of the King Talal Reservoir.

f) Control and minimization of salts, boron, foam causing chemicals, and metals in the effluent

g) Protection and preservation of antiquities at Ain Ghazal, along the wadis. and at the As-Samra site.

h) Conservation of water and power in delivery and treatment.

i) Reduction of risks of uncontrolled or accidental by-passing, leakage, and release of raw sewage or poorly-treated effluent.

Other areas of environmental concern but not presented in the Scoping Session or of lesser concern related to the existing and future systems were:

a) Odors and nuisances from surface water in the Wadi Dhuliel and Wadi Zarqa.

Odors from water in the Wadies appear usually after storms and there does not appear to be any direct relationship between the proposed project facilities and odors and nuisances that appearer after storms. Those odors and nuisances existed before the existing project was completed.

b) Conservation of resources.

Use of resources during construction is a requirement of all construction. However, the use of wastewater ponds will reduce the use of resources i.e. concrete and steel,that would be required in other types of treatment facilities.

c) Protection and improvement of biotic resources of the Zarqa basin.

The Seil Zarqa before the WSP was seriously limited as an aquatic habitat by extremely low flows and poor water quality. The discharge of effluent from the existing WSP has no impact on fisheries as a commercial or recreational activity as fish are non-existant in the Seil Zarqa. Any wildlife habitat in the area is a result of the discharge from the WSP and the proposed project will only enhance these habitats.

d) Mitigation and rehabilitation of areas distributed by construction.

As the proposed sewer/siphon will travel along the Seil Zarqa, which is disturbed during every winter storm, the rehabitation of areas after construction appear to be of little concern. However, the pipeline must be protected from erosion and dust, noise, and traffic disruption will be mitigated during construction.

e) Support for and avoidance of interference with existing land uses.

The major land use of the area is farming using effluent for irrigation. The area can be returned to farming after construction with little interference and is of little significant concern.

REVIEW OF EFFECTS FROM THE EXISTING AND FUTURE SYSTEMS

The presentation at the scoping session briefly reviewed the effects of the existing system on the environment and those anticipated from the various alternative concepts for upgraded and expanded delivery and treatment facilities.

Existing Delivery Facilities

The existing delivery system has reduced risks of uncontrolled wastewater discharges and has eliminated chronic adverse health and water quality conditions along the Wadi Ain Ghazal and Wadi Zarqa. At the same time, the sewer/siphon delivery system has reduced effluent stream flow in these same Wadis for irrigation. Construction of the delivery facilities generated adverse effects from disturbance for both adjacent residents and archaeological resources.

Existing Treatment Facilities

Construction of the existing ponds used large areas of highly overgrazed grasslands and desert and perhaps archaeological resources. Biota of the area has recovered due to grazing exclusion and surface irrigation, and the site generally provides a refuge for many migratory and resident birds (several thousand at times during the winter migration). Insects also breed because of the availability of water and are a nuisance.

Wastewater delivered to the treatment facilities contain odorous gases which are released at the headworks of the ponds and cause persistent and significant odor complaints from the nearby communities. The wastewater stabilization ponds have been overwhelmed hydraulically and organically and generally are anaerobic and produce effluent with high levels of ammonia and nitrogen, although parasitic eggs levels meet the requirements and fecal coliform and filtered BOD5 approach or meet the original effluent limits. During the winter and high wet weather flows, treatment quality is further reduced and discharges do not meet the design requirements, except with high dosing of chlorine. Seepage from the ponds is minimal. However, groundwater and surface water are affected by the effluent discharge which carries dissolved solids including boron, chlorides and trace elements. Indirect effects include use of effluent for farming along the Seil Zarqa, which has increased the economic condition of the area.

Future Delivery Alternatives

Four different delivery alternatives have been reviewed for possible inclusion in the project. Concerns for their general environmental effects focus on 1) the significant land related resources, archeological and construction disturbance, and risk reduction of uncontrolled discharges involved in three alternatives with parallel gravity sewer/siphons and 2) the high power consumption, conservation, and a higher risk of uncontrolled discharges of untreated wastewater in the one pumped alternative.

Future Treatment Alternatives

Wastewater treatment at As-Samra must be upgraded and expanded to improve the effluent quality being discharged and to provide for the increase in future wastewater flows. Treatment should minimize losses of water and other resources while protecting the local and downstream environmental resources. Three general alternatives involve: 1) expanded natural wastewater stabilization ponds, 2) mechanical aeration at the existing ponds, and 3) convention secondary activated sludge facilities along with use of some of the existing ponds. The expanded ponds using natural wastewater ponds would have substantial and significant adverse construction impacts on land resources, would dramatically increase potential evaporation and generally increase the salt in any surface water reaching King Talal Reservoir. Conventional treatment would drastically increase power consumption and operational complexity and risk of upset and discharge of poorly treated effluent but would substantially reduce total evaporation. The aerated pond alternative would require the use of all existing ponds and would maintain existing evaporation and would require intermediate power demands for aeration.

Ability to Pay

Balanced with the public health and environmental considerations must be the practical consideration of the ability to pay and the social obligation of public facilities. Existing and anticipated unit costs (JD per treated volume or user served) for delivery and treatment in the As-Samra system are and will be lower than any other wastewater delivery and treatment system in Jordan.

APPROACH TO ENVIRONMENTAL ISSUES IN THE PROJECT REPORT

In accordance with the Terms of Reference and scope of work for this project, the following environmental evaluations have been and will be prepared to support the environmental and project planning/design:

- Environmental Assessment of existing facilities (part of the Survey Report)
- Scoping Session and Statement (herein)
- Evaluation and ranking of conceptual alternatives (part of the Conceptual Study Report)
- Environmental Assessment of the Proposed Project (part of the Feasibility Study Report)

Existing available data will be reviewed and analyzed during preparation of the environmental assessment and the following disciplines will be involved : Hydrogeology, Agronomy, Air Quality, Biology and Archeology.

Data and information will be or has been collected from many agencies and organizations supplemented by numerous field trips, surveys, and studies and by interviews and discussions with specialists. Qualitative judgements will be supported by simple mathematical models and conceptual and numeric mass balances.

SCHEDULE AND DECISIONS

Studies for this project began in October, 1991 with the evaluation of the existing As-Samra system facilities. Following review of existing facilities and projection of future requirements and water management objectives, conceptual alternatives were evaluated and ranked for their environmental effects and these were integrated with the overall review of alternatives. As part of the development and review of conceptual alternatives, the Scoping Session was held in March, 1992. Environmental assessment of the recommended alternative and approved project began in February, 1992 and will be concluded in May 1992 for incorporation with the Feasibility Study Report.

APPENDIX F

Section 9 - " Environmental Assessment of the Project"

from the

Draft Feasability Study

by Engineering - Science, Inc. August 1992.

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SECTION 9

ENVIRONMENTAL ASSESSMENT

The Environmental Assessment forms a section of the Feasibility Study Report and represents the final element of the environmental review process starting with a review of the environmental effects of the existing As-Samra WSP System from the AGTP to the KTR (Survey Report) and from developing the environmental ratings of alternatives (Conceptual Study Report). As part of the Feasibility Study Report, alternatives, the Approved Project, and various technical discussions of treatment and delivery facilities and discharge requirements are presented in other sections and are not repeated herein.

9.1 PURPOSE AND NEED

The environmental assessment (EA) process has a central purpose of providing an independent and full-disclosure evaluation of the effects of the proposed upgrading and expansion of the WSP System upon the human and natural environment.

The environmental studies for this project began in October, 1991 with the evaluation of the effects on the exising As-Samra system. Conceptual alternatives were evaluated and ranked for their environmental effects and these were integrated with an overall review of alternatives as part of the Conceptual Report. The Scoping Session was held in March, 1992. Environmental assessment of the recommended alternative and approved project began in February, 1992 and is incorporated within the Feasibility Study Report.

9.1.1 Evaluation of Existing Facilities

Evaluation of the existing WSP system highlighted those effects created by the existing system facilities and those that should be addressed by upgrading and expanding existing facilities. This initial element of the EA process defined the existing and most probable future effects and information regarding the magnitude and trends of those effects.

9.1.2 Scoping Session and Statement

This element of the EA process provided a definition of what effects are considered as significant and insignificant (or much less significant). A wide array of interested and knowledgeable specialists and representatives contributed several concerns and issues and presented their estimation as to what is significant. These contributions to the consultants assured them that they would receive local advice and direction as to the major concerns of the public who will be most affected by the construction and operation of the upgraded WSP facilities.

9.1.3 Conceptual Evaluations

Conceptual alternatives for upgrading and expanding the WSP system were developed to establish the ranking of environmental effects of the alternatives.

The recommended alternative included the best combination of environmental, engineering, and financial considerations. Some elements of the project were common to all alternatives and were not included in environmental review process or the integration with other aspects of the total project.

9.1.4 Feasibility Study Report

Once the Recommended Project was approved and more fully developed, purposes of the EA process shifted from a comparative evaluation to a more detailed evaluation of the approved project including the postions not originally considered as they were common to all alternatives. This evaluation focuses on the significant effects and development of suitable mitigation to reduce any adverse effects.

9.2 COMPARISONS OF PROPOSED PROJECT AND ALTERNATIVES

The proposed project evolved from reviews and comparisons presented in the Conceptual Study Report. During that phase of project development, primary focus was on differences between alternatives which all provided the same effluent quality from the same influent characteristics and alternative methods of delivering wastewater from the Amman and Zarqa areas to the As-Samra area as well as an area some 10 - 15 km further North from the existing site. Since the wastewaters and effluent were identical, the related sludge production was similar, although produced in somewhat different form. Detailed differences were not included in the comparisons nor were components which would be common to all alternatives.

9.2.1 Major Alternatives

Three general delivery and three treatment alternatives were reviewed: 1) pumped delivery, 2) gravity pipeline delivery, and 3) pumped and gravity pipeline combination; a) "natural" stabilization pond treatment, b) aerated lagoons, and c) conventional secondary treatment plant using the activated sludge process (similar to Ain Ghazal Treatment Plant).

Delivery Systems

The major delivery alternatives developed and reviewed, included: (1) pump conveyance from AGTP and from Zarqa, and (2) gravity flow from Ain Ghazal and pumped from Zarqa.

Pumped systems reduce the land areas and disturbances required for additional long sewer/siphons or force mains. Increased pumping into a single sewer/siphon system increases the risks from damage to and levels of damage from a single delivery system; no contingency is available and thus any maintenance must be conducted while the system is in operation. Gravity systems require dedicated easements and large amounts of imported construction materials (pipe) although they minimize long-term energy use (Except for that required to inject Zarqa flows into the main sewer/siphon).

The recommended Project's delivery facilities of a separate parallel sewer/siphon (cross-connected at AGTP and Zarqa) causes adverse effects related to land resources, archaeological and short-term biotic impacts, construction resource use in the areas of Ain Ghazal, Rusiefa, Zarqa, Sukhna, and Hashimiyeh. Long-term use of the gravity flow system reduces the very high cost of energy use and reduces the risks and magnitude of sewage spills to surface water and the dependent irrigation systems.

Treatment Systems

Three general types of treatment methods for expansion were developed: (1) "natural" wastewater stabilization ponds (similar to the existing system), (2) conversion of the existing waste stabilization pond system to a mechanical aerated lagoon system, and (3) installation of a conventional secondary treatment plant along with using the remaining ponds. All three alternative treatment systems achieve the same effluent discharge value. As in the delivery alternatives, the more "natural", non-mechanical systems require much larger land areas than the existing WSP site while the conventional facilities requires minimal land areas but long-term energy and resource use. Conversion of some ponds to mechanically aerated lagoons requires little additional land and only moderate energy use. Similarly, aeration provides moderate risk factors from possible failure of mechanical systems, because of the greater assimilative capacity of the waste stabilization pond system.

Disposal of Effluent and Solids

As indicated above, all delivery and treatment alternatives discharge identical effluent to Wadi Dhuleil. De-nitrification is impractical and not required to meet basic requirements for agricultural use and the downstream effects from the discharge of effluent are virtually indistinguishable (especially below Sukhna and in King Talal Reservoir). One improvement for the Wadi Dhuleil channel is a series of cascades with a few small ponds to capture algae.

All treatment alternatives discharge settleable and suspended solids into the anaerobic ponds or primary clarifiers (activated sludge alternative). Treatment produces sludge which must be periodically, or continuously, removed and disposed of at disposal sites. For all practical conditions, the sludges are sufficiently similar that no significantly different process can be used for one and not the others and the eventual disposal will be burial or land-filling.

9.2.2 Comparative Summary

In summary, the recommended Project can be evaluated as follows:

Parallel Gravity Delivery of Sewage

1. Provides contingency in case the existing delivery system is out of service.
2. Reduces the risk of equipment failure (pumps) and discharge of untreated sewage to surface waters.
3. Reduces long term energy requirements.
4. Increases the possibility of archaeologic site disturbances.

Aerated Lagoon System at the As-Samra Site

1. Eliminates the need for site expansion and additional piping.
2. Uses available trained labor but requires a moderate increase in O&M costs and efforts.
3. Requires long-term electric power use.
4. The upset risk for treatment and effluent quality is considered minimal.
5. Archaeological impacts are significantly minimized.

9.2.3 Recommended Project

The four major components of the recommended project as they relate to the environmental effects are discussed below :

Ain Ghazal Preliminary Treatment Plant Site

The existing headworks (standby) and the new delivery facilities must be improved and expanded to eliminate discharge of raw sewage to Wadi Ain Ghazal and thence to Wadi Zarqa. Removal of debris and grit will protect the existing and new delivery facilities from erosion and settlement of solids. Rehabilitation of the existing odor control facilities will protect maintenance personnel and reduce release of odorous gases to the atmosphere.

Ain Ghazal - As-Samra Delivery Sewer/Siphon and Corridor

The existing delivery facilities must be expanded to eliminate the possibility of discharge of wastewater. Existing and new facilities should make maximum use of gravity systems in order to conserve energy for long-distance transmission and to reduce the potential for equipment malfunctions leading to the release of wastewater. Construction of new facilities must provide for recovery and preservation of antiquities along the transportation corridor. Construction of new facilities must be integrated with existing land uses in order to minimize construction and long-term impacts to the environment.

Zarqa Pump Station and Site

The existing pump station requires expansion to assure complete control of wastewater that would otherwise be discharged directly to Wadi Zarqa. Construction and future operations must be conducted with regard to increasingly urbanized surroundings and the need to protect farming and wildlife areas near the pump station and to be "good neighbors" with the nearby residents.

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As-Samra Wastewater Stabilization Ponds and Effluent Disposal

Wastewater treatment at As-Samra must be upgraded and expanded to improve the effluent quality being discharged from the ponds. In order to provide continuing effluent quality, the upgraded system must provide for almost tripling the treatment capacity. Treatment should minimize loss of water while protecting the local and downstream environmental resources. Similarly, disposal of sludge should minimize adverse effects upon the biotic resources of the area. Future development should support other environmental programs of the Government of Jordan, e.g., "Greening of Jordan".

Improvements of the effluent channel should reduce nuisance and odor complaints and reduce channel infiltration losses of water to the local groundwater tables.

9.3 AFFECTED ENVIRONMENT

Existing and proposed Project facilities occur in six areas each with distinguishable combinations of environmental and human conditions. Secondary uses of effluent occur in two of these areas and along the remainder of the downstream Seil Zarqa channel, KTR, and Jordan Valley irrigation areas.

9.3.1 Ain Ghazal

The Ain Ghazal site (AGTP) is an area enclosed by the concrete channel of Wadi Ain Ghazal and the Amman-Zarqa Highway, the major intersection of Hashemite/King Abdullah, National 30, and National 70 roads, the Hijaz Railway and the rocky cliffs below the Hamza area of Ain Ghazal district, and the Amman Municipal Slaughter House. The site includes the original Ain Ghazal Treatment Plant, the headworks and septage facilities in the westerly portion, and the relatively undeveloped easterly portion. The entire site contains many trees and is relatively secluded from the general urban residential areas on the ridges and industrial areas to the southwest, except for the existing digesters which protrude some 20 meters above existing grade.

9.3.2 Ruseifa

Northeast of the Ain Ghazal site (downstream along Wadi Ain Ghazal), urban development ceases for about 5 km; the existing pipeline (and the future route) pass along the irrigated floodplain of Wadi Ain Ghazal. At 4 k, downstream of the inlet to the sewer/siphon, the Wadi Ain Ghazal joins the westerly flowing Wadi Zarbi and from here the wadi is referred to as Wadi Zarqa. Irrigated floodplains continue to the Yeast Plant (north, left bank) adjacent to the older, abandoned phosphate mining areas. North of Ain Ghazal, the pipeline generally parallels the Hijaz Railway and in some locations is directly adjacent to its right-of-way. From the beginning of the Wadi Zarqa, the existing pipeline route continues through the developed areas of Ruseifa and Zarqa. The pipeline passes under local streets and along the main road between Ruseifa and Zarqa. At numerous points, industrial and commercial development are close to the pipeline. Once the route reaches the

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Zarqa Pump Station site, structural uses are generally restricted to areas above the floodplain.

9.3.3 Zarqa Pump Station - Sukhna

This section extends northward from the Zarqa Pump Station (20,400 m from Ain Ghazal) along the irrigated and cultivated valley floor of Wadi Zarqa (approximately 400 m wide) for about 8 km to the existing Emergency Pond, northwest of Sukhna (near the confluence of Wadis Zarqa and Dhuleil and the new Sukhna-Qunaiyeh road bridge). Some residential and commercial chicken farm structures exist on higher terraces along the road and on the floodplain. Residential areas of Sukhna extend westward down to the road and to a limited extent on the right bank of the floodplain.

9.3.4 Sukhna - Sallih

Between the Sukhna Road bridge, the existing pipeline route turns eastward and passes along the southern (left) bank of the narrow Wadi Dhuleil valley with high basalt bluffs. Some irrigation supports narrow fields on the lower valley floor of the north bank. In the Sukhna, Wadi Said, and Abu Sallih (village) areas, some surface water from the wadi channel is also lifted more than 50 m to the plateau and high terraces north of Sukhna, in the Wadi Said valley, and at Abu Sallih. Above the Sukhna Bridge, a second bridge connects Sukhna with the smaller village of Abu Sallih. A paper processing plant lies on the south side of the bridge and river, while several chicken farms lie at the base and on top of the north end of Jebel Bakiya (a high basalt plateau between Wadis Dhuleil and Said).

Abu Sallih includes cultivated farms and olive groves which extend up the Wadi Abu Sallih for several kilometers. A second road on the east of the village connects with Hashimiyeh (via National Road 11). This narrow valley begins to expand along the north (right) bank of Wadi Dhuleil from a point around 1 km east of the Sukhna-Abu Sallih Bridge.

9.3.5 Hashimiyeh

The Hashimiyeh area lies west of As-Samra (5-6 km) and receives direct effects from the existing WSP. Effluent irrigation supply from the Wadi Dhuleil channel supports the entire agricultural development along the widened wadi valley upstream of Abu Sallih. The main developed commercial and residential area lies midway through the section and at the main road (Highway 20) and extends eastward up onto the basalt plateau and toward the WSP. The Jordanian Petroleum Refinery and Al Hussein Thermal Power Station lie 1 to 2 km south of Hashimiyeh. Within the area, a few small commercial-industrial enterprises include a pre-fabricated concrete plant, a dairy (with several feedlots), and several chicken farms. Two steel fabricating plants exist along the main road to Mafraq and the secondary road to Abu Sallih. Less than ten farm residences lie along the floodplain and lower terraces.

9.3.6 Seil Zarqa - KTR

Downstream of the confluence of Wadis Dhuleil and Zarqa, the Seil Zarqa passes through a relatively narrow lower valley between terraces (30 - 80 m above the valley floor). which continue upward on either side to divides. Several villages (e..g, Dauqara) lie on the terraces and higher slopes, and Jerash is located about 4 km north of the Jerash Bridge, 35 km downstream of the WSP. Only the major Amman-Jerash and Zarqa-Jerash roads bridge the Seil Zarqa above King Talal Reservoir. Irrigated farmland is limited to within 50 - 150 m of the channel, although some olive orchards on the lower hill slopes may receive pumped water from the channel.

The Wadi Jerash (35 km downstream of WSP) receives discharge of treated wastewater from the Jerash Wastewater Treatment Plant and discharges to the Seil Zarqa. Seil Zarqa enters the KTR pool area about 45 km downstream of the WSP; the pool extends for another 2 km in a narrow deep, flooded valley before discharging from the King Talal Dam into the Jordan Valley area (about 15 km below the dam).

9.4 ENVIRONMENTAL EFFECTS OF THE RECOMMENDED PROJECT

Assessment of environmental effects involves the evaulation of the important activities during construction and operations. The assessment assumes that the Project will be implemented as designed in accordance with the drawings and specifications and that contract provisions will be complied with. It also assumes that the constructed facilities will be operated in accordance with recommended procedures and generally accepted operating practices and will be provided with adequate financial resources for normal operations and maintenance.

9.4.1 Impact Designation and Relationships

Impacts can be grouped into the general categories given below:

Direct - occurs within the corridor and at each site of work and includes:

- Surface water flow and quality
- Local groundwater quality and levels
- Pond and channel evaporation and seepage
- Disruption and disturbance of land uses
- Biota changes and loss of antiquities

Indirect - occurs beyond the aligment corridor route and actual sites of work and includes:

- Construction noise, air pollution, traffic congestion, and temporary disturbance of the environment
- Land use and air quality

- Pollution of the groundwater
- Evaporation

Secondary - side effects of the project which include:

- Odors from the Wadi Dhuleil and Seil Zarqa
- Levels and quality of the rural water supply
- Evaporation and non-point discharges of pollutants

Virtually all environmental effects can be avoided with sufficient economic resources (e.g., trenchless versus trenched construction for delivery systems). Some effects, such as those on commonly available resources may not be sufficiently significant (loss of limestone or basalt materials). Many other effects (once created) may not be reversible e.g., loss of unique archaeological antiquities and rare/endangered species.

The effects are summarized below as they are discussed in subsequent sections:

Significant Effects

- Surface water quality
- Construction
- Operations (Short Term)
- Groundwater quality
- Air quality
- Antiquities
- Biology
- Use of resources
- Land use
- Community Economy
- Health/Safety Risk

Less Significant Effects

- Ground resources and geotechnical
- Operations (Long Term)

As indicated above, most, if not all, effects of the Project are included as significant. During the Scoping Session and development of the proposed alternatives, the direct and indirect effects of facilities covering a route of 40 km and land areas of more than 300 ha and producing one of the most important products in the Kingdom - water - were reviewed. All are important to virtually all sectors of the natural environment and human community of the area. Criteria for importance reflect the following: (1) the significance of the affected sector (health, water, antiquities, and biota all being significant) (2) the reversibility of effects (significant

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if irreversible), (3) the type of project activities (construction, operations), (4) the duration of effects, and (5) the levels of directness (direct effects being more significant).

9.4.2 Mitigation of Consequences

The following discussions of Project activities presume that no mitigation has been separately developed and approved (funded) for implementation either for upgrading of the existing facilities nor for expansion of the As-Samra WSP system.

Specific mitigation measures may be considered and included in the detailed design of the facilities; the mitigation measures included in Section 9.5 herein may be included in the detailed Project design.

9.4.3 Significant Effects

Significant effects have been summarized above and are developed in more detail in the sections below. The consequences deal entirely with the adverse effects of the Project activities on the natural environment and human communities and resources in the Project area and those areas affecting by construction and operations but are beyond the geographical limits of sites and routes. Many effects are indirect and secondary and are beyond the specific jurisdiction and authority of the WAJ but they result from the Project and would not occur without the Project. The alternative facilities have been reviewed in the Conceptual Study Report and summarized in the Section 9.3 herein.

Surface Water Flows and Quality

Environmental effects on surface water extend beyond the limits of the pipeline route and sites of the work and are considered to include irrigation use of the effluent from As-Samra WSP which flows to the King Talal Reservoir.

Desludging of existing anaerobic ponds, excavation (deepening) of existing ponds and construction of new inlets and outlets within the WSP will require a partial loss in treatment efficiency during the period of construction. This will result in the discharge of less-well treated effluent.

Levels of ammonia, sulfides, organic matter, and fecal bacteria are expected to increase during construction since the present chlorination system can not meet the demands of the present flows.

The expansion will treat sewage to eliminate these adverse effects. Construction sequencing of work will reduce these effects to insignificant levels and effluent will be treated to a level to maintain and support downstream users and beneficial uses of stream flows below As-Samra. Effluent and stream water quality will be improved over that at present and especially over that before the As-Samra WSP System was implemented in 1985/86.

Effluent Irrigation

Increased volume and improved quality of effluent will further encourage irrigation along Wadi Dhuleil and Seil Zarqa. Without proper irrigation and agricultural management, various indirect or secondary effects will arise including:

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- Increased fertilizer and pesticide use for agriculture and the subsiquent return to surface water channels.
- Maintenance and increase of rural population growth, agricultural intensification, and livestock rearing along Wadi Dhuleil and Seil Zarqa which in turn generates a greater demand for water supplies and thus more wastewater.

Groundwater Quality

The effluent of As-Samra can enter the local groundwater through minor seepage from the ponds, infiltration from the wadi channels , and through soil infiltration from irrigation.

Based upon available information and field surveys, the following environmental effects from effluent can be reasonably assumed:

- As-Samra ponds infiltrate minor amounts of effluent into the local groundwater tables
- Effluent in the Wadi Dhuleil channel infiltrates into the local groundwater tables
- Irrigation with effluent concentrates constituents in the soil
- Rural development has increased infiltration of pollutants into the local groundwater and also results in overpumping of groundwater thus reducing the groundwater ability to assimilate and dilute pollutants

Local groundwater quality in the area was seriously degraded in the 1970's, reaching 3000 mg/l TDS. The WSP Effluent contains much lower values of TDS and thus can be considered to reduce (dilute) the groundwater TDS. Minor seepage from the ponds can be expected, based on the performance of the existing ponds. Groundwater quality, however, is being equally, or more affected by the rapid expansion of abstraction, improperly operated wells, and surface developments, which contribute seepage from irrigation, feedlots, solid waste disposal and cesspools.

Chemical constituents in groundwater arise from those of water infiltrating into the groundwater and those acquired during the process of infiltration. The major groundwater constituents of concern are those which will interfere with common rural uses for irrigation supplies including bacteria, sulfides, ammonia, iron, salt, boron and heavy metals.

Virtually all well water quality data from WAJ and other sources demonstrate increasing levels of contamination in the groundwater since the early 1970's, especially for salts (total dissolved solids, sodium, and chlorides in particular). Where recorded, water levels in the aquifers have decreased even before and after operations of Ain Ghazal and As-Samra treatment facilities. Available data are insufficient for any statistical analyses to ascertain the relative contributions of effluents from either Ain Ghazal Treatment Plant (1970 - 1985) for groundwater along Wadi Zarqa, or As-Samra WSP (1985 - 1991) for groundwater along Wadi Dhuleil).

WAJ influent/effluent records suggest that wastewater from the WSP is seeping into the underlying soil and alluvium. Records indicate that on average over the last six years; seepage rates were about 2400 cu m/d.

The generally rocky bottom of the Wadi As-Samra, Wadi Dhuleil, and Seil Zarqa would typically allow surface water in the channel to infiltrate the underlying valley alluvium. No adequate data is available to document locations and quantities of infiltration and exfiltration of groundwater along the wadi channels.

Effluent infiltration from the wadi channels represents a highly variable contribution, although its quality will greatly improve due to improved effluent quality once the project has been implemented. Further contributions of improved effluent should gradually dilute other contributions and may provide some improvement to the alluvial groundwater wells adjacent to the channel.

Most farmers of the floodplain and terraces near the Wadi Dhuleil and Seil Zarqa draw effluent from the channel throughout most years and especially during the normal summer irrigation period. Cultivation generally uses either small plot or row flood irrigation and some drip irrigation. Some cultivation still uses pumped well irrigation or mixes well water with effluent drawn from the channel. Effluent irrigation of previous dryland farming has increased surface infiltration of water not directly used by plants or lost as evaporation. If no infiltration occurs, salts would rapidly increase in the root zone and kill poorly irrigated crops. Flood irrigation using earthen ditches also has a very low efficiency, i.e. water infiltrated compared to water used by the plants.

Existing and anticipated irrigation practices along Wadi Dhuleil and Seil Zarqa may improve after further degradation causes significant impacts on the cash value return from irrigation. Irrigation effects using effluent from the expansion will not differ significantly from those at present. Chronic salt leaching will persist much as is the case now. Groundwater tables are generally small and isolated and the effects of chronic and accelerated salt leaching from the soil may render some smaller tables virtually unuseable.

Irrigated farming along the Wadi Dhuleil and Seil Zarqa depends on effluent during the summer. Increased crop production and the economic benefits of the crops have supported agricultural intensification, increased rural population growth, and general improvement of rural economics and standards of living. These "improvements" have increased demands on existing groundwater sources.

Rural development in the Zarqa and Hashimiyeh areas have greatly accelerated due to increased roadway access, piped potable water supplies, and general economic improvement generated from increased cash return from irrigated crops. Dairy livestock, chicken and egg farms, increasing populations, and improving rural lifestyles all generate greater demands for water from local groundwater sources for irrigation and upon the piped water system supply for human consumption.

This same rural population also generate increased non-point sources of wastewater and runoff from feedlots, solid waste disposal sites and septic tanks and cess pools.

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Air Quality

The residents of Hashimiyeh and others in the vicinity have endured odor and other sewage-related nuisance problems over the last few years. Odor generation must considered as a significant adverse effect, no matter how short-term or infrequent.

Maintenance of the anaerobic ponds will require desludging of the existing anaerobic ponds from time to time. Sludge will require dewatering and drying on large sites (Dabba Plains represent the only existing available lands). Various methods of dewatering in-place using the existing ponds or in special drying beds will expose the sludge to air and generate odor releases of entrapped sulfide and other gases. Past experience has demonstrated that odorous gases from the As-Samra area affect the residents of Hashimiyeh and future desludging will also significantly affect the same residents. However, procedures and chemicals can be use to mitigate and reduce the release of odorous gases.

Archaeological Resources

Archaeological resources include both the antiquities or artifacts themselves and, equally important, the context and arrangement of their preservation. Both elements are unique and losses are irretrievable once disturbed or removed. Although the direct effects of construction may be short-term for the resources themselves, losses to archeology and studies of culture and perhaps tourism will occur if antiquities are disturbed during construction which must be deemed as significant effects.

Most citizens accept the significance of direct destruction of antiquities, but continued expansion of irrigated agriculture and conversion of floodplain and terrace areas for cultivation, rural structures, and livestock facilities further expands and generates the long-term secondary effects of the covering, disturbing and loss of antiquities. If no irrigation water was available, land conversion would be much reduced in these areas.

Archaeological resources are known along most of the valley floors and many higher terraces and plateau areas in the Ain Ghazal to Khirbet As-Samra area. Direct effects of construction for the sewer/siphon, headworks at Ain Ghazal, expansion of the Zarqa Pump Station, the new anaerobic ponds, and any sludge disposal facilities nearby will have a high potential for encountering and destroying significant archaeological resources.

Indirect excavations for construction equipment access, pipe bedding and materials, and local concrete aggregates may further expand the adverse effects of construction on archaeological resources. Because of the importance of proper bedding materials for the pipeline, off-site excavations for these materials could generally occur along the Wadis Zarqa and Dhuleil, where archaeological resources are known or anticipated.

Continuation of existing and future irrigation supply will generate secondary detrimental effects as more irrigation and intensive farming and livestock rearing occurs along Wadi Dhuleil and Seil Zarqa in areas where archaeological resources have the highest probabilities of occurring.

Increasing agricultural activities and rural intensification will cause excavations and land surface disturbance which may generate secondary losses of significant archaeological remains and information along Wadi Dhuleil and Seil Zarqa. These secondary effects are probably of greater significance than the more limited but intense direct impacts of pipeline and pond excavations. The availability of irrigation water is supporting agricultural excavations, trenching, grading, and leveling in the Sukhna area, while the new Sukhna-Qunaiya road along the north (right) bank of Seil Zarqa (west from Sukhna) has been excavated across numerous terraces with improved access to irrigated fields and olive groves. Such secondary activity may have destroyed or disturbed antiquities.

Biotic Resources

Biotic resources of the Project sites and areas differ markedly and have been both improved and degraded by earlier construction and operation of the existing facilities. In a similar manner, the Project activities will generate a complex mixture of benefits and detriments for the "natural biota" of the areas.

The Ain Ghazal Treatment Plant site contains many introduced trees, shrubs, and grasses and generally provides a moderate to high value biotic habitat especially for birds and other wildlife in an otherwise biotically-barren urban landscape. Project activities at the site are limited generally to the headworks area which is generally disturbed and recently planted with young trees. Demolition of above-ground structures in the central and eastern parts of the site would generate considerable disturbance which would be most significant during the fall-spring bird migrations and over-wintering. Some existing trees will be removed which will require replacement.

Land use conversion of "undeveloped and cleared" areas of the Ain Ghazal area to industrial purposes would result in indirect or secondary adverse effects and would reduce the avialable "safe-havens" for the remaining birds and other wildlife.

Direct, short-term effects of pipeline construction on biota are well recognized but generally very localized and short-term. In general, the existing and anticipated Project route will pass through already highly disturbed irrigation and urban areas between Ain Ghazal and Zarqa Pump Station where the existing biota has little or no value. Beyond the Zarqa Pump Station, irrigation and over-grazing have left only small areas of "natural" riparian vegetation and associated wildlife. These areas represent low-value biota. These areas can and may be avoided or replanted and represent only minor short-term effects.

Expansion of the Zarqa Pump Station and associated pipeline-related construction will destroy a few trees and shrubs around the existing facility. The existing facility has provided a "safe-haven" for birds in the relatively barren urban and desert area. Although irrigated fields provide some useful habitats especially during winter migrations, more protection is provided by the fenced enclosure of the pump station. As at Ain Ghazal, the biotic value of the site and future impacts have been created by the existing facility and its operation. Future construction will eventually provide the same habitat and protection but with a loss for several years. Because of the temporary nature of construction, any effect the resident and migratory wildlife and "natural areas", any losses of trees and shrubs and disturbance by workers, equipment, and activities must be considered as minor.

As with the other Project sites, the existing site at As-Samra has proved a relatively safe and undisturbed refuge for many thousands of birds during the fall-spring migrations. Because of the greatly improved biotic value and the greater importance assigned to it by the continued and expanding losses in the surrounding areas, any future adverse effects from the Project activities assume even greater significance.

Construction of the parallel sewer/siphon, headworks, three additional anaerobic ponds, and other related facilities will have direct and significant adverse effects on the biotic resources of the As-Samra site. Construction disturbance and direct removal of vegetation will affect resident and migratory wildlife for at least two years.

A new sphere of potentially adverse effects will arise regarding sludge disposal. Sludge disposal will require conversion of nearby land to drying or landfill areas.

Improved and increasing amounts of effluent will become available for riparian irrigation and indirectly lead to increased conversion of existing disturbed and overgrazed areas and riparian vegetation. Increased rural development will also increase the disturbance to resident and migratory birds and other wildlife. Increased rural populations will promote increased grazing pressures on remaining upland and vegetated habitats. As such, these increasing disturbance pressures represent indirect and secondary effects upon the few existing significant biotic resources.

Community Disturbance by Construction

The communities of Ruseifa, western Zarqa, Sukhna, and Hashimiyeh will be subject to construction disturbance and disruption of community life, residences, and transportation. Truck traffic will use existing congested streets and roads for moving materials and equipment to and from the sites of work. Truck traffic will disrupt normal traffic, and generate considerable dust, exhaust fumes and noise, especially in the congested areas of Ruseifa and Zarqa.

Construction of the sewer/siphon through the south-westerly portions of Zarqa and eastern end of Ruseifa will interfere directly with road use and generate considerable local disturbance. Because of the limited road capacities between Zarqa and Amman, increased congestion on one road will indirectly divert and further congest the remaining roads. All traffic will have to travel through the central commercial and residential area of Zarqa in order to reach the route. Since this route also lies along the main road from Zarqa to Jerash (and Syria) increased

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congestion during construction will generate, significant temporary disturbance effects for these areas.

Construction Use of Resources

Construction of a major infrastructure and supply of equipment for the WSP will cause a large increase in the demand for construction materials and generate considerable employment, income, and local revenue. In general this will benefit many people in the Amman - Zarqa area, but unfortunately the construction employment will be of relatively short duration.

Rapid increases in demand for unskilled and semi-skilled labor will increase wage rates. Short-term increases in wages and commercial economic activities will stimulate local economic development. Such increases may not be sustained after construction is completed and the rapid declines following construction are detrimental, but expected.

Operational Use of Resources

Wastewater production is related to the conservation and reuse of the wastewater arriving at As-Samra WSP and discharged to the Wadi Dhuleil-Seil Zarqa. Water use and wastewater generation in Amman and Zarqa will increase, and as the standards of living increase, residents will undoubtably increase their use of water using appliances.

The proposed Project has been developed to maintain as much as possible the existing water surface areas and thereby the total evaporation. Aeration may increase the water evaporation somewhat but evaporation should remain less than 20 percent of the average throughput of the WSP. At present, very few surface coverings or chemical evaporation inhibitors can be practically used for reducing evaporation from large surface water bodies and have not been included in the proposed Project.

Additional water losses will occur along the Wadi Dhuleil and Seil Zarqa above King Talal Reservoir due to continuation and expansion of agriculture. These losses cannot be avoided without total disruption of existing irrigation which has been developed over the past six years. Existing and continuing future uses of effluent for irrigation and other local farming activities will contribute to the reduction of the channel flow for downstream irrigation uses.

Conservation of the water from the As-Samra system requires programs to reduce industrial discharges without pretreatment streams and the management of irrigation and eventually the leaching and discharge of irrigation drainage water to the Wadi Dhuleil and Seil Zarqa.

Proposed delivery and possible sludge disposal systems will increase the total amount of land dedicated for infrastructure support. Because of the remote location of treatment and sludge facilities, little significant effect will arise from conversion of existing open areas for infrastructure uses. The Ain Ghazal site and the first half of the pipeline route lie in desireable and developing lands and dedication of the land to infrastructure support will constrain future land use along the route.

Land acquisition and use for infrastructure will remove usable land areas from future availability and increase values of remaining lands in the general area. Land use in the immediate vicinity of the existing and proposed sewer/siphons must be controlled in order to avoid damage to the sewer/siphon. Land use between the pipeline and the wadis will be of particular importance because of potential erosional effects due to construction. Imposition of land use controls in the vicinity of the sewer/siphons will limit existing owners' use and therefore the future land use value of their properties. Some properties between the sewer/siphons and natural land, use constraints (wadi banks and steep slopes) will further reduce land available for agricultural uses. The sewer/siphon routes through Ruseifa, Zarqa, Sukhna, and Hashimiyeh will be most affected by these infrastructural land dedication and use restrictions.

The Project will use gravity to deliver over 200,000 cu m/d (avg. daily flow) of wastewater in the year 2005 through a 39-km pipeline without pumping from Amman. Because of the location of Zarqa, more than 50,000 cu m/d must be pumped into the pipeline which then flows by gravity siphon to As-Samra. The Project treatment plant at the As-Samra WSP however, will use considerable (at least in the winter) amounts of electricity for the aeration of wastewater.

The existing delivery system and hydraulic flow through the WSP make use of about 100 m of elevation and do not use any direct energy. By such use, the energy required to deliver well or surface water to Amman and Zarqa are conserved. Conventional treatment alternatives would require large amounts of electric power generated from the power station at Zarqa and commensurate use of imported oil. These power uses are balanced against the use of agricultural lands and evaporative losses from a wastewater stabilization system.

Discharge of the effluent from WSP will increase the power generation through the turbine at King Talal Dam.

Indirect energy consumption off the project site is also represented by the imported aerators and other equipment which requires manufacturing and transport to the site.

Other energy resources may be represented by chemical disinfection, and the nutrient and soil conditioning value of treatment by-products.

Use of greater volumes of liquid chlorine for chlorination creates adverse resource conservation effects because of the large amount of energy requirements for its generation and delivery to the site. Solar-biotic "natural" disinfection however, to treat the same volume would expand the size of maturation ponds and lead to evaporation of large amounts of water.

For the local Jordanian resource base, importation of liquid chlorine and reduced water losses may be a suitable alternative to surface water importation.

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The current WSP effluent contains about 50 mg/l of ammonia and oxidation to nitrates along with organic removal or denitrification will diminish the nutrient value of the effluent and increase requirements of fertilizer use for downstream irrigation.

Increased use of resources generates related adverse effects in other environmental sectors: air pollution from oil-fuelled power generation in Zarqa-Hashimiyeh basin, increased traffic and air pollution for delivery of chlorine and fertilizers, and health risk from discharges of poorly disinfected effluent if chlorine is not used.

Economies, Lands, and Development

The Jordanian industries concentrate on light construction materials, foods/beverages, and other light industries focusing on domestic and light commercial products. Medium to heavy industries are few and generally are not capable of producing equipment required for safe and sustained operations of the WSP System. A parallel sewer/siphon would require importation of about 39 km of large diameter steel pipe and accessory fittings which cannot be manufactured locally. The aeration treatment alternative would require imported mechanical aerators, supporting switch gear, and other electro-mechanical equipment and controls and contribute to dependency on foreign equipment, spares, and technical assistance and reduces or inhibits development in the medium industries. Some development in mechanical related industries may occur, because of the continuing preventive maintenance which will be conducted in Jordan.

The presence and operation of the existing facilities at Ain Ghazal, Zarqa Pump Station, and WSP have reduced the adjacent land values and the possibility for intensive land uses in these areas. Improved service at the facilities may reduce the adverse effects but continued presence will probably continue the depression of surrounding land values in conjunction with the more significant effects of dedicated land uses and land use restrictions.

Community Health, Safety Risks and Management

Improved treatment of the As-Samra effluent will produce beneficial health effects for rural populations using the effluent from the channel for irrigation. Improved effluent quality will allow untreated non-point sources to have less effect due to the dilution and improved assimilative capacity of the stream.

Persistent improved quality of effluent, stream flow, and irrigation water will cause many to presume the safety of the water and reduce avoidance and precautions which are more normal for the existing "identifiable" sewage effluent. Since the effluent's health-related quality is largely determined by mechanical treatment and disinfection, periodic upsets and malfunctions may be expected in all types of treatment plants and can expose downstream users to possible water-borne diseases for which they will be unprepared.

Catastrophic Risk and Management

Risk from major malfunctions will persist in any system with such long delivery pipelines, mechanical equipment, and chemical disinfection facilities, although upgrading and expansion will significantly reduce the risks compared to existing conditions. Provision of a second sewer/siphon will increase the potential risk from third-party damage, but its existence will improve maintenance capability for both and reduce the risk from facility and equipment failures. Dependency upon mechanical treatment systems and chemical disinfection will increase the risk and significance of malfunction, although the great redundundancy of aerators and proper redundent design for chlorination should reduce any increase in risk to an insignifcant level.

The stabilization ponds provide some limited habitat for ducks and other floating birds and some diving birds which feed on debris discharged in the first anaerobic ponds. Many wading and shore birds make use of floating scum-layers and flotsum stranded along the pond edges, while insect-feeding birds feed over all ponds but especially over the scum-layers. Because of the relative isolation and low operating activities, all migratory birds can make use of and are protected in most areas of the As-Samra site.

Although initially enclosed by a security fence, the fence has been opened in many areas and local residents make use of the site for grazing and harvesting forage for livestock. A more immediate fence has been established to partially restrict direct access to the ponds but it has little exclusion value.

Planting of several thousand trees have greatly improved the original overgrazed habitats of the site. Secondary woodland habitats have been formed around the perimeter and especially the westerly area of the site. Such planting and general protection from hunting and severe overgrazing has greatly enhanced the biotic value of the As-Samra site.

9.4.4 Less Significant Issues

Several environmental conditions will arise during the long-term operation of the facilities which can be anticipated but do not cause significant detrimental effects.

Ground Resources and Geotechnical Constraints

The proposed Project will use relatively small amounts of cement, aggregate, and sands during construction. Larger use will be for bedding materials for the sewer/siphon and various concrete structures for the inlets/outlets at the ponds, pumping station and headworks additions.

Land slippage and bank stability/erosion are a major concern for the routing of the second sewer/siphon in relationship to the relatively narrow topographic corridor and the presence and protection of the existing sewer/siphon. Additional measures will be taken to avoid interference and damages from land slippage to either the existing or Project sewer/siphons.

The Project area is seldom exposed to earthquakes but damages have occurred to structures in Amman (e.g., 1927 earthquake). Major seismic epicenters are generally located to the west of Amman in the Jordan Valley and further west to the Mediterranean coast. Structures will be designed in accordance with the required dynamic loading for above and below ground structures. No additional adverse effect is anticipated for the proposed Project or resulting from construction, operations, or presence of the Project facilities.

Operation Disturbances

Operation of the proposed Project and the existing WSP system facilities will be relatively isolated and secluded from general urban and public access. Odor controls, lighting, and screening of the Ain Ghazal and Zarqa sites will reduce disturbance below existing levels. Some traffic improvements for turning and parking will be provided for Zarqa, especially for trucks hauling debris and grit.

Operation at As-Samra will generate some increase in activities and noise levels from aerators and trucks. All activities will be at least 1000 m from any residential or significant public access areas. Traffic to the site will increase slightly but not significantly. Most vehicular movement will be limited to the expanded site and generally involve movement between the anaerobic pond area and the sludge drying and/or burial areas. Truck deliveries of chemicals or debris and grit from Ain Ghazal, Zarqa, and Hashimiyeh will be primarily responsible for traffic to the site.

Operational Air Quality and Meteorology

Operations of the upgraded and expanded ponds are expected to require: (1) continuous odor control at the AGTP and WSP headworks, (2) periodic (5 to 10 years) desludging of the anaerobic ponds, (3) aeration of wastewater during treatment, and (4) increas- ed and improved chlorination. These activities may contribute to some periodic releases, and/or infrequent accidental releases, of malodorous gases which may detrimentally affect local nearby residents.

Mechnanical aeration will require a significantly greater use of power which will increase the base load for generation at the power station at Zarqa. Since the station uses oil with a moderate to high level of sulfur (> 2%) and has relatively short stack, some local degradation of air quality nearby can be expected in this industrial area of Zarqa and in the residential areas of Hashimiyeh and Sukhna.

9.5 MITIGATION, MONITORING, AND CONTROLS

Mitigation measures are specific elements to be implemented in a project that go beyond normal construction and operations requirements in reducing or minimizing adverse effects of other project activities (e.g., archaeological monitoring and recovery during trenching excavations). As such they will be included in the Project Tender Documents and Operations and Maintenance Manuals. These measures will be indicated in the following discussion.

Monitoring and controls are generally proposed to assure that (1) levels of anticipated effects are not exceeded without further mitigation, (2) implemented mitigation measures are in fact fully implemented and provide adequate mitigation

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to achieve the anticipated overall reduction in significant effects, and (3) additional measures are implemented when either unknown effects are encountered or anticipated effects are exceeded.

9.5.1 Construction

Construction mitigation measures have been well developed for most projects and are generally accepted within the design, procurement and construction activities. These typical measures are summarized below and must be incorporated in specifications and tender documents in order to have any direct enforcement. Construction inspection must also be managed in order to assure enforcement of the controls provided in the construction tender documents.

Archaeological Resources

Mitigation for disturbance and loss of archaeological and historic resources (antiquities) has been applied in Jordan (even the King Talal Reservoir construction involved archaeological mitigation in the 1960s). Standard mitigation should include:

- Surface surveys of all excavation and grading areas prior to construction.
- Trial excavations on significant sites and areas located by surveys within access and earthwork areas.
- Complete archaeological recovery for significant areas which are to be excavated or graded.
- Sterile cover of remaining significant remains adjacent to but not within excavation areas
- Onsite monitoring of all equipment excavation and training of supervisory staff for monitoring of hand excavations, during construction.
- If significant sites are to be excavated, the trench or structural excavation should be manually excavated through the site prior to construction in the area
- Onsite conservation and preservation of remains for future transport and handling.
- If earthwork and archaeological resources are significant and extensive, early surface surveys and testing can delineate areas and allow for realignments or relocations in order to minimize construction time delays for salvage excavations of the resources

Construction Disturbance

Mitigation and compensation for construction disturbance generally involves improved management of activities, scheduling, and some direct equipment and other controls. These include:

Timing of Construction. -- Seasonal and night-time scheduling of work to allow maximum activity in those areas well separated from residences and public area. Reducing night-time activities in areas adjacent to or within 100 m of residences and public areas. Seasonal effects can be reduced by timing construction in agricultural areas to periods after harvesting and before planting.

Equipment Restrictions -- Equipment should be muffled or enclosed or located in such positions so as to reduce or minimize noise, vibration, and exhaust from affecting nearby residences, institutions, and public areas. If muffling is not practical, then construction should only allow use of low-noise equipment within 200 m of residences.

Traffic Control -- When many deliveries are involved (i.e. imported pipe), traffic controls on routes, off-site holding areas, scheduling, and stacking of vehicles should be required to reduce disturbance to traffic and residents along the haul routes. Traffic direction may require flagmen and additional traffic officers at major impacted intersections. It may be desinable to develop and, require compliance with, specific routings and schedules in the Ruseifa, Zarqa, Sukhna, and Hashimiyeh areas and provide traffic control personnel at major intersections.

Dust, Rubble, Debris, and Sludge Control and Cleanup. -- Contracts should have standard conditions regarding maintaining of the construction sites in an clean, safe, and orderly condition, but they should also include direct specifications and bid items for watering of site and access routes; rubble/debris and sludge removal; covering of loads during transport to/from the sites; control of drainage and runoff; cleaning equipment before entry to ashalted public streets/roads; and remediation of runoff sediment, debris and mud which leaves the sites of work and cause a public or environmental nuisance.

Protection of Wadis -- Since major pipeline construction will be adjacent to or crossing existing wadis which may have high winter-time flows, provision must be included to eliminate sources of eroded soils and debris or transport to the wadi channels. Between November 15 and April 15, construction should require surface runoff controls for drainage and runoff.

Biotic Resources

Tree planting should commence as one of the first items of work and should concentrate at the Ain Ghazal site, Zarqa Pump Station, and around the headworks area. Within the As-Samra area, all fencing for the existing site, new fencing around the new facilities and new fencing for any sludge disposal area should also be established as a first item of work. All grazing, forage gathering, and soil tilling should cease on the existing As-Samra site. Such exclusion should continue for at least three and if possible, five years. Once grasses, herbs, and young shrubs have re-established themselves, limited grazing can be established on specific test plots, and limited tilling can be concentrated beneath the canopy areas of the olive trees.

Other biotic mitigation and compensatory measures are included below for longer term mitigation.

9.5.2 Mitigation for Long-Term Operations

Air Quality

Operations will cause some adverse effects due to maintenance of the anaerobic ponds (desludging). Odors from the operation can be overcome by recirculating aerobic water, performing work when the wind is away from nearby residential areas or by masking the odor.

Surface Water Quality

Longer-term water quality improvements must focus on improving the influent wastewater quality delivered to WSP. A major WAJ program must be undertaken to control sources of high strength salts and boron. These are essentially unaffected by the wastewater treatment process. Industries must pre-treat prior to discharge and have redundent features if a unit must be taken out of service for maintenance. In part, this is susbtantially an enforcement program, since regulatory compliance alone is not sufficient to reduce influent salts.

Wadi Dhuleil Improvements

Residents of Wadi Dhuleil have been adversely and significantly affected by the WSP. However, they have also received considerable economic benefit from improved and continuous irrigation supplies.

Initial review of alternative Wadi Dhuleil channel improvements indicated that costs were very high for relatively limited beneficial effects. The evaluated improvements, however, provided for a concrete channel. The following improvements would provide significant benefits to the local residents.

- Establish a defined channel routing, and
- Develop a low-flow channel alignment, and excavate and grade the alignment to contain low flows. Provide minimal surface controls of the channel such as gabions and riprap.
- Provide a piped water supply and sewer system to residents from Sukhna to Hashimiyeh who do not presently have those services.
- Provide improved irrigation management training services to irrigators along Wadi Dhuleil valley.

King Talal Reservoir- Surface Water Resources

The King Talal Reservoir is an irrigation and power generation storage reservoir, although attempts have been considered to use it for recreation and fisheries. These uses are totally inappropriate because of its location and configuration and consequently no mitigation is proposed related to any activities or uses.

Local Groundwater Quality and Volume

All water discharged from As-Samra is dedicated for irrigation purposes in the Jordan Valley. No formal diversion of water for local groundwater recharge has been anticipated. Improved effluent water quality from As-Samra WSP will have little beneficial effect upon the downstream groundwater tables.

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Monitoring of WSP process flows and local groundwater levels will provide information regarding which ponds are seeping the most and some specific seepage controls could be initiated once the seepage has been localized.

Biotic Resources

The proposed Project will intensify activities and convert some "improved" and rehabilitated natural biotic areas for ponds and sludge disposal. These effects require both short- and longer-term mitigation. Generally, measures would involve the following:

- Restore existing fencing and exclude grazing and harvesting of vegetation for a minimium of three years and then control grazing according to a range management program suited to the seeding requirements demonstrated during the three-year exclusion period
- Acquire and protect large (500 ha) upland areas adjacent to WSP for future sludge disposal areas and allow the "natural" recovery of upland vegetation (grassland steppe) by preventing grazing.
- Provide a perennial source of water of approximately 1000 cu m/d for marshland development along the eastern portions of the Wadi As-Samra watershed.

The potential evaporation and bottom seepage represents about 4,000 cu m/d depending on the season. This water loss should be reduced although it cannot be eliminated. During desludging and pond restoration and upgrading and for any new ponds, bottom seepage must be reduced by placing a clay or other impervious lining.

Although desludging will occur during the construction period of the Project, desludging forms an integral part of the long-term operations of the WSP system. Sludge and effluent are the major products of wastewater stabilization, and sludge will be generated in large quantities. After proper handling and treatment, the sludge may be used for soil amendments such as an organic conditioner which is needed by most Jordanian soils. Because of the high costs for transport, the lack of nitrogen fertilizer value, and the tillage requirements, sludge may have to be distributed free to the farmers east of the WSP (Khirbet As-Samra Village area) and along Wadi Dhuleil/Seil Zarqa in order to recover any value for the land. However the sludge should be first tested to determine that no harmful effects will occur.

A short-term measure of the Project could demonstrate the "land-farming" of sludges within the WSP site or on adjacent areas (e.g., Dabba Plains to the east). If sufficient long-term interest and dedication were evidenced, a sludge conveyance pipeline and filling facility could be developed in the Khirbet As-Samra and Dabba Plains area. Such use would mitigate the adverse effects for resource conservation and other environmental sectors arising from landfill disposal of the sludge.

Fisheries – Long-term improved treatment and effluent allows for some beneficial and mitigation through aquaculture with fisheries. Introduction of fish can provide some reduction of suspended solids when properly harvested.

Maintenance of a standing fish crop assures that water quality should be acceptable for general downstream uses.

Generally the fish could not be used for direct human consumption, but it could be processed for livestock (chicken and cattle) feed or even as fertilizer in the local area.

Risk Management and Emergency Response

An immediate and long-term consequence of the existing and proposed delivery system involves the risk of accidental release of untreated wastewater. Time risk must be reduced to the maximum extent possible.

A flow monitoring system capable of detecting leaks can be used to identify when a leak is occurring. Once a spill has been detected, a spill response plan, staff, and equipment must be available and set in motion immediately. An immediate measure would be to notify the affected residents and agencies and the actions required of them. Following control of the leak, a remedial action plan must be initiated for clean-up and to provide a longer-term evaluation of what caused the leak and how similar conditions can be controlled.

9.6 LIST OF PREPARERS

The following persons worked on/or reviewed the Environmental Assessment :

- Dr. C. Thomas Williams, an environmental specialist, who has over 20 years experience in the preparation of environmental impact reports, environmental assessments and other environmental reports to meet both CEQA and NEPA requirements both in the USA and overseas.
- Mr. Philip N. Storrs, Chief of Environmental Studies, with over 22 years experience in technical supervision and direction of multidisciplinary environmental studies.
- Mr. Richard R. Deussen, Project Manager, who has over 30 years experience in managing large study and design projects with environmental concerns both in the USA and overseas.
- Mr. Ali Mobadda Al-Labadi, Geologist and Hydrogeologist, with over 15 years experience in geology and hydrology with the Natural Resources Authority and a private consulting firms.
- Mr. Samir Maher, Agronomist, has over 15 years experience in crop management and irrigation methods.
- Ms. Elvira V. Gaddi, Senior Environmental Engineer, with 12 years experience in air quality and environmental report preparation.

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