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ONEP

AZEMMOUR WASTEWATER TREATMENT FEASIBILITY STUDY

USTDA GRANT No. GH1172652

Final Report

Prepared by

GLOBAL ENVIRONMENTAL SUSTAINABILITY INC

P.O. Box 3149, Princeton, NJ 08543

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Thank you.

Ahmed Hamidi, Ph.D., P.E., P.H
President of GESI

AZEMMOUR WASTEWATER TREATMENT AND REUSE
FEASIBILITY STUDY
ONEP, MOROCCO

Activity No. 2001-10072A
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SUBCONTRACTORS LIST

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223 South Wacker Drive
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AZEMMOUR WASTEWATER TREATMENT FEASIBILITY STUDY
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CROSS REFERENCE BETWEEN THE TERMS OF REFERENCE AND THE FINAL REPORT

TERMS OF REFERENCE	REFERENCE IN THE FINAL REPORT
Task 1.1: Data Collection on Azzemour's Environment, Analyze Existing Data and Wastewater Characterization	Section 1
A. The Contractor shall collect information on Azzemour's physical environment (topography, climate, hydrology, geology, hydrogeology, ground water quality), socio-economic conditions, land use, biology and ecology, archeological and historical resources, and institutional and regulatory setting.	Section 1, Chapter 1.3, 1.4 and 1.5
B. The Contractor shall also analyze the reports of studies conducted by the Province of El Jadida on the wastewater treatment for Azzemour. This analysis will result in a report that will include comments and recommendations of the Contractor on existing studies.	Section 1, Chapter 1.2
The Contractor shall analyze the results of flow and effluent characterization from previous sampling campaigns and will determine whether new sampling campaigns are necessary for the study. Sampling will be done by ONEP. The Contractor will define, together with ONEP, the main elements of the flow measurement and wastewater effluent characterization strategy (choice of measurement points, frequency, list of effluent quality parameters). This strategy must address the three following points: 1) main effluents released by the sewage network, 2) receiving media, and 3) industrial wastewater.	Section 1, Chapter 1.9 The consultant reviewed the results of the wastewater characterization by LPEE in 1989 and by IAV in 1997 (see Chapter 1.9.2.1) and performed additional sampling analysis as shown in Chapter 1.9.2.2
Deliverable: The Contractor shall provide a detailed tabulation of wastewater physical/chemical characteristics and presentation of Azzemour's environmental setting, as well as conclusions and recommendations concerning the analysis performed in previous studies.	Section 1, Chapter 1.10 and 1.11

Task 1.2: Develop Alternatives for Wastewater Treatment Recognizing that the current discharge of Azzemour's raw sewage threatens public health and the environment, the Contractor shall formulate a set of alternative schemes for treating wastewater and reusing it for irrigation, particularly for the watering of a golf course and tourist resort. In developing the alternatives, the Contractor shall consider various technical aspects, such as:	Section 2
• The identification (which the Contractor will undertake) of various options for wastewater treatment (type of unit and treatment and pre-treatment steps) and reuse that are appropriate for local conditions and beneficial for the city (each option must exhibit the characteristics of operational ease, flexibility of use, cost effectiveness (economical) in terms of capital and operational and maintenance costs, and high performance that meets the requirements for wastewater treatment and reuse).	Section 2, Chapter 2.2.1
• The wastewater treatment and reuse system must be capable of serving Azzemour's population for the next 20 years (e.g., recirculating sand filters, waste stabilization ponds);	The wastewater treatment plant was designed to handle wastewater flows up to year 2025 (see Section 4, Chapter 4.2.1)
• A sewer line collecting wastewater from the existing outfalls to the treatment plant;	The design includes a force main (sewer line) to convey wastewater from the existing outfall, where a new pump station will be installed, to the new treatment plant. The length of the force main is 705 m (See Section 4, Chapter 4.3.7)
• Pumping stations (as needed) to direct wastewater to the treatment plant; and	Section 4, Chapter 4.3.9
• A vehicular access road to the treatment site and the pumping stations.	Section 4, Chapter 4.6

For each alternative, the Contractor shall provide: • Site requirements, • Building requirements, • Equipment requirements, • Process sidestreams, if any, • Air emission and effluent treatment requirements, • Utility requirements, • Estimated quantity and quality of residuals for disposal or reuse (i.e., nutrient value, level of stabilization for pathogen and odor control, physical characteristics, leachate potential), and • Transportation requirements.	Section 3, Chapters 3.2, 3.3, 3.4 and 3.5.
Deliverable: The Contractor shall provide descriptions of each alternative including design capacities, site locations, major equipment needs, etc. Descriptions shall also include flow charts, diagrams, tables, and maps.	Section 3

Task 1.3: Evaluate Alternatives and Develop Preliminary Implementation In this task, the Contractor shall evaluate and compare each alternative considering a range of issues, including:	Section 2 and Section 3
• Technical suitability (i.e., performance, reliability, implementability, and safety),	
• Costs (construction costs, equipment costs, land and site development, building and services, engineering expenses, contingencies, transportation costs, and operation and maintenance --O&M-- costs),	Section 3, Chapter 3.4
• Detailed estimates of the costs of implementation and operation of the plant – costs will be expressed in Moroccan Dirhams per m^3 of treated wastewater, and the economic analysis will be conducted using rates of return (8, 10 and 12 percent),	Section 7, Chapter 7.1
• Institutional and regulatory concerns,	Section 3, Chapter 3.2.4.2 and 3.2.6.2
• Environmental impacts, and	Section 5
• Reuse market issues (including potential revenue generation from sales to farmers, the future golf course, the municipality's green spaces).	Section 3, Chapter 3.3.2
Deliverable: The Contractor shall provide descriptions of the results of the evaluation of each alternative presented in both narrative and tabular form so as to allow for comparison across all issues.	Section 3

Task 2.1: Detailed Study of the Selected Option The purpose of this task is to refine the study of the technological option selected in Tasks 1.2 and 1.3. The Contractor must perform the following activities:	Section 4
• Define the design of the sewage collectors, assess their longitudinal profiles and the dimensions of the piping network,	Section 4, Chapter 4.2.5 and Annex 1: Drawings
• Specify in detail all works and equipment required for potential pumping stations,	Section 4, Chapter 4.3.9; Chapter 4.4 and Annex 1: Drawings
• Determine the location of the main and accessory components of the wastewater treatment plant, taking into account the potential expansion of the wastewater treatment plant,	Section 4, Chapter 4.4.2; Chapter 4.4 and Annex 1: Drawings
• Identify the basic characteristics of the wastewater (raw wastewater, treated wastewater, water elevation at the entrance and exit points of the system, etc.)	Section 4, Chapter 4.2
• Determine implantation of works, taking into account topographical and other site-specific constraints,	Section 4, Annex 1: Drawings
• Specify materials to be used in construction,	Section 4, Chapter 4.4
• Identify the areas of implantation and characterize materials for the construction of basins	Section 4, Annex 1: Drawings and Chapter 4.4
• Determine how waterproofing of basins should be done and how to test water resistance during construction,	Section 4, Chapter 4.3
• Define operation and maintenance tasks,	Section 4, Chapter 4.5 and Section 5, Chapter 5.4.4
• Determine mode of construction,	Section 4, Chapter 4.4

• Identify characteristics of on-site buildings (laboratory and guard house) o Electrical and water supply requirements o Hook-up points with electricity and water supply lines o Location and detailed description of the electrical transformation unit,	Section 4, Chapter 4.6
• Identify access roads to the plant	Section 4, Chapter 4.6
• Identify on-site details (internal paths, gardens, lighting, fences, gates, exterior access roads, telephone installations, flood protection for the wastewater treatment plant, etc.),	Section 4, Annex 1: Drawings
• Provide detailed cost estimates of the civil engineering works (basin, buildings, other constructions, etc.) and of electro-mechanical equipment.	Section 7, Chapter 7.1.1.1
With respect to operating costs, the Contractor shall estimate the annual costs of energy, personnel, and materials. The Contractor will also provide detailed planning for various expenses.	Section 7, Chapter 7.1.1.2
Deliverable: The Contractor shall provide a conceptual design of the wastewater treatment plant. The report setting forth this design should include lists of equipment, design criteria, general arrangement drawings, and process diagrams. It should also include detailed cost estimates (capital and O&M) for each component, as well as revenue estimates associated with any reuse activities.	Section 3 and Section 4

Task 2.2: Environmental Assessment	
The purpose of this task is to assess the positive and negative environmental impacts of the project on human health and the environment. The project will be analyzed based on the following principal components that could have an impact on receiving media: o Main collector including pumping stations and feeding collectors, o Wastewater treatment plant and potential pre-treatment units, o Sludge treatment, o Treated wastewater evacuation, and o Reuse of treated wastewater.	Section 5 Section 5, Chapter 5.5 Section 5, Chapter 5.4
The analysis will define critical environmental issues, classify these issues by order of sensitivity and identify environmental impacts of the project on receiving media. The site of the wastewater treatment plant will be analyzed using several criteria: • Distance between the site and the population (impact of odors); • Ownership of the site (private or public land); • Access to the site; • Conveyance of raw sewage; • Topography and geotechnical characteristics; • Risks of flooding; • Risks of polluting ground water; • Reuse of treated wastewater; • Proximity to water extraction wells; • Potential for plant expansion; • Existing utilities; and • Future land use plans.	Section 5, Chapter 5.5
After identifying and assessing environmental impacts, the Contractor shall propose mitigating measures that should accompany all phases of the project's operation.	Section 5, Chapter 5.5
Deliverable: The Contractor shall provide an environmental impact assessment report.	Section 5

Task 2.3: Develop Implementation Plan	Section 6
The Contractor shall review issues associated with the construction of the wastewater treatment plant. These include a review of implementation alternatives, review of legal issues, recommendations regarding procurement, evaluation of financing options, and development of a milestone schedule. The Contractor shall establish an optimal phasing for implementation based on physical and operational constraints. Based on this review, the Contractor will develop an implementation plan.	Section 6, Chapter 6.1; 6.2; and 6.3
Deliverable: The Contractor shall provide an implementation plan.	Section 6

Task 2.4: Prepare Financing and Cost Recovery Strategy	Section 7
Sales of treated wastewater should cover some of the treatment costs. Upfront disbursement of money will be necessary, however, to pay capital expenses. The Contractor shall identify a number of funding sources and mechanisms that can be tapped to finance the facilities, including state guaranteed bonds or loans, tax structure incentives, international agency loans and grants, supplier loans, and counter-trade agreements. Based on this identification, the Contractor will develop, in coordination with ONEP, a financing strategy specifying the availability of one or several funding sources for this project as well as the amount of money that can be financed and the conditions for reimbursement. The Contractor will assist ONEP in contacting people responsible for these funding sources and present to them the Azzemour project in order to get preliminary approval. The Contractor will examine various options for cost recovery, taking into account the self-financing capacity of the wastewater treatment plant. The Contractor will also study the impact of different fees on cost recovery (sewage hook-up fees, sewage charge as a percentage of the potable water consumption, sale of treated wastewater, property tax, and other potential sources of revenues).	Section 7, Chapter 7.1 and 7.2
Deliverable: The Contractor shall provide a financing strategy.	Section 7

Task 3.1: Prepare Final Report The Contractor shall prepare a Final Report presenting the results and findings of all tasks. The Final Report should identify U.S. suppliers of goods and services consistent with Clause I of Annex II of the Grant Agreement. The Final Report shall include the following elements:	Present report
• The results of the analysis of existing studies,	Section 1
• A justification for and explanation of the planned wastewater treatment plant,	Section 2 and 3
• A technical and economic evaluation of the various options,	Section 3
• Detailed cost estimates for the different components of the selected option,	Section 4, 5 and 7
• A planning schedule showing the timing of construction activities, and	Section 6
• The proposed strategy for cost recovery and financing.	Section 7

US VENDORS OF WASTEWATER EQUIPMENT

The following table gives a list of US wastewater equipment vendors who might be interested in providing equipment for this project.

A.R.I. USA, Inc.
4241 Jutland Drive
San Diego, CA 92117
Phone - (559) 269-9653 or (877) 536-6201
Fax - (858) 225-0894
www.arivalves.com

Acrison, Inc.
20 Empire Boulevard
Moonachie, NJ 07074
Phone - (201) 440-8300
Fax - (201) 440-4939
www.acrison.com

Air Liquide Industrial U.S. LP
2700 Post Oak Boulevard
#1800
Houston, TX 77056-5797
Phone - (713) 624-8000
Fax - (713) 624-8525

Applied Process Technology, Inc.
3333 Vincent Road
#222
Pleasant Hill, CA 94523
Phone - (925) 977-1811 or (888) 307-2749, ext. 0
Fax - (925) 977-1818

Atlantic Ultraviolet Corporation
375 Marcus Boulevard
Hauppauge, NY 11788
Phone - (631) 273-0500
Fax - (631) 273-0771
www.ultraviolet.com

Chlorinators Incorporated
1044 SE Dixie Cutoff Road
Stuart, FL 34994
Phone - (772) 288-4854
Fax - (772) 287-3238
www.regalchlorinators.com

Eden Equipment Company
1485 East 3rd Street
Pomona, CA 91766
Phone - (909) 629-5106 or (800) 842-5081
Fax - (909) 629-0243
www.edenequipment.com

Process Solutions, Inc.
560 Division Street
Campbell, CA 95008-6906
Phone - (408) 370-6540
Fax - (408) 866-4660

WC Equipment Sales, Inc.
3585 Lawrenceville Suwanee Road
#201
Suwanee, GA 30024

Phone - (678) 730-0997
Fax - (770) 614-5992

Aeration Industries Inc.
P.O. Box 59144
Minneapolis, MN 55459-0144
Phone: (952)448-6789
Fax: (952)448-7293
www.aero2.com

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EXECUTIF SUMMARY

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1. SCOPE OF WORK AND PROJECT BACKROUND

The Moroccan National Office of Drinking Water (ONEP) and the United States Trade and Development Agency (USTDA) selected Global Environmental Sustainability, Inc. (GESI) to conduct a feasibility study of the treatment and re-use of wastewater of the city of Azemmour, Morocco. The feasibility study was funded by USTDA and organized in eight (08) Tasks as follows:

Task 1	: Review and Analyze existing Studies and Data
Task 2	: Identification of treatment and reuse alternatives
Task 3	: Technical-economic and environmental comparison of alternatives
Task 4	: Detailed study of the selected alternative
Task 5	: Environmental Impacts Assessment
Task 6	: Development of Implementation Plan
Task 7	: Financial analysis and proposal strategy of project financing
Task 8	: Preparation of the final report of the feasibility study.

The area of study includes primarily the town of Azemmour and the Center of Sidi Ali, however the wastewater and water irrigation needs of the tourist complex of Mazagan were also taken into account. Therefore, the feasibility study considered the possibility of installing one wastewater treatment system for Azemmour, Sidi Ali and Mazagan and/or re-using the treated wastewater for the water irrigation needs of the complex of Mazagan.

2. OBJECTIVES

The objective of Task 1 is to collect the data necessary for the evaluation and design of the wastewater treatment system for the town of Azemmour and the center of Sidi Ali and Mazagan.

The objective of Task 2 is to identify and evaluate technologies of treatment and re-use of wastewater, applicable to the town of Azemmour, the center of Sidi Ali, and Mazagan.

The objective of Task 3 is to compare the treatment and reuse alternatives and to select the most appropriate alternative.

The objective of Task 4 is to design the selected wastewater treatment alternative and to prepare preliminary drawings and technical specifications for this alternative.

The objective of Task 5 is to evaluate the environmental impact of the selected wastewater treatment alternative and define the appropriate remedial measures to reduce the impact.

The objective of Task 6 is to identify the management methods and prepare an implementation plan for the construction and operation of the selected wastewater treatment alternative.

The objective of Task 7 is to prepare a financial analysis for the construction and operation of the selected treatment alternative.

3. STUDY CONCLUSIONS AND RECOMMANDATIONS

3.1 Analyses of existing data and studies

3.1.1 Analyses of current treatment system

The existing wastewater network of the town of Azemmour is a combined type. It has a length of approximately 27 km. The wastewater network of Sidi Ali is a separated type. It is in an early state and has several effluents. In addition, the sewr networks of the town of Azemmour and the center of Sidi Ali do not cover the whole developed area.

The sewer lines of the wastewater network of the town of Azemmour are generally very old and insufficient for collecting rain water. Problems exist in the districts with mountainous sub basins whose system was installed without planning or control at the time of the construction.

The depth of the network is often low (varies between 0.25 m and 1.10 m), this situation thus generates problems of routing of wastewater of the dwellings which are often at a lower elevation than those of the collectors.

The Municipality of Azemmour completed rehabilitation work and renovations during the last few years. Work concerned the old médina, the Northwestern extensions, and the avenue Moulay Hassan. According to the Municipality of Azemmour, all this work permitted the elimination of the black spots and to ensure that the time of stagnation of water does not exceed half an hour.

Also, according to the municipality of Azemmour, the work carried out during the last few years relates to a linear distance of 11210 ml of renewed and rehabilitated collectors. As for the Médina, it should be noted that an interceptor (DN 500 mm, length: 700 ml) collecting wastewater along the wadi Oum Erbia, was installed by the ANHI.

Currently, the wastewater of the town of Azemmour is discharged without treatment in the Wadi Oum er-Rbia, as indicated in the figure below. This effluent joins the beach of Hawzia located approximately 2 km from the outfall. The organic matter carried by the water is of domestic origins.

The town of Azemmour and the center of Sidi Ali discharge daily more than 2500 m3 of wastewater in the Oum Erbia river. This flow is expected to increase and reach approximately 3000 m3/day in 2010 and 4200 m3/day in 2025. This wastewater flow generates nauseous odors and contributes to the pollution of the Oum er-Rbia river.

3.1.2 Review and critical analyzes of existing studies

The main studies previously undertaken on wastewater treatment for the town of Azemmour and of the center of Sidi Ali include:

1. Wastewater Master Plan for the town of Azemmour, carried out by the engineering firm Techno Export Stroy (1989, SDAL): Task 1: Diagnosis of the network of the Kasbah and the new Médina ; Task 2: Study of the extension zone.

2. Wastewater treatment Study for the town of Azemmour (1998), conducted by Guigues Morocco: Task 1: Cost analysis of alternative of purification and re-use; Task 2: Preliminary Design.

These studies identified the following sites for wastewater treatment of Azemmour and Sidi Ali

- Site 1 on the left bank of the wadi Oum er-Rbia to treat waste water of the Town of Azemmour;

- Site 2 on the right bank of the wadi Oum er-Rbia to treat waste water of the center of Sidi Ali Ben Hamdouche.

Site 1 suggested for the treatment of waste water of the town of Azemmour is logical because of its proximity to the city, there is no other alternatives since the town of Azemmour is surrounded by a forest to the west and north sides and by the river on the east side. On the other hand, site 2 suggested for Sidi Ali is not really appropriate because of its location in a potentially easily flooded zone. In addition, it would be less expensive to build and operate one treatment plant for Azemmour and Sidi Ali than to have two separate treatment plants, one for Azemmour and another for Sidi Ali.

In addition, the study of the SDAL retained a mechanical and biological treatment, with percolation fieldsi. The advantage of this type of treatment is that it produces an effluent of good quality; however the capital cost and the costs of operations of such a system of purification are high.

The study of Guigues Morocco proposed an alternative, which recommends a natural treatment by lagoons. The advantage of such a system of treatment is its simplicity and lower cost. However, it has disadvantages in terms of necessary surface area and potential odors emitted by this type of process.

3.1.3 Establishment of design criteria

The projected wastewater flows from Azemmour and Sidi Ali were calculated by taking into account the population census in 1971, 1982 and 1994 and the forecasts of increases retained by the ONEP in projections for the drinking water requirements.

The quality of the wastewater was established by conducting, in December 2003, a detailed wastewater characterization in the towns of Azemmour and Sidi Ali.

The results of the simulation of the quantities and qualities of the wastewater are summarized in the following table, for 2010 and 2025 horizons:

Table 1: Quality and Quantity of Waste

Parameter	Concentration	Concentration
Year	**2010**	**2025**
Population Served	49700	63150
Population Connected	39737	59609
Flow (m3/day)		
Minimum per Hour	1768	2532
Daily Average	2940	4220
Maximum per Hour	3675	5275
Peak per Hour	5880	8440
Concentration (mg/l)		
BOD5	544	598
COD	1262	1286
MES	404	446
TKN	136	141
Charge (kg/day)		
BOD 5 Average per day	1599	2524
BOD5 Maximum per day	2000	3160
COD Average per day	3712	5427
COD Maximum per day	4639	6784
MES Average per day	1303	1958
MES Maximum per day	1628	2448
TKN Average per day	391	574
TKN Maximum per day	489	717

For the effluent criteria, GESI retained the following minimal values for the discharge to the Oum er-Rbia river. However, the water treatment plant was conceived with a tertiary treatment, which will allow the re-use of purified water where necessary.

Table 2: Effluent criteria

Maximum concentration of the Effluents	Frequency	Value
BOD (mg/l)	Monthly average	30
COD (mg/l)	Monthly average	150
MES (mg/l)	Monthly average	50
Dissolved solids (mg/l)	Monthly average	2000
Coliforms (MPN/100 ml)	Weekly average	<1000
Nematode eggs	Weekly average	<1
PH	Weekly average	6.5-8.5
Oils and greases (mg/l)	Daily	30
Nitrate (mg/l)	Monthly average	50
Phosphorus Total P (mg/l)	Daily	2
Sulfides (mg/l)	Daily	250
Temperature, Degree C	Daily	<30

3.1.4 Site selection of the wastewater treatment plant

Research and identification of the potential sites were undertaken based on the lands and the cartographic plans available.

The identified sites include:

- Site 1: located at the left bank of the Wadi Oum Errabia close to the principal wastes of the town of Azemmour
- Site 2: located at the right bank of the Wadi Oum Errabia close to the Layachi hospital. The site is currently cultivated.
- Site 3: Located close to the future tourist zone of Haouzia.

The figure below shows the location of these sites. It should be noted that sites 1 and 2 were also proposed by the SDAL and the study of Guiges Morocco. It should be also noted that there is no other site alternatives apart from the forest since the town of Azemmour is surrounded to the west and north by the forest and to the east by the river of Oum er-Ribia.

A technical, environmental and socio-economic comparison was carried out between these sites to determine potential sites of less impact and to identify opportunities and constraints for each potential site. The advantages and disadvantages of each site are summarized in the table below:

Table 3: Comparison of the Potential Sites of Purification

Sites	Advantages	Disadvantages
Site 1	- Proximity of the principal existing outfall of the town of Azemmour - Public ground, relatively easy acquisition. - No need for crossing the Wadi	- Presence of the forest - Requires stripping - Requires authorization of the administration of Water and Forest)
Site 2	- flat and clear ground (no trees) - no pumping needed of waste water from Sidi Ali	- Prequires crossing Wadi to convey water of Azemmour - private land, problems of land acquisition - Ground potentially untitled
Site 3	- Close to the zone of re-use (Mazagan) - Public ground (forest) - No crossing needed of Wadi	- Rough ground - Far from the town of Azemmour - Cost of pumping important - Near to the tourist complex (problems of the odors)

From this comparison, we can conclude that Site No 1 is most advantageous. Indeed, the site is:

- Not very far from the city, therefore does not require long distances of piping or pumping.
- Less visible from outside and does not present problems of odors, because of the strong density of the vegetation in place and the retained process of aerated lagoons.
- Next to the existing outfall, treated wastewater can be discharged directly into the river or re-used for watering of the forest.

3.2 *Identification and evaluation of technologies and alternatives*

The treatment technologies that were evaluated in this study include grit removal for the pretreatment; lagoons, activated sludge, oxidation ditches, sequential biological reactions, biological filters, biological disc and a sea outfall for the secondary treatment; and biological treatment, mechanical filtration, artificial wetlands and stabilization ponds for the tertiary treatment.

The treatment alternatives were then defined according to the source of wastewater to treat (Azemmour and Sidi Ali only or Azemmour, Sidi Ali and Mazagan combined together) and according to the goal required for the treatment (the re-use or no re-use of the purified effluent). Sub-alternatives are then defined for these alternatives according to the type of technology used for the treatment.

Whereas grit removal is the only choice of technology for pretreatment in all the alternatives considered, the choice of technology for secondary or tertiary treatment remains closely related to the objectives and constraints of the alternative in question and depends on several technical, institutional and environmental factors of the area. For this reason, GESI conducted a multi-criterion analysis to classify technologies of secondary and tertiary treatment for each alternative and to identify the most promising technologies for these alternatives.

The multi-criterion analysis is based on a qualitative matrix approach in which each technology considered promising was evaluated, by assigning a weight with the principal criteria and a numerical value with the sub-criteria or indicators associated with each criterion. In this way, technologies had a total ranking based on their weights in each category of comparison. This classification was thus used to draw up the list of the alternatives and sub-variants studied. The table below shows these alternatives and sub-alternatives.

Table 4: Identification of alternatives of treatment

Alternative	Description	Technology
1	Purification of waste water of the town of Azemmour and Sidi Ali and direct outfall of the effluent to the sea in the wadi Oum er-Rbia	Alternative 1a: : Lagoons Alternative 1b: Ventilated Lagoons Alternative 1c: Infiltration Percolation
2	Purification of waste water of the town of Azemmour and Sidi Ali and re-use of the water purified for irrigation of green spaces, parks and walking zones	Oxidation trench + Marshes
3	Purification of waste water of the town of Azemmour, Sidi Ali and the tourist development of Mazagan and re-use of the effluent purified for the irrigation of the golf courses, and the green spaces in the complex of Mazagan	Oxidation trench + Marshes
4	Purification and re-use of waste water of the complex of Mazagan	Alternative 4a: Lagoons + Marshes + Drying beds Alternative 4b: Oxydation trench + Marshes

3.3 Comparison of alternatives

Each Alternative and sub-alternative presented above has its advantages and its disadvantages, and also a cost per cubic meter when one takes into account investments costs, operatinaol costs and possible incomes generated by the sale of the treated effluent in the case of re-use.

The table below gives the costs of construction and management as well as the cost per cubic meter of each alternative during the lifespan of the station. This table shows that Alternative 3 is the most advantageous if the tourist complex of Mazagan decides to join Azemmour and Sidi Ali for the construction and the management of only one purification station. If not, Alternative 1a is more advantageous if Azemmour and Sidi Ali must manage their wastewater on their own. The following paragraphs describe the advantages and the disadvantages of each alternative and the reasons of selecting the recommended alternatives.

Table 5: Costs of the alternatives of treatment (before taxes)

Cost (DH)	Alternative 1a	Alternative 1b	Alternative 1c	Alternative 2	Alternative 3	Alternative 4a	Alternative 4b
Volume Treated water (m3)	23.354.525	23.354.525	23.354.525	23.354.525	35.063.725	11.709.200	11.709.200
Construction cots	38.881.924	33.219.269	36.977.919	50.466.084	59.872.835	40.683.322	38.516.657
O&M cost over 20 years	8.540.000	19.540.000	17.781.600	17.540.000	22.240.000	7.640.000	9.640.000
Slate of treated effluent @ 1,50 Dh/m3	0	0	0	31.528.609	47.336.029	15.807.420	15.807.420
Total project cost over 20 years	**47.421.924**	**52.759.269**	**54.759.519**	**36.477.475**	**34.776.806**	**32.515.902**	**32.349.237**
Cost DH/m3	2,03	2,26	2,34	1,56	0,99	2,78	2,76

Alternative 1 has the advantage of not requiring a thorough treatment (tertiary) since the effluent will be rejected directly into the wadi Oum Er_Rbia and that it is an alternative, which can be installed independently of what Mazagan wants to do with its wastewater. Its disadvantage on the other hand is that it does not benefit from the potential of the re-use of the effluent.

Alternative 1 can be carried out by simple lagoons, aerated lagoons or percolation basins as indicated respectively in sub-alternatives 1a, 1b and 1c. The simple lagoons alternative (Alternative 1a) has the advantage of simplicity of construction and management, and the disadvantage of requiring more land for construction. The aerated lagoon alternative (Alternative 1b) has the advantage of requiring less space but the disadvantage of requiring more energy for its operation. The percolation alternative (Alternative 1c) has the advantage of requiring a little less space compared to the simple lagoons, but requires more materials (sand) and personnel for his operation. In addition, this sub-alternative presents serious risks of clogging and emission of odors. When the 3 sub-alternatives are compared, from the unit cost point of view per cubic meter treated, it is clear that the simple lagoons (Alternative 1a) is less expensive compared to the aerated lagoons (Alternative 1b) and percolation basins (Alternative 1c).

Alternative 2 has the advantage of being able to benefit from the re-use of the purified effluent and possible incomes which can be generated by the sale of this effluent; but it has the disadvantage of being a little more expensive since it requires a thorough treatment (tertiary) to meet the standards of re-use. For this alternative, a system of oxidation ditches, followed by maturation ponds and wetlands proved to be most favorable, compared with other technologies, since it requires less land for its installation and offers a water of quality in conformity with the standards of re-use. The cost value per cubic meter treated for this alternative is of 1.37 dh/m3.

Alternative 3 has the advantage of economy of scale since it combines the wastewater of Azemmour, Sidi Ali and Mazagan in one wastewater treatment plant, therefore the cost per cubic meter of water treated in this alternative is lower than all the other alternatives considered. This alternative also makes it possible to realize savings not only for Azemmour and Sidi Ali but also for the tourist complex of Mazagan in terms of the construction of the treatment works and the operating costs of the station. Indeed, in this alternative, Azemmour and Sidi Ali can on the one hand, require a contribution from Mazagan to cover part of the expenses of construction and management of the station and on the other hand, sell the purified effluent to Mazagan for the irrigation for the golf courses and parks. The tourist complex of Mazagan will profit, also, from this alternative since it will not have to build and manage a treatment plant which will become, in any event, more expensive (since its flow by itself is small) as indicated in the alternatives 4a and 4b; and at the same time it will have a greater quantity of purified water which will cost it much less than if it buys this water from ONEP at a price of more than 2 Dh/m3 (drinking water being sold at 4.13 dh/m3) instead of 1.50 Dh/m3 for the treated effluent. Based on this comparison, one can conclude that Alternative 3 offers the lower cost of treated water per cubic meter for Azemmour and Mazagan.

Alternative 4 supposes that the tourist complex of Mazagan constructs and manages all alone its own wastewater treatment plant. Two sub-alternatives were considered for this scenario. The first sub alternative 4a prescribes the lagoons and wetlands mode of treatment and the second alternative 4b prescribes the oxidation ditch and wetlands mode of treatment. The first alternative is, obviously, more expensive since it requires more land which must be waterproofed, the second is less expensive although its operating costs are higher. These two alternatives remain both more expensive for Mazagan if it does not decide to join Azemmour and Sidi Ali in building and operating a single wastewater treatment plant.

Indeed, the cost of 2.55 Dh/m3 for Alternative 4b, is almost three times higher than the cost of 0.83 Dh/m3 offered by Alternative 3. More specifically, as in Alternative 3, Mazagan can have a greater quantity of treated water which will cost less than buying this water from ONEP.

Thus, it will be easier to convince Mazagan to join Azemmour and Sidi Ali in building only one wastewater treatment plant. The mode of management of this station can be negotiated with Mazagan to take into account its concerns in particular with regard to the quality of the purified effluent. A way of alleviating this concern would for example the delegate the operation of the treatment plant to a private company. In this mode of management, the private company can construct and operate the station, and each party can pay the company their cost share per cubic meter of treated effluent. In turn, the company will guarantee the quality of the treated effluent.

In the case where Mazagan is not interested in the treatment of its effluents in a common treatment station with Azemmour and Sidi Ali (alternative 3), it is clear that the Alternative 1a (simple lagoons), followed by Alternative 1b (aerated lagoons) are less expensive for Azemmour and Sidi Ali. However, given the risk of odors which can emanate from the simple lagoon system, the project committee decided on June 8, 2005 to retain the aerated lagoons (Alternative 1b) system for wastewater treatment for Azemmour and Sidi Ali.

3.4 Description of selected alternative

Following is a description of the proposed wastewater treatment facility.

The selected wastewater treatment alternative will be an aerobic lagoon system capable of treated the combined wastewater generated by Azemmour and Sidi Ali through the year 2025. The selected technology will require design and construction of the following processes:

- A central sewage pump station
- A new influent structure to include mechanically cleaned bar screens, a manually cleaned bypass screen,
- New Aerated lagoons with mechanical surface aerators;
- Facultative Settling Ponds to remove suspended solids;

- A chlorination building with internal chemical storage area and disinfection contact tank;
- A sludge pumping facility to convey sludge from the settling ponds to the sludge dewatering area;
- Sludge dewatering and processing area;
- Site piping and flow splitting structures to accommodate the flows and facilities, and;
- Miscellaneous site work including roadway system, grading, seeding and landscaping, as well as a security barrier around the entire plant.

It should be stated that the base facility design considers that the minimum number of process units has to be based on taking all equipment, process lines, tanks, reactors, etc. out of operation one at a time for maintenance while still meeting effluent requirements and incorporates necessary process unity redundancy to meet this condition.

3.5 Environmental impact assessment

The environmental impact assessment shows that the project presents some very important positive impacts.

One of those major positive impacts consist in treating wastewater of Azemmour and Sidi Ali before its discharge into the Oum Er-bia river and alleviating the pollution of this river where non-treated wastewater from these cities has been discharged from many years.

Furthermore, the re-use of treated effluent will allow safeguarding, at least partly, of water that can be used for irrigation of arable land.

Compensatory measures to protect the groundwater table (water proofing of the basins), elimination of the odors (aeration of the lagoons), and integration of the station in the neighboring landscape (plantings around the basins), etc. are envisaged.

The potential negative impacts are related to the nuisances during construction (excavations, sludge, etc) and from the nauseous odors emanating at the time of lagoon dewatering. These impacts, however, are generally of low importance and can be counterbalanced by the application of mitigation measures.

In addition, environmental monitoring and follow-up of the operations of the treatment plant can ensure the safeguarding of the environment.

3.6 Financial analysis

3.6.1 Project Cost

3.6.1.1 Capital costs

The capital costs include the cost of construction of civil structures, purchasing equipment and instrumentation and controls, the cost of studies, analyses, training and startup, and contingencies. Table 6 below, presents the preliminary estimates of the capital cost for the water treatment plant.

Table 6: Preliminary estimates of the capital cost in DH

Work	Total Cost in Dirhams
Preparation of the Site	9,048,000
Buildings	870,000
Guard house	93,000
Startup work	74,296
Flow meters	300,000
Distributor 1	489,965
Aerated Lagoons	5,547,788
Distributor 2	466,910
Secondary Lagoons	3,638,050
Distributor 3	20,510
Maturation ponds	4,033,510
Outfall Works	344,063
Treatment of sludge	2,749,500
Collection and pumping for Sidi Ali	896,000
Collection and pumping for Azemmour	2,927,750
TOTAL CONSTRUCTION	**31,499,341**
Construction management (5%)	1,574,967
Contingency (15%)	4,724,901
Grand Total	**37,799,209**

3.6.1.2 Operation an Maintenance Costs

The operating costs are comprised of the following expenses:

- Energy expenses of the aeration system, the wastewater treatment plant, the sludge pumps, lighting, etc....
- Expenses of maintenance of the generators, the aerators and the electromechanical equipment.
- Expenses of the personnel.

Table 7: Operation and Maintenance Cost in DH

Item	*Cost (DH/year) for 2025 capacity*
Personnel	***320,000.00***
Maintenance of equipment	***1,878,199.00***
Energy	***402,461.00***

A financial analysis was carried out to establish the cost per cubic meter of treated water, which ensures a financial balance, under various scenarios of financing of the project

3.7 Implementation Plan and project management

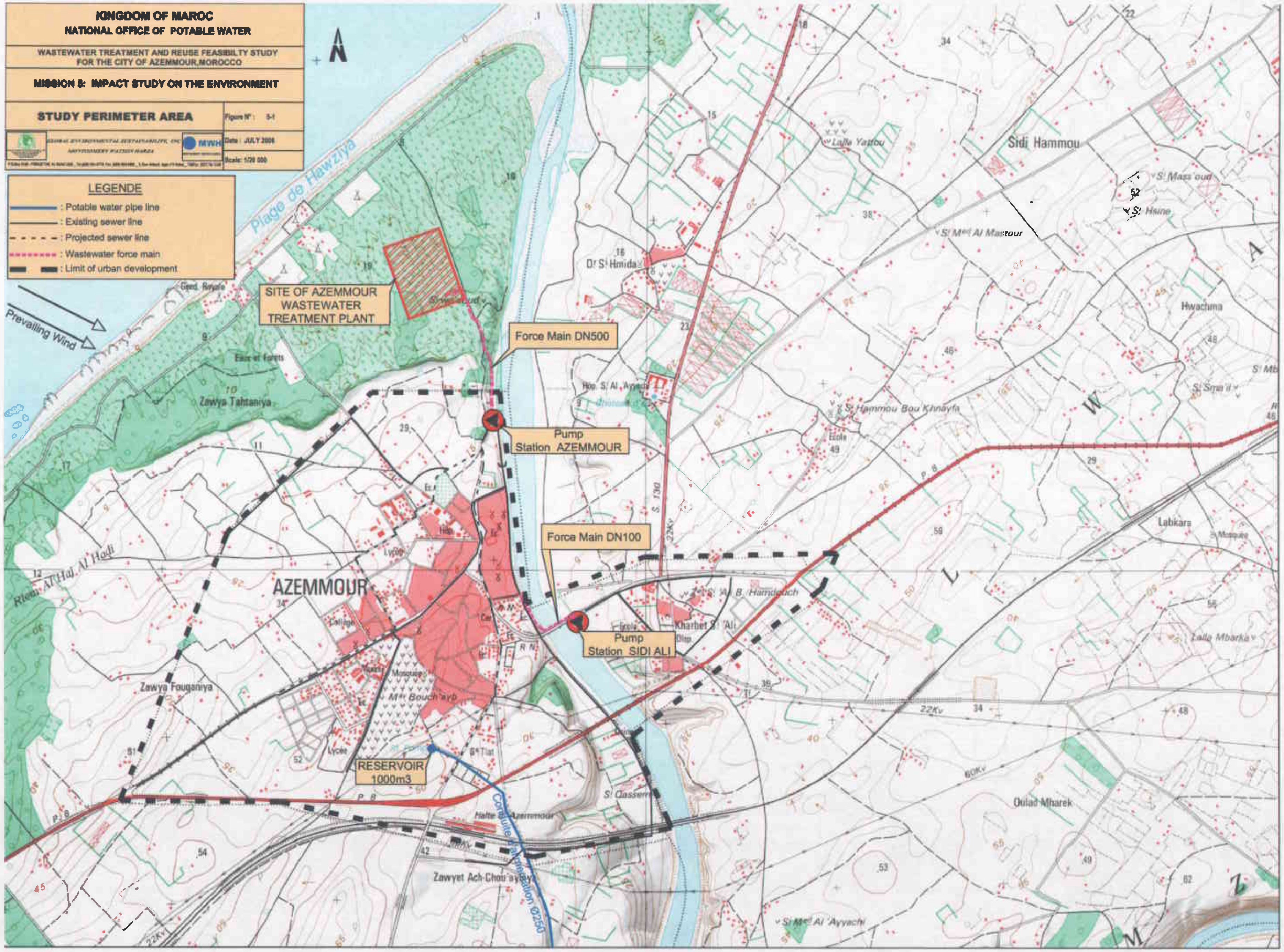
3.7.1 Type of management system

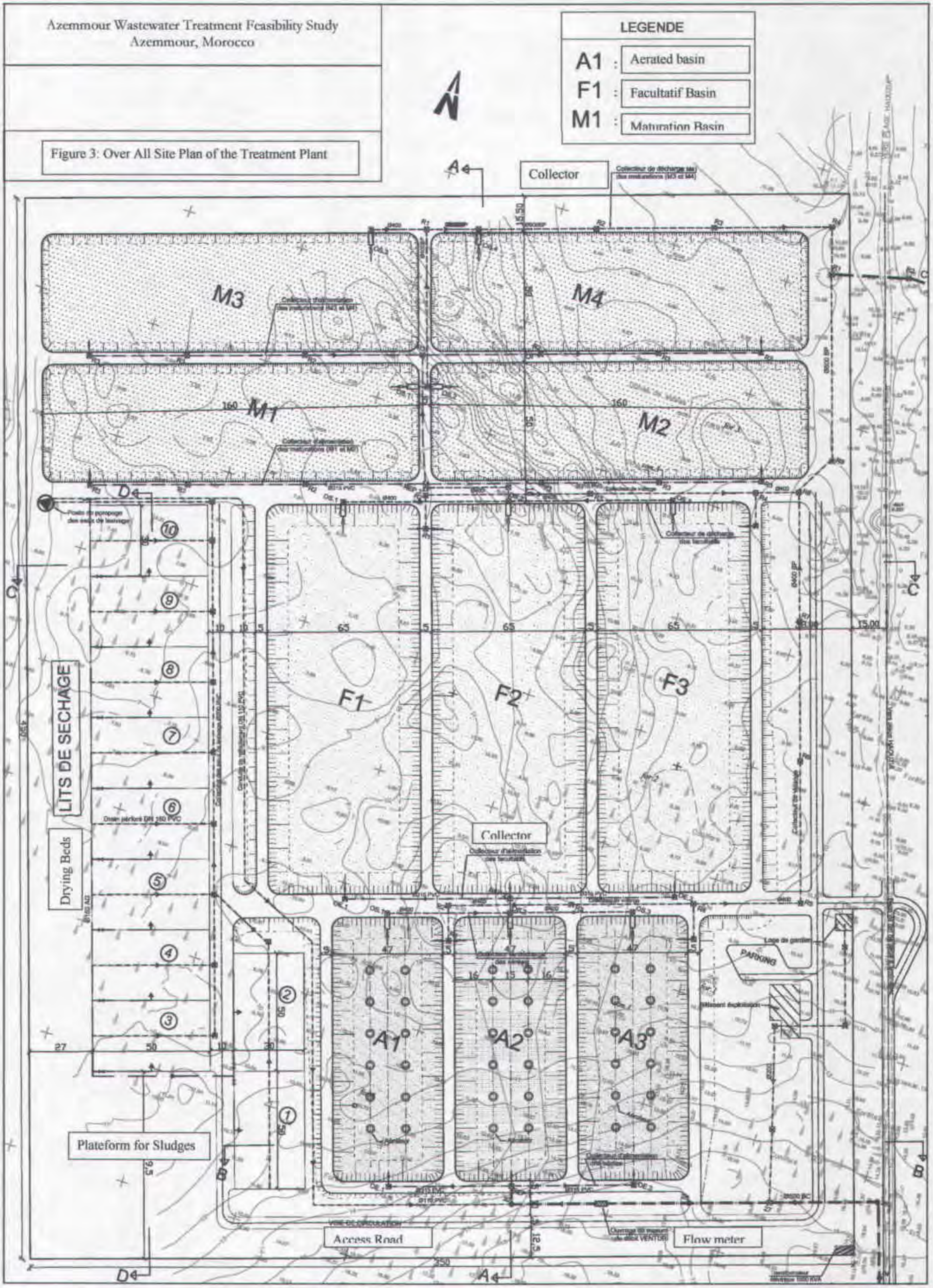
The system suggested for the purification of wastewater of the town of Azemmour and Sidi Ali can be implemented as Turn-key or Build-Operate-Maintain (BOT). The advantages and limitations of each are outlined in Section 6.

3.7.2 Project Schedule

The wastewater treatment plant can be built in two phases. The first phase will be built to satisfy the requirements in wastewater treatment until the year 2010 and will consist of the construction of the pre-treatment works, two aerated lagoons, two secondary lagoons, and two maturation ponds.

The second phase will be built in 2010 to satisfy the needs for the year 2025 and will consist of the construction of the third aerated lagoon, the third secondary lagoon, and the last two maturation ponds.


KINGDOM OF MAROC
NATIONAL OFFICE OF POTABLE WATER
WASTEWATER TREATMENT AND REUSE FEASIBILTY STUDY FOR THE CITY OF AZEMMOUR,MOROCCO
MISSION 5: IMPACT STUDY ON THE ENVIRONMENT
STUDY PERIMETER AREA
Figure N° : 5-1
Date : JULY 2006
Scale: 1/20 000
MWH
LEGENDE
: Potable water pipe line
: Existing sewer line
: Projected sewer line
: Wastewater force main
: Limit of urban development
SITE OF AZEMMOUR WASTEWATER TREATMENT PLANT
Force Main DN500
Pump Station AZEMMOUR
Force Main DN100
Pump Station SIDI ALI
RESERVOIR 1000m3
Conduite d'alimentation Ø250
Prevailing Wind
Plage de Hawziya
AZEMMOUR
Sidi Hammou
Zawya Tahtaniya
Zawya Fouganiya
Zawyet Ach-Chou'aybiya
Oulad Mharek
Labkara
Hwachma
Kharbet S' Ali
Halte Azemmour
Lalla Yattou
Lalla Mbarka
S' Hammou Bou Khnayfa
S' M^{ed} Al Mastour
S' M^{ed} Al 'Ayyachi
Dr S' Hmida
22Kv
60Kv
P 8
S. 130


Azemmour Wastewater Treatment Feasibility Study
Azemmour, Morocco
Figure 3: Over All Site Plan of the Treatment Plant
LEGENDE
A1 : Aerated basin
F1 : Facultatif Basin
M1 : Maturation Basin
Collector
M3
M4
M1
M2
F1
F2
F3
A1
A2
A3
LITS DE SECHAGE
Drying Beds
Collector
Plateform for Sludges
Access Road
Flow meter
PARKING
65
47
250

SECTION 1: REVIEW AND ANALYSIS OF EXISTING DATA

TABLE OF CONTENT

1.1 OBJECTIVES

The objectives of this Task are to acquire and review previous studies and reports concerning the Azemmour / Sid Ali WWTP and effluent Reuse project, and recommend and expedite acquisition of additional information and data if required. The goal of the activity is to assemble data from these previous studies and develop design criteria for the new wastewater treatment plant, based on the assembled data.

Under this task, GESI collected from ONEP and other local authorities, all of the documentation available on wastewater management for the cities of Azemmour and Sidi Ali, namely:

- The existing Wastewater Master Plan (SDA).
- Potable water supply studies for Azemmour and Sidi Ali.
- Former studies on the purification of wastewater for the town of Azemmour.
- The cartography of the area, the geographical and administrative situation.
- Climatic data, precipitation, hydrology;
- Geology, hydrogeology, geotechnical;
- Demographic and urban development, industrial activities, their effluents, and types of pollution they generate.

The documentation collected was analyzed and useful information was extracted and synthesized by subject to be used within the framework of the study.

A coordination meeting with representatives of ONEP was held to present the findings of the data collection task and determine the additional investigations necessary to conduct the study (such as wastewater characterization and flow measurements)

1.2 CONSULTED DOCUMENTS

- Wastewater master plan for the town of Azemmour, prepared by the consulting firm Techno export stroy (1989),
  - Mission 1: Diagnosis of the network of the Kasbah and the new Médina.
  - Mission 2: Study of the area of expansion,

- Study of the wastewater treatment plant of the town of Azemmour (1998),
  - Mission 1: Study costs advantages of the options of purification and re-use
  - Mission 2: Detailed preliminary design,

- Study of drinking water supply of the tourist project Mazagan, (ONEP, 2003),

- Geotechnical study of the proposed wastewater treatment plant sites by LPEE (1999),

- Position paper of the town of Azemmour,
- Master Plan of the town of Azemmour (1987),
- Quantitative and qualitative characterization of the wastewater in the center of Azemmour, wastewater campaign carried out from the 4^{th} to 20^{th} of December, 2003.

1.3 GENERAL DATA ON THE AREA

1.3.1 Geographical situation

The town of Azemmour is located on left bank of the Wadi Oum Er Rbia at four kilometers to the south of the confluence with the Atlantic Ocean (see figure 1).

It is on the principal road RP8 connecting the town of El Jadida to Casablanca.

The center of Sidi Ali constitutes the urban development of the town of Azemmour on the right bank of Wadi Oum Erabia. This urban extension extends between old principal road RP8 and its current deviation.

Figure 1: Geographical situation of Azemmour

1.3.2 Administrative status

On the administrative level, the town of Azemmour is a municipality belonging to the Province of El Jadida (Wilaya of the Abda-Doukkala area).

Its zone of extension, which is Sidi Ali Ben Hamdouche, is the main center place of a rural district belonging to the town of Azemmour.

The town of Azemmour is made of six rural communes (Chtouka, Haouzia, Loghdira, Lamharza, Oueld Rahmoune and Sidi Ali Ben Hamdouche).

1.3.3 Physical data

1.3.3.1 Geology

The town of Azemmour is located on the littoral edge, which develops along the Atlantic Ocean from Rabat to Essaouira. It is located in the main geology called "Coastal Chaouia".

The surveys carried out in the area of Azemmour revealed three types of distinct formations:

- The cretaceous base
- The consolidated quaternary
- The current quaternary

In the major part of coastal Chaouia, the paleozoic base forms the substratum.

This base consists of impermeable and slightly permeable formations whose higher fringe is weathered.

The most dominant formations are acadian schists or ordovicians and quarzites which sandstones join:

- The paleozoic schists form impermeable substrata. However their deterioration supports the retention of a water table. The power of the formed water table is conditioned by the weathered zone.

- The quarzites of the ordovician are sandstones quarzites often fissured. This formation can give rise to permanent sources of low flow or form important drains when they level.

- In the low valley of the Oum-Er Rbia, effleurent yellow marno-limestones and yellow marls and clear green which continue towards the North-East and the covering consists of plio-quaternary.

The formations of pliocene cannot be distinguished from those of the cycles of the quaternary one, even if the orogenetic phase finivillafranchienne were very important. Continental deposits with crusts and silts cover these formations of quaternary, a few centimeters thick.

1.3.3.2 Weather

1.3.3.2.1 General

The town of Azemmour is marked by a mild climate following the moisture of the masses of air on the coast during the autumn and spring.

1.3.3.2.2 Climate

The climate of the east zone is semi-arid, moderate in the winter, it shows the following principal characteristics:

a) Precipitation:

Starting from a series of the rainfall records of the station of Azemmour recorded for the period 1988/89 to 1998/99 (collected near the Management of National meteorology DMN at the time of the study of the water management strategy, under mission 1.1 relating to the review of the rainfall records of April 2003, Agence Hydraulic basin of Oum er Rbia), one notices important inter-annual irregularities in the distribution of precipitation, highlighting an alternation of cycles of wet years and dry years.

Almost all the precipitations were recorded during the rainy season from October until April. The remainder of the year corresponds to a period of almost total dryness.

Annual average precipitation is important. It is approximately 423 mm and is distributed over the months as follows (period 1988-98):

Table 1.1: Monthly average precipitation for Azemmour (1988-1998)

Year	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
average	2.7	35.2	63.2	120.6	122.0	43.3	29.2	35.2	13.0	3.4	1.0	0.4	**422.8**
Max	10.0	137.5	129.7	313.5	359.4	111.6	85.6	96.6	44.1	11.5	4.3	3.5	**773.2**
Min	0.0	5.5	0.0	4.8	0.0	0.0	0.0	5.9	0.0	0.0	0.0	0.0	**132.3**

Source : DMN (Poste 1384)

Table 1.2: A number of rainy days at Azemmour (1988-1998)

Year	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	July	Aug	Total
Average	0.6	4.5	8.1	9.2	10.2	5.4	4.9	4.4	2.8	1.3	0.3	0.3	**44.1**
Max	1.0	11.0	16.0	21.0	21.0	10.0	12.0	9.0	7.0	3.0	1.0	2.0	**60.5**
Min	0.0	1.0	1.0	1.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	**26.0**

Source : DMN (Poste 1384)

The precipitation in winter is consistently high, while the least rainy months are: June, July and August.

The inter-annual variations of precipitations are important: during the period of 1988 to 1998, the annual total varied from 132.3 mm (in 1994/95) to 773.2 mm (in 1995/96) with an average of 423 mm.

With regard to the number of rainy days, it varies from a minimum of 26 days of rain per year (recorded in 1994/95 which is a year dry) to 61 days (in 1995/96 which is the wettest year of the period) with an average over the period of observations of about 44 days.

b) Temperatures

The maximum, average and minimum monthly average temperatures recorded for period 1988-1997 are summarized in the table below:

Table 1.3: Maximum, average and minimum monthly average temperatures (1988-1997)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min	11,4	12,2	14,2	14,7	17,5	19,8	22,3	22,2	20,2	15,6	15,2	12,4
Average	12,7	13,5	15,1	16,2	18,6	20,7	22,8	23,1	21,7	19,2	16,6	14,5
Max	15,4	14,9	16	18	20,1	22,2	23,5	23,9	22,9	21,0	19,1	16

Source : Station DMN El Jadida

c) The wind speed:

The wind speed of the town of Azemmour is measured by the synoptic station of the national meteorology of El Jadida.

The winds are rather frequent, with a North-eastern dominant direction. Speeds of the winds are:

- Average: 22 km/h
- Minimum: 12 km/h
- Maximum: 32 km/h.

1.3.3.2.3 Hydrology

The town of Azemmour and the extended urban area to Sidi Ali are located on two banks of the Oum-Erbia River.

Currently, urban and industrial wastewater produced by the build up of the town of Azemmour is poured directly into the estuary of Oum-Erbia.

Several hydraulic installations were carried out on the River Oum Er Rbia. Among the most important installations carried out in the area one can cite:

- Dam Dchar El Oued (740 Mm3)
- Dam Al Massira (2720 Mm3).

1.3.3.2.4 Hydrogeology

The town of Azemmour is located between two distinct hydro geologic zones: coastal Chaouia (zone ranging between Casablanca and Azemmour) and the Sahel. Given below is a description of the hydrogeology of the zone of coastal Chaouia.

Hydrogeology of coastal Chaouia:

One notes the existence of ground water that generally extends along the area especially in the quaternary one and the cretaceous where the primary layer is faded.

Two piezometric charts could be distinguished:

- Piezometric chart of high waters;
- Piezometric chart of low waters

The comparison between the two charts makes it possible to analyze the seasonal variations of the pieziometric surface of the water table for the same year.

1. **Pieziometric surface in period of high waters:**

The ground water of coastal Chaouia runs almost entirely toward the sea.

In South-west, the threads of current are deviated, being directed towards the West and expressing a natural drainage by Oum-Erbia which constitutes the South-western limit of the area. The curves hydroisohypses are parallel between them. The localized anomalies reveal some little variations accentuated in the shape and appearance of the curves.

At the Southwestern limit, the hydroisohypse curves have a convex form, which highlights the drainage of the aquifer by Oum-Erbia.

The depths of the piezometric surface passing from 1 m in the South to 53 m in the South-west and five zones can be distinguished:

- Depth lower than 5 m: along the coast;
- Depth ranging between 5 and 10 m: the zone of the center and the East of the area;
- Depth ranging between 10 and 20 m, in several places located at the West, the center and the East of the area;
- Depth ranging between 20 and 30 m: in the West in limestones cénomanien and by places in the North-East;
- Depth higher than 30 m: in the West in limestones of the cénomanien.

2. Piezometric surface in period of low waters:

In general, the form of the piezometric surface is unchanged and the hydroisohypse curves preserve their parallelism at the coast, from where a permanent flow occurs towards the sea. However, the convexity of the hydroisohypse curves shows the phenomenon of permanent drainage which proves that the piezometric level of the aquifer constantly remains higher than the level of water in the wadi.

The direction of the flow is preserved in particular at the East where it is always oriented in the South-North direction.

The variations of the piezometric level are more important in the center and the upstream along the coast (5 to 6 m to the upstream versus 1 to 2 m to the downstream).

3. Marine intrusion

The influence of the tides on the piezometry of the water table presents a permanent danger of marine intrusion and consequently the increase in the conductivity of the littoral water.

1.4 EXISTING INFRASTRUCTURE

1.4.1 Potable Water System

The potable water supply of the town of Azemmour has been managed since 1976 by the Inter-commune Autonomous Control of Distribution of Water and Electricity of the province of El Jadida (RADEEJ). The transmission system providing drinking water to the town of Azemmour is illustrated by a diagram presented as Figure 2.

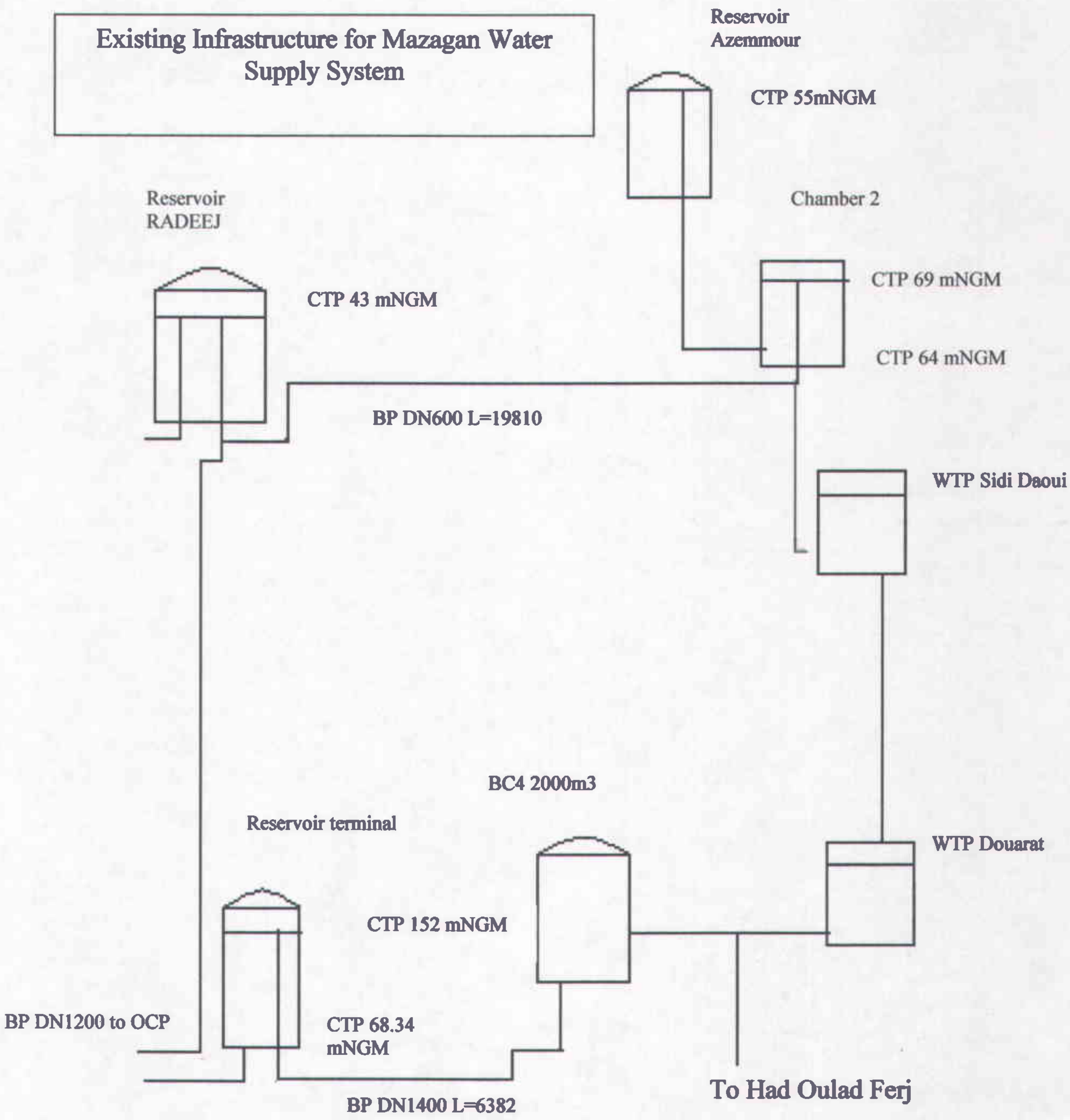
Potable water supplied to the Villages of Azemmour and Sidi Ali is treated by the Sidi Daoui Treatment Station, located 18 km upstream of the mouth of the Oum-Erbia. The station has a treatment capacity of 200 l/s. The Sidi Daoui Station was commissioned in 1954 to ensure the drinking water supply of the coastal zone ranging between Azemmour and Jorf El Asfar. The station is managed by the Moroccan Company of Distribution (S.M.D.)

Potable water delivery infrastructure includes:

- A raw water pump station located on the Oum Erbia, equipped with 4 pumps. (two duty pumps and two on standby (2 X 400 m3/h and 2 X 200 m3/h));
- A treatment facility including: Clarifiers. Rapid filtration, and chlorination, and;
- A treated water pump station.

The Village of Azemmour and the center of Sidi Ali Ben Hamdouche are served by a distribution network supplied by two main reservoirs with capacities of 1000 m3 and 3500 m3. The first is on the hill to the South of Moulay Bouchaib. Approximately 26 km of distribution network make up the Azemmour / Sidi Ali distribution system.

Figure 2: Potable Water Transmission System Supplying Azemmour and Sidi Ali



1.4.2 Wastewater Collection Network

The wastewater collection network of the town of Azemmour is approximately 27 km in length. Table 1.4 presents a summary of pipe lengths and diameters of the existing wastewater collection system.

Table 1.4: Summary of Pipe Lengths and Diameters of the Existing Wastewater Collection System

Pipe Type (Diameter mm)	Total Length (meters)
Oval T 1.5	600
Oval T 1.3	2,600
Oval T1.0	1,000
Circular Φ 600	1,450
Circular Φ 500	2,400
Circular Φ 400	6,950
Circular Φ 300	12,000
TOTAL	**27,000**

Existing Wastewater Collectors

Existing wastewater collectors of the town of Azemmour are generally very old and insufficiently sized to accommodate storm water runoff generated in the service area.

Problems exist in lower lying collection areas where design and construction of the system where completed without adequate planning, design, and construction oversight. As a result the depth of the collection network in these areas is often shallow (varies between 0.25 m and 1.10 m). The shallow nature of the collection network is problematic as often house connections to the collection network are deeper than the system hindering discharge to the system.

There are two main interceptors serving the Village of Azemmour: CP O-1-15 and CP 1-36-50. The geometrical characteristics of these two interceptors are presented in Table 1.5:

Table 1.5: The Geometrical Characteristics of Interceptors Serving The Village Of Azemmour

Name of Interceptor	Geometric Characteristics	
	Section	Length (m)
CP 0-1-15	T100 T130	690 180+1300=1480
CP 1-36-50	T100 T130	1300 850

These two interceptors serve the center of the Village of Azemmour (New médina). Several secondary collectors are connected to these main interceptors. Rehabilitation of the old médina, the North-western extensions, and the avenue Moulay Hassan main collectors was recently completed by the Municipality of Azemmour. This work was intended to facilitate coverage to all points within the service area and to improve storm retention of the system. The diameter and length of wastewater collectors in the town of Azemmour and the center of Sidi Ali are summarized in Table 1.4.

Old Médina and Kasbah

The Médina of the town of Azemmour is serviced by a very old sewerage collection system that has not been maintained nor expanded. The existing system is overloaded and clogged in several locations. It consists of circular reinforced concrete piping with diameters of 300 mm and 400 mm.

Wastewater collected in the medina is discharged directly to the Oum Erbia River through a total of 11 outfalls. Eight outfalls service the existing collection network, and three discharging from residences constructed on the cliff at the medina boundary wall overlooking the River by some eight meters.

Presently an interceptor collector running along the River's bank is planned for construction by the ANHI. This new collector would intercept existing network collector number CP- 18-28- 29 as well as all outfalls discharging sewage collected in he Medina.

Table 1.6 presents a listing of main laterals in the old network that are connected to the principal collectors.

Table 1.6: Existing Lateral Connections to Main Collectors

Catchment Area	Trunk Main	Collector Connection
B.V.II	CP 1-36-50	CII-5 CII-4
B.V.II	CP II-5	CII-3
B.V.II	CP 1-36-50	CII-2
B.V.Ia	CP 1-36-50	CI-4
B.V.Ia	CP 1-36-50	CPI-0.1
B.V.Ia	CPI-0.1	CI-14
B.V.Ia	CPI-0.1*	CI-13
B.V.Ia	CPI-0.1*	CI-12
B.V.Ia	CPI-0.1*	CI-2
B.V.Ia	CPI-0.1*	CI-3
B.V.IaI	CI-4*	CI-1
B.V.I	CP 0-1-15	CI-5
B.V.I	CP 0-1-15	CI-8
B.V.I	CP 1-36-50	CI-9
B.V.I/B.V.II	CP 1-36-50	CP 1-36-50

Table 1.7: Characteristics of Wastewater Collectors in the Town of Azemmour and the Center of Sidi Ali

N°	Collector	Geometric Characteristics	
		Section	Length
1	CS 46b-215	Φ400	755
2	CP III	Φ400	1900
3	Conduit (18-35)	Φ200 (acier)	220
4	Canal CIO (BV IIa)	T 130 Open Channel	380 800
5	Collector EPD042	Φ600	200
6	CP 36-11	Φ700 Φ400 Φ130	218 1900 440
7	CS 250a-35	Φ500	230
8	Main Interceptor CP 15-196	Φ300	560
9	Lateral Collectors	Φ200	2755
10	Storm Collection BV Iib Cp 15-196	Φ700 Φ130 Φ150	315 35 190
11	Secondary Storm Collectors BV Ib	Φ500 Φ600 Φ700	270 210 380
12	Wastewater Collectors BV Ic CP 25a-201	Φ400	2090
13	Lateral BV Ic	Φ200	1435
14	CP IV (21-31)	Φ200 Φ250 Φ300	300 150 805
15	CP IV (21-.....)	Φ400	1125
16	Lateral	Φ200 Φ300	2315 1050
17	Principle Wastewater collectors CP SE – 250a	Φ700	1590
18	Channel with Sediment Traps (BV Ia)		655

Insufficiencies of Storm Water Runoff Collection

The majority of the wastewater collection network was built before 1980 without preliminary study and without taking into account Storm drainage. As a result certain areas of the city including Avenue Mohamed V, Avenue Moulay Hassan, Rue of the beach, and Derb Bouzroug, are prone to flooding. The principal causes of these floods are generally the insufficiency of the capacity of the collectors of the old district, as well as the insufficient number of gullies.

Two principal collectors, CP 1-36-50 and CP 1-0-15 serving collection areas adjacent to the new medina are dimensioned to evacuate storm water.

In the zone of the old médina, the rain water flows by gravity to accumulate in low points, or flows to the wadi Oum Erbia.

Conclusions

From the assessment of the existing wastewater collection network the following conclusions can be made:

- The existing network does not effectively evacuate combined sewage and storm water,
- The collectors of the old network are undersized
- The majority of the existing roadway system is not covered causing collectors to become filled by sediment,
- The poor condition and under sizing of the existing collectors, combined with the lack of coating of the streets, and the minimal number of storm collector grills in the system are the primary causes of the flooding.

1.5 URBAN AND DEMOGRAPHIC ANALYSES

1.5.1 Urban analysis

The purpose of conducting an urban structure analysis was to identify the most realistic projection of the present population and the spatial growth of the present service area. Information used as the basis for this analysis was provided by The Master Plans of the Village Azemmour and Center of Sidi Ali Ben Hamdouche (1987). The following information was provided by these planning documents:

- Present and future areas of urban development within the service area;
- Existing land use and division of the service area into homogeneous districts;
- The spatial distribution and density of the population within homogeneous districts;
- Existing density compared to maximum saturation density of the service area.

Spatial Analysis

The Azemmour / Sidi Ali Service Area was divided into the following land-use categories:

- Old medina;
- Illegal Settlements;
- Commercial;
- Multi-Level Buildings;
- Densely populated residential;
- Industrial;
- Tourist Areas;
- Sparsely Populated areas, and;
- Villas.

<u>Old Médina</u>

The town of Azemmour contains old médina representing only a small percentage of the total wastewater collection area.

<u>Illegal Settlements</u>

No illegally settled areas are identified by the Master Planning documents of the villages,

Commercial

Small shops and stores are located on the ground floors of buildings throughout Azemmour and the center of Sidi Ali Ben Hamdouche. Commercial buildings are built in two levels. Upper stories are added later, serving as residences and commercial storage. Commercial areas have also been developed from poor settlement areas through the government funded improvement programs.

Multi-Level Buildings

Three categories were considered for multi-level buildings including:

- Category 1 : More than 4 buildings alligned ;
- Category 2; 1 to 3 buildings alligned, and ;
- Category 3: Discontinuous

This distinction was necessary to account for variations of density and ground impermeability

Densely populated residential

Densely populated residential areas are those built with a surface area population of one person per 300 to 400 m^2.

Sparsely Populated areas

Areas of dispersed habitat include individual residences and farms. This type of land use occurs in the surrounding vicinity of the town of Azemmour and the Center of Sidi Ali.

Villas

Villas occupy a large and prominent area to the north of the existing zone of development. Areas occupied by villas are sparsely populated.

Industrial

Types and amounts of wastewater generated by the industrial sector is diverse, making a general analysis of wastewater treatment requirements challenging. General parameters can nevertheless be gathered in three principal groups according to the type of industry including:

- Size of the industry in terms of number of employees;
- Land Area occupied by the industry, and;
- Quantitative and qualitative analysis of the wastewater discharged to the sewer.

In the current industrial park, only three factories are established including a fruit preserve factory; gelatin factory and a factory for manufacturing mirrors.

The fruit preserve factory is the only facility currently in operation. A new industrial park is planned on the site of the existing market area of the town of Azemmour. A tannery which is not yet in operation and a slaughter-house are the only facilities currently built at this new location.

Tourist Areas

The areas natural beauty and proximity to the Atlantic Coast make it attractive for tourism development. An important tourist project (Mazagan) is planned for the coastal zone of Hawzia. The Mazagan Tourist Development will be located in edge of sea between the mouth of the Oum Erbia Wadi and the golf of El Jadida. The planned development will occupy a total area of 476 ha and is to include:

- 2 golf courses;
- Villas;
- Conference Center;
- Vacation village ;
- Hotels;
- Shopping Centre, coffees, restaurants, and;
- Public Services.

Construction of the tourist resort will be carried out in two phases. The completed development will include a total of 8190 beds, including 4540 hotel and 3650 residential.

1.5.2 Assessment of Urban Land use

An assessment of urban land use was conducted over the project area. Classification of the service area by land use category and associated population densities are summarized in Table 1.8 and Table 1.9.

Table 1.8: Classification of Urban Land Use in the Village of Azemmour

Type of Land Use	Area ha	(%)
1- Land Use Classification		
* Dense Residential	131.7	24.6
* Dispersed Residential	8.5	1.6
* Continuous Buildings	6.4	1.2
* Villas	53	9.9
Sub total	199.9	37.3
2- Other Uses		
* Public Places	2	0.4
* Pasture and Timbering	32	6
* Public Parks and Gardens	40	7.5
* Servitude non aedificandi	14.5	2.7
* Sporting facilities	6	1.1
* Agriculture Production	66	12.3
* Cemetery	16.4	3
* Areas Reserved for Schools	24.7	4.6
* Area Reserved for Public Services	19.8	3.7
* Industrial Area	17.8	3.3
* Railway Area	18	3.4
* Mosques and Churches	0.6	0.1
* Roadways	78	14.6
Sub total	335.8	69.7
Total	**535.4**	**100 %**

Table 1.9: Classification of land use in the center of Sidi Ali Ben Hamdouche

Type of Land Use	Area ha	(%)
1- Land Use Classification		
* Dense Residential	7.9	9.2
* Dispersed Residential	8.9	10.3
* Rural	12.2	14.2
Sub total	29	33.7
2- Other Uses		
* Pasture and Timbering	21.9	15
* Public Parks and Gardens	0.4	0.5
* Servitude non aedificandi	7.6	8.8
* Sporting Facilities	0.4	0.5
* Agriculture Production	10.7	12.4
* Mosques and Churches	0.4	0.5
* Cemetary	0.2	0.2
* Public Services	1.4	1.6
* Public Instruction	2.5	2.9
* Industrial Area	0.5	0.6
* Roadways	20	23.3
Sub total	57	66.3
Total	**86**	**100 %**

1.5.2.1 Population Density

Maximum Population Density

Maximum densities statistics are presented by Table 1.10.

Table 1.10: Maximum densities of occupation of the ground (hab/ha)

Habitat Type	Residence per ha	Persons per Residence	Density (ha/ha)
Residential Areas	144	5	720
Continuous Buildings	240	5	1200
Villas	25	5	125
Sparsely inhabited	6	5	30

Capacity of Occupancy

The capacity of occupancy of any land use category is given on the basis of average household (5 people by housing) or by the maximum density of the corresponding land use. The saturation populations are presented in Tables 1.11 and 1.12.

Table1.11: Saturated Occupancy Capacity under the Village of Azemmour Development Plan

Habitat Type	Density (hab/ha)	Surface Area (ha)	Capacity(hab)
Residential Areas	720	131,7	94824
Continuous Building	1200	6,4	7680
Villas	125	53	6625
Sparsely Inhabited	30	8,5	255
Total		**199,6**	**109384**

Table 1.12: Saturated Occupancy Capacity under the Center Sidi Ali Development Plan

Habitat Type	Density (hab/ha)	Surface Area (ha)	Capacity (hab)
Habitat continuous dense	720	7,9	5688
Habitat rural	30	12,2	366
Habitat dispersed	30	8,9	267
Total		**29**	**6321**

The combined total saturated population of the Villages of Azemmour and Sidi Ali center will be 115,705.

1.5.3 Demographic Analysis Censuses Results

The population of the town of Azemmour in 1971, 1982, and 1994 according to the general census of the population and habitat (RGPH) is presented by Table 1.13.

Table 1.13: Census Population of the municipality of Azemmour

Year	1971	1982	1994
Population (hab)	17182	24774	32739
Number of Households		5403	6978
Household Size		4.6	4.7
Average Annual Growth Rate		3.38 %	2.35 %

The average annual growth rate between the period of1971 to 1982 was 3.38 %. This rate dropped to 2.35 % between 1982 and 1994. The censuses of 1971 and 1982 do not include the center of Sidi Ali Ben Hamdouche. The population recorded at the time of the census of 1994 in this center was 2632 inhabitants. The number of households reported was 499, thus the average family size was 5.3 people per household.

Projected Future population

The annual growth rates used by ONEP, and subsequently the rates used in this study are presented in Table 1.14.

Table 1.14: Annual Growth Rates Used by ONEP

Annual Growth Rate (%)	Azemmour	Sidi Ali
1994-2000	2.2	3.3
2000-2010	2.0	2.5
2010-2020	1.8	2,0
After 2020	1.5	1.8

Project population estimated calculated by using the Census population and ONEP Annual Growth rates results in future population projection summarized in Table 1.15.

Table 1.15: Projected Future Populations of Azemmour and Sidi Ali

Year	1994	2000	2010	2020
Azemmour	32,739	37,452	46,103	57,200
Sidi Ali	2.640	3.213	4.113	5.014
Population total	35,379	40,665	50,216	62,214

1.6 CONCLUSIONS AND RECOMMENDATIONS OF PREVIOUS STUDIES

1.6.1 The Techno-Export Stroy (SDAL) 1989 Study

Network

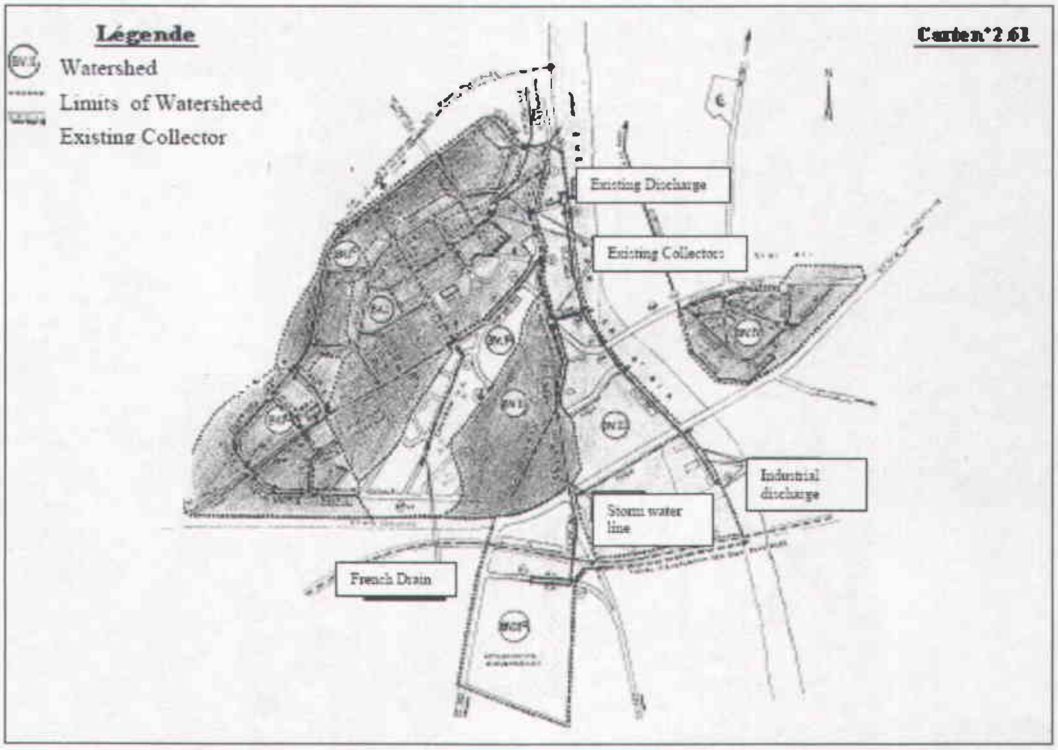
In a study conducted by Techno-Export Stroy (1989), several potential alternatives to wastewater collection and treatment were investigated. The improvements recommended by this study included directing wastewater drainage from BVI (New Médina), BVIIa (zone of Southern extension), BVIb (zone of Western Southern extension), BVIc (Western Northern zone), BVIa, and BVII towards the site of a new wastewater treatment facility to be constructed on the left bank of the Wadi Oum Erbia. Collection of stormwater from CPIII (old medina) and existing-B VIII (industrial park) are excluded. The type of the network more adapted for each zone is presented in Table 1.16.

Table 1.16: The Type Of The Collection Network Adapted For Each Collection Zone

Zone (BV)	Type of Collection	Observations
Azemmour New médina (BV I)	Combined	Situation existing (CP 0-1-15)
Azemmour New médina (BV Ia)	Partly Separate	Situation existing (CI-12)
Azemmour New médina (BV II)	Combined	Situation existing (CP 1-36-50)
Azemmour New médina (BV I)	Combined	Situation existing (CP 0-1-15)
Azemmour Old médina, Kasbah, zone industrielle existante (BV III)	Separate	BV III (after construction)
Azemmour Zone d'extension Sud-Ouest (BV Ib)	Separate	(Horizon 2000)
Azemmour Zone d'extension Nord-Ouest (BV Ic)	Separate	(Horizon 2000)
Sidi Ali (BV IV)	Separate	Separate Collection

The existing and proposed wastewater collection network is shown on Figure 3.

Figure 3: Existing and projected Wastewater Collection Network (according to SDAL)



Wastewater Treatment Facility Site Selection

The Techno-Export Stroy Study 1989 (SDAL) recommends the realization of wastewater treatment facilities for the Villages of Azemmour and Center of Sidi Ali. Potential sites for wastewater treatment facilities were selected on the left bank and right bank of the Wadi Oum Erbia.

<u>Site Number 1</u>

The site No.1 (Azemmour) addresses wastewater collected from the service area located on the left bank of the Wadi Oum Erbia. This site is public land under the management of National Forestry Commission of the province of El Jadida.
Located on the left bank of Wadi Oum Erbia, in the "area of the dunes", WWTP Site No.1 lies at elevation +22, having a slope of 0.06 towards the Atlantic Ocean to elevation + 13, and is approximately 1 km from the Village of Azemmour. Soils analysis revealed a sandy soil mixed with clay having an effective diameter of 0,08 - 0,03 mm, and a coefficient of filtration K = 0,004 - 0,001 cm/s. Groundwater at the sight was found 10 to 15 meters below the surface by measuring existing wells.

Proposed Site Number 1 is favorable; having a suitable slope, facilitating good gravity flow of wastewater through the wastewater treatment process train, including discharge and the prevalent wind direction away from the village minimizes associated odor impacts.

Site Number 2

The second proposed WWTP site is on the right bank of the river, approximately 300 meters from the hospital "Sidi Layachi", and 1 km to the North of Sidi Ali. The site No.2 (Sidi Ali Ben Hamdouche) located out of right bank of the Oum Erbia. This area is privately owned and presently used for agriculture and livestock grazing. The elevation of the site is + 12 to +14 meters above sea level with a slope of 0.01 towards the River. The aquifer is 3-4 m below the ground. This site was not considered suitable, since prevalent winds will bring odor towards the town of Azemmour. The location of the proposed wastewater treatment sites is presented in Figure 4.

Wastewater flow and load data for the year 2000 presented by the SDAL report is presented in Table 1.17.

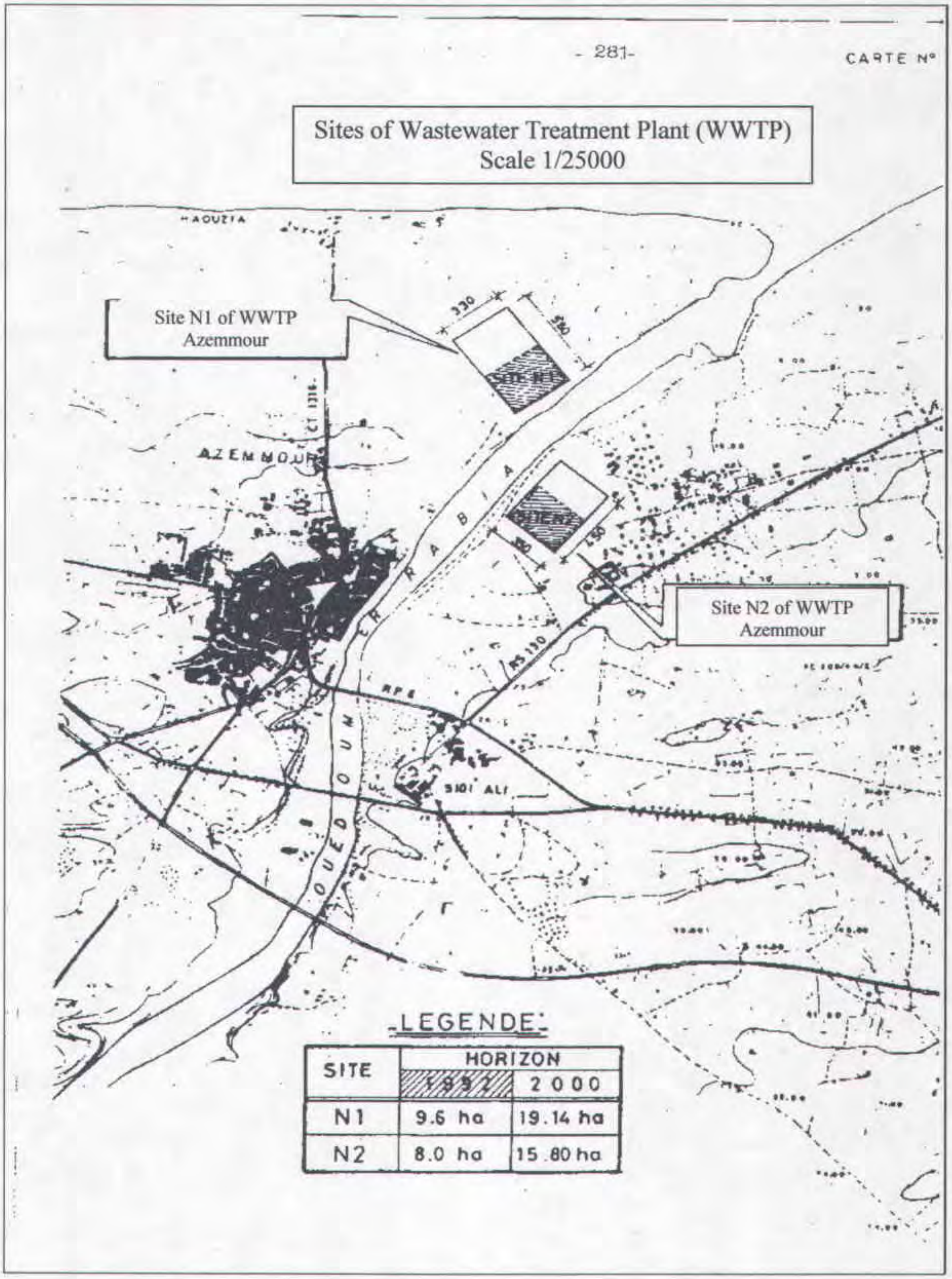
Table 1.17: Wastewater Data for the year 2000 presented by the SDAL report

Parameter	Q_{day} (m^3/j)	Qpt (l/s)	TDS (kg/j)	BOD_5 (kg/j)	TDS (mg/l)	BOD_5 (mg/l)	nTDS	$nBOD_5$
Azemmour (popul. + tourists)	5184	109	2780	2524	536	487	90.6	94
Sidi Ali (popul. + tourists)	784	21	417.5	379	532	482	90	93
Azemmour + Sidi Ali (popul. +tourists)	5968	130	3199.5	3153	536	528.3	90.6	94.3
Industry	1920	44	614	537.6	320	280	84	89
Slaughter house	14.85	0.34	33.9	30.9	2282	2080	97.8	98.6
Hospital Sidi Layachi	5120	1.48	11.06	9.97	216	194.8	76.9	84.6

1.6.2 Selection of Wastewater Treatment Technology

The study of the SDA proposed three wastewater treatment technology alternatives. Mechanical and biological treatment, followed by filtration and irrigation reuse were the recommended treatment options proposed by the SDA Study. Under the recommended option waste water of the town of Azemmour, Sidi Ali and the hospital "Sidi Layachi" would be treated separately.

Figure 4: Location of the Wastewater Treatment Sites Proposed By SDAL



Azemmour - Site No.1:

Waste water generated by the town of Azemmour will be centrally collected at the existing outfall. A wet well and pump station will be constructed at this collection point. Wastewater will be pumped from the wet-well by the new pump station, approximately 700 meters to the proposed WWTP Site Number 1.

The wastewater treatment process train recommended for the Village of Azemmour includes:

1. Head-works and distribution chamber,
2. Two parallel bar-racks, of which one with mechanical cleaning and the other manual cleaning;
3. Grit removal chamber,
4. Primary clarifier,
5. Filtration beds,
6. NaHCl mixer,
7. Chlorine contact basin,
8. NaHCl Storage facility,
9. Drying Beds
10. Discharge of effluent to the Oum Erbia River.

Sidi Ali - Site No. 2:

The wastewater treatment process train recommended for the Center of Sidi Ali includes:

1. Head-works and distribution chamber,
2. Two bar-racks, one with coarse bars and the other a fine screen (manual cleaning),
3. Grit removal chamber,
4. Stabilization ponds,
5. Disposal by irrigation,

1.6.3 Conclusions and recommendations of previous studies

Tables 1.18 and 1.19 provide a summary of pollutant loads for the Villages of Azemmour and Sidi Ali as provided by the 1999 Study.

Table 1.18: Pollutant Loading of Wastewater Generated by the Village of Azemmour

Year	2000	2010	2020
Population	35,858	46,104	56,201
% Pop. Connected EU	***80***	***85***	***90***
Pop connected EU	31,640	41,383	53,413
BOD5 (g/hab/day)	30	35	35
TDS (g/hab/day)	40	45	45
COD(g/hab/day)	80	85	85
TKN (g/hab/day)	15	15	15
Organic Material	40	45	45
P total (g/hab/day)	5	5	5
BOD5 Load (kg/day)	949	1448	1869
TDS Load (kg/day)	1266	1862	2404
COD Load (kg/day)	2531	3518	4540
Organic Material	1144	1287	1287
P total (kg/day)	158	207	267

Table 1.19: Pollutant Loading Of Wastewater Generated By Sidi Ali Ben Hamdouche

Year	2000	2010	2020
Population	3,202	4,099	4,996
% Pop. Connected EU	***80***	***85***	***90***
Pop connected EU	2,561	3,484	4,497
BOD5 (g/hab/day)	30	35	35
TDS (g/hab/day)	40	45	45
COD(g/hab/day)	80	85	85
TKN (g/hab/day)	15	15	15
Organic Material	40	45	45
P total (g/hab/day)	5	5	5
BOD5 Load (kg/day)	77	122	157
TDS Load (kg/day)	102	157	202
COD Load (kg/day)	205	296	382
Organic Material	93	105	105
P total (kg/day)	13	17	22

Selection of the Site for the WWTP

The sites retained for the station of treatment are those proposed in the SDAL: left bank for the town of Azemmour and right bank of the Wadi for the center of Sidi Ali

Selection of Wastewater Treatment Technology

Wastewater treatment technologies recommended by the SDAL Study were:

1. **Alternative 1**: Two separate Lagoon systems, one located on the right bank of the Oum Erbia to treat wastewater generated by the Village of Azemmour. A second, located on the left bank of the River to treat wastewater generated by the Center of Sidi Ali.

2. **Alternative 2:** Considers one activated sludge facility sized to treat wastewater generated by Azemmour and Sidi Ali combined.

Alternative 1 was the preferred alternative recommended by the study.

Effluent Reuse

Reuse of treated effluent from the proposed WWTP's is presented as a disposal option. Both WWTP sites offer potential reuse options by irrigation.

At the Azemmour Site No.1 the dune area located out along left bank of the Wadi Oum Erbia offers a potential area for irrigation.

At the Sidi Ali site No.2 the boundaries potentially irrigated land include the site of the station of purification of Sidi Ali, minor road RS 130 and the Wadi Oum Erbia.

1.7 COMPARISON AND ANALYZES OF PREVIOUS STUDIES

1.7.1 Sewer network

The problems with the existing sewer network as presented by the 2 former studies (SDAL, and STEP) are summarized below:

SDAL study	STEP Study
Network carried out without studies	-
Transmission lines not covered	The majority of the existing transmission lines not covered
Insufficiency of yield of the collectors	Insufficiency of drainage of rain water
Surface drainage of rain water by gutter not used	Surface drainage of rain water by gutter not used
Insufficient number of drainage inlets and heads	Insufficiency in the number of manholes

According to the above comparative table, one notes that the problems raised in the master plan (SDAL) were confirmed by the wastewater treatment study of 1998. Actually, one can say also that efforts were made by the Municipality of Azemmour to improve the treatment network but these efforts remain insufficient.

According to the municipality of Azemmour, the work carried out during the last years concerns about 11210 m of renewed and rehabilitated collectors. The zones concerned include:

- Derb Bouzroug
- Boulevard Mohamed V
- Derb Abda
- Derb Ben Amina
- Lotissement Khalafi
- Derb Sabata
- Derb Arssa
- Derb Abdeljalil
- Derb Ben Tami
- Derb Caïd Ragragui
- Derb Lalla Rkia Jilalia
- Derb Znata
- Derb Khachala
- Derb Ben Aïcha
- Derb Derkaoua
- Derb Dhab

- Derb Ben Brahim
- Rue Ouad Dahab 1, 3, 4
- Arsat Hantati
- Derb Sbitar
- Derb Haj Hammou.

Taking into account the advantages and disadvantages of the combined and separate sewer systems presented below, the recommendations to be made about the future development of the sewer network of the town of Azemmour relates to the type of network suggested within the framework of the SDAL (see table 7.1). Indeed, the type of recommended network is a combined sewer for the new medina and separate sewer for the old medina, the Kasbah, the industrial park, Sidi Ali, the zones of north-western and southern western extension.

1. The disadvantages of the combined sewer network are:

   - the flow at the treatment plant is very variable;
   - at the time of a storm, waste water is diluted by rain water;
   - sand contribution is important at the station of purification;
   - routing of a rather important flood of pollution at the time of the first rains after a dry period;
   - direct discharge of the mixture "waste water rain water" at the storm water outfalls.

2. The advantages of the separate treatment network are:

   - reduction in the diameter of the pipes collecting waste water;
   - easier operation of the purification station;
   - better safeguarding of the environment from domestic polluting flows;
   - certain costs of operation are reduced (pumping only waste water).

1.7.2 Purification System

The analysis of the results and recommendations of the previous studies in terms of purification "and the additional investigations which will be carried in future tasks of this feasibility study will determine the most appropriate alternative for the treatment of Azemmour wastewater based on technical and economical constraints.

1.7.2.1 Potential sites of purification

The site selection is generally adressed at the time of the establishment of the Wastewater Master Plan which lays down the main trends in the treatment system and in particular the best adapted purification system. The choice of the potential sites depends on many constraints.

Various constraints connected to the site such as the nature of the ground, the land status of the ground, the distance to the closest dwellings, direction of the dominant winds, zones not easily flooded (basin, river bed, outlet system of a large catchments area...), the existence of outlets to discharge the water after treatment, the possibilities of re-use for irrigational, the permeability and the depth of the water table, presence of rock or an impermeable layer, fluctuations of the waste water flow to the site, the slope of the ground or the surface available; can constitute obstacles with the establishment of a purification station. Thus preliminary studies, such as geotechnical, geological, topographic, hydro geological, are necessary to validate the potential sites.

Complementary investigations can, if necessary, be conducted within the framework of the preliminary studies, in particular concerning the re-use of spoil for the construction of berms for example in the event of treatment in lagoons. Laboratory tests are in this case necessary to determine the aptitude of the soils to be used for berms.

The sites identified in the Wastewater Master Plan (SDAL) and confirmed by the study of Guigues Morocco (1999) are two:

- Site 1 on the left bank of the River Oum Er Rbia to treat waste water of the Town of Azemmour;
- Site 2 on the right bank of the river Oum Er Rbia to treat waste water of the center of Sidi Ali Ben Hamdouche.

Because of the planning of the tourist zone of Haouzia, it would be more judicious to study the possibility of proposing other sites in order to benefit this tourist zone from the purification station from the town of Azemmour. For this it is necessary to conduct complementary investigations to research new potential sites of purification.

1.7.2.2 Systems of purification

The study of the SDAL retained a mechanical and biological treatment, with filtration fields and irrigation fields for the stations of Azemmour and Sidi Ali.

The study of Guigues Morocco proposed an alternative, which recommends a natural treatment using lagoons for the stations of Azemmour and Sidi Ali.

In the present study, we will describe the various possible purification systems by stressing the conditions for their applicability to the town of Azemmour and the degree of purification that each system offers. We will then choose at the end the system of purification to be adopted for the town of Azemmour.

1.7.2.3 Characterization of wastewater and calculation of the pollution loads

A presentation and a comparison of the characterizations of the wastewater carried out within the framework of existing studies are given in the following chapter "Study of the pollution and the quality of the waste". These characterizations were carried out within the following studies:

- SDAL: Laboratory of the LPEE in 1989
- Study Guigues Morocco: Laboratory of the IAV in 1997.

A summary of the polluting loads of BOD5 and of TSS calculated within the framework of the existing studies for the horizon 2000 is given below:

Table 1.20: Parameters used for the calculation of the pollution loads of Azemmour and Sidi Ali in the existing studies (Horizon 2000)

Parameters	SDAL (1989)	Guigues Morocco (1999)
BOD_5 (g/d/hab)	50	30
MES (g/d/hab)	55	40

Table 1.21: Comparison of the pollution loads of the town of Azemmour and Sidi Ali based on existing studies (Horizon 2000)

	Azemmour		Sidi Ali	
	SDAL	Guigues Maroc	SDAL	Guigues Morocco
Population	44000	35858	6500	3195
Average waste water flow (m3/d)	7104	2107	784	149
BOD5 (kg/d)	3102	949	379	77
TSS (kg/d)	3439	1266	417,5	102

According to the above table of the pollution loads, the calculations carried out within the framework of the SDAL are much higher than those of the study of Guigues Morocco, in terms of both population, average waste water flows and loads of BOD5 and TSS. The calculations carried out within the framework of this feasibility study are closer to the study of Guigues Morocco than those of the study of the SDAL.

1.7.3 Re-use of purified waste water

The study of Guigues Morocco recommended an agricultural re-use of the treated effluent on the left bank and on the right bank of the river but did not develop this aspect. In addition, the study did not take into account the re-use of the treated wastewater by the future tourist complex.

The study by the SDAL, which recommended the re-use for irrigation fields, did not propose the sites concerned with the re-use.

1.8 WATER AND WASTEWATER USAGE

1.8.1 Drinking water Needs

1.8.1.1 Analysis of existing statistical data

The statistics of consumption received from RADEEJ over the last 5 years for the town of Azemmour and of the center of Sidi Ali are summarized on the table below:

Year	1998	1999	2000	2001	2002
Distribution (m3/yr)	1 585 294	1 543 477	1 530 000	1 500 000	1 486 004
Consumption (m3/yr)	931 918	993 649	980 000	1 050 000	1 011 415
A number of subscribers	5 556	5 911	6 105	6 270	6 494

The statistics of distribution and consumption enable us to determine the output of the distribution network of Azemmour.

year	1998	1999	2000	2001	2002
Output of the network (%)	59	64	64	70	68

On the basis of the number of population per connection which is equal to 6, the rates of connection as well as the populations connected and not connected the last 5 years are:

Year	1998	1999	2000	2001	2002
Rate of connection (%)	86	89	90	91	92
Population connected	33336	35466	36630	37620	38964
Population not connected	5370	4139	3878	3768	3268

The total net allowance calculated on the basis of statistics for the last 5 years for the town of Azemmour and the center of Sidi Ali led to the results presented on the table below:

Year	1998	1999	2000	2001	2002
Total net allowance (l/per/d)	66	69	66	69	65

1.8.1.2 Evaluation of drinking water needs

Assumptions for calculation of needs:

The assumptions for calculations held for the calculation of the water needs for the town of Azemmour and the center for Sidi Ali are those needs of the ONEP for 2003 for Azemmour and for Sidi Ali for 1996. These assumptions are summarized below:

- **Azemmour**

  - Rates of increase in the population: the rates of increase in the population which were useful for the forecasts of the populations of Azemmour are given in chapter 6.
  - Rates of connection of the population: the adopted rates of connection vary from 93% in 2003 to 98% in 2020.
  - Water allowance of the connected population: this allowance is taken equal to 65 l/per/d.
  - Water allowance of the non-connected population: the water allowance retained for the calculation of the future needs for this population amounts to 10 l/per/d.
  - Administrative water allowance: the water allowance retained for the calculation of the future needs for the administrations amounts to 13 l/per/d.
  - Industrial water allowance: the water allowance retained for the calculation of the future needs for industries amounts to 10 l/per/d.

A summary of these assumptions is presented in the table below:

Year	2003	2005	2010	2015	2020	2025
POPULATION						
RATE OF GROWTH (%)	2.00			1.80		1.50
RATE OF CONNECTION (%)	93%	94%	95%	96%	98%	98%
ALLOWANCES (l/per/d)						
POPULATION CONNECTED	65	65	65	65	65	65
POPULATION NOT CONNECTED	10	10	10	10	10	10
ADMINISTRATIVE	13	13	13	13	13	13
INDUSTRIAL	10	10	10	10	10	10

- **Sidi Ali**
  - Rates of increase in the population: The rates of increase in the population which were useful for the forecasts of the populations of Sidi Ali are given in chapter 1.5 .
  - Rates of connection of the population: The adopted rates of connection are identical to those which are adopted for the town of Azemmour.
  - Water allowance of the connected population: This allowance is taken equal to 55 l/per/d for all the horizons.
  - Water allowance of the population not connected: The water allowance retained for the calculation of the future needs for this population amounts to 10 l/per/d.
  - Administrative water allowance: The water allowance retained for the calculation of the future needs for the administration amounts to 13 l/per/d.
  - Industrial water allowance: The water allowance retained for the calculation of the future needs for industries amounts to 5 l/per/d.

A summary of the assumptions retained for the calculation of the water needs for Sidi Ali is given in the table below.

Year	2000	2003	2005	2010	2015	2020	2025
POPULATION							
RATE OF GROWTH (%)	3.30	2.50	2.50	2.50	2	2.00	1.80
RATE OF CONNECTION (%)	91%	93%	94%	95%	96%	98%	98%
ALLOWANCES (l/per/d)							
POPULATION CONNECTED	55	55	55	55	55	55	55
POP. NOT CONNECTED	10	10	10	10	10	10	10
ADMINISTRATIVE	13	13	13	13	13	13	13
INDUSTRIAL	5	5	5	5	5	5	5

Evaluation of water needs: The water needs (l/s) for production are summarized in the tables below.

Table 1.22: Drinking water needs for the production of the town of Azemmour

YEAR	2005	2010	2015	2020	2025
Average needs (l/s)	56	59	62	68	72
Peak needs (l/s)	70	74	78	85	90

Table 1.23: Drinking water needs for the production center of Sidi Ali

YEAR	2005	2010	2015	2020	2025
Average needs (l/s)	3.9	4.4	4.9	5.5	6
Peak needs (l/s)	4.9	5.5	6.1	6.9	7.5

1.8.1.3 Evaluation of drinking water needs for the hospital and the slaughter-houses

- **Layachi Hospital**

Currently the hospital is provided with drinking water from the network of the town of Azemmour.

Wastewater of the hospital is discharged into the immediate proximity of the hospital without any treatment. This can cause contamination of the population affected with tuberculosis staying in the hospital.

The current capacity of the hospital is 100 beds. The medical personnel of the hospital are lodged in 10 houses (5 people/house) built in the enclosure of the hospital. The total number of the people of the hospital is 50+100 = 150.

Considering the consumption of the hospital is intended primarily to satisfy the water needs for the patients and the people occupying the dwellings inside the enclosure for the hospital, we consider a water allowance of 100 liters/day/person (slightly higher than the water allowance of the population), the current consumption of the hospital would be of:

Q Average/d = 150x100 = 15 m3/d = 0.17 l/s

- **Slaughter-houses**

The slaughterhouses are provided with drinking water from the city network.

The current production of the slaughter-house is almost 4,000 heads of cattle per year.

The drinking water consumption of the slaughter-house is calculated on the basis of a water allowance per capita of cattle at 200 l/day/head (value retained in the SDAL), that is to say 200 X 11head/d = 2.2 m3/day = 0.025 l/s.

Generally, the water allowance of the slaughter-houses is higher than that of the population. It is pointed out that the latter is 65 l/person/day. In addition, the water allowance retained for the slaughter-houses is close to the values adopted for the slaughter-houses of other cities of the kingdom.

The drinking water consumption of the Layachi hospital and the Slaughter-houses are very low, their waste will therefore be neglected.

1.8.1.4 Assessment of the drinking water requirements for the tourist zone of Mazagan

The drinking water needs for the tourist zone of Mazagan are calculated by the ONEP within the framework for "the study for drinking water supply for the tourist project for Mazagan, with the help of the AEP of the town of Azemmour and the neighboring douars". The calculation holds account of the elements presented on the needs assessment and the schedule of repayments for the realization of the project as programmed by the installation plan and study of the economic and financial feasibility which is in the course of finalization by the Department of Tourism.

The water needs (in l/s) for production for the future tourist station in Mazagan are established as follows:

Table 1.24: Peak needs of production of the Mazagan project

YEAR	2005 (*)	2007 (**)	2010	2015	2020
- Drinking water	27	48	48	48	48
- Landscaping water	36	75	76	76	76
Total needs	**63**	**124**	**124**	**124**	**124**
Production of purified water by the STEP	8	14	14	14	14
Balance of needs to satisfy	**55**	**110**	**110**	**110**	**110**

(*): Estimated date of startup of the first phase;
(* *): Estimated date of startup of the second phase.

NB: The STEP can ensure a partial flow of 14 l/s (8 l/s in 1st phase and 6 l/s in 2nd phase) for the watering of the golf courses.

Peak coefficient: 1.4

According to the table above, the needs to satisfy the tourist zone are 55 l/s in the 1st phase and 110 l/s in the 2nd phase. These figures are calculated by considering that a part of the needs will be satisfied by water purified within the tourist complex which is 8 l/s in the 1st phase and 14 l/s in the 2nd phase. Within the framework of this study, hypothetically, satisfaction of a part of the water needs by water purified for the tourist complex will not be considered. The water needs for the tourist zone which will be considered are 55 + 8 = 63 l/s in the 1st phase and 110 + 14 = 124 l/s in the 2nd phase.

SUMMARY OF THE NEEDS:

Taking into account what precedes, the drinking water needs for peak productivity are given in the following table:

Table 1.25: Peak needs for drinking water for production of the zone of study (l/s)

YEAR	2005	2010	2015	2020	2025
Tourist complex of Mazagan(*)	63 (36)	124 (76)	124 (76)	124 (76)	124 (76)
Azemmour	70	74	78	85	90
Sidi Ali	4.9	5.5	6.1	6.9	7.5
Total peak needs (l/s)	137.9(36)	203.5(76)	208.1(76)	215.9(76)	221.5(76)

(*) 63(36) : 63 corresponds to the global needs of the tourist zone of which 36 l/s are the watering needs.

One notes according to the table above that beyond 2005 the needs for the tourist complex are higher than those of the town of Azemmour and Sidi Ali. In addition, the needs for the town of Azemmour are equivalent to those of the needs for watering of the tourist zone for the years 2010 and 2015. Consequently, the waste of the town of Azemmour will be thus sufficient to satisfy the needs for watering of the tourist complex.

1.8.2 Calculations of the waste water flow

1.8.2.1 Methodology of evaluation of rough waste water flow

The domestic, administrative, and industrial waste water flows are given on the basis of the demographic and drinking water consumption data, affected by coefficient of return to the sewer.

$$\mathbf{Q}\text{ avg, ww} = \mathbf{Q}\text{ avg, dom} + \mathbf{Q}\text{ avg, adm} + \mathbf{Q}\text{ avg, ind}$$

Domestic waste water: Q avg, dom = Tres×Trac×Cdom
Administrative waste water: Q avg, adm = Tres×Trac× Cadm
Industrial waste water: Q avg, ind = Tres×Trac×Cind

Where:
Q avg, dom = Average flow of domestic waste water (m3/d);
Q avg, adm = Average flow of administrative waste water (m3/d);
Q avg, ind = Average flow of industrial waste water (m3/d);
Cdom = domestic consumption of drinking water (m3/d);
Cadm = administrative consumption of drinking water (m3/d);

Cind = industrial consumption of drinking water (m3/d);
Tres = Rate of refund to the sewer;
Trac = Rate of connection to the waste water network.

The peak output of wastewater "Qpk, ww" will be calculated by the multiplication of the average flow of waste water (Q avg, ww) by the coefficient of peak hour Kh. Within the framework of the characterization of waste water of the town of Azemmour, Kh is given in two ways, by measurement of the flows and calculation by means of the formula:

$$\mathbf{Kh = 1.5+2.5/(Q\ avg,\ ww)^{0.5}) \text{ and } Kh \leq 3}$$

The Kh values are given in § 10.2.2 of chapter 10.

In addition to the waste water flow calculated above, there is added waste water called parasitic. This water relates to seepage waters to the network in dry times due to the intrusions of clear water (ground water, escape of the drinkable water supply network...). Based on the results of the characterization campaign of wastewater in Azemmour carried out in December 2003, this parasitic water is not being considered

1.8.2.2 Rate of return to the sewer

The rate of return or coefficient of return to the sewer is taken equal to 80.

1.8.2.3 Rate of connection to the treatment network

The rate of connection to the treatment network is 80% for the town of Azemmour and it is 70% for the center of Sidi Ali.

The rates of connection to the treatment network for the population of Azemmour and Sidi Ali which will be adopted for the future years are summarized in the table below:

Rate of connection (%)	Azemmour	Sidi Ali
2005	82%	72%
2010	85%	75%
2015	90%	80%
2020	95%	85%
2025	95%	90%

The rate of future connection to the sewer network from the administrative, industrial and tourist zone is assumed to be100%.

1.8.2.4 Calculation of the flows of raw wastewater of Azemmour and Sidi Ali

The methodology of evaluation of the flows of wastewater was presented in the above paragraphs.

The flows of wastewater for the town of Azemmour and the center of Sidi Ali are summarized on the following tables:

Table 1.26: Daily average flows of waste water for the town of Azemmour

	2003	2005	2010	2015	2020	2025
Total population (per)	39 639	41 241	45 533	49 781	54 426	58 632
Average domestic WW flow (m3/d)	1534	1653	1912	2237	2635	2838
Average administrative WW flow (m3/d)	412	429	474	518	566	610
Average industrial WW flow (m3/d)	317	330	364	398	435	469
Total average WW flow (m3/d)	2263	2412	2750	3153	3636	3917

Table 1.27: Daily average flows of waste water for the center of Sidi Ali

	2003	2005	2010	2015	2020	2025
Total population (per)	3 454	3 629	4 106	4 534	5 005	5 472
Average domestic WW flow (m3/d)	100	110	131	159	191	221
Average administrative WW flow (m3/d)	36	38	43	49	54	59
Average industrial WW flow (m3/d)	14	15	17	19	21	23
Total average WW flow (m3/d)	151	163	191	227	266	303

1.8.2.5 Calculation of the flows of raw wastewater of the tourist project Mazagan

The wastewater flow calculated for Mazagan, are summarized in the table below:

Table 1.28: Daily average flows of wastewater for the tourist zone of Mazagan

	2005	2010	2015	2020	2025
Average WW flow (m3/d)	1013	1801	1801	1801	1801

1.8.2.6 Summary of the flows of raw wastewater

A summary of the wastewater flows of the town of Azemmour, Sidi Ali, and the tourist zone of Mazagan is presented in the table below:

Table 1.29: Summary of the Daily Average Flows of Waste Water

	2003	2005	2010	2015	2020	2025
Average WW Flow of Azemmour (m3/d)	2263	2412	2750	3153	3636	3917
Average WW Flow of Sidi Ali (m3/d)	151	163	191	227	266	303
Average WW Flow of tourist zone (m3/d)		1013	1801	1801	1801	1801
Total Average WW Flow (m3/d)	2414	3588	4742	5181	5703	6021

1.9 EVALUATION OF WASTEWATER POLLUTION

The objective of this chapter is the study of the domestic and industrial wastewater pollution discharged by the town of Azemmour and the center of Sidi Ali. This chapter also considers the wastewater from the future tourist zone of Mazagan. One starts initially with the presentation of the results of the measurement and analysis campaigns conducted in 1989 and in 1997, in addition to the 2003 campaign conducted by this feasibility study.

The 2003 campaign results were used to calculate the current and future pollution loads of Azemmour and Sidi Ali.

1.9.1 Range of concentration of urban wastewater

The ranges of concentration of Moroccan domestic wastewater concentration (according to the National Waste Water Master Plan, SDNAL) are:

Parameters	Concentrated wastewater	Common range	Diluted wastewater
BOD5 (mg/l)	>= 400	200-400	<= 200
COD (mg/l)	>= 1000	500-800	<= 500
MES (mg/l)	>= 500	250-500	<= 250
NTK (mg/l)	>= 80	40-80	<= 40
P (mg/l)	>= 16	8-16	<= 8
Total coli forms (U/100 ml)	$>= 10^8$	10^7-10^8	$<= 10^7$
Fecal coli forms (U/100 ml)	$>= 10^7$	10^6-10^7	$<= 10^6$
Fecal Streptococus (U/100 ml)	$>= 10^6$	10^5-10^6	$< = 10^5$
Helminth eggs (U/l)	$>= 10^3$	10^2-10^3	$<= 10^2$

The usual values of the ratios of the concentrations are, according to the SDNAL:

- MES/BOD5 = 1.2-1.5
- BOD5/NTK = 4-5
- COD/BOD5 = 2-2.5
- BOD5/P = 25-30.

As for the industrial wastewater, it should be treated before its discharge into a municipal wastewater treatment plant, given the fact that industrial wastewater contains substances likely to disturb, by their nature or their concentration, the correct operation of the treatment plant.

The discharge limits recommended by the SDNAL and the Moroccan draft standard for the industrial wastes are:

	SDNAL	Proposed Moroccan Standards
BOD_5 (mg/l)	800	500
COD (mg/l)	2000	2000
MES (mg/l)	600	600
NTK (mg/l)	150	100
Pt (mg/l)	50	10

1.9.2 Wastewater Characterizations and completed analyses.

1.9.2.1 Campaigns of 1989 and 1997

The wastewater characterization for the town of Azemmour were carried out in 2 periods by:

- In 1989 by Technoexportstroy (laboratory LPEE) within the framework of the study of the wastewater master plan for the town of Azemmour.
- In 1997 by Guigues Morocco (laboratory IAV) within the framework of the wastewater treatment plant study for the town of Azemmour.

A summary of the results of theses analyses are presented on the table below:

Table 1.30: Summary of the results of the Standard tails assays Liquidate of Azemmour (1989 et1997)

	Technoexportstroy, LPEE (27.9.89)											GUIGUES, IAV (10.97)			
	SPECIFIC SAMPLES									AVR SAMP		REJECTIONS DOMEST		REJECTIONS INDUST	
PARAMETRE	8H	10H	12H	14H	16H	18H	20H	22H	00H	1	2	E 1*	E 2*	U1*	U3*
Temperature °C:															
Air	29,5	31,8	31,6	32,8	29,6	28,0	28,6	25,6	26		28				
Eau	25,6	26,2	26,2	26	26,5	26,5	26,0	25,8	25		25				
pH	7,45	7,55	7,35	7,45	7,55	7,30	7,50	7,70	7,70		7,90	6,92	6,90	4,3	7,88
Conductivité (mmhos/cm)	2870	2910	2540	2160	2420	2350	2180	2120	2220		6690	1,6	1,8	2,3	2,6
Matières décantables (ml l^{-1})														6	0,1
NH_4^+ (mg l^{-1})														3,8	0,5
Cl^- (mg l^{-1})														1125,4	905,25
Ca^{++} (mg l^{-1})														128,25	182,76
Mg^{++} (mg l^{-1})														1317,5 6	395,00
Na^+ (mg l^{-1})														400	2761
K^+ (mg l^{-1})														22,40	134,40
Pb (µg l^{-1})										152				5,8	45,7
Cu (µg l^{-1})														18,53	21,27
Cr (µg l^{-1})														20,26	10,87
Zn (µg l^{-1})														123	26
Fe (µg l^{-1})										0,23				1460	600
Débit l/s	12,95	19,35	30,11	26,94	18,84	16,83	14,47	9,42	5,57						
PO_4	58,43	58,83	59,77	56,36	40,14	51,81	43,48	44,39	36,15	51,87	0,15				
CT.	6.10^{7}	$4,9.10^{8}$	2.10^{8}	3.10^{9}	$.10^{9}$	$3,1.10^{9}$	$1,4.10^{9}$	$1,7.10^{9}$	$2,7.10^{9}$		5700				
CF.	7.10^{6}	$1,5.10^{7}$	$5,9.10^{7}$	2.10^{6}	$4,3.10^{8}$	$3,2.10^{8}$	5.10^{6}	$.10^{7}$	$3,3.10^{8}$		200				
SF.	6.10^{6}	$3,9.10^{7}$	$9,5.10^{7}$	$.10^{7}$	6.10^{6}	$4,5.10^{8}$	4.10^{7}	6.10^{7}	3.10^{7}		1200				
SP.	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*	ND*		ND*				
COD (mg l^{-1})	1860	1580	1600	2180	1020	1000	800	880	580	1400	36	787,2	748,8	2880	67,2
BOD5 (mg l^{-1})	645	655	494	520	394	392	338	335	226	471	0,2	264,8	342,7	460	28,2
Matières décantables(ml l^{-1})												5,5	5,3	6,0	
TSS (mg l^{-1})	1056	742	685	716	438	358	390	310	102	632	15,2	270	232	376	8
NO_3^- (mg l^{-1})												0,54	0,42	3,08	13,68
NO_2^- (mg l^{-1})												0,0	0,0	184	0,57
NTK (mg l^{-1})	186,2	208,6	131,6	116,2	100,8	95,2	91	98	106,4	100,8	2,212	170,94	132,86	3,92	0,42
P.total (mg l^{-1})	24,90	22,39	23,00	24,55	15,12	22,05	17,25	27,27	21,18	22,95	0.59	47,73	47,61	3,05	1,41
Cl^- (mg l^{-1})												372,75	347,90	1125,4	905,25
Huiles & graisses (mg l^{-1})												32,0	28,4	122,6	2,4
Résidu sec (mg l^{-1})												1,1	0,94	2,23	0,03
Acidité(méq l^{-1})												0,46	0,48	1,4	0,08
Alcalinité(méq l^{-1})												0,18	0,16	0,00	0,06

CT: coliformes total
SF: Streptocoques fecal
SP : staphyllocoques pathogènes
ND : Not detected (presence of staphyllocoques nonpathogenic)

Interpretation of the results of the analyses carried out in 1989 and 1997:

The comparison of the results of the analyses (carried out by LPEE in 1989 and IAV in 1997) of the BOD_5, COD, and TSS for the domestic effluents in the case of the average sample is given on the following table:

	01/10/1997	05/10/1997	27/09/1989
BOD_5 (mg/l)	264.8	342.7	471
COD (mg/l)	787.2	748.8	1400
TSS (mg/l)	270	232	632

According to the table above, the recorded values of the BOD_5 and COD show that the values measured into 1997 are normal values and representative of wastewater quality from average size towns whereas those which are measured in 1989 are excessive. One also notes divergences between the values measured for TSS in 1989 and 1997.

The difference between the results of the analyses carried out by the LPEE and the IAV can come from the urban development of the city recorded between 1989 and 1997. Indeed, an evolution of the inhabited surfaces as well as an improvement of the living conditions of the populations can be at the origin of the evolution of the concentrations of the effluents of wastewater. With regard to the industrial evolution, one notes that the town of Azemmour did not experience an industrial development between 1989 and 1997. Consequently, the load of industrial pollution thus has little effect on quality of the effluents of the city.

Thus and because of the divergences between the results of the analyses of 1989 and 1997 and also with an aim of having a recent characterization of the effluents, an additional waste characterization campaign was conducted in 2003 by GESI and ONEP.

1.9.2.2 Recent quantitative and qualitative wastewater characterization campaign

The central laboratory of the ONEP conducted the measurements of the flow and quality of wastewater of the town of Azemmour and Sidi Ali in December 2003 based on a program developed by GESI. A description of work carried out and interpretations of the results are given below:

1.9.2.2.1 Sample location and duration

The locations where samples were taken and the duration of sampling are summarized in the table:

Sample points	Discharge location	Duration of follow-up	Period of follow-up
Principal Waste	Wadi Oum Erabia	5 days	from 00h the 14/12/2003 to 00h on the 19/12/2003
Waste of Sidi Ali	Wadi Oum Erabia	3 days	from 00h the 11/12/2003 to 00h on the 13/12/2003
Waste of slaughter-houses	Sewer Network	2 days	from 06 to 09 h the 04/12/2003 and from 04 to 10 h on the 09/12/2003 (market day)
Waste of SOVEM	Wadi Oum Erabia	2 days	from 08h to l6h the 08 and 09/l2/2003
Hospital Waste	Wadi Oum Erabia	Prompt Sample	at 12h on the 05/12/03

1.9.2.2.2 Type and Frequency of Sampling

Two types of samples were taken:

- Composite samples - C2 - for 2 hours integrated in time, taken using an automatic sampler at a rate of extraction of 250ml every l5min, a sample of 2 L every two hours.
- Composite samples - C24- proportionally made up with the flow over one period of 24 hours (from 00h to 24h).

For the industrial wastes (SOVEM and the slaughter-houses) the composite samples - CF - were made proportionally with the flow on a cycle of operation. For the group of points, specific samples - EP- were taken for the bacteriological analyses.

The number and the nature of the samples taken by waste are summarized in the table below:

Sample point	Main Azemmour discharge					Sidi Ali discharge			Slaughter-houses waste		SOVEM waste		Hospital discharge
Sampling date	14 dec	15 dec	16 dec	17 dec	18 dec	11 dec	12 dec	13 dec	04 dec	09 dec	08 dec	09 dec	05 jan
Sample taken	1C24	1C24 + 1EP	1 C24 + 12C2 + 1EP	1C24 + 12C2	1 C24	1 C24 + 1EP	1 C24 + 12 C2	1 C24 + 12 C2	1CF + 1EP	1CF	1C F	1CF + 1EP	1EP
Total number of samples	5C24+24C2+2EP					3C24+24C2+1EP			2CF+1EP		2CF+1EP		1EP
Total samples	66 samples (8C24 + 48C2 + 4CF + 6EP)												

1.9.2.2.3 ***Results of flow measurements***

According to the recorded results, we note that the flows measured at the Main discharge location (Azemmour), during the five days period, show a trend usually seen for this type category of waste with a peak about mid-day and a minimum flow at the end of the day. In the night period, the flow rate is relatively low for the town of Azemmour. For the center of Sidi Ali, a rather important residual flow persists in the night period. This flow accounts for 20% of the daily average flow of wastewater of this center.

From the tables of the results, the following elements can be determined.

1- Parasitic water:

The measurements taken on the main discharge point of the town of Azemmour do not show the presence of parasitic water by contrast with the center of Sidi Ali this water account for 20% of the daily average flow of wastewater.

The results of Sidi Ali can find an explanation in the fact that the period of measurement of the flows followed one rainy period and that the combined sewer network drained, in addition to waste water, surface water runoff coming from precipitation.

Consequently, the parasitic flows will not be taken into account for the center of Sidi Ali because their quantity is negligible. It is pointed out that the wastewater of Sidi Ali accounts for only 10% of the waste of the town of Azemmour.

2- Coefficient of peak hour:

The coefficients of peak hour calculated and measured for Azemmour and the center of Sidi Ali are:

- Azemmour:

	14/12/03	15/12/03	16/12/03	17/12/03	18/12/03
Peak coefficient measured	3.0	2.9	2.5	2.6	2.6
Peak coefficient calculated	2.0	2.1	2.0	2.1	2.0

- Sidi Ali:

	11/12/03	12/12/03	13/12/03
Peak coefficient measured	1.7	1.5	1.5
Peak coefficient calculated	3.1	3.1	3.0

One notices according to the tables above that:

The coefficients of peak hour observed are higher than those calculated by the formula in the case of Azemmour and one notes the reverse for the case of the center of Sidi Ali.

The current operating condition of the network can explain this fact. Indeed, this network cannot ensure a normal flow of the effluents if it presents mild slopes producing a progressive backup and clogging of the drains.

Thus, the wastewater corresponding to the periods of strong drinking water consumption are stored in the conduits thus reducing the peak output. On the other hand, the effect of accumulation gives rise to outflows with relatively important rates during the off-peak hours. This is confirmed by the recorded high night flows with Sidi Ali.

3- Rates of return to the sewer:

The cross reference of the consumed flows with the measured waste flows makes it possible to appreciate and determine the rate of return to the sewer.

The correlation between drinking water consumption and the volumes discharge in the sewer assumes taking into account the following factors:

- the rate of connection to the sewer
- the discharge rate (or rate of return) of the population connected to the sewer corresponding to the part of the drinking water consumed and returned to the sewer.

The assumed rate of connection to the sewer line is 80% for the town of Azemmour and 70% for the center of Sidi Ali. The assumed output of the network is 72%.

The discharge rate to the sewer (Tres) is calculated from the following formula:

$$T_{res} = \frac{Q_{avg\ WW}}{T_{rac} . V_{cons}}$$

Q_{avgWW} :Average wastewater flow
V_{cons} : Consumed volume of drinking water, with
Trac: Rate of connection to the waste water network

The consumed volume is calculated from the volume distributed using the following equation:

$$V_{cons} = \eta_{res} \times V_{dist}$$

η_{res}: output of the drinkable water supply network
Vdist: distributed volume of drinking water

The results of calculations of the rate of return to the sewer of the town of Azemmour and the center of Sidi Ali are reported on the table below for the dates of the 14/12/03 to the 18/12/03.

	14/12/03	**15/12/03**	**16/12/03**	**17/12/03**	**18/12/03**
Average volume distributed of drinking water (m3/d)	3452	3108	2976	3050	2580
Average volume consummed (m3/d)	2485	2238	2143	2196	1858
Waste of average daily waste water of Azemmour (m3/d)	2170	1560	1882	1624	2139
Waste rate to the sewer	1.09	0.87	1.09	0.92	1.44

The return rate thus calculated for the town of Azemmour is very large and exceeds the usual rate, which lay in the range 0.6 – 0.8.

For the rest of this the study we will use the value of 0.80.

In addition, it should be noted that we do not have data of drinking water consumption specific to the center of Sidi Ali. We therefore cannot determine the wastewater return rate corresponding to Sidi Ali. We will retain for this study for the center of Sidi Ali the same rate as that of Azemmour.

1.9.2.2.4 Qualitative results of domestic pollution

Presented below is a summary of the qualitative results of the composite samples (C24) and specific samples (C2) for the town of Azemmour and center of Sidi Ali..

A- Results of the Town of Azemmour:

1- Presentation of the Results of the composite samples:

Table 1.31: Results of qualitative measurements of the principal wastes of Azemmour

Parameters	Unit	24 hours composite sample - principal wastes of Azemmour-					Usual ranges (documents SDNAL And/or ONEP/GTZ)
		14/12/2003	15/12/2003	16/12/2003	17/12/2003	18/12/2003	
MES totals	mg/L	420	370	340	420	380	250 - 500
MVS totals	mg/L	350	340	270	350	300	-
MVS/MES	%	83	91	79	83	79	70
Gross BOD_5	mg 02/L	560	580	480	540	540	200 - 400
MES/BOD_5	-	0.75	0.64	0.71	0.78	0.71	1.2 - 1.5
Gross COD	mg 02/L	1200	1200	1100	1100	1200	500 - 800
Gross COD / BOD_5	-	2.1	2.1	2.3	2.0	2.2	2 -2.5
Ammonium (NH4)	mg N/L	96.8	96.8	115	114	99.6	-
Azote Kjeldahl (NTK)	mg N/L	121	132	142	139	126	40 - 80
NH4/NTK	%	80	73	81	82	79	40 - 60
Phosphore total (Ptot)	mg P/L	26	25	26	25	30	8 - 16
BOD_5 /N/P	-	100/22/5	100/23/4	100/30/5	100/26/5	100/23/5	100/30/5

2- Presentation the specific samples results:

The results of the specific samples (C2) for the discharges of Azemmour are present below with the min and max values of the parameters measured during the dates of the 16 and 17/12/03 for the town of Azemmour.

	16/12/03		**17/12/03**	
	Minimum	**Maximum**	**Minimum**	**Maximum**
BOD_5 (mg/l)	280	890	270	830
COD (mg/l)	610	2000	580	1700
MES (mg/l)	110	480	80	750
Azote Kjeldahl NTK (mg/l)	104	253	113	253
Ammonium NH4 (mg/l)	81,1	198	84	215
Phosphore total Pt (mg/l)	8,5	31	18	33

3- Interpretation of the composite samples results of the town of Azemmour:

- **BOD and COD**:

The results recorded for the composite samples of the BOD_5 (480 to 580 mg/l) and of the COD (1100 to 1200 mg/l) exceed the usual ranges of an average size agglomeration. The ratio of the COD/BOD_5 which remains almost constant and is equal to 2, shows that the pollution is easily biodegradable. This is due to the fact that the wastewater of the town of Azemmour is predominantly of domestic type.

- **TSS:**

The values recorded for TSS vary from 340 to 420 mg/l falling under the usual range of the towns of average size. The ratio MES/BOD_5 which represents the natural decantation, presents values varying from 0,6 to 0,8. These values are lower than the usual values, which could be explained by the effect of the natural decantation in the sewer network.

- **Nitrogen and Phosphorus:**

Ratios BOD_5/NTK and BOD_5/PT present values in conformity with the ratios recommended by the documents of the SDNAL.

- **Metals:**

For the metals, the results obtained on the two urban discharges (Azemmour and Sidi Ali) are lower than the limits required for biological treatments, except for mercury at the outfall of Azemmour.

- **Bacteriological analyses:**

The analyses carried out for the fecal contamination led to the following results:

 - Coliformes thermotolérents in NPP/100 ml: >$1,0 \times 10^8$
 - Streptocoques fecal in NPP/100 ml: 1,4 with $3,5 \times 10^7$

B - Results for the center of Sidi Ali:

1 - Presentation of the Results of the composite samples:

The results of the composite samples of wastewater discharge from Sidi Ali taken during the dates of the 11, 12 and 13/12/03, are summarized on the table below:

2- Presentation the specific samples results:

The results of the specific samples (C2) for the discharges of Azemmour are present below with the min and max values of the parameters measured during the dates of the 16 and 17/12/03 for the town of Azemmour.

	16/12/03		**17/12/03**	
	Minimum	**Maximum**	**Minimum**	**Maximum**
BOD_5 (mg/l)	280	890	270	830
COD (mg/l)	610	2000	580	1700
MES (mg/l)	110	480	80	750
Azote Kjeldahl NTK (mg/l)	104	253	113	253
Ammonium NH4 (mg/l)	81,1	198	84	215
Phosphore total Pt (mg/l)	8,5	31	18	33

3- Interpretation of the composite samples results of the town of Azemmour:

- **BOD and COD**:

The results recorded for the composite samples of the BOD5 (480 to 580 mg/l) and of the COD (1100 to 1200 mg/l) exceed the usual ranges of an average size agglomeration. The ratio of the COD/BOD5 which remains almost constant and is equal to 2, shows that the pollution is easily biodegradable. This is due to the fact that the wastewater of the town of Azemmour is predominantly of domestic type.

- **TSS:**

The values recorded for TSS vary from 340 to 420 mg/l falling under the usual range of the towns of average size. The ratio MES/BOD_5 which represents the natural decantation, presents values varying from 0,6 to 0,8. These values are lower than the usual values, which could be explained by the effect of the natural decantation in the sewer network.

- **Nitrogen and Phosphorus:**

Ratios BOD_5/NTK and BOD_5/PT present values in conformity with the ratios recommended by the documents of the SDNAL.

- **Metals:**

For the metals, the results obtained on the two urban discharges (Azemmour and Sidi Ali) are lower than the limits required for biological treatments, except for mercury at the outfall of Azemmour.

- **Bacteriological analyses:**

The analyses carried out for the fecal contamination led to the following results:

  - Coliformes thermotolérents in NPP/100 ml: >1,0x10^8
  - Streptocoques fecal in NPP/100 ml: 1,4 with 3,5x10^7

B - Results for the center of Sidi Ali:

1 - Presentation of the Results of the composite samples:

The results of the composite samples of wastewater discharge from Sidi Ali taken during the dates of the 11, 12 and 13/12/03, are summarized on the table below:

Parameters	Unit	24 hours composite sample - Sidi Ali-wastewater			Normal range (documents SDNAI And/or ONEP/GTZ)
		11/12/2003	12/12/2003	13/12/2003	
TSS totals	mg/L	180	120	230	250 - 500
MVS totals	mg/L	130	54	170	-
MVS/MES	%	72	45	74	70
BOD_5 Gross	mg 02/L	180	200	290	200 - 400
TSS/DBO_5	-	1	0.6	0.8	1.2 - 1.5
COD Gross	mg 02/L	580	660	630	500 - 800
COD / BOD_5 Gross	-	3.2	3.3	2.2	2 -2.5
Ammonium (NH4)	mg N/L	87.3	72.9	75.9	-
Nitrogen Kjeldahl (NTK)	mg N/L	89.5	139	102	40 - 80
NH4/NTK	%	97	52	74	40 - 60
Phosphore total	mg P/L	14	19	12	8 - 16
BOD_5/N/P	-	100/49/8	100/69/9	100/35/4	100/30/5

2 - Results of the specific samples:

Presented below are the min and max values of the parameters measured during the dates of the 12 and 13/12/03 for the center of Sidi Ali:

	12/12/03		**13/12/03**	
	Minimum	**Maximum**	**Minimum**	**Maximum**
BOD_5 (mg/l)	120	400	90	290
COD (mg/l)	300	860	270	840
MES (mg/l)	55	300	50	330
Azote Kjeldahl NTK (mg/l)	52,1	122	52	140
Ammonium NH4 (mg/l)	45,8	100	46,7	116
Phosphore total Pt (mg/l)	9	22	9,5	24

3- Interpretation of the results of the composite samples:

- **BOD_5 and COD:**

The measured values of the BOD_5 vary from 180 to 290 mg/l. They are lower than those which are measured on the main outfall of the town of Azemmour. The values measured for the COD vary from 580 to 660 mg/l, these values lay in the usual range (500 - 800 mg/l according to the SDNAL). The ratio COD/BOD_5 (2,2 to 3,3) is higher than the usual values (2 - 2,5).

- **TSS**:

The results of TSS vary from 120 to 230 mg/l. These values are lower than the current range (250 - 500 mg/l). The ratio TSS/DBO5 varies from 0,6 to 1 and is lower than the usual values (1,2 - 1,5). These values are explained by the effect of the natural decantation in the network.

- **Nitrogen Kjeldahl and Phosphore:**

The ratios BOD_5/NTK and BOD_5/Pt are higher than the usual values, which are respectively 4 to 5, and 25 to 30.

- **Bacteriological analyses:**

The results of the bacteriological analyses for the center of Sidi Ali are: Coliformes thermotolérents in NPP/100 ml: 2,8 X 106; Streptocoques fecal in NPP/100 ml: 5 x106

1.9.2.2.5 Qualitative results of industrial pollution:

1- Results from the slaughterhouses and SOVEM:

Table 1.32: Results of qualitative measurements of the industrial wastes

Parameters	Unit	Composite sample Waste of the slaughter-houses		Composite sample – SOVEM wastes -	
		08/12/2003	09/12/2003	08/12/2003	09/12/2003
MES totals	mg/L	690	1600	540	740
MVS totals	mg/L	630	1200	490	680
MVS/MES	%	91	75	91	92
Gross BOD_5	mg 02/L	5000	4500	5000	1900
MES/BOD_5	-	0.69	0.36	0.1	0.4
Gross COD	mg 02/L	10000	13000	9600	3600
Gross COD / BOD_5	-	2	2.9	1.9	1.9
Oils & greases	mg /L	18.3	110	-	-

2- Interpretations of the results of the industrial composite samples:

- **BOD_5 and COD:**

The wastewater rejected by the slaughterhouses and industry SOVEM is very concentrated in organic matter. Indeed, the BOD_5 is 4500 to 5000 mg/l for the slaughterhouses and is 1900 to 5000 for SOVEM. With regard to the COD the measured values are 10 000 to 13 000 mg/l for the slaughterhouses and is 3 600 to 9 600 mg/l for the SOVEM. The ratio COD/BOD_5 varies from 2 to 2,9. It remains in the range of the biodegradable wastes, which is natural for the agro wastes.

- **TSS:**

The measured values are 690 to 1600 mg/l for the slaughterhouses and 540 to 740 mg/l for the SOVEM. The ratio MVS/MES borders the 90% indicating that the suspended matter of the discharge from the slaughterhouses and the SOVEM is mainly of origin organic.

- **Oils and greases:**

  For the discharge from the slaughterhouses, the concentrations of oils and greases know an important increase during the day of the weekly souk (Tuesday).

- **Metals:**

  Important concentrations of mercury are found in the discharge from SOVEM.

Hospital Sidi Layachi:

The results of the wastewater analysis of the hospital Sidi Layachi show that the discharge of this hospital does not present a particular pollution. The quality of discharged water is identical to that of domestic wastewater.

1.9.3 Wastewater pollution load estimate

1.9.3.1 Parameters of wastewater pollution load estimate

1- Parameters retained for the town of Azemmour:

Based on the results presented above, we calculated the loads of BOD_5, COD, MY, NTK Pt and CT, by taking into account the flows and concentrations measured punctually (each 2 hours) for these parameters;

$$Xp = (Somme\ (Xi\ .\ Qi))/(Somme\ (Qi))$$

Xp: Average concentration, weighed, of parameter
Xi: Specific concentration of the parameter in period i
Qi: Specific flow in period i:

These calculations were carried out for the days of the 16/12/03 and 17/12/03 for Azemmour. The computation results of the average concentrations for the town of Azemmour are presented on the table below:

Table 1.33: Average concentration for Azemmour

	16/12/03	17/12/03	Moyenne
BOD_5 (mg/l)	639	627	633
COD (mg/l)	1355	1301	1328
MES (mg/l)	403	454	429
NTK (mg/l)	151	161	156
Pt (mg/l)	26	28	27

A similar calculation was performed with the results of the composite samples. We find values of lower average concentrations (BOD_5: 541 mg/l, COD: 1160 mg/l, MES: 387 mg/l, NTK: 132 mg/l, Pt: 26 mg/l) to those calculated for the specific samples.

Taking into account these results, and since the composite samples were proportionally made up with the flow, the values of the concentrations retained for Azemmour are those of the daily weighed average, which is:

- BOD_5: 540 mg/l
- COD: 1160 mg/l
- MY: 400 mg/l
- NTK: 130 mg/l
- Pt: 26 mg/l

These concentrations lead to the design values presented in the table below. These values are compared with those which are proposed by the SDNAL for a population ranging between 20 000 and 100 000 inhabitants.

	SDNAL Pop Ratios: 20 000 – 100 000	Calculated Ratios
BOD_5 (g/hab/j)	32	36
COD (g/hab/j)	60	77
TSS (g/hab/j)	42	26
NTK (g/hab/j)	9	9
Pt (g/hab/j)	1,5	1,7

The values of the ratios proposed by the SDNAL are comparable with those, which are calculated, in the present study for the BOD_5, NTK and Pt. For the value of the ratio of TSS, it is lower than that of the SDNAL (calculated 26 g/hab/day, SDNAL: 42 g/hab/day). On the other hand the calculated ratio of the COD exceeds that of the SDNAL.

For the future ratios, we will keep the assumption of the SDNAL which consists in making the change of the ratios of polluting flows of the BOD_5 to take into account of the improvement of the standard of living. This increase will be 0,5% per annum (40 g/hab/day in 2025). In addition, we propose to increase the ratio of TSS at a rate of 0,5% per year because of its important variation compared to the ratio of the SDNAL. The value considered for 2025 is of 29 g/hab/day. The other ratios will be maintained constant. The values to be retained for the future horizons are reproduced on the table below:

	2003	2005	2010	2015	2020	2025
BOD_5(g/hab/d)	36	36	37	38	39	40
COD (g/hab/d)	77	77	77	77	77	77
MES (g/hab/d)	26	26	27	28	28	29
NTK (g/hab/d)	9	9	9	9	9	9
Pt (g/hab/d)	1,7	1,7	1,7	1,7	1,7	1,7

2 - Parameters retained for Sidi Ali:

On the basis of their interpretation and preceding result, the average concentrations calculated on the basis of specific result of wastewater of the center of Sidi Ali are:

	12/12/2003	13/12/2003	Average
BOD_5 base (mg d'O_2/L)	259	236	248
COD brute (mg d'O_2/L)	642	654	648
MES totales (mg/L)	187	237	212
Azote Kjeldahl (mg of N/L)	92	105	99
Phosphore total (mg of P/L)	17	18	18

The values retained for the concentrations of Sidi Ali are:

- BOD_5 : 250 mg/l
- COD : 650 mg/l
- MES : 220 mg/l
- NTK : 100 mg/l
- PT : 18 mg/l

These concentrations are used for the calculation of the ratios of Sidi Ali which are presented on the table below which contains also the ratios of the SDNAL in the case of a population lower than 20 000 inhabitants.

	SDNAL Ratios for Population < 20 000 inhabitants	calculated Ratios
BOD_5 (g/hab/d)	28	15
COD (g/hab/d)	50	39
MES (g/hab/d)	38	13
NTK (g/hab/d)	9	6
Pt (g/hab/d)	1,5	1,1

The values of the ratios calculated are lower than those which are proposed by the SDNAL.

For the future horizons, we will retain an evolution of 1% per annum for all the ratios presented on the table above. The ratios to be adopted for the future horizons are on the table given below.

	2003	2005	2010	2015	2020	2025
BOD_5 (g/hab/d)	15	15	16	17	18	19
COD (g/hab/d)	39	40	42	44	46	48
MES (g/hab/d)	13	13	14	15	15	16
NTK (g/hab/d)	6	6	6	7	7	7
Pt (g/hab/d)	1,1	1,1	1,2	1,2	1,3	1,4

3- Industrial Parameters selected:

- **Parameters of the slaughterhouses and SOVEM:**

On the basis of the preceding results and their interpretation, the concentrations of the slaughterhouses of SOVEM factory are:

	BOD_5	DCO	MES	Oils and greases	NTK	NH4	PT
Slaughter-houses	4700	11000	1100	80	-	-	22
SOVEM	3500	7000	640	-	30	25	10

It is assumed that industrial wastewater will be pretreated at each production facility before their discharge in the sewer network of the town of Azemmour.

The concentrations of the industrial polluting loads to use within the framework of this study are selected following a comparison between the concentrations suggested in the framework of the SDNAL and the concentrations of the draft standard of the indirect wastes.

A summary of these concentrations is presented on the table below:

	SDNAL	**Draft standard indirect discharge**
BOD_5 (mg/l)	800	500
COD (mg/l)	2000	2000
MES (mg/l)	600	600
NTK (mg/l)	150	100
Pt (mg/l)	50	10

A comparison of the concentrations, which are reproduced on the table above, shows that the concentrations of the draft standard of the indirect discharge are lower than those of the SDNAL. The concentrations, which will be adopted in the calculation of the industrial polluting loads, are the values suggested by the Moroccan draft standard of the indirect discharge.

4- Parameters retained for the tourist zone:

Because of the lack of data on wastewater characterization of wastewater of the tourist zone, for the calculation of the polluting loads, we will retain the parameters of domestic wastewater of the usual range proposed by the SDNAL and which is given below. The concentrations retained for the tourist zone are lower than those of the town of Azemmour because wastewater of the zone is regarded as being diluted than domestic water of this city.

- BOD_5 : 300 mg/l
- COD : 600 mg/l
- MES : 300 mg/l
- NTK : 60 mg/l
- Pt : 12 mg/l

1.9.3.2 Domestic wastewater pollution loads

- **Calculation of the load and the concentration of domestic and administrative pollution:**

The load is given by the following formulate

$$C_x = Pbr \times d_x \times T_{rac}$$

Cx: Pollution load (X = BOD_5 gold COD or TSS), Kg/j
Pbr: Population connected with the potable water supply network, hab
dx: Ratio (X = BOD5 or COD or TSS MY), g/hab/j
T_{rac}: Connection rate to the sewer network

Consequently, the concentration in pollution, expressed in mg/l, will be calculated by dividing the pollution load (Kg/j) by the flow arriving at the treatment plant.

The results of the domestic pollution loads for Azemmour and Sidi Ali are summarized in the tables below.

Table 1.34: Domestic polluting loads (Azemmour and Sidi Ali)

		2003	2005	2010	2015	2020	2025
BOD_5 (Kg/d)	Azemmour	1062	1144	1360	1634	1976	2183
	Sidi Ali	34	37	47	62	78	95
	Total	1096	1181	1407	1696	2054	2278
COD (Kg/d)	Azemmour	2271	2448	2831	3312	3902	4203
	Sidi Ali	89	100	125	159	199	241
	Total	2360	2548	2956	3471	4101	4444
MES (Kg/d)	Azemmour	767	826	993	1204	1419	1583
	Sidi Ali	30	32	42	54	65	80
	Total	797	858	1035	1258	1484	1663
NTK (Kg/d)	Azemmour	265	296	331	387	456	491
	Sidi Ali	14	15	18	25	30	35
	Total	279	301	349	412	486	526
PT (Kg/d)	Azemmour	50	54	63	73	86	93
	Sidi Ali	3	3	4	4	6	7
	Total	53	57	67	77	92	100

1.9.3.3 Industrial wastewater pollution loads

It is assumed that all industries will pre-treat their raw wastewaters before its discharge in the sewer network and that they respect the above mentioned limits of concentration in pollution. The polluting load will be calculated by multiplying discharge limit by the flow of industrial wastewater. The results are summarized on the tables below.

Table 1.35: Industrial polluting loads (Azemmour and Sidi Ali)

		2003	**2005**	**2010**	**2015**	**2020**	**2025**
BOD_5 (Kg/d)	Azemmour	159	165	182	199	218	235
	Sidi Ali	7	7	8	9	10	11
	Total	**166**	**172**	**190**	**208**	**228**	**246**
COD (Kg/d)	Azemmour	634	660	729	796	871	938
	Sidi Ali	28	29	33	38	42	46
	Total	**662**	**689**	**762**	**834**	**913**	**984**
MES (Kg/d)	Azemmour	190	198	219	239	261	281
	Sidi Ali	8	9	10	11	12	14
	Total	**198**	**207**	**229**	**250**	**273**	**295**
NTK (Kg/d)	Azemmour	32	33	36	40	44	47
	Sidi Ali	1	1	2	2	2	2
	Total	**33**	**34**	**38**	**42**	**46**	**49**
PT (Kg/d)	Azemmour	3	3	4	4	4	5
	Sidi Ali	0,1	0,1	0,2	0,2	0,2	0,2
	Total	**3**	**3**	**4**	**4**	**4**	**5**

1.9.3.4 Wastewater pollution loads from the tourist zone

The polluting loads of the tourist zone are calculated based on the assumptions presented above. A summary of the results of these pollution loads is given below:

Table 1.36: Pollution loads from the tourist zone of Mazagan

	2005	2010	2015	2020	2025
BOD5 (Kg/d)	304	540	540	540	540
COD (kg/d)	608	1081	1081	1081	1081
MES (Kg/d)	304	540	540	540	540
NTK (Kg/d)	61	108	108	108	108
Pt (Kg/d)	12	22	22	22	22

1.9.3.5 Summary of the wastewater pollution load

The tables hereafter summarize calculations of the polluting loads for the two stations of purification (Azemmour and Sidi Ali):

Table 1.37: summary of the wastewater pollution load

		2003	2005	2010	2015	2020	2025
BOD5 (Kg/d)	Domestique	1096	1182	1408	1696	2054	2279
	Industriel	166	172	190	208	228	246
	Touriste t	-	304	540	540	540	540
	Total	**1262**	**1658**	**2134**	**2444**	**2822**	**3065**
COD (Kg/d)	Domestique	2360	2547	2956	3471	4101	4444
	Industriel	662	689	762	834	913	984
	Touriste	-	608	1081	1081	1081	1081
	Total	**3022**	**3844**	**4799**	**5386**	**6095**	**6509**
MES (Kg/d)	Domestique	796	859	1034	1259	1484	1663
	Industriel	198	207	229	250	273	295
	Touriste	-	304	540	540	540	540
	Total	**994**	**1370**	**1803**	**2049**	**2297**	**2498**
NTK (Kg/j)	Domestique	279	301	349	412	486	526
	Industriel	33	34	38	42	46	49
	Touriste	-	61	108	108	108	108
	Total	**312**	**396**	**495**	**562**	**640**	**683**
PT (Kg/d)	Domestique	53	57	66	77	92	100
	Industriel	3	3	4	4	4	5
	Touriste	-	12	22	22	22	22
	Total	**56**	**72**	**92**	**103**	**118**	**127**

1.10 DESIGN CRITERIA FOR THE TREATMENT SYSTEM

1.10.1 Horizon of design

The horizon of design of the wastewater treatment plant for the town of Azemmour is 2025.

1.10.2 Standards and qualitative goals for the treatment

The level of wastewater treatment is a function of objectives of treatment and the desired degree of protection of public health and the environment.

In order to guarantee the protection of the public health and to ensure the protection of surface water, it is essential to set up standards and regulations based on the specific use of the treated effluent such as: re-use in agriculture, protection of the groundwater and other water resources. We will use in this study the recommendations and standards of the WHO (1989), those of the ONEP and those of the Moroccan draft standard.

The main objective is to eliminate the health risks. The countries of North Africa in general follow the European Standards. These standards are as follows:

- $BOD_5 \leq 30$ mg/l on average over 24 hour (40 mg/l maximum acceptable)
- COD $\leq$ 90 mg/l on average over 24 hour (120 mg/l maximum acceptable)
- TSS $\leq$ 35 mg/l

In the event of a re-use in irrigation without restriction (Category A of treatment: raw cultures consumed) according to OMS, the standards are:

- Number of coliformes fecal (CF) <1000 CF / 100ml
- Number of Egg of helminthe <1 Egg / l.

For zones that are sensitive to the eutrophisation, discharges have to meet also the following requirements:

- The content of total phosphorus $\leq$1 mg / l.
- The content of total nitrogen $\leq$ 10 mg / l for a temperature of the water to be treated in the upper or equal to 12°C.

1.10.3 Design flows and loads

The design loads and flows for 2025 are presented below:

Parameters	STEP – Azemmour	STEP – Sidi Ali	STEP- Site touristique Mazagan
- **Daily medium flow m3/day**	3917	303	1801
- **pollution Loads, Kg/day**			
o **DBO5**	2418	106	540
o **DCO**	5141	287	1081
o **TSS**	1864	94	540
- **Concentrations of pollution, mg/l**			
o **DBO5**	617	353	300
o **DCO**	1312	346	600
o **TSS**	476	318	300

1.11 SITE SELECTION FOR THE WASTEWATER TREATMENT PLANT

The sites selected in the 1999 study by Guigues Morocco, for the proposed wastewater treatment plants, are the same as those proposed by the SDAL. They include the left bank of the river for the town of Azemmour and right bank of the river for the center of Sidi Ali. GESI and the study committee visited these sites in November 2003, to check their potential. In addition, another site located near the tourist zone of Mazagan was also visited. Therefore the potential sites for the treatment are:

- **Site 1**: is located out on left bank of the Wadi Oum Errabia close to the existing wastewater outfall of the town of Azemmour
- **Site 2**: is out on right bank of the Wadi Oum Errabia close to the Layachi hospital. The site is currently cultivated.
- **Site 3**: new site close to the future tourist zone of Haouzia.

The advantages and the disadvantages of these sites are summarized on the table below:

Sites	Avantages	Inconvénients
Site 1	Proximity of the main wastewater discharge of the town of Azemmour - public land, easy acquisition - No need to cross the river	Hilly site Requires excavation Possible Odor (proximity of the city)
Site 2	Flat land and bare soil (no trees) - does not require the pumping of wastewater of Sidi Ali	Requires 2 crossings of the River – Private land, extra cost of acquisition – Far from the zone of re-use
Site 3	Close to the zone of re-use – Public land (forest) – Does not require a crossing of the river	Hilly site – Requires excavations Absence of infrastructure – Cost of important pumping - Near tourist complex (problems of the odors)

The site recommended for the future treatment plant for the town of Azemmour is site 1. The main reasons of this choice are:

- Low cost of acquisition
- Multiple use of the site (treatment plant, park, lake.....)

The choice of this site will be developed in the next Task of this study. In addition, GESI proposes to build only one treatment plant for the towns of Azemmour and Sidi Ali. GESI proposes also pretreatment of the industrial effluents before their discharge into the sewer network.

SECTION 2: IDENTIFICATION OF TREATMENT AND REUSE ALTERNATIVES

TABLE OF CONTENT

The purpose of this Task is to identify and screen potential applicable wastewater treatment and reuse alternatives. The results of this Task will identify recommended alternatives to be given more detailed evaluation.

2.1 APPLICABLE WASTEWATER TREATMENT TECHNOLOGIES

There are wide ranges of proven wastewater treatment and reuse technologies that have been applied across the industry. The options are typical broken down into the following wastewater treatment and/or sludge processing steps:

- Wastewater Treatment:
  - Preliminary Treatment
  - Primary Treatment
  - Secondary Treatment
  - Natural Treatment
  - Advanced Treatment
  - Disinfection
  - Effluent Disposal and Reuse
- Sludge Processing and Disposal:
  - Thickening
  - Stabilization
  - Dewatering
  - Disposal/Reuse

Based on MWH's past experience, the following wastewater/sludge treatment and reuse technologies are generally deemed appropriate for the Azemmour situation:

- Wastewater Treatment:
  - Preliminary Treatment:
    - Influent Sampling
    - Metering
    - Influent Pumping
    - Screening
    - Grit Removal
  - Primary Treatment:
    - None
    - Rectangular Clarifiers
    - Circular Clarifiers

- Secondary Treatment:
  - Biological Filters
  - Conventional Activated Sludge
  - Oxidation Ditch
  - Sequential Batch Reactor (SBR)
  - Lagoons
- Natural Treatment:
  - Land Application
  - Wetlands
- Advanced Treatment:
  - Biological Nutrient Removal
  - Filtration
- Disinfection:
  - Chlorination/Dechlorination
  - Ozonation
  - Ultraviolet Radiation
- Effluent Disposal and Reuse:
  - Direct Discharge
  - Reuse
    - Agricultural & Irrigation
    - Industrial
    - Recreational
- Sludge Processing and Disposal:
- Thickening:
  - Gravity Thickener
  - Gravity Belt Thickener
  - Centrifugal Thickening
- Stabilization:
  - Aerobic Digestion
  - Anaerobic Digestion
  - Lime Stabilization
  - Composting
- Dewatering:
  - Drying Beds
  - Belt Filter Press
  - Centrifuge
- Disposal/Reuse:
  - Landfill
  - Land Application
  - Land Reclamation

2.2 TECHNOLOGY DESCRIPTION

The following discussion further describes the applicable wastewater treatment/reuse and sludge processing/disposal technologies identified above. This description will aid in the subsequent screening to select the most viable technologies for further evaluation.

2.2.1 Wastewater Treatment

The overall purpose of wastewater treatment is to reduce the levels of organics, solids and pathogenic organisms present in wastewater prior to retuning it back to the environment. Additional, in some cases, some of the wastewater nutrients are removed before discharge. As previously noted, the treatment is typically accomplished through a series of treatment steps.

2.2.1.1 Preliminary Treatment

The primary purpose of the preliminary treatment step is the removal of materials from the waste stream that could interfere or damage subsequent treatment operations of processes. Additional, this step is used to monitor and characterize the influent wastewater flow and strength.

2.2.1.1.1 Influent Sampling and Metering

The purpose of the influent sampling and metering step is to monitor and characterize the raw influent wastewater. The specific type of metering and sampling equipment used is a function of the final design details of the planned system and therefore beyond the scope of this feasibility study. However, the necessary facilities should be incorporated into any proposed treatment system and properly configured to monitor only the influent raw wastewater prior to the reintroduction and any in-plant return flows.

2.2.1.1.2 Influent Pumping

In most instances where wastewater is received at the site of the wastewater treatment plant under gravity flow conditions an influent wastewater pumping system is required to lift the flow up to allow gravity flow through the treatment plant. This situation applies to all sites under consideration for this project and therefore influent pumping would be required as one of the initial treatment steps for all systems considered. There are many different types of pumping systems used for a raw wastewater application, including conventional wet well/dry well installations and submersible pumping systems. Selection of a specific type of pumping system is premature however at this point in the wastewater treatment system selection process.

2.2.1.1.3 Screening

Screening is employed to remove larger materials and debris, such as rocks, sticks, rags, etc., from the raw wastewater so they do not damage or interfere with subsequent treatment systems. In most cases, a combination of manual and mechanical screens is installed and this would be the recommendation for the Azemmour facility. There are many different types of mechanical bar screens available in the market and selection of a specific type is beyond the scope of this feasibility study.

2.2.1.1.4 Grit Removal

Grit removal unit operations are installed to remove heavier solid material such as sand so that it does not settle out in unwanted locations of the treatment plant or cause excessive wear on rotating mechanical equipment. There are three generally used grit systems:

- Gravity systems
- Aerated systems
- Vortex systems

Vortex grit removal systems are becoming the most popular in the industry over the other two common systems for the following reasons:

1. Most effective grit removal system;
2. Lower space requirements than other two systems; and
3. Fewer appurtenant systems than the aerated system.

For the above reasons, a vortex type system is the recommended grit removal system for any of the proposed overall wastewater treatment systems evaluated for Azemmour.

2.2.1.2 Primary Treatment

The purpose for primary treatment is to remove settable solids from the wastewater. Additionally, a small percentage of the organic material is removed as well during the operation. This treatment step can be used as the only step in treatment (where effluent treatment goals allow) or as the upstream operation preceding most secondary treatment processes. However, it is not required to precede all secondary treatment processes.

Primary treatment is most commonly accomplished through the use of sedimentation tanks and therefore other approaches will not be considered for this application. The sedimentation tanks can either be rectangular or circular. While circular tanks generally take up more land than rectangular, they remain the preferred choice by many engineers since they tend to be a little more effective and eliminate the need for chain driven sludge collectors, which can become a maintenance issue. Therefore, for purposes of this study, it is assumed that circular primary clarifiers will be used for those treatment trains requiring primary treatment.

All primary clarification systems generate significant amounts of primary sludge, which is part of the purpose of this treatment step. However, primary sludge needs substantial further processing to make it stable and can result in significant odor problems.

2.2.1.3 Secondary Treatment

The secondary treatment step is where the majority of organic material in the wastewater is removed and this step is normally considered the heart of the wastewater treatment system. There are many secondary treatment process options available, but the following are judged to be the most applicable to the Azemmour situation:

- Biological Filters
- Conventional Activated Sludge
- Oxidation Ditch
- Sequential Batch Reactors
- Lagoons

It should be noted that, with the exception of the sequential batch reactor and lagoon systems, all of the above secondary treatment processes require the installation of secondary clarifiers and their associated return and waste activated sludge handling systems. Each of these process options is further discussed below.

2.2.1.3.1 Biological Filters

A biological filter is the most common form of the aerobic fixed growth treatment process. The filter media can consist of either rock or various forms of plastic media. Biological filters can achieve excellent effluent quality and generally have lower operation and maintenance (O&M) requirements than an activated sludge system. However, they are not as easily upgraded to allow biological nutrient removal as is an activated sludge system and they may require more land and additional pumping of the wastewater. Additionally, primary treatment upstream of the filters is a requirement.

2.2.1.3.2 Conventional Activated Sludge

Conventional activated sludge is the most commonly used suspended growth secondary treatment process, especially for larger wastewater treatment installations. There are many process variations available and all can achieve a very high effluent quality. This process is also very amenable to being upgraded to achieve biological nutrient removal should effluent discharge requirements so require this level of treatment. On the downside, these types of systems can be rather expensive to construction and are more sophisticated to operate and maintain. The also normally require primary treatment upstream of the aeration basins.

2.2.1.3.3 Oxidation Ditch

The oxidation ditch is a variation of the conventional activated sludge treatment system. These have found most applicability to smaller size facilities such as that anticipated for Azemmour. Most oxidation ditch treatment systems do not employ primary treatment upstream of the ditch and are simpler and more flexible to operate and maintain than a conventional activated sludge system due to its larger aeration basins. They can however take up more land than a conventional activated sludge system, but this land requirement is generally offset in those cases where primary treatment is not installed as part of the oxidation ditch system. A final advantage of this system over other suspended growth biological systems is that it produces lower quantities and a nearly fully stabilized waste sludge due to its long solids retention time in the ditch. Since no primaries are generally used as part of the overall process, the use of an oxidation ditch also eliminates the generation of primary sludge.

2.2.1.3.4 Sequential Batch Reactor

The sequential batch reactor (SBR) is also a form of the suspended growth activated sludge process. Like the oxidation ditch system, primary treatment is normally not used upstream of the SBR reactor. However, unlike the oxidation ditch, this is a batch process rather than a continuous flow through process as is the case for almost all other secondary treatment processes. As a result of this fact, SBRs have traditionally been used for small installations, although several large-scale installations have been constructed and are working quite successfully. The SBR are relatively simple to operate and maintain and have been shown to be flexible and robust. However, given that they are a batch type process, they are sensitive to wide flow variations as may be the case in Azemmour given that combined sewers serve portions of the collection system. The resulting waste sludge is also not as well stabilized as that from an oxidation ditch system and there will be higher quantities of the waste sludge.

2.2.1.3.5 Lagoons

Lagoons are also a form of the suspended growth activated sludge process. Given their extensive land requirements, they have traditionally been mainly used in small more rural settings where land is readily available. A lagoon system has probably the lowest O&M costs of any secondary treatment system; however the quality of the final effluent is not as high as with the other secondary treatment processes under consideration. If not properly operated, lagoon systems also are subjected to potentially serious odor problems. Finally, lagoon system are difficult to upgrade to achieve nutrient removal is the need arises.

2.2.1.4 Natural Treatment Systems

As the name implies, these treatment systems rely more on natural process for wastewater treatment. As a result, they generally are low cost, simple biological treatment processes. Potentially applicable systems for Azemmour include:

- Land Application
- Wetlands Systems

Both of these systems are further discussed below.

2.2.1.4.1 Land Application

Land application is a process by which partially treated wastewater is applied to forests or crops to complete the overall treatment process. There are several process options, with the most common being irrigation. In most cases, preliminary, primary and perhaps some level of secondary treatment is first employed before the partially treated wastewater is applied. The end result is a relative simple and low cost treatment system with beneficial reuse of the wastewater. Drawbacks of land application include the need for large amounts of land to store the wastewater during periods when it cannot be applied and the need for large land areas for the physical application. Land application is however a very effective means to treat the wastewater.

2.2.1.4.2 Wetland Systems

Wetlands, either natural or constructed, have been used effectively for wastewater treatment. They have the capability to remove both organic matter and nutrients by biological processes that are similar to those in the activated sludge process. Like lagoons, they require some form of pretreatment of the wastewater before it is discharged into the wetlands for final treatment. Therefore, most installations are used to polish the effluent prior to the beneficial reuse. Many of these installations offer multi-purpose benefits such as wastewater treatment, wildlife refuge and public recreation. One of the main disadvantages of wetland treatment systems is the large land requirements and the level of treatment that can be accomplished.

2.2.1.5 Advanced Treatment

The primary purpose of advanced treatment is to provide higher quality of effluent where treated effluent discharge requirements are very restrictive or the treated effluent is to be reused for very high end uses in developed areas. The common forms of advanced treatment include:

- Biological Nutrient Removal
- Filtration

Biological nutrient removal, as previously discussed, is an extension of biological secondary treatment. It is becoming come today to design suspended growth activated sludge systems to either accomplish biological nutrient removal or to be readily upgraded in the future to do so. At this point in time, there does not appear the need to provide for nutrient removal at the planned Azemmour facility; however it may be prudent to make provisions to add this feature in the future.

Filtration is the unit operation intended to further polish the effluent by further reducing the level of suspended solids. It is similar to the filtration step performed in most potable water treatment systems. As a result, this operation adds O&M complexity to the wastewater treatment facility as well as significant additional construction cost. In the case of Azemmour, final filtration will only be required should one of the final uses of treated effluent be urban irrigation.

2.2.1.6 Disinfection

The purpose of disinfection of the effluent is to further reduce pathogens in the wastewater prior to discharge. The most common disinfection processes include:

- Chlorination (perhaps with dechlorination)
- Ozonation
- Ultraviolet Radiation
- Long Term Storage

Each of these disinfection processes is further discussed below.

2.2.1.6.1 Chlorination/Dechlorination

Chlorination is the most common approach to wastewater disinfection. While the use of chlorine gas is most predominant, other forms of chlorine can be used such as sodium hypochlorite. Chlorination is generally an effective and inexpensive approach to disinfection; however it has several significant drawbacks. The storage and use of chlorine gas, especially near populate areas, has series safety concerns should a leak occur. In addition, the chlorine residual may have toxic impacts on aquatic life or form potentially harmful byproducts in the receiving body of water. To counter this, dechlorination with sulfur dioxide is used, which adds cost and complexity to the overall disinfection system. In the case of reuse of the effluent for irrigation purposes, this latter disadvantage becomes less significant.

2.2.1.6.2 Ozonation

Ozone is an effective disinfectant. While mainly used in the potable water field, ozone has successfully been used for wastewater disinfection. However it is not very common. Ozonation is also very expensive from both a capital and annual O&M cost standpoint as compared to other wastewater disinfection approaches. Its effectiveness in wastewater disinfection is also very sensitive the quality of the treated effluent.

2.2.1.6.3 Ultraviolet Radiation

Ultraviolet (UV) radiation is becoming a popular alternative to the use of chlorination for disinfection of wastewater since it does not have the safety or residual issues associated with chorine. Depending of the quality of the effluent UV (high solids concentrations reduce the transmittance of the UV light), disinfection is very effective and relatively simply to operate. However, it is more expense to install than chlorination and consumes a significant amount of electricity. Overall however, it can be cost competitive. However, the UV lamps need routine replacement and this is expensive.

2.2.1.6.4 Long Term Storage

A very simply approach to disinfection is to store the treated effluent for a long period of time. If the storage basin is shallow as well, the effects of natural UV radiation enhance the disinfection. This is essentially what normally occurs in a lagoon system's maturation pond. The drawbacks of this disinfection approach are obviously the large land requirements. Other than land, it is a very simply and low cost approach.

2.2.1.7 Effluent Disposal/Reuse

The final step in wastewater treatment is the treated effluent disposal and/or reuse. The purpose of this step is to return the treated water back to the environment. Common disposal/reuse options include:

- Direct Discharge to Receiving Body
- Effluent Reuse

Both of these approaches are further discussed below.

2.2.1.7.1 Direct Discharge to Receiving Body

Direct discharge to an adjacent water body is the normal method of treated effluent disposal. In this case the logical receptor would be the Oum Erbia River, which then directly discharges into the Atlantic Ocean. This remains a very acceptable method of disposal and would be a back up option to any reuse scheme proposed.

2.2.1.7.2 Effluent Reuse

Treated effluent reuse is becoming a more common practice, especially where water resources are scare year round or seasonally. Depending on the use and method of application, the effluent may need to be of higher quality than if the effluent was directly discharged into a body of water. Potential reuse options include agricultural irrigation, urban irrigation, industrial reuse or recreational uses. Of these, the irrigation and industrial reuse options are most common. In the case of Azemmour, one very viable opportunity for reuse would be associated with various irrigation uses in the proposed tourist development, including on the planned golf courses and other open green areas.

2.2.2 *Sludge Processing and Disposal*

During the treatment of wastewater, certain residual byproducts are produced. The largest of these residuals is waste sludge. Further processing of this byproduct is normally performed as part of the overall wastewater treatment system to produce a final stable product that is safe for disposal or beneficial reuse. As with the treatment of the liquid portion of the wastewater, this further processing is done in different steps, all of which may not be necessary for every treatment facility.

2.2.2.1 Sludge Thickening

The purpose of sludge thickening is to reduce the liquid volume of the sludge prior to further processing or disposal. The most common unit operations to accomplish thickening include:

- Gravity Thickening
- Gravity Belt Thickening
- Centrifugal Thickening

Each of these thickening options is further discussed below.

2.2.2.1.1 Gravity Thickening

Gravity thickening is accomplished in a tank that is very similar to a primary clarifier. This operation is commonly used on primary sludge or a mixture of primary and waste secondary sludge. It achieves only limited success when thickening only waste activated sludge. It is one of the more costly thickening approaches from a capital cost but has fairly low O&M costs. Since it is mainly used for primary sludge, odor can be a major side effect associated with gravity thickening.

2.2.2.1.2 Gravity Belt Thickening

Gravity belt thickening is becoming a very popular thickening operation. Liquid sludge is applied to the gravity-thickening belt, which is essentially the top portion of the belt filter press dewatering device. It works well on various types of sludge including pure waste activated sludge. Its capital cost is relatively low, but the O&M costs are higher since it is more labor intensive than gravity thickening and requires polymer to condition the sludge prior to thickening. Polymer can be expensive and since it is not commonly used in Morocco, it may be difficult to obtain.

2.2.2.1.3 Centrifugal Thickening

Centrifuges have most successfully been used for waste activated sludge thickening. Unfortunately, they are rather expensive to install and have fairly high O&M costs associated with their power consumption and labor requirements. They may also require the use of polymer to condition the raw sludge, but centrifuge designs are available that do not require polymer under normal operating conditions.

2.2.2.2 Sludge Stabilization

Sludge stabilization is the process whereby the residual sludge is processed to reduce its organic content. The benefits of doing so include:

- Reduces the biological activity of the material prior to disposal;
- Reduces the odor potential of the sludge; and
- Reduces the vector nuisance potential of the sludge during storage or disposal.

The most common approaches to sludge stabilization include the following processes:

- Aerobic Digestion
- Anaerobic Digestion
- Lime Stabilization
- Composting

Each of these processes is further discussed below.

2.2.2.2.1 Aerobic Digestion

Aerobic digestion is a process very similar to the suspended growth activated sludge process whereby liquid waste sludge is retained and mixed and aerated tanks. As a result, the operation is essentially the same as a complete mix activated sludge tank. This process is most suited to smaller facilities. While it produces a well stabilized end product, it can be somewhat expensive in that fairly large tanks are required along with associated aeration equipment. Also, significant electrical power is required for the aeration system. In some cases, such as extended aeration facilities or oxidation ditches, aerobic digestion is already nearly completed in the activated sludge tankage, making additional aerobic very cost-effective.

2.2.2.2.2 Anaerobic Digestion

Anaerobic digestion is a well-proven sludge stabilization option and there are numerous process options available today. It is however very expensive from a construction standpoint. It is also fairly complex to operate and requires close monitoring. As a result, it traditionally has been employed primarily at larger treatment facilities. One advantage is that methane gas is generated during the anaerobic digestion process, which can be used as the fuel to heat the sludge to the temperature required by the process.

2.2.2.2.3 Lime Stabilization

Adding a lime chemical to the sludge to elevate the pH of the material and then holding it for a set period of time can accomplish lime stabilization. Many different forms of lime can be used. This process is has a very low initial construction cost and moderate O&M cost since generally lime is an inexpensive chemical. However, the process needs to be closely monitored to ensure that the material is held at the appropriate pH for the required time.

Also, the high pH stabilized sludge may limit the locations where it can be beneficially reused depending on the natural pH of the land where the sludge is to be applied and the crops to be grown.

2.2.2.2.4 Composting

Composting is becoming an attractive stabilization approach, especially for smaller facilities. It has a relatively low capital and O&M cost associated with it. However, it requires a significant amount of land and can be somewhat labor intensive. The process does produce an excellent final product that has been beneficially used for various purposes.

2.2.2.3 Sludge Dewatering

The purpose of dewatering is to reduce the water content of the sludge prior to disposal. This reduces the volume to be disposed of and the costs associated with the disposal. Dewatering is not used at all facilities. Common dewatering operations include:

- Drying Beds
- Belt Filter Press
- Centrifuge

Each of these dewatering operations is further discussed below.

2.2.2.3.1 Drying Beds

Drying beds are one of the oldest methods used for sludge dewatering. Traditional sand drying beds or paved beds can be used. The resulting dewatered sludge is perhaps the driest of any of the available dewatering operations. While this approach has a moderate construction cost, it does require a large amount of land and therefore has historically been used only for smaller facilities. The operation is also labor intensive and greatly affected by the local climatic conditions, with warm drying climates being the most effective.

2.2.2.3.2 Belt Filter Press

Belt filter pressing dewatering is the most common sludge dewatering approach used where mechanical equipment is employed. It is a very effective dewatering operation on a wide variety of sludge and takes up the least amount of physical space. It has moderate construction and O&M requirements. Its biggest disadvantage is that the operation requires chemical conditioning (generally polymer) of the sludge for it to be effective, which adds cost and complexity to the operation.

2.2.2.3.3 Centrifuge Dewatering

Centrifuges have been used very effectively for sludge dewatering. This mechanical dewatering approach can produce a dryer filter cake than belt filter presses but generally not as dry as drying beds. However, the centrifuge dewatering system is very expensive from capital cost standpoint as well as having a relatively high O&M cost associated with the power and chemical conditioning requirements. The associated equipment also has significant maintenance requirements due to the nature of the material being dewatered.

2.2.2.4 Sludge Disposal/Reuse

The final step in the sludge processing/disposal part of the overall wastewater treatment process is sludge disposal or reuse. The purpose of this step is to safely dispose or beneficially reuse the processed sludge or what is commonly called biosolids at this point in the treatment operation. Disposal or reuse options commonly employed include:

- Landfill
- Land Application
- Land Reclamation

Each of these options is further discussed below.

2.2.2.4.1 Landfill

Disposing of dewatered sludge in a landfill is the most common option for the disposal of sludge. It can be either landfilled separately in a dedicated sludge landfill or co-disposed of with municipal solid waste. This option requires a significant amount of land and precautions need to be taken to avoid the potential contamination of groundwater.

2.2.2.4.2 Land Application

Land application is the most common form of reuse of the processed biosolids. The treated sludge can either be applied in liquid or dewatered form. Sludge has been applied for various agricultural purposes as well as to wooded areas. This reuse approach also requires a significant amount of land, however normally this land is not owned by the treatment plant owner but rather remains the property of the local farmer and an agreement is reached to allow the wastewater treatment plant operator to apply the sludge. This operation is also more labor intensive than landfilling and more monitoring and record keeping is required. Careful site and crop selection is mandatory for proper application to avoid pollution of the adjacent waterways or transferring the sludge to food crops.

2.2.2.4.3 Land Reclamation

Dewatered sludge has successfully been used to reclaim marginal land. One of the most successful uses has been on old strip mining areas. Dewatered sludge has also been used in desert settings to aid in establishing good topsoil.

2.3 TECHNOLOGY SCREENING

Based on the above discussion of the applicable wastewater treatment technologies, the size of the planned Azemmour system and our past experience, the following overall treatment trains are judged to be most viable and were subjected to a further screening:

- Preliminary Treatment:
  - Influent Sampling
  - Influent Metering
  - Influent Pumping
  - Manual & Mechanical Screening
  - Vortex Grit Removal
- Primary Treatment – None Recommended (except if conventional activated sludge is recommended)
- Secondary Treatment:
  - Conventional Activated Sludge
  - Oxidation Ditch
  - Sequential Batch Reactor (SBR)
  - Lagoons
  - Wetlands
- Disinfections:
  - Chlorination/Dechlorination
  - Ultraviolet Radiation
- Effluent Disposal and Reuse:
  - Direct Discharge
  - Agricultural & Irrigation Reuse (with Effluent Filtration)
  - Recreational
- Sludge Thickening:
  - Gravity Thickener
  - Gravity Belt Thickener
- Sludge Stabilization:
  - Aerobic Digestion
  - Composting
- Sludge Dewatering:
  - Drying Beds
  - Belt Filter Press

- Sludge Disposal/Reuse:
  - Landfill
  - Land Application

Where sub-alternatives exist for the viable wastewater/sludge treatment and reuse treatment trains, these sub-alternatives were next screened using a subjective screening process. Factors considered during this screening process included:

- Relative Cost
- Performance
- Sensitivity to raw wastewater characteristics
- Technical feasibility
- Acceptability/complexity of proposed technology
- Construction considerations;
- System reliability/flexibility
- O&M considerations
- General environmental considerations
- Community impacts
- Land availability
- Adaptation to phased implementation
- Future expansion potential
- Meet reuse goals

The screening was performed using a qualitative matrix approach. Each viable sub-alternative was evaluated for each of the above factors by assigning a rating and associated numerical value to each criteria. Sub-alternatives were rated for each criteria as either good (+2), fair (+1), insufficient information or not applicable (0), marginal (-1) or poor (-2). Scores for all criteria for each alternative were then totaled to develop a relative measure of how well the sub-alternative meets the goals of the project relative to the other viable sub-alternatives. The results of this screening process are summarized in Table 2.1.

From the alternative-rating summary presented on Table 2.1, the best apparent alternatives were identified. These alternatives are then recommended for detailed evaluation. These alternatives are presented in the following section of this memorandum.

Table 2.1: Alternative rating summary

Technology \ Criteria	Cost	Performances	Complexity	Total	Ranking
Preliminary treatment					
Screening					
Manual	2	-2	1	1	2
Mecanical	-1	2	1	2	1
Grit removal					
Gravity	-1	-1	2	0	2
Aeated	-2	1	-1	-2	3
Vortex	-1	2	1	2	1
Secondary treatment					
Ponds	2	-1	0	1	1
Activated sludge	-2	2	-1	-1	3
Oxidation ditch	-1	2	-1	0	2
Sequential Batch Reactor	-1	1	-2	-2	4
Biological filter	1	-2	-2	-3	5
Biological disc	-1	-1	-1	-3	5
Sea outfall	-2	-2	1	-3	5
Tertiary treatment					
Biological	-2	2	-1	-1	3
Mechanical filtration	-2	0	-2	-4	4
Wetlands	2	0	1	3	1
Maturation ponds	2	-1	1	2	2
disinfections					
Chlorination	1	2	1	4	1
UV	-1	1	-2	-2	2
Sub alternative of discharge or reuse					
Direct discharge	2	-1	-1	12	1
Reuse for irrigation	-1	1	0	6	2
Reuse for Parks	0	0	-1	3	3

2.4 ALTERNATIVES RECOMMENDED FOR DETAILED EVALUATION

Based on the results of the above initial qualitative screening of the viable wastewater treatment systems, the following alternatives are recommended to be further evaluated under Task 3.

2.4.1 Secondary Wastewater Treatment

The 3 means of secondary wastewater treatment that appear to be most suitable for the situation in the Azemmour & Sidi Ali service area include the following.

- Oxidation Ditch
- Lagoon System
- Wetlands

These alternatives will be considered in more detail under Section 3 and a recommended arrangement will be developed, along with the other required system components.

2.4.2 Disinfection

The secondary treatment system effluent will be disinfected prior to discharge. The means of wastewater disinfection is somewhat dependent upon the ultimate means of wastewater disposal. If the wastewater is reused for irrigation, it may be necessary to use more than one means of disinfection. If the wastewater is discharged directly to receiving water, then either chlorination with dechlorination or UV disinfection would be suitable. Either of these options will be considered as the means of treatment evolves.

2.4.3 Effluent Disposal and Reuse

The treated wastewater may have value as a non-potable water supply, for applications such as agricultural irrigation, landscape irrigation, or industrial uses. If the value of the treated wastewater is not suitable for a reuse system installation, operation, and maintenance, then the treated wastewater can be discharged directly to a receiving stream. Either of these alternatives will be considered for effluent disposal and refined as the treatment process develops.

2.4.4 Sludge Handling and Disposal

Sludge handling and disposal includes numerous stages of treatment, including the following.

- Thickening
- Stabilization
- Dewatering
- Disposal

The means of wastewater treatment will have an impact on the sludge generated by the treatment system. The type of sludge will impact the means by which each of the above items are handled. The sludge handling and disposal system will need to evolve as the wastewater treatment system develops. The initial sludge handling and disposal alternative will include thickening with gravity belt thickeners, drying on sludge drying beds, stabilization via composting, and disposal by land application. Additional variations will be considered if necessary to accommodate the selected treatment system.

SECTION 3: COMPARISON OF ALTERNATIVES

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3.1 INTRODUCTION

This memorandum summarizes activity undertaken and completed by the GESI/MWH Team as mandated under Task 3 of the USTDA SOW, entitled Feasibility Study for Wastewater Treatment and Reuse for the City of Azemmour Morocco.

Task 3 entailed conducting a detailed evaluation of pre-selected wastewater treatment options presented to ONEP under Task 2.

Pre-selected technologies were evaluated for four different treatment scenarios involving wastewater generated by the villages of Azemmour, Sidi Ali, and the planned tourist resort development of Mazagan.

GESI/ MWH recommended the most appropriate technologies based upon evaluation criteria specified under the SOW and the conditions put forth under each of the treatment scenarios considered.

3.1.1 Pre-Selected Wastewater Treatment Technologies

Under Task 2, secondary wastewater treatment technologies presented by the GESI/MWH Team were screened under the assumption that sewage from Azemmour, Sidi Ali, and the planned Mazagan Resort would be treated at the preferred location (Site # 1) to a quality which could be reused as an irrigation source for golf courses and resort landscaping. Under this assumption, technologies were ranked in the following order of descending applicability: extended activated sludge (oxidation ditch), conventional activated sludge, sequential batch reactors (SBR), engineered wetland treatment systems, and finally integrated lagoon systems.

3.1.2 Alternative Wastewater Treatment Scenarios

ONEP wishes at this time to consider four different scenarios for treatment of wastewater from the Town of Azemmour, the Village of Sidi Ali, and the planned tourist development of Mazagan.

Different scenarios of interest to ONEP include:

- Scenario 1 –Treating Azemmour and Sidi Ali together to a quality suitable for direct discharge to the Oum R'bia River;
- Scenario 2 –Treating Azemmour and Sidi Ali to a higher quality suitable for unrestricted reuse for recreation including passive recreation, parks, and urban green areas.
- Scenario 3 –Treating Azemmour, Sidi Ali, and the planned Mazagan tourist development for unrestricted effluent reuse as golf course irrigation, and;
- Scenario 4 –Treating Mazagan for reuse separately.

3.1.3 *Engineered Wetlands*

Since the initial screening, wetland systems were dropped from the list of secondary treatment applications considered under Task 2, but have now been added as tertiary treatment or a polishing option to provide multiple uses such as reservoir storage, passive recreation, and wildlife habitat as initially discussed in the November meetings between GESI/MWH and the ONEP Project team.

The use of engineered wetlands has been included in several of the recommended treatment alternatives as a form of tertiary treatment.

Wetland treatment technology is an effective way to provide secondary and/or tertiary treatment to municipal sewage. The effectiveness of this technology in reducing BOD/COD, suspended solids, pathogens and macronutrients is supported by over 50 years of successful application world-wide. In addition to water treatment, wetlands provide many other benefits and opportunities including, wild-life habitat, recreational opportunities, and reservoir storage for irrigation or fire suppression.

Wetlands should be designed with multiple uses and limited public access in mind, disinfection should occur prior to discharge of treated effluent to wetlands. Wetlands should be sized and designed to provide tertiary polishing and pathogen removal as well as contain additional storage for passive recreational possibilities, wildlife habitat, and to contain reservoir storage for effluent reuse for irrigation. Wetlands should be contoured to blend with the surrounding topography in a natural and aesthetically pleasing manner.

3.1.4 *Pump Stations*

Under all the existing scenarios of interest pump stations may be required to pump:

- Untreated sewage to the wastewater treatment facility, and
- Treated effluent from the wastewater treatment facility to the point of reuse.

3.1.4.1 Central Wastewater Pump Station

Because of the topography of the existing sewage collection system of Town of Azemmour the proximity of the Village of Sidi Ali on the opposing bank of the Oum R'bia River, and the preferred location of the future wastewater treatment plant site, a lift station will be required to pump sewage collected at central wet- well to the head-works of the new wastewater treatment facility. A central wastewater pump station will be required in all treatment scenarios of interest to ONEP.

3.1.4.2 Treated Effluent Reuse Pump Station

Treatment Scenarios 2, 3, and 4 require reuse of treated effluent for irrigation. Under these scenarios a treated effluent pump-station will be required to deliver treated effluent from the outlet of the wastewater treatment facility to the site of reuse. In Scenario 2 this may be a point of localized reuse such as a nearby park or urban green areas near to the treatment facility. In Scenario3 treated effluent will be pumped to the Mazagan Tourist Resort for irrigation of the resort golf courses and gardens. Finally, in

Scenario 4, treated effluent will be pumped from a second treatment plant presumably near to the tourist resort to nearly golf courses and gardens.

3.1.5 Objective

With the pre-selection of treatment technology alternatives complete, the objective of Task 3 is to *conduct a technical, financial, and environmental comparison of the proposed technologies.*

To achieve this objective the GESI/MWH Team conducted a detailed comparison of the Pre-Selected Treatment Technologies with specific consideration for each of the scenarios of interest. From this comparison, the most appropriate technology alternative (s) to meet applicable load and discharge requirements were selected for each scenario. After analyzing costs and benefits associated with each of the recommended alternatives, the most suitable alternative and scenario was proposed for conceptual design.

3.2 ACTIVITIES

Activities undertaken to fulfill the requirements of Task 3 and the request of ONEP included:

Calculating wastewater flow, characteristics, and load under each of the four scenarios considered;

Adopting appropriate effluent quality objectives for discharge and reuse under each of the scenarios;

Developing and conducting a qualitative comparison methodology using preconceived indicators to rank pre-selected technologies;

Compiling an overall ranking of pre-selected treatment technologies;

Proposing the best treatment alternative for each scenario considered

Developing general sizing and cost estimates for each alternative; and
Recommending the most appropriate scenario and technology alternative for future conceptual design.

3.2.1 Wastewater Flow, Characteristics, and Loads

Table 3.1 provides a summary of the base loading conditions, wastewater characterization, and effluent water quality targets for each of the four scenarios.

As can be seen in the table, each alternative provides different benefits to the environment and will have differing costs associated with these benefits. Considering different scenarios provides ONEP the opportunity to assess a variety of alternatives and their respective costs and benefits but adds complexity to the evaluation process in that equal alternatives are not being compared. The analysis of alternatives will attempt to factor appropriately these differences to tailor the recommended technology to each scenario.

3.2.2 Effluent Water Quality Objectives

National Moroccan water quality standards for effluent discharge have been adapted by ONEP. These standards are included as Section 1.

Moroccan effluent discharge standards are categorized as either direct or indirect discharge. Discharge of treated sewage to the Oum Rbia River is considered direct discharge under Moroccan Law and therefore must meet or exceed the water quality parameters under the existing ONEP Water Quality Discharge Standards for direct discharge. Direct discharge is considered under Scenario 1.

Acceptable water quality for effluent reuse is a function of its intended use. Treated effluent has historically been used for recreational purposes, as irrigation supply for agriculture and urban green spaces, and by industry where applicable.

Scenarios 2, 3, and 4 consider the option of reusing treated effluent. Effluent standards for irrigation reuse are much more stringent than for direct discharge.

Presently the ONEP Azemmour project team wishes to consider effluent reuse for irrigation of parks, golf courses and urban landscaping. Treated effluent used for this purpose should be safe for human contact. At the time of this memorandum National reuse standards for the Kingdom of Morocco were not available.

World Health Organization (WHO) has established internationally accepted water quality parameters for re-use of treated effluent. WHO effluent reuse standards are included in Section 1. WHO standards for unrestricted effluent reuse were applied in comparing treatment alternatives for each scenario considered.

Table 3.1 also provides a summary of water quality treatment objectives selected for comparison of technologies.

Table 3.1 Summary of Wastewater Characteristics Loading, and Water Quality Discharge Requirements

Year	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	Design 2010	Future 2025	Design 2010	Future 2025	Design 2010	Future 2025	Design 2010	Future 2025
Total Service Area Population	49,700	63,150	49,700	63,150	57,890	71,340	*8190*	*8190*
Connected Population	39,737	59,609	39,737	59,609	47,927	67,799	*8190*	*8190*
Flow (m3/day)								
Minimum Hour	1768	2532	1768	2532	2845	3613	*1081*	*1081*
Average Day	2941	4220	2941	4220	4742	6021	*1801*	*1801*
Maximum Day	3676	5275	3676	5275	5928	7526	*2251*	*2251*
Peak-hour	5882	8229	5882	8229	9484	11,741	*3602*	*3602*
Concentration (mg/l)								
BOD5	544	599	544	599	544	598	*300*	*540*
COD	1262	1286	1262	1286	1264	1286	*600*	*600*
TSS	443	464	443	464	429	464	*300*	*540*
TKN	133	136	133	136	134	135	*108*	*108*
Load (kg/day)								
BOD5 Average Day	1599	2528	1599	2528	2580	3601	*540*	*540*
BOD5 Maximum Day	2000	3160	2000	3160	3225	4501	675	*675*
COD Average Day	3712	5427	3712	5427	5994	7743	*1081*	*1081*
COD Maximum Day	4639	6784	4639	6784	7493	9678	*1351*	*1081*
TSS Average Day	1303	1958	1303	1958	2034	2794	*973*	*973*
TSS Maximum Day	1628	2448	1628	2448	2543	3492	*1216*	*1216*
TKN Average Day	391	574	391	574	635	813	195	195
TKN Maximum Day	489	717	489	717	794	1016	243	243
Effluent Quality Objective (mg/l):								
BOD5	100	100	24	24	24	24	24	24
COD	500	500	20	20	20	20	20	20
TSS	50	50	10	10	10	10	10	10
TKN	30	30	NA	NA	NA	NA	NA	NA
Coliform (mpn /100 ml)	ND	ND	<100	< 100	<100	< 100	ND	ND
Helminthes (no./ 1000ml)	ND	ND	ND	ND	ND	ND	ND	ND

Scenario 4 – *italics indicates Mazagan Tourist Development*

3.2.3 Qualitative Comparison

The four wastewater treatment scenarios were compared to help select a recommended wastewater treatment program. The comparison procedure is discussed in this section.

3.2.4 Evaluation Criteria

Engineering, institutional and social, and environmental criteria indicators identified in the SOW were used to compare alternative treatment technologies. Indicators of each of these major criteria were applied.

3.2.4.1 Engineering

- Engineering Criteria applied included:
- Functionality;
- Design, and;
- Flexibility.

Functionality - is a measure of the operational complexity of the alternative that will be measured by the following indicators:

- Required technical expertise;
- Operation and Maintenance;
- Adaptability to fluctuations in loading, and;
- Energy required by the selected process.

Design - is a measure of technical difficulties anticipated in realizing each alternative considered. Indicators of design used include:

- Technical and feasibility;
- Capital cost;
- Land availability;
- Constructability;
- Required area;
- Site access;
- Potential for effluent reuse;
- Geological and hydrological constraints, and;
- Flooding risks

Flexibility - considers the possible variation in population growth in relation to construction schedule in relation to:

- Adaptability to unknown urban development, and;
- A progressive implementation schedule.

3.2.4.2 Institutional and Social

This criterion includes institutional aspects as well as public acceptance. Indicators used to measure institutional aspects and public acceptance included:

- Proximity to the urban population;
- Land ownership;
- Public acceptance, and;
- Compatibility with existing land use.

3.2.4.3 Environmental

- Environmental indicators applied included:
- Impact on surface water quality;
- Impact on soil stability;
- Degradation of water resources (groundwater);
- Loss of agricultural land, and;
- Noise, odor levels, and nuisance vectors such as flies and mosquitoes.

3.2.5 Methodology

A relative comparison of pre-selected technologies was performed using a qualitative matrix approach. Each viable sub-alternative was evaluated for the above factors by assigning a rating and associated numerical value to each criterion. Sub-alternatives were rated for each criteria as either good (+2), fair (+1), no impact (0), marginal (-1) or poor (-2). Scores for all criteria for each sub-alternative were then totaled to develop a relative measure of how well the sub-alternative meets the goals of the project relative to the other viable sub-alternatives.

First a determination of an overall cumulative ranking of the technologies was conducted. To accomplish this, all of the indicators for each of the three major criteria were averaged to determine a cumulative score for each category. Cumulative scores for each category were then weighted according to the relative significance of each as deemed appropriate by the GESI/ MWH Team. Eighty percent of the weighted final score was based upon engineering indicators, 10% was based upon social and institutional considerations, and 10% was based upon environmental performance. The final weighted averages were then added to produce a final overall score. Technologies were then given an overall ranking based upon their weighted scores in each of the comparison categories.

Next, technologies were considered under the conditions and requirements of each of the scenarios by considering qualitative performance of each of the technologies in indicators critical and specific to each scenario. The most appropriate treatment alternatives were selected for each of the four scenarios.

3.2.6 *Results of the Qualitative Technology Comparison*

Results of the qualitative comparison for each of the pre-selected alternatives are summarized by Table 3.2. These results are discussed in detail in the following paragraphs.

Table 3.2: Summary of the Results of the Qualitative Comparison

Comparison Indicator	Conventional Activated Sludge	Oxidation Ditch	Sequential Batch Reactor	Lagoon Treatment	Aerated Lagoons
Engineering Weighted (80%)	**-0.13**	**1.29**	**1.11**	**1.02**	**-.067**
Engineering Raw Score	**-0.16**	**1.61**	**1.39**	**1.28**	**-0.83**
Functionality	-1.33	-0.33	-1.00	2.00	0
Required technical expertise Operation and Maintenance	-2	0	-2	2	1
Adaptability to fluctuations in loading	-1	1	1	2	1
Energy required by the selected process	-1	-2	-2	2	-2
Design	0.67	0.44	0.88	-0.22	-0.33
Technical feasibility	2	2	2	1	1
Capital cost	0	0	0	1	0
Land availability	1	0	2	-1	-1
Constructability	0	0	0	2	1
Required area	1	0	2	-2	-1
Site Access	0	0	0	0	0
Potential for effluent reuse	2	2	2	–2	-2
Geological and hydrological constraints	0	0	0	-1	-1
Flood Risks	0	0	0	0	0
Flexibility	0.50	1.50	1.50	-0.50	-0.50
Adaptability to unknown urban development	-1	1	1	–2	-2
A progressive implementation schedule	2	2	2	1	1
Institutional and Social Weighted (10%)	**0.05**	**0.08**	**0.08**	**-0.10**	**-0.1**
Institutional and Social Raw score	**0.50**	**0.75**	**0.75**	**-1.0**	**-1.0**
Proximity to the urban population	1	2	2	–2	-2
Land ownership	0	0	0	0	0
Public acceptance	1	1	1	–2	-2
Compatibility with existing soil use	0	0	0	0	0
Environmental Weighted (10%)	**0.04**	**0.10**	**0.12**	**-0.06**	**-0.06**
Environmental Raw Score	**0.40**	**1.00**	**1.20**	**-0.60**	**0.06**
Impact on surface water quality	1	1	2	–1	-1
Impact on soil stability	0	0	0	0	0
Degradation of water resources	2	2	2	1	1
Loss of agricultural land	0	0	0	0	0
Noise and odor , nuisance levels	-1	2	2	–1	-1
OVERALL WEIGHTED SCORE	**-0.04**	**1.47**	**1.31**	**0.86**	**-0.82**

Rating Key:
2 = Good
1 = Fair
0 = No Impact
-1 = Marginal
-2 = Adverse

3.2.6.1 Engineering

Required technical expertise Operation and Maintenance:

Lagoons ranked first in terms of required technical expertise, operation and maintenance since lagoon treatment requires the lowest degree operational know-how of the technologies considered. Lagoons can be operated on a daily basis without the presence of highly skilled or specially trained staff.

Oxidation ditch rated second under this criterion. Oxidation ditch technology requires the presence of skilled labor on a daily basis to operate mechanical equipment such as pumps, motors and chemical feed system and to monitor and make appropriate adjustments according to fluctuations in flow and load.

Both Sequencing Batch Reactors and Conventional Activated Sludge Treatment require a skilled operator to monitor and oversee all aspects of the reactor process. Skilled labor is required to make system adjustments dictated by variations in flow and load characteristics. These technologies are considered the most operationally intensive and complex of the technologies considered.

Adaptability to Fluctuations in Loading:

Lagoon treatment is most adaptable to fluctuations in loading due to larger volume and longer associated retention time.

SBR and oxidation ditch technologies are less adaptable to fluctuation in loading than lagoons since operational adjustments must be made to accommodate fluctuations.

Conventional activated sludge is the least adaptable to wide fluctuations in loading.

Energy required by the selected process:

Lagoons are the most energy conservative of the technologies considered. Relying exclusively upon natural elements such as gravitational settling, solar radiation, algae, and wind energy to provide treatment, lagoon treatment systems require little to no additional energy for operation provided that they are not artificially aerated.

Conventional Activated Sludge, Oxidation Ditches, and SBR technologies require electrical power to operate motors, pumps, and aeration devices and were therefore rated lower than lagoons for this criterion.

Oxidation Ditches and SBR require the greatest amount of energy of the technologies considered due to extended aeration requirements. However, proper system design with dissolved oxygen control and supplemental submersible mixers can result in little additional energy use compared with the other activated sludge processes.

Technical Feasibility:

Technical feasibility in design is an indication both of the complexity of design required to realize each wastewater treatment technology as well as the ability of the completed system to meet design and performance requirements.

In terms of design complexity conventional activated sludge, oxidation ditches and SBR's are equally complex but can easily achieve performance and design standards.

While the biological treatment processes involved are complex, the lagoon is simpler treatment system to design. Lagoons received a lower rating in terms of technical feasibility because performance is strongly effected by uncontrollable environmental factors, wind, rain, solar energy, and both animal and plant factors.

Capital Cost:

Provided that the cost of acquiring land is relatively inexpensive or already available, as is the present condition, lagoons have the lowest capital cost of the technologies considered.

Conventional activated sludge facilities in turn, have the highest capital cost, requiring the construction of tanks and basins as well as the installation of motors, pump works, an aeration system, and relatively extensive yard piping.

The SBR was considered to be more costly than the lagoon , however less costly than the conventional activated sludge and oxidation ditch due to the fact that less basin volume is required.

The oxidation ditches have the highest capital cost since they require larger aeration tank volumes than conventional activated sludge facilities and additional power and mechanical equipment for extended aeration. However, the capital costs can be similar or even lower for oxidation ditches due to the need for primary clarification facilities and more complex sludge treatment facilities for the conventional activated sludge process.

Land Availability:

Presently there are 19.2 hectares available at the preferred site for the WWTP. Under all scenarios there exists adequate land area for the wastewater treatment facility with the exception of the application of lagoons under Scenario 3. Under this scenario additional land area will be required for construction of a lagoon system capable of achieving water quality objectives for unrestricted reuse. As such, SBR, oxidation ditch, and conventional activated sludge were rated equally. Lagoons were rated lower since in general they require a greater area than the other technologies considered.

Constructability:

Lagoons are the most easily constructed of the treatment technologies considered. Lagoons typically require excavation and earth moving combined with a relatively small number of hydraulic structures and minimal yard piping.

Conventional activated sludge, oxidation ditches, and SBR's are the most complex of the technologies and therefore can be difficult to construct, requiring substantial excavation (foundation), basin construction, and mechanical/electrical, as well as substantial and often complex yard piping.

Required Area:

SBR technology requires the least area for treatment of the technologies considered, followed by the Conventional activated sludge, then the oxidation ditch, and finally lagoons, which require the largest overall land area.

Site Access:

Adequate site access exists at the preferred site regardless of the treatment technologies employed. Site access therefore has no impact on technology selection.

Potential for Effluent Reuse:

The potential for reuse of treated sewage effluent is a function of physical, chemical, biological as well as public and environmental health considerations.

Acceptable water quality standards have been established to protect human and environmental health from pathogens and toxic substances that may be present in effluent. Of specific interest is the presence of nematodes, a human pathogen whose eggs taking a cystic form, may only be effectively removed from sewage through gravity settling, extended retention, and or filtration.

As lagoons are the only treatment technology to incorporate extended retention (Pathogen reduction requires about 10 days of detention time to be effective) and settling opportunity, which removes nematode eggs, they may be considered the best stand alone treatment system for effluent reuse when considering helminthes removal.

However it should be stated that there are real world factors occurring in lagoons that can suspend settled pathogenic material. Settling may occur in lagoons but they are also highly susceptible to wind and animals disturbing the settled materials. and potentially re-suspending lagoon solids.

Further, lagoons generally have a lower quality effluent than the other technologies considered. In many instances lagoon effluent can have a high algae concentration. Algae are difficult to remove and manage in piped irrigation networks or where water-saving micro emitting equipment is utilized.

The presence of algae significantly reduces the ability to reuse the water. When reused, lagoon effluent is typically applied as irrigation water via overland flow, open channel, and in some instances via "large bore" irrigation sprinklers. For this reason lagoon treatment, while capable of removing pathogenic helminthes, was rated lower in terms of reuse potential since its application has been traditionally limited to open channel agricultural irrigation.

All other technologies considered were rated equal since they are each capable of creating a high quality effluent in terms of BOD, TSS and nutrient reduction potential, and while they each have difficulty reducing helminthes concentrations, most regulations require filtration prior to reuse.

Geological and Hydrological Constraints:

Since the preferred site is neither in an existing floodplain, a region of historically active seismic activity, or believed to contain abnormally shallow groundwater aquifer, none of the technologies considered would be impacted by hydrological or geological constraints.

However in terms of construction, lagoon construction requires soils capable of creating low permeability berms to minimize pollution of the groundwater. Without suitable soils, a lagoon system will require installation of artificial impermeable barriers at an added cost.

Flooding Risks:

Due to the elevation of the preferred site, the risk of flooding is considered minimal and of no consequence regardless of the treatment technology selected.

Flexibility:

The oxidation ditch, SBR, and conventional activated sludge processes are equally adaptable to unexpected urban growth as they are all three compartmentalized mechanical processes and can be expanded as such.

The lagoon, while capable of handling wide fluctuations in diurnal and seasonal loading, it is less accommodating of unexpected urban expansion. Although some modifications such as mechanized aeration of lagoons can accommodate increases in capacity a terminally overloaded lagoon can not be modified to handle increased loads without more land area Further, lagoon systems do not lend themselves to a progressive implementation schedule unless initially oversized or compartmentalized in an accommodating manner.

3.2.6.2 Institutional and Social

The SBR and the Oxidation Ditch were found to be the most institutionally and socially acceptable of the sewage treatment technologies.

Lagoons received the lowest rating due to the large land area that they may require and the strong potential for odors associated with anaerobic stabilization basins.

Proximity to the Urban Population:

Neither the oxidation ditch nor the SBR require primary settling or processing of primary solids thus minimizing odors and other associated nuisances.

While the small area required for conventional activated sludge is advantageous where land costs are high, this process was determined to be less acceptable in close proximity to an urban population than either the SBR or Oxidation Ditch due to odors associated with the drying and processing of unstable primary bio-solids. Odor control may be necessary if applied in close proximity to an urban population.

Lagoons require a large land area which may be cost prohibitive in the urban setting where land values are generally higher. Lagoons may also have strong odors associated with the operation of anaerobic lagoons, however removing and disposing of sludge occurs only after long intermittent periods and odors associated with sludge should be minimal due to the generally stabilized nature of the lagoon bio-solids. Solids also need to be removed from the anaerobic lagoons periodically.

Land Ownership:

As the preferred site is existing public land, land will have no impact on the treatment technology selected. However, the lagoon system requires considerably more land area than the other alternatives and may limit room for future expansion of the system.

Public Acceptance:

In this comparison, public acceptance for a given treatment technology was considered as a function of the level of convenience, cost/benefit, and performance provided.

Lagoons were considered to be slightly less acceptable than the other technologies considered because they require more area, may produce odors, and may have a higher cost where land is a premium. This additional cost is offset, however, by the robust performance of the lagoon system combined with low operational costs.

Compatibility with Existing Soil Use:

None of the technologies considered will have an appreciable impact on existing soil use.

3.2.6.3 Environmental

Impact on Surface Water Quality:

While all technologies considered will have a positive impact on the water quality of sewage discharged, the oxidation ditch and SBR are capable of creating the highest quality effluent of the technologies compared.

Conventional activated sludge will be of somewhat lesser quality than that of an extended aeration process, but will generally produce effluent of higher water quality than that produced by a lagoon system.

Lagoon systems produce an effluent of lesser quality than the other technologies considered but provide a significant improvement over the no treatment option. Lagoon effluent can contain high concentrations of algae which can boost total BOD and may be difficult to remove.

Impact on Soil Stability:

None of the technologies considered will have an appreciable impact on existing soil stability therefore all technologies received a no impact in this category.

Degradation of Water Resources (Groundwater):

In general terms, all treatment technologies if implemented would have a positive impact on water resources by providing a source of treated effluent for either beneficial use or environmentally safe discharge, however specifically speaking, the quality of the effluent is dependent upon the process selected and may vary considerably between those presented.

Loss of Agricultural Land:

Implementation of any of the technologies considered at the preferred site will not result in the loss of agricultural land. All technologies received a "no effect" rating in this category. Lagoons may not allow room for expansion without converting to a less area intensive process in the future.

Noise and Odor Levels:

The oxidation ditch and SBR technologies were rated highest in terms of odor levels since primary solids processing is not required. The extended aeration process should produce a more stable sludge than the conventional activated sludge processes. Noise levels will be similar for all of the mechanical activated sludge treatment processes.

While overloaded lagoons may produce odor, they do not require primary solids processing on a regular basis and if properly designed and operated should have minimal odors.

Conventional activated sludge received the lowest rating of the technologies considered with regard to odor due to the fact that primary solids processing must be undertaken on a continual basis.

3.3 RECOMMENDED TREATMENT TECHNOLOGIES

3.3.1 Overall Ranking

First technologies were scored and given an overall ranking in terms of meeting engineering indicator criteria.

The oxidation ditch was selected as the best overall technology considered because it produces a very high quality effluent, is adaptable to wide fluctuations in flow and load, and does not generally produce foul odor or other nuisances.

The oxidation ditch can be situated in close proximity to an urban population. Under the extended aeration occurring through oxidation ditch technology, 95% removal rates are common. Treated effluent therefore has a high value for reuse imparting minimal impact to the surrounding environment or to human health. As most mechanical processes, oxidation ditches lend themselves to a progressive implementation schedule. The only real disadvantage to the oxidation ditch technology is that it can be energy intensive resulting in higher treatment costs and initial capital costs can be large.

Sequential Batch Reactors were rated as the second best overall technology. The major advantage of the SBR is it occupied a much smaller foot print than the other technologies considered. SBR technology can be easily implemented in a progressive manner as required. The disadvantage of SBR Technology is that it is operationally complex, requiring skilled personnel and is not overly resilient to large fluctuations in flow and load.

Lagoons were rated third in the overall qualitative technology comparison because the quality of effluent produced through lagoon treatment is generally of a lesser quality than that produced by the other technologies considered. As a result lagoon effluent has less reuse potential and may have a greater impact on the surrounding environment. Also lagoon systems do not adapt well to unexpected population growth as additional land is necessary to expand lagoon systems. Finally care must be taken in design, locate, and operate a lagoon system to minimize the impacts of potential odors.

While significant disadvantages exist, lagoon systems have several strong advantages over mechanical treatment technologies. Lagoon systems offer significant cost and operational advantages over the other treatment technologies considered when land is available and inexpensive. Further, lagoons are simple and inexpensive to design, construct and operate. Lastly, lagoons are robust and able to handle large diurnal and seasonal fluctuations in load and flow due to their large volume and long associated retention time.

Conventional activated sludge treatment was rated four since it produces effluent of quality lower than the oxidation ditch and SBR. The disadvantages of conventional activated sludge are that, it requires a relatively large amount of energy and a skilled operator. Conventional activated sludge treatment requires primary settling and thus processing of un-stabilized bio-solids, increasing the potential for foul odors and reducing its applicability close to large urban populations.

Aerated lagoons treatment was rated last since it produces effluent of quality lower than the oxidation ditch and SBR. The disadvantages of aerated lagoon system, compared to the simple agoon system, are that, it requires a relatively large amount of energy. Although the aerated lagoon system has limitations, it was further evaluated at the request of ONEP since it produces less odors and it could constitute a compromise to the simple lagoon system, in case Mazagan is not interested in treating their wastewater with Azemmour.

Another treatment alternative, consisting of percolation basins was considered at the request of ONEP, however, this alternative was later rejected due to its operation and maintenance problems and lack of experience with technology for large scale treatment system.

3.3.2 Treatment Alternatives

As previously mentioned, ONEP wishes to consider four different treatment scenarios. Technologies were therefore considered in terms of the requirements and conditions set forth under each of the four scenarios. Treatment alternatives were selected that best fulfilled the requirements of each scenario. A total of seven treatment alternatives were selected from the technologies considered. One alternative each for Scenarios 2 and 3, three alternatives for Scenario 1 and two alternatives for Scenario 4.

Alternative	Description	Technology/sub-alternative
1	Purification of waste water of the town of Azemmour and Sidi Ali and direct outfall of the effluent to the sea in the wadi Oum er-Rbia	Alternative 1a: Simple Lagoons Alternative 1b: Aerated Lagoons Alternative 1c: Infiltration Percolation
2	Purification of waste water of the town of Azemmour and Sidi Ali and re-use of the water purified for irrigation of green spaces, parks and walking zones	Oxidation trench + Wetlands
3	Purification of waste water of the town of Azemmour, Sidi Ali and the tourist development of Mazagan and re-use of the effluent purified for the irrigation of the golf courses, and the green spaces in the complex of Mazagan	Oxidation trench + Wetlands
4	Purification and re-use of waste water of the complex of Mazagan	Alternative 4a: Lagoons + Wetlands + Drying beds Alternative 4b: Oxydation trench + Wetlands

The seven recommended treatment alternative were sized to meet desired discharge objectives. Facilities were staged over 5-year intervals with an ultimate capacity to meet projected 2025 loads and flows.

Treatment Alternative 1:

Scenario 1 requires the treatment of a maximum of 5,275 m^3/day with an average BOD of 600 mg/l to a maximum effluent concentration of 100 mg/l for direct discharge to the Oum R'bia River.

Since there is not a requirement for a high quality effluent, requirements for discharge can be met easily by a lagoon system. The lagoon system will be preferred over the other technologies considered in this instance as it is simpler to design and construct, as well as to operate and maintain. Further, like the oxidation ditch, the lagoon is very adaptable to wide ranges in flow and load, but in addition, it requires little energy relative to the other technology alternatives considered.

Treatment Alternative 1a:

Treatment Alternative 1a is a lagoon system with a treatment process train consisting of screening, anaerobic lagoons, facultative lagoons, polishing ponds; disinfection, a sludge dewatering area, and direct discharge. Alternatively, it may be possible that the anaerobic lagoons may be foregone if additional volume is provided in the facultative lagoon for sludge accumulation. If this variation is considered, return pumping may be required to reduce the influent BOD concentration.

Preliminary sizing calculations indicate that a lagoon system designed to treat the small volume of sewage generated by Azemmor and Sidi Ali to the legal limit for direct discharge can be accommodated on the available land area with some additional area for future expansion or enough area later to enhance the lagoon system to meet water quality effluent objectives for reuse by adding additional polishing ponds, a multi use wetland, and or a filtration system. A process schematic of Treatment Alternative 1a is included as Figure 3.1a. Area requirements for each of the major components of Treatment Alternative 1a are summarized in Table 3.3a.

Figure 3.1a: A Conceptual Layout of Treatment Alternative 1a

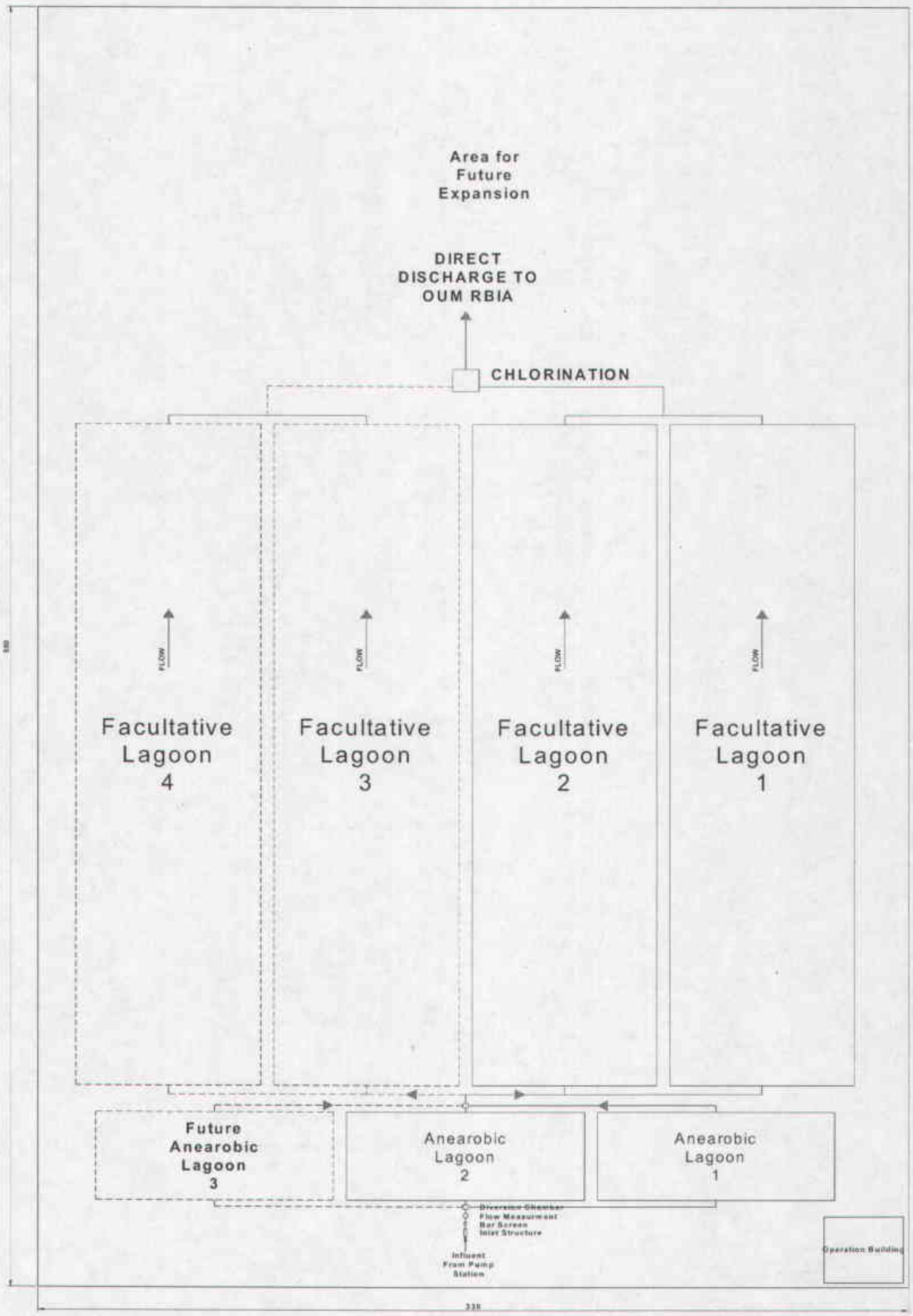


Table 3.3a: Summary of Sizing of Major Components of the Recommended Lagoon Facility Sized to Accommodate Scenario 1a

Unit Process	Area Per Unit (m2)	Number of Units Required		Area Required (m2)	
		2010	2025	2010	2025
Influent Chamber	3.6	1	1	4	4
Anaerobic Lagoon	3600	2	3	7,200	10,800
Facultative Lagoon	21000	2	4	42,000	84,000
Disinfection	100	1	1	100	100
Sludge Processing	9000	1	1	9,000	9,000
Roads	12000	1	1	12,000	12,000
Operations	6400	1	1	6,400	6,400
Total Area Required (hectare)				**7.7**	**12.2**

Treatment Alternative 1b:

Treatment Alternative 1b is an aerated lagoon system with a treatment process train consisting of screening, aerated lagoons, facultative lagoons, polishing ponds; disinfection, a sludge dewatering area, and direct discharge.

Preliminary sizing calculations indicate that a lagoon system designed to treat the small volume of sewage generated by Azemmor and Sidi Ali to the legal limit for direct discharge can be accommodated on the available land area with some additional area for future expansion or enough area later to enhance the lagoon system to meet water quality effluent objectives for reuse by adding additional polishing ponds, a multi use wetland, and or a filtration system. A process schematic of Treatment Alternative 1b is included as Figure 3.1b. Area requirements for each of the major components of Treatment Alternative 1a are summarized in Table 3.3b.

Figure 3.1b: A Conceptual Layout of Treatment Alternative 1b

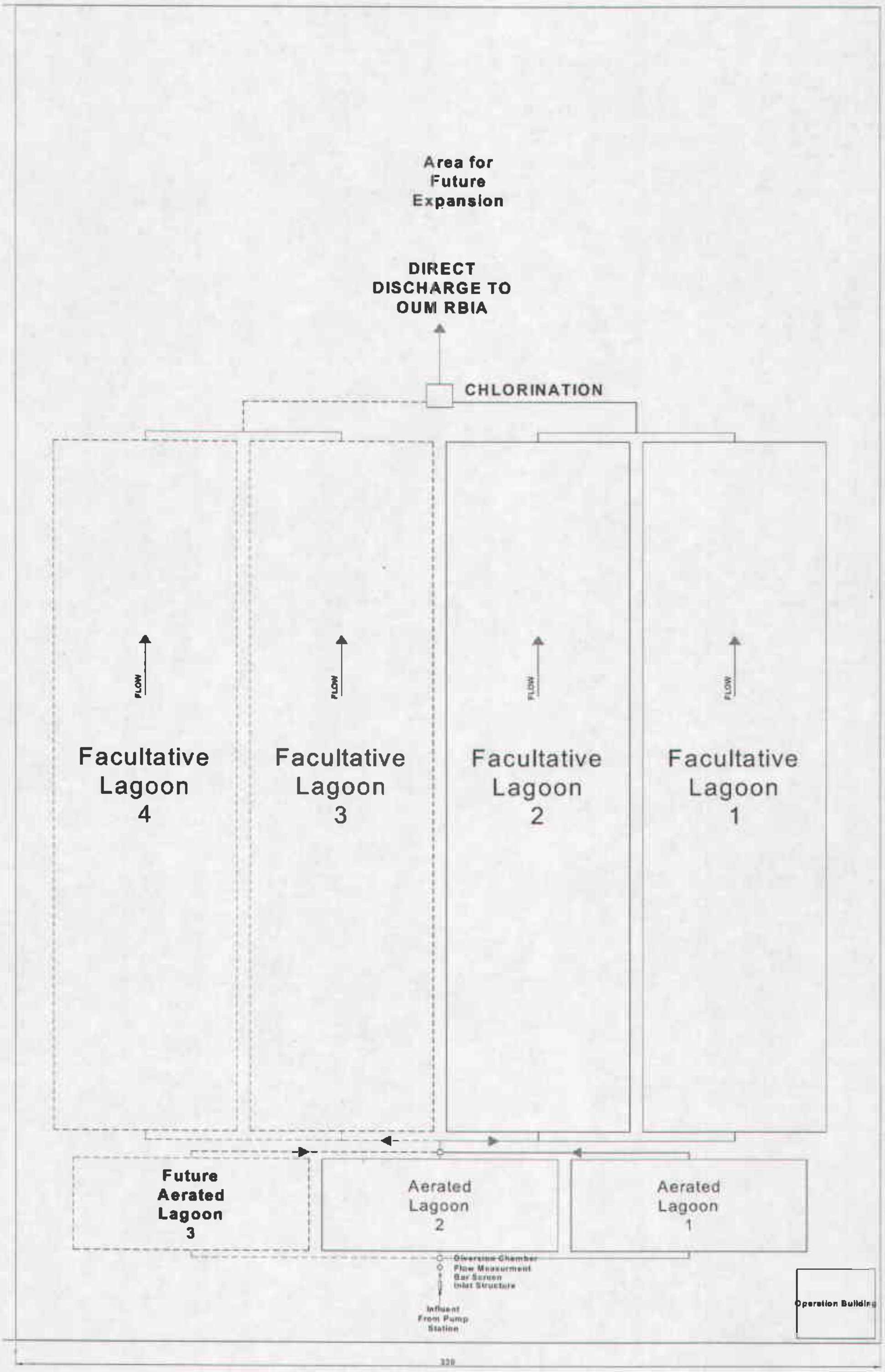


Table 3.3b: Summary of Sizing of Major Components of the Recommended Lagoon Facility Sized to Accommodate Scenario 1b

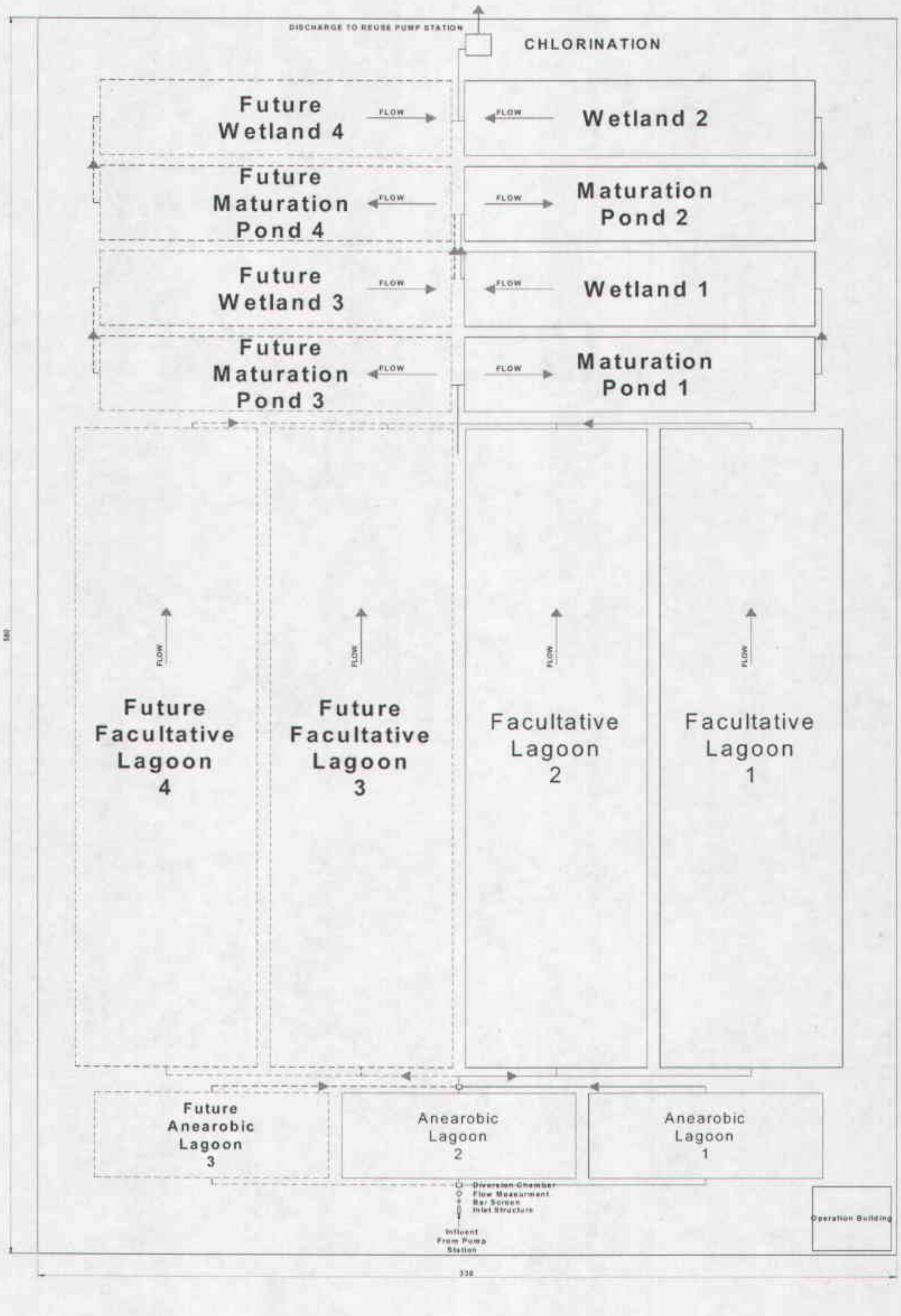
Unit Process	Area Per Unit (m2)	Number of Units Required		Area Required (m2)	
		2010	2025	2010	2025
Influent Chamber	3.6	1	1	4	4
Aerobic Lagoon	1984	2	3	3968	5951
Facultative Lagoon	2000	2	3	4,000	6,000
Disinfection	100	1	1	100	100
Sludge Processing	9000	1	1	9,000	9,000
Roads	12000	1	1	12,000	12,000
Operations	6400	1	1	6,400	6,400
Total Area Required (hectare)				**3.5**	**4**

Treatment Alternative 2:

Scenario 2, sewage generated by Azemmour and Sidi Ali would be treated to produce an effluent suitable for unrestricted reuse as an irrigation source for parks and urban green areas. Scenario 2 requires the treatment of a maximum of 5275 m3/day with an average BOD of 600 mg/l to a maximum effluent concentration of 24 mg/l and a non detectable count for helminthes eggs for unrestricted re-use.

It is possible to construct a lagoon system capable of meeting the requirements of Scenario 2. However, such a system would require the majority of the existing site leaving little area for future expansion beyond 2025 (Figure 3.2).

Figure 3.2: A Conceptual Layout of Treatment Lagoon Designed to Meet WHO Unrestricted Reuse Limits for Scenario 2



To save site area for future expansion, an oxidation ditch treatment system is recommended as the appropriate treatment alternative for meeting the requirements of Scenario 2. Oxidation ditch technology, while having a higher capital cost, will occupy a much smaller area than lagoons, provide superior treatment than conventional activated sludge and will not require primary solids handling with associated odor management issues, or possess the operational complexity of the SBR.

Recommended Treatment Alternative 2 is to include screening, grit removal, oxidation ditch, final clarifier, disinfection, wetland treatment, and drying beds.

A schematic displaying a conceptual layout of the recommended treatment alternative is included as Figure 3.3. Table 3.4 provides a summary of sizing of major treatment components of Treatment Alternative 2.

Table 3.4: Summary of Sizing of Major Components of Treatment Alternative 2

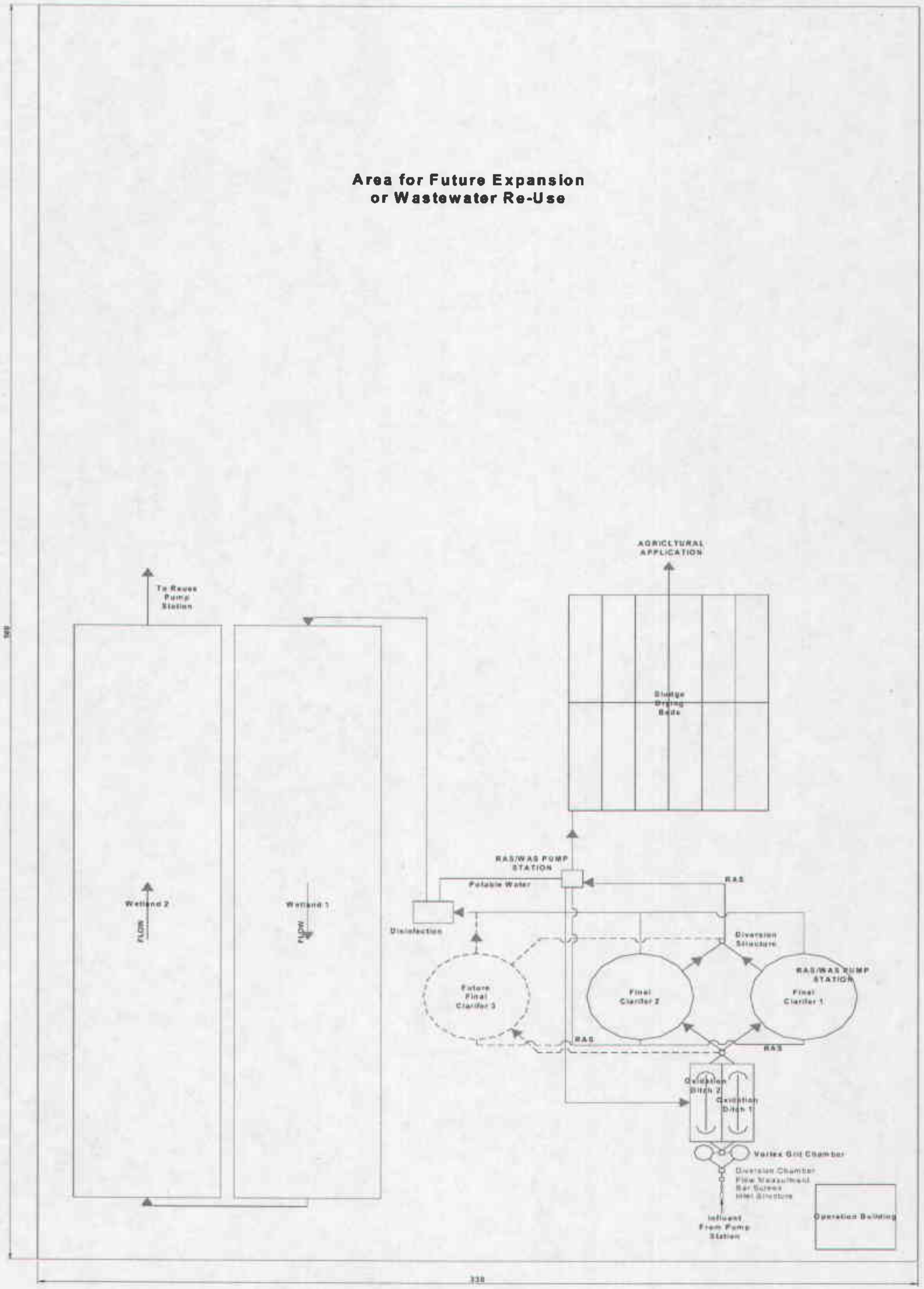
Unit Process	Area Per Unit (m^2)	Number of Units Required		Area Required (m^2)	
		2010	2025	2010	2025
Influent Chamber	3.6	1	1	4	4
Vortex Grit Chamber	11	2	2	22	22
Oxidation Ditch	360	2	2	720	720
Final Clarifier	210	2	3	420	630
Disinfection	100	2	3	200	300
Wetland Treatment	12000	2	3	24,000	36,000
Sludge Processing	9000	1	1.5	9,000	13,500
Roads	12000	1	1	12,000	12,000
Operations	6400	1	1	6,400	6,400
Total Area Required (hectare)				**5.3**	**7.0**

In order to provide area for future expansion beyond 2025 on the existing site, an oxidation ditch system is the preferred Treatment Alternative for Scenario 2. It is further recommended that the oxidation ditch be followed by a wetland designed to accommodate multiple uses, namely water polishing, passive recreation (fishing, bird-watching), wildlife habitat, and as a reservoir for irrigation water storage.

Since public access to wetland is envisaged, chlorination will be required prior to discharge of effluent from the oxidation ditch.

The recommended wetland would be sized to fit within the available site area, leaving room for future expansion of the treatment facility to accommodate population growth beyond the design year 2025. The wetland will have a minimum of 10 day retention to facilitate helminthes egg removal and additional capacity for recreational opportunity as well as irrigation storage to support a community park including a garden, and sports fields. Wetland effluent will be filtered and chlorinated prior to discharge for unrestricted reuse.

Figure 3.3: A Conceptual Layout of Treatment Alternative 2



Treatment Alternative 3

Under Scenario 3 Azemmour, Sidi Ali, and the planned tourist development of Mazagan would be treated at the preferred 19.2 hectare site to a level acceptable for unrestricted reuse.

Preliminary sizing calculations indicate that a lagoon system sized to meet the desired treatment objects would require more land area than is presently available at the preferred site. Table 3.5 provides a summery of area required by a lagoon system designed to meet the requirements under Scenario 3.

Table 3.5: Summary of Sizing of Major Components of the Recommended Lagoon Facility to Accommodate Scenario 3

Unit Process	Area Per Unit (m2)	Number of Units Required		Area Required (m2)	
		2010	2025	2010	2025
Influent Chamber	3.6	1	1	4	4
Anaerobic Lagoon	3600	3	4	7,200	10,800
Facultative Lagoon	21000	4	6	84,000	126,000
Maturation Ponds	9600	4	6	38,400	57,600
Wetlands	9600	4	6	38,400	57,600
Disinfection	100	1	1	100	100
Sludge Processing	12000	1	1	12,000	12,000
Roads	18000	1	1	18,000	18,000
Operations	6400	1	1	6,400	6,400
Total Area Required (hectare)				**20.5**	**28.9**

Since the lagoon system exceeds the available land area, an oxidation ditch system is recommended as the most appropriate technology to address the conditions of Scenario 3. As in Scenario 2, utilization of oxidation ditch technology, while having a higher capital cost, occupies a much smaller area than lagoons, provides superior treatment to that of conventional activated sludge, does not require primary solids handling with the associated odor management issues, or possess the operational complexity of the SBR.

The proposed oxidation ditch system would include: an inlet structure, screening; grit removal, oxidation ditch, secondary clarifier, uv disinfection; engineered wetlands, and sludge drying beds. Table 3.6 provides a summary of sizing of major treatment components of Treatment Alternative 3.

Table 3.6: Summary of Sizing of Major Components of the Recommended Treatment Alternative 3

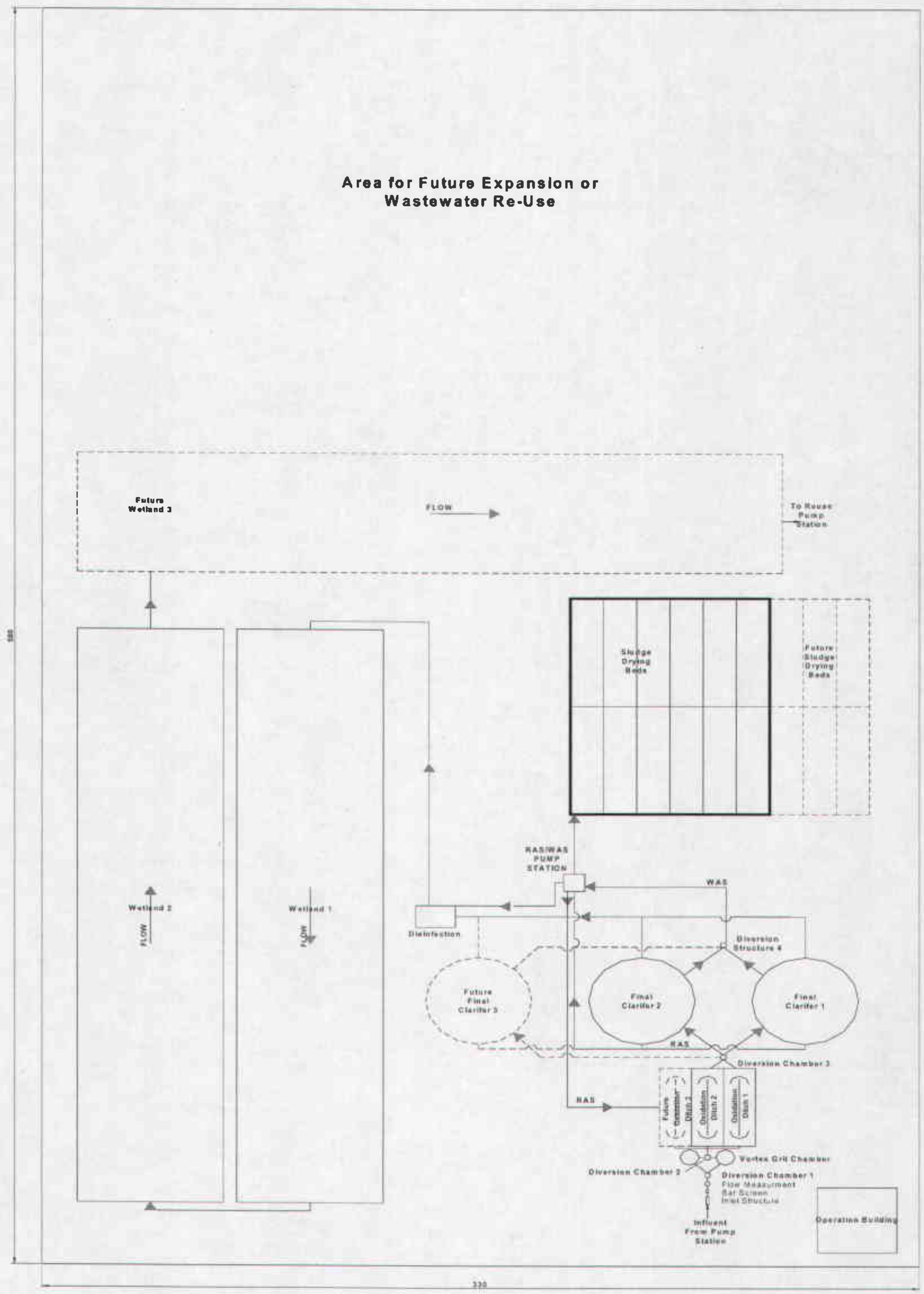
Unit Process	Area Per Unit (m^2)	Number of Units Required		Area Required (m^2)	
		2010	2025	2010	2025
Influent Chamber	3.6	1	1	4	4
Vortex Grit Chamber	11	2	2	22	22
Oxidation Ditch	432	2	3	864	1,296
Final Clarifier	314	2	3	628	942
Disinfection	150	2	3	300	450
Wetland Treatment	15000	2	4	30,000	60,000
Sludge Processing	9000	1	1.5	9,000	13,500
Roads	19200	1	1	19,200	19,200
Operations	8000	1	1	8,000	8,000
Total Area Required (hectare)				**6.9**	**10.4**

A schematic displaying a conceptual layout of Treatment Alternative 3 is included as Figure 3.4.

Irrigation requirements for the tourist resort are bound to be large given the scale of the proposed development. It is doubtful that there will be adequate area available at the existing site to provided adequate reservoir storage to meet the resort's dry season irrigation needs.

One means to provide additional irrigation storage for the resort and avoid the cost of filtration, might be to provide unfiltered effluent in bulk to the tourist development, leaving the final filtration, disinfection, and polishing required at a separate location to be performed by the resort. Storage of treated effluent for resort irrigation could be integrated into the resort landscape to serve the functions of landscaping, water hazard and storage.

Figure 3.4: A Process Schematic of Treatment Alternative 3



Treatment Alternative 4

In this Scenario, two separate alternatives are considered to treat wastewater of the Mazagan Tourist Resor. The first alternative would consider the use of Lagoons and wetlands (Alternative 4a) and the second alternative would consider the use of oxidation ditch and wetlands (Alternative 4b).

Treatment Alternative 4a:

Provided that adequate space and siting requirements can be met, a lagoon system is recommended for Mazagan. A lagoon system is recommended as a first consideration for Mazagan due to ease of operation and low operational costs. The lagoon system will be designed to handle seasonal load fluctuations anticipated. Where possible, the lagoon system will be located and incorporated into surrounding landscape to minimize aesthetic impact by incorporating treated effluent storage into ponds and wetland areas serving the dual function of landscaping in the resort's gardens, and as water hazards on its golf courses.

The process treatment train for this alternative includes: an inlet structure, screening facilities, anaerobic lagoons, facultative lagoons, polishing ponds, disinfection, wetlands and ornamental ponds, and unrestricted reuse. Figure 3.5 displays a process schematic of the proposed Lagoon System. Table 8 provides a summary of area requirements for Treatment Alternative 4.

Figure 3.5: A Conceptual Process Schematic of Treatment Alternative 4a

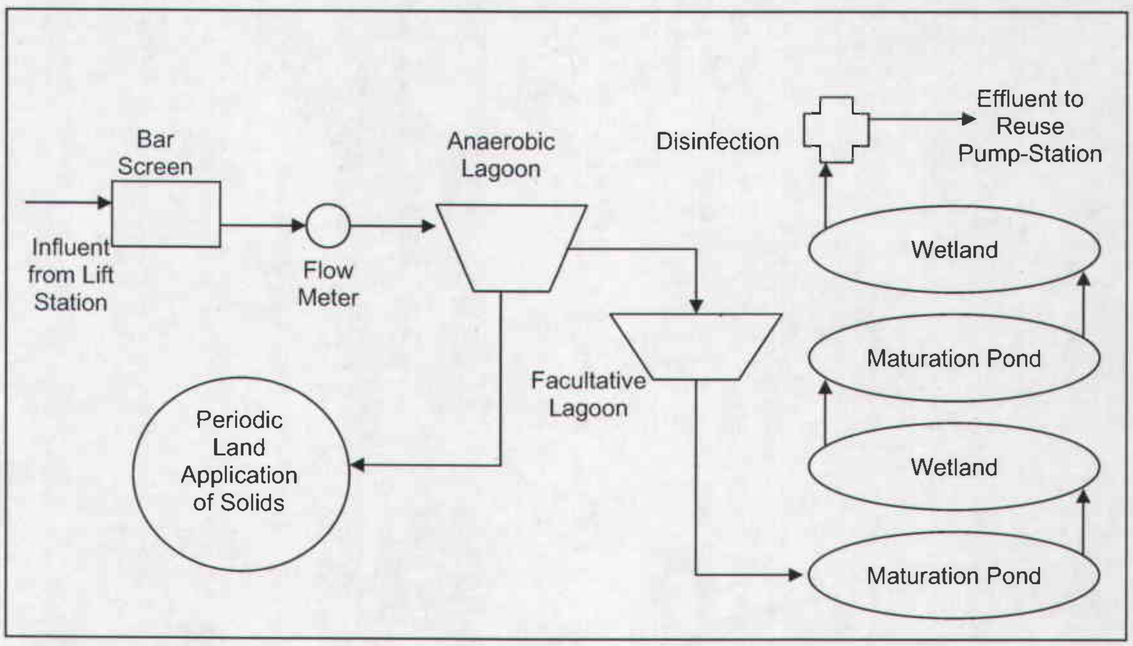


Table 3.8: Summary of Sizing of Major Components of the Recommended Lagoon Facility Sized to Accommodate Scenario 4a Mazagan Tourist Facility

Unit Process	Area Per Unit (m^2)	Number of Units Required		Area Required (m^2)	
		2010	2025	2010	2025
Influent Chamber	3.6	1	1	4	4
Anaerobic Lagoon	3600	2	2	7,200	7,200
Facultative Lagoon	11000	2	2	22,000	22,000
Maturation Pond	7000	2	2	14,000	14,000
Disinfection	100	1	1	100	100
Wetland Treatment	7000	2	2	14,000	14,000
Roads	6000	1	1	6,000	6,000
Operations	4000	1	1	4,000	4,000
Total Area Required (hectare)				**6.7**	**6.7**

Treatment Alternative 4b:

Treatment Alternative 4b considers the case in which adequate land area in unavailable to implement Treatment Alternative 4. In this instance, utilization of an oxidation ditch system to meet unrestricted reuse water quality targets is recommended as Treatment Alternative 5. Figure 3.6 displays a process schematic of the resulting oxidation ditch system.

Figure 3.6: A Conceptual Process Schematic of Treatment Alternative 4b

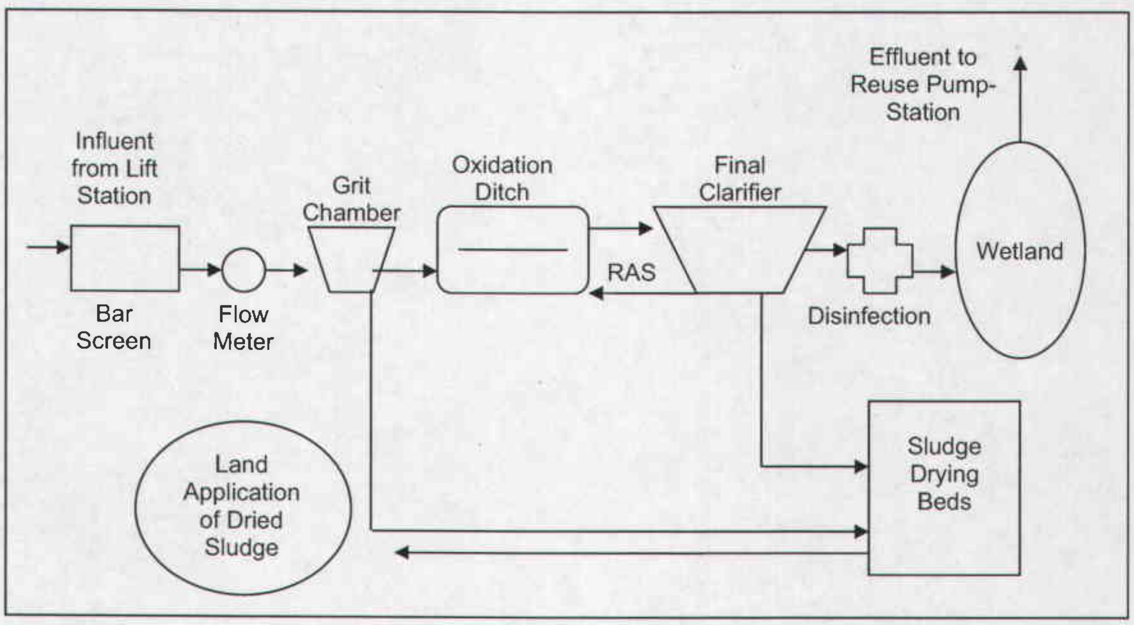


Table 3.9 provides a summary of sizing of major components of Treatment alternative 4b

Table 3.9: Summary of Sizing of Major Components of Treatment Alternative 4b

Unit Process	Area Per Unit (m^2)	Number of Units Required		Area Required (m^2)	
		2010	2025	2010	2025
Influent Chamber	3.6	1	1	4	4
Vortex Grit Chamber	11	2	2	22	22
Oxidation Ditch	200	2	2	400	400
Final Clarifier	140	2	2	280	280
Disinfection	100	1	1	100	100
Filtration	4000	2	2	8,000	8,000
Sludge Processing	12000	1	1	12,000	12,000
Roads	6000	1	1	6,000	6,000
Operations	4000	1	1	4,000	4,000
Total Area Required (hectare)				**3.1**	**3.1**

3.4 TREATMENT ALTERNATIVE COSTING

All cost estimates are preliminary in nature and developed for the sake of comparing relative costs of recommended treatment alternatives. Cost estimates therefore should be considered on an order of magnitude basis.

3.4.1 Design and Construction Costs

A summary of the overall construction costs of the five treatment alternatives is provided by Table 3.10. Cost estimates for each of the five treatment alternatives are summarized by major component in Tables 3.11 through 3.15. Estimates were based upon Moroccan unit cost data provided by GESI and equipment pricing provided by MWH.

Table 3.10: Overall Construction Costs of Recommended Treatment Alternatives

Alternative	Total Cost (DH)
1a	38 881 924
1b	33 219 269
1c	36 977 919
2	50 466 084
3	59 872 835
4a	40 683 322
4b	38 516 657

Table 3.11a: Construction Cost Estimate by Major Component of Treatment Alternative 1a

CIVIL WORK	Cost (DH)
Site Preparation	9.696.340
Buildings	1.005.000
Pump Stations	4.191.300
Sub Total	**14.892.640**
Construction supervision (5%)	**744.632**
Contingency (10%)	**1.563.727**
Total	**17.200.999**
PRELIMINARY TREATMENT	
Head Works	140.522
Screening	800.000
Flow measurements	450.000
Diversion chamber 1	673.423
Sub Total	**2.063.944**
Construction supervision (5%)	**103.197**
Contingency (10%)	**216.714**
Total	**2.383.855**
SECONDARY TREATMENT	
Anaerobic Lagoons	1.734.391
Facultative Lagoons	11.969.639
Diversion chamber 2	665.230
Chlorination	1.811.695
Outfall	526.465
Sub Total	**16.707.419**
Construction supervision (5%)	**835.371**
Contingency (10%)	**1.754.279**
Total	**19.297.069**
Total construction cost	**33.664.003**
Total construction supervision (5%)	**1.683.200**
Total contingencies (10%)	**3.534.720**
GRAND TOTAL	**38.881.924**

Table 3.11b: Construction Cost Estimate by Major Component of Treatment Alternative 1b

CIVIL WORK	Cost (DH)
Site Preparation	9.346.340
Buildings	1.005.000
Pump Stations	4.191.300
Sub Total	**14.542.640**
Construction supervision (5%)	**727.132**
Contingency (10%)	**1.526.977**
Total	**16.796.749**
PRELIMINARY TREATMENT	
Head Works	140.522
Screening	800.000
Flow measurements	450.000
Diversion chamber 1	673.423
Sub Total	**2.063.944**
Construction supervision (5%)	**103.197**
Contingency (10%)	**216.714**
Total	**2.383.855**
SECONDARY TREATMENT	
Aerated Lagoons	8.549.763
Diversion chamber 2	665.230
Chlorination	2.413.230
Outfall	526.465
Sub-Total	**12.154.688**
Construction supervision (5%)	**607.734**
Contingencies (10%)	**1.276.242**
Total	**14.038.664**
GRAND TOTAL	**33.219.269**

Table 3.11c: Construction Cost Estimate by Major Component of Treatment Alternative 1c

CIVIL WORKS	**Cost (DH)**
Site Preparation	8.851.300
Buildings	1.005.000
Pump Stations	4.191.300
Sub-Total	14.047.600
Construction supervision (5%)	702.380
Contingencies (10%)	1.474.998
Total	**16.224.978**
PRELIMINARY TREATMENT	
Head works	140.522
Screening	800.000
Flow measurements	450.000
Diversion chamber 1	673.423
Sub-Total	2.063.944
Construction supervision (5%)	103.197
Contingencies (10%)	216.714
Total	**2.383.855**
SECONDARY TREATMENT	
Anaerobic lagoons	2.186.080
De-nitrification basins	2.535.585
Diversion chamber 2	665.230
Percolation basins	6.912.150
Diversion chamber 3	665.230
Chlorination	2.413.230
Outfall	526465
Sub-Total	15.903.970
Construction supervision (5%)	795.199
contingencies (10%)	1.669.917
Total	**18.369.085**
TOTAL CONSTRUCTION COST	**32.015.514**
TOTAL CONSTRUCTION SUPERVISION (5%)	**1.600.776**
TOTAL CONTINGENCIES (10%)	**3.361.629**
GRAND TOTAL	**36.977.919**

Table 3.12: Construction Cost Estimate by Major Component of Treatment Alternative 2

CIVIL WORKS	**Cost (DH)**
Site Preparation	7.434.400
Buildings	1.005.000
Pump Stations	4.191.300
	12.630.700
Construction supervision (5%)	**631.535**
Contingencies (10%)	**1.326.224**
	14.588.459
PRELIMINARY TREATMENT	
Head works	140.522
Screening	800.000
Flow measurements	450.000
Diversion chamber 1	173.423
Grit removal	1.504.078
Sub-Total	**3.068.022**
Construction supervision (5%)	**153.401**
contingencies (10%)	**322.142**
Total	**3.543.565**
SECONDARY TREATMENT	
Diversion chamber 2	185.230
Oxidation ditch	9.162.570
Diversion chamber 3	435.230
Final clarifier	2.775.629
Diversion chamber 4	185.230
Sub-Total	**12.743.889**
Construction supervision (5%)	**637.194**
contingencies (10%)	**1.338.108**
Total	**14.719.192**
TERTIARY TREATMENT	
Wetlands	1.845.280
Filtration	2.201.900
Pump station of treated effluent	3.107.450
Chlorination	1.464.750
Sub-Total	**8.619.380**
Construction supervision (5%)	**430.969**
contingencies (10%)	**905.035**
Total	**9.955.384**

Table 3.12 (cont.): Construction Cost Estimate by Major Component of Treatment Alternative 2

	Cost (DH)
SLUDGE HANDLING	
Drying beds	6.821.560
Sous-Total	**6.821.560**
Construction supervision (5%)	**341.078**
Contingencies (10%)	**716.264**
Total	**7.878.902**
Total construction cost	**43.883.551**
Total supervision cost (5%)	**2.194.178**
Total contingencies (10%)	**4.388.355**
GRAND TOTAL	**50.466.084**

Table 3.13: Construction Cost Estimate by Major Component of Treatment Alternative 3

CIVIL WORKS	Cost (DH)
Site Preparation	8.914.180
Buildings	1.005.000
Pump Stations	4.161.300
	14.080.480
Construction supervision (5%)	**704.024**
Contingencies (10%)	**1.478.450**
	16.262.954
PRELIMINARY TREATMENT	
Head works	140.522
Screening	800.000
Flow measurements	450.000
Diversion chamber 1	173.423
Grit removal	1.504.078
Diversion chamber 2	435.230
Sub-Total	**3.503.252**
Construction supervision (5%)	**175.163**
Contingencies (10%)	**367.841**
Total	**4.046.256**
SECONDARY TREATMENT	
Oxidation ditch	12.282.050
Diversion chamber 3	435.230
Final clarifier	4.181.483
Diversion chamber 4	435.230
Sub-Total	**17.333.993**
Construction supervision (5%)	**866.700**
Contingencies (10%)	**1.820.069**
Total	**20.020.762**
TERTIARY TREATMENT	
Wetlands	2.895.650
Filtration	2.861.900
Pump station for treated effluent	3.101.750
Chlorination	1.464.750
Sub-Total	**10.324.050**
Construction supervision (5%)	**516.203**
Contingencies (10%)	**1.084.025**
Total	**11.924.278**

Table 3.13 (cont.): Construction Cost Estimate by Major Component of Treatment Alternative 3

	Cost (DH)
SLUDGE HANDLING	
Drying beds	6.821.560
Sub-Total	**6.821.560**
Construction supervision (5%)	**341.078**
Contingencies (10%)	**716.264**
Total	**7.878.902**
Total construction cost	**52.063.335**
Total supervision cost (5%)	**2.603.167**
Total contingencies (10%)	**5.206.333**
GRAND TOTAL	**59.872.835**

Table 3.14: Construction Cost Estimate by Major Component of Treatment Alternative 4a (Mazagan Only)

CIVIL WORK	**Cost (DH)**
Site Preparation	9.498.360
Buildings	810.000
Pump stations	4.191.300
Sub-Total	**14.499.660**
Construction supervision (5%)	**724.983**
Contingencies (10%)	**1.522.464**
Total	**16.747.107**
PRELIMINARY TREATMENT	
Head works	136.614
Screening	800.000
Flow measurements	450.000
Diversion chamber 1	673.423
Sub-Total	**1.923.423**
Construction supervision (5%)	**96.171**
Contingencies (10%)	**201.959**
Total	**2.221.553**
SECONDARY TREATMENT	
Anaerobic lagoons	3.315.708
Facultative lagoons	6.124.860
Diversion chamber 2	560.230
Sub-Total	**10.000.798**
Construction supervision(5%)	**500.040**
Contingencies (10%)	**1.050.084**
Total	**11.550.922**
TERTIARY TREATMENT	
Maturation ponds	2.406.240
Wetlands	2.462.855
Chlorination	823.230
Pump station for treated effluent	3.107.450
Sub-Total	**8.799.775**
Construction supervision (5%)	**439.989**
Contingencies (10%)	**923.976**
Total	**10.163.740**
Total construction cost	**35.223.656**
Total supervision cost (5%)	**1.761.183**
Total contingencies (10%)	**3.698.484**
GRAND TOTAL	**40.683.322**

Table 3.15: Construction Cost Estimate by Major Component of Treatment Alternative 4b (Mazagan Only)

CIVIL WORKS	Cost (DH)
Site preparation	5.939.720
Buildings	765.000
Pump stations	4.191.300
Sub-Total	**10.896.020**
Construction supervision (5%)	**544.801**
Contingencies(10%)	**1.144.082**
Total	**12.584.903**
PRELIMINARY TREATMENT	
Head works	136.648
Screening	800.000
Flow measurements	450.000
Diversion chamber 1	169.351
Grit removal	1.025.914
Diversion chamber 2	169.351
Sub-Total	**2.751.263**
Construction supervision (5%)	**137.563**
Contingencies (10%)	**288.883**
Total	**3.177.709**
SECONDARY TREATMENT	
Oxidation ditch	7.030.703
Diversion chamber 3	169.351
Final clarifier	2.876.686
Diversion chamber 4	430.683
Chlorination	1.017.610
Sub-Total	**11.525.032**
Construction supervision (5%)	**576.252**
Contingencies (10%)	**1.210.128**
Total	**13.311.412**
TERTIARY TREATMENT	
Filtration	2.861.900
Pump station for treated effluent	3.107.450
Sub-Total	**5.969.350**
Construction supervision (5%)	**298.468**
Contingencies (10%)	**626.782**
Total	**6.894.599**

Table 3.15 (cont.): Construction Cost Estimate by Major Component of Treatment Alternative 4b (Mazagan Only)

	Cost (DH)
SLUDGE HANDLING	
Drying beds	2.351.080
Sub-Total	**2.351.080**
Construction supervision (5%)	**117.554**
Contingencies (10%)	**246.863**
Total	**2.715.497**
Total construction cost	**33.492.745**
Total supervision cost (5%)	**1.674.637**
Total contingencies (10%)	**3.349.274**
GRAND TOTAL	**38.516.657**

3.4.2 Personnel and Staffing Costs

The United States Environmental Protection Agency (EPA, 1973) guidelines were utilized to estimate the number of staff required for the operation and maintenance of the proposed facilities. Graphs of annual hours vs. wastewater treatment plant size for major operation and maintenance activities were used to estimate the annual hours required to maintain and operate each of the five treatment alternatives. Once total annual hours required for O&M were estimated, the number of individual staff required to undertake plant activities was calculated. Table 3.16 provides a summary of operation and maintenance hours required for each of the proposed treatment alternatives.

Table 3.16: Summary of Hours Required for Operation and Maintenance for the Proposed Treatment Alternatives

Duration O&M Activities / (hours / year)	Alternative 1 (1a, 1b et 1c)			Alternative 2	Alternative 3	Alternative 4 (4a et 4b)	
Supervision Management	545	545	545	545	675	340	340
Office Personnel	59	59	59	59	92	24	24
Laboratory personnel	630	630	630	630	790	400	400
Laborers	490	490	980	490	640	290	290
Pump station personnel	335	335	670	335	360	300	300
Grit personnel	69	69	69	69	110	32	32
Aeration personnel	0	1020	0	1020	1260	0	700
Chlorination personnel	375	375	375	375	385	260	260
Sedimentation Pers.	0	225	450	225	280	0	155
Sludge pers.	0	250	250	250	290	0	180
Maturation pond pers.	220	0	440	0	0	180	0

To determine the number of personnel required it was assumed that each staff member will work an average of 1,500 hours per year. The number of staff was rounded up the nearest whole number.

Table 3.17: Summary of Staffing Requirements for the Proposed Treatment Alternatives

Recruitment & Placement Activity /Personnel	Alternative 1 (1a, 1b et 1c)			Alternative 2	Alternative 3	Alternative 4 (4a et 4b)	
Laborers	3	3	5	3	3	3	3
Technicians	2	3	5	3	3	2	3
Total (No.)	5	6	10	6	6	5	6

Applying typical annual salary data for water treatment plant personnel in Morocco, the annual cost of personnel and staffing was determined. Table 3.18 provides a summary of annual staffing costs for each of the five treatment alternatives.

Table 3.18: Summary of Annual Staffing Costs for Recommended Treatment Alternatives

Salaries Activity /Personnel	Alternative 1 (1a, 1b et 1c)			Alternative 2	Alternative 3	Alternative 4 (4a et 4b)	
Laborers	120 000	120 000	200 000	120 000	120 000	120 000	120 000
Technicians	200 000	300 000	500 000	300 000	300 000	200 000	300 000
Total Personnel Salary (DH)	**320 000**	**420 000**	**700 000**	**420 000**	**420 000**	**320 000**	**420 000**

3.4.3 Consumable Materials Costs

Consumable materials are those items such as chemicals and power. Consumable costs were estimated for each of the proposed treatment alternatives based upon unit costs provided by the GESI/MWH Team. Table 3.19 provides a summary of annual consumable material costs associated with each of the treatment alternatives. Consumable material costs were estimated based upon Moroccan unit costs provided by GESI and previous MWH experience with similar treatment facilities elsewhere.

Table 3.19: Summary of Annual O&M and Consumable Material Costs

Alternative	Annual cost of energy (DH/an)	Annual cost of chemical products (DH/an)	Annual cost for renewing sand filters (DH/an)	Total annual cost of consumables (DH /an)
1a	25 000	82 000	-	107 000
1b	475 000	82 000	-	557 000
1c	25 000	82 000	82 080	189 080
2	375 000	82 000	-	457 000
3	570 000	122 000	-	692 000
4a	21 000	41 000	-	62 000
4b	210 000	41 000	-	62 000

3.5 ANALYSIS OF RESULTS

The cost of construction of each treatment alternative is a one-time capital investment. Annual operation and maintenance costs, on the other hand, are carried out annually over the life-time of the treatment facility. In order to determine the total overall alternative cost, it is necessary too compare the total cost not only of constructing the recommended alternatives but also of maintaining them through their project lives. This is achieved by comparing the total present worth of each of the alternatives. For the purpose of this analysis the total life of each alternative was considered to be 25 years. The interest of annual monies associated with O&M is assumed to be 5% per year.

In order to select the most appropriate treatment program it is necessary to consider any economic benefits such as those derived through the direct sale of effluent for reuse. Treated effluent will be used in place of potable water as an irrigation supply. Since potable water has an associated cost, it is fair to assume that treated effluent used in place of potable water also has monetary value. For the purposes of this comparison it is assumed that treated effluent will have a value of 0.15 US$ per cubic meter. Table 3.20 provides a summary of costs and immediate economic benefits associated with each if the treatment alternatives and the total present worth of each of the treatment alternatives considered.

Table 3.20: Summary of Costs Associated With Each If The Treatment Alternatives

Cost (DH)	Alternative 1a	Alternative 1b	Alternative 1c	Alternative 2	Alternative 3	Alternative 4a	Alternative 4b
Volume Treated water (m3)	23.354.525	23.354.525	23.354.525	23.354.525	35.063.725	11.709.200	11.709.200
Construction cots	38.881.924	33.219.269	36.977.919	50.466.084	59.872.835	40.683.322	38.516.657
O&M cost over 20 years	8.540.000	19.540.000	17.781.600	17.540.000	22.240.000	7.640.000	9.640.000
Slate of treated effluent @ 1,50 Dh/m3	0	0	0	31.528.609	47.336.029	15.807.420	15.807.420
Total project cost over 20 years	**47.421.924**	**52.759.269**	**54.759.519**	**36.477.475**	**34.776.806**	**32.515.902**	**32.349.237**
Cost DH/m3	2,03	2,26	2,34	1,56	0,99	2,78	2,76

3.5.1 Construction Costs

Construction costs of lagoon systems (Alternative 1) are appreciably less (31%) than oxidation systems (Alternatives 2, 3). It should be remembered however, that effluent from the oxidation ditch system is of significantly higher quality and intended for reuse, while lagoon effluent is intended for discharge without reuse.

Savings in construction costs of (14 to 18 %) are realized by combining facilities to handle flows from all three sources. It should be noted that savings in construction costs of combining facilities would be appreciably larger if similar technologies were being considered. For example, if we compare the costs of using oxidation ditch technology at two facilities Azemmour and Sidi Ali and Mazagan with a single combined facility as recommended under scenario 3 a savings of 22 % in construction costs is realized.

3.5.2 Staffing and Personnel

In terms of staffing, there exists significant advantage in serving all three sources with a single treatment facility. Elimination of redundant staff in combining flows to a single facility results in a savings of 4 operations personnel at a cost savings of 47,000 US$/yr. Also as in Alternative 2, sale of treated effluent can generate revenues to offset the additional costs of using oxidation ditch technology.

3.5.3 Consumable Materials

Though costs associated with consumable are preliminary, two points can be made. First, the operation of the oxidation ditch system is more than ten-fold that of a lagoon system further, power costs increase with additional capacity whereas it does not increase appreciably when additional capacity is added to the lagoon system. Chemical costs between the two technologies are the same as they were considered solely as a function of hydraulic load in this comparison.

Secondly, There are significant saving in consumables associated with combining flows and treating at one central facility. In order to make this comparison, like alternatives were considered. Alternative 3 and a similar case in which two separate oxidation ditch systems with equal capacity are compared. From this comparison we see that a single larger facility will use approximately 36% less power than two smaller separately operated facilities and 31% less chemical will be required for laboratory analysis.

3.5.4 Effluent Reuse

Economic benefit can be gained through the sale of treated effluent for irrigation of green areas, golf courses, and or agriculture. Alternative 2, for example, will produce more than 4000 m3 of reusable irrigation water per day. If treated effluent produced under this alternative were sold for 0.15 US$/m3 it would equate to an annual revenue of 230,000 US$. Similarly under Alternative 3 approximately 2.3 million cubic meters of treated effluent will be created representing a possible revenue of as much as 330,000 US$/year at 0.15 US$/m3. In comparing total projects costs, the economics of producing and selling more treated effluent become apparent when comparing

Alternatives 2 and 3. In this case the production and sale of additional effluent produced under Alternative 3 makes this alternative less costly then Alternative 2.

3.6 CONCLUSIONS AND RECOMMENDATIONS

3.6.1 Recommended Treatment Program

Alternative 1 has the advantage of not requiring a thorough treatment (tertiary) since the effluent will be rejected directly into the wadi Oum Er_Rbia and that it is an alternative, which can be installed independently of what Mazagan wants to do with its wastewater. Its disadvantage on the other hand is that it does not benefit from the potential of the re-use of the effluent.

Alternative 1 can be carried out by simple lagoons, aerated lagoons or percolation basins as indicated respectively in sub-alternatives 1a, 1b and 1c. The simple lagoons alternative (Alternative 1a) has the advantage of simplicity of construction and management, and the disadvantage of requiring more land for construction. The aerated lagoon alternative (Alternative 1b) has the advantage of requiring less space but the disadvantage of requiring more energy for its operation. The percolation alternative (Alternative 1c) has the advantage of requiring a little less space compared to the simple lagoons, but requires more materials (sand) and personnel for his operation. In addition, this sub-alternative presents serious risks of clogging and emission of odors. When the 3 sub-alternatives are compared, from the unit cost point of view per cubic meter treated, it is clear that the simple lagoons (Alternative 1a) is less expensive compared to the aerated lagoons (Alternative 1b) and percolation basins (Alternative 1c).

Alternative 2 has the advantage of being able to benefit from the re-use of the purified effluent and possible incomes which can be generated by the sale of this effluent; but it has the disadvantage of being a little more expensive since it requires a thorough treatment (tertiary) to meet the standards of re-use. For this alternative, a system of oxidation ditches, followed by maturation ponds and wetlands proved to be most favorable, compared with other technologies, since it requires less land for its installation and offers a water of quality in conformity with the standards of re-use.

Alternative 3 has the advantage of economy of scale since it combines the wastewater of Azemmour, Sidi Ali and Mazagan in one wastewater treatment plant, therefore the cost per cubic meter of water treated in this alternative is lower than all the other alternatives considered. This alternative also makes it possible to realize savings not only for Azemmour and Sidi Ali but also for the tourist complex of Mazagan in terms of the construction of the treatment works and the operating costs of the station. Indeed, in this alternative, Azemmour and Sidi Ali can on the one hand, require a contribution from Mazagan to cover part of the expenses of construction and management of the station and on the other hand, sell the purified effluent to Mazagan for the irrigation for the golf courses and parks. The tourist complex of Mazagan will profit, also, from this alternative since it will not have to build and manage a treatment plant which will become, in any event, more expensive (since its flow by itself is small) as indicated in the alternatives 4a and 4b; and at the same time it will have a greater quantity of purified water which will cost it much less than if it buys this water from ONEP at a price of more than 2 Dh/m3 (drinking water being sold at 4.13 dh/m3) instead of 1.50 Dh/m3 for the treated effluent. The quotas of Azemour/Sidi Ali and Mazagan in the construction and the management of the treatment plant (proportionally with their flows) as well as the benefits which can be realized, possibly, by each town are presented in the following table. From this table, one can conclude that Alternative 3 offers the lower cost of treated water per cubic meter for Azemmour and Mazagan.

Table 3.21: Cost value of alternative 3

Cost share (DH)	Azemmour and Sidi Ali	Mazagan
Percentage of the flow (%)	66.61%	33.39%
Construction (DH)	(39,878,867)	(19,993,968)
O&M (DH)	(14,813,162)	(7,426,838)
Revenue from sale of treated effluent (DH)	31,528,609	0
Cost savings by purchase of treated effluent (DH)	0	15,778,676
Total Cost (DH)	(23,163,420)	(11,642,130)
Cost per cubic meter (Dh/m3)	**0.99**	**0.99**

Alternative 4 supposes that the tourist complex of Mazagan constructs and manages all alone its own wastewater treatment plant. Two sub-alternatives were considered for this scenario. The first sub alternative 4a prescribes the lagoons and wetlands mode of treatment and the second alternative 4b prescribes the oxidation ditch and wetlands mode of treatment. The first alternative is, obviously, more expensive since it requires more land which must be waterproofed, the second is less expensive although its operating costs are higher. These two alternatives remain both more expensive for Mazagan if it does not decide to join Azemmour and Sidi Ali in building and operating a single wastewater treatment plant.

Indeed, the cost of 2.76 Dh/m3 for Alternative 4b, is almost three times higher than the cost of 0.99 Dh/m3 offered by Alternative 3. More specifically, as in Alternative 3, Mazagan can have a greater quantity of treated water which will cost less than buying this water from ONEP.

Thus, it will be easier to convince Mazagan to join Azemmour and Sidi Ali in building only one wastewater treatment plant. The mode of management of this station can be negotiated with Mazagan to take into account its concerns in particular with regard to the quality of the purified effluent. A way of alleviating this concern would for example the delegate the operation of the treatment plant to a private company. In this mode of management, the private company can construct and operate the station, and each party can pay the company their cost share per cubic meter of treated effluent. In turn, the company will guarantee the quality of the treated effluent.

In the case where Mazagan is not interested in the treatment of its effluents in a common treatment station with Azemmour and Sidi Ali (alternative 3), it is clear that the Alternative 1a (simple lagoons), followed by Alternative 1b (aerated lagoons) are less expensive for Azemmour and Sidi Ali. However, given the risk of odors which can emanate from the simple lagoon system, the project committee decided on June 8, 2005 to retain the aerated lagoons (Alternative 1b) system for wastewater treatment for Azemmour and Sidi Ali.

SECTION 4: DETAILED STUDY OF THE SELECTED ALTERNATIVE

TABLE OF CONTENT

4.1 OBJECTIVES

The objective of Task 4 is to design the wastewater treatment plant and prepare related technical documents and engineering drawings. The report of this Task contains the following details:

- Design criteria
- Design calculations
- Operations and maintenance procedures of the treatment plant
- Technical specifications of the treatment plant.

4.2 DESIGN CRITERIA

4.2.1 Wastewater flows and loads

A summary of the wastewater flow and pollution loads of the town of Azemmour and Sidi Ali are presented on the table below:

Table 4.1: Summary of the daily average flows of Waste Water

	2005	2010	2015	2020	2025
Average WW flow of Azemmour (m3/d)	2412	2750	3153	3636	3917
Average WW flow of Sidi Ali (m3/d)	163	191	227	266	303
Total flow (m3/d)	2575	2941	3380	3902	4220

Table 4.2: Domestic and industrial wastewater pollution loads

		2005	2010	2015	2020	2025
BOD5 (Kg/d)	Azemmour	1309	1542	1833	2194	2418
	Ali Sidi	66	80	100	120	141
	Total	**1375**	**1622**	**1933**	**2314**	**2559**
COD (Kg/d)	Azemmour	3108	3560	4108	4773	5141
	Ali Sidi	129	158	197	241	287
	Total	**3237**	**3718**	**4305**	**5014**	**5428**
TSS (Kg/d)	Azemmour	1024	1212	1443	1680	1864
	Ali Sidi	41	52	65	77	94
	Total	**1065**	**1264**	**1508**	**1757**	**1958**
NTK (Kg/d)	Azemmour	329	367	427	500	538
	Ali Sidi	16	20	27	32	37
	Total	**345**	**387**	**454**	**532**	**575**
PT (Kg/d)	Azemmour	57	67	77	90	98
	Sidi Ali	3	4	4	6	7
	Total	**60**	**71**	**81**	**96**	**105**

4.2.2 Basic parameters of the treatment station design

The design year is 2025. The treatment plant will operate in 2025 at an average daily flow of 4220 m^3/d of wastewater at an average BOD concentration of 598 mg/l and an TSS of 446 mg/l.

The design parameters for the year 2010 and 2025 are indicated in Table 4.3.

Table 4.3: Parameters of dimensioning (Azemmour + Sidi Ali)

Parameter	Concentration	Concentration
Year	**2010**	**2025**
Population served	49,700	63,150
Population connected	39,737	59,609
Flow (m3/day)		
Minimum per hour	1768	2532
Daily Average	2940	4220
Daily Peak	3675	5275
Hourly Peak	7350	10550
Diluted Flow (From DO)	11025	15825
Concentration (mg/l)		
BOD5	544	598
COD	1262	1286
TSS	404	446
TKN	136	141
Load (kg/jour)		
BOD5 Average per Day	1599	2524
BOD5 Maximum per Day	2000	3160
COD Average per Day	3712	5427
COD Maximum per Day	4639	6784
TSS Average per Day	1303	1958
TSS Maximum per Day	1628	2448
TKN Average per Day	391	574
TKN Maximum per Day	489	717

4.2.3 Effluent discharge limits

The treatment plant is planned to treat wastewater at the levels indicated in the following Table 4-4. The treated effluent can either be re-used for the irrigation of the forest or discharged in the Oum Er-Rbia river.

Table 4.4: Effluent limits

Maximum concentration of the Effluent	Frequency	Value
DBO (mg/l)	Monthly average	30
COD (mg/l)	Monthly average	150
TSS (mg/l)	Monthly average	50
Dissolved solids (mg/l)	Monthly average	2000
Coliforms (MPN/100 ml)	Weekly average	<1000
Nematode eggs	Weekly average	<1
PH	Weekly average	6.5-8.5
Oil and grease (mg/l)	Daily	30
Nitrate (mg/l)	Monthly average	50
Total Phosphorus P (mg/l)	Daily	2
Sulphites (mg/l)	Daily	250
Temperature, °C	Daily	<30

The sludge produced in the purification station will be treated to allow its transport and re-use in agriculture or its discharge according to the regulation in force.

4.2.4 Design criteria for treatment

Base design:

BOD entry = 598 (mg/L)
MES entry = 446 (mg/L)

BOD exit = 30 (mg/L)
TSS exit = 30 (mg/L)

Temperature of the air in summer = 23 °C
Temperature of the air in winter = 13 °C
Temperature of wastewater = 23 °C
Density of sludge = 1.06
Compression of the layer of sludge 85%

Coefficients

Y = 0.65 (g/g)
K_s = 100 (g/m3)
K = 6.0 (g/g.d)
K_d = 0.07 (g/g.d)
T = 20 – 25 °C

Total Solids = (Total Volatile Solids) / 0.85

Rate of Elimination of BOD first order:

$$K_{20} = 2.5j^{-1} \alpha\ 20\ °C$$

Coefficient of Temperature θ = 1.06

Coefficient of aeration α = 0.85 β = 1.0
Rates of Aeration Transfer of Oxygen = 1.8 kg O2/kWh
Elevation 50 m
Minimum Oxygen Dose 1.5 mg/L
Depth of the basin 3.5 Meters
Total Residence time SRT 5 days
Power necessary for mixture 8 kW/1000m3

Treatment works :

$$V = Q / (L \times D)$$

V: speed of water (<1m/s)
Q: Water flow rate, m3/s
L: Width of the opening, m
D: Depth of the opening, m.

Distributor of flow:

$$V = Q / (L \times D)$$

V: speed of water (<1 m/s)
Q: Water flow rate, m3/s
L: Width of the opening, m
D: Depth of the opening, m

Grit chamber (principal and by-pass):

- Minimal speed   Vmin = 0.6 m /s
- Maximum speed   Vmax = 1.2 m/s

- Δh (pressure loss) ranging between 0.1 and 0.4 m.

$$\Delta h = \beta \times (s / b)^{4/3} \times V^2 / 2g \times \sin\alpha$$

b: Spacing between the bars
S: Thickness of the bars
V: Rate of flow in front of the grid
α: The grid angle of inclination compared to the horizontal
β: Form coefficient

Aeration Ponds:

$$V = Q * SRT$$

V = Volume (m^3)
Q = Flow (m^3/s)
SRT = Residence time of the solids (days)

$$A = V/d$$

A = Surface (m^2)
d = Depth (m)

$$T_w = (AfT_a + QT_i) / (Af + Q)$$

Tw = Temperature of water °C
Ta = Temperature of the air °C
Ti = Temperature of waste water 20 °C
F = Factor of Proportionality

$$k_T = k_{20}\theta^{(T-20)}$$

k_T = Coefficient of Reaction at the temperature T

k_{20}= Coefficient of Reaction at temperature T
θ = Temperature coefficient
T = Temperature °C

$$S = S_O / (1 + (k)\tau)$$

S = Concentration of soluble BOD of the Effluent (mg/L)
S0 = Concentration of soluble BOD of the river (mg/L)
K = Reduction amount of the BOD (j^{-1})

$$X = Y (S_0 - S) / (1 + (k_d) SRT)$$

X = Concentration of the biological solids produced (mg/L)
S = BOD Concentration of the Effluent (mg/L)
S0 = BOD Concentration of the river (mg/L)
Kd = Coefficient of endogenous decline (j-1)
SRT = Time of residence of the solids (d)

$$R_0 = Q(S_0 - S) - 1.42P_{x,bio} \text{ and } P_x = WQ/1000$$

R0 = Required Oxygen
S = Concentration of DBO of the Effluent (mg/L)
S0 = Concentration of DBO of the river (mg/L)
$P_{X,\,bio}$ = Biological Solids (m3/d)

$$SOTR = AOTR (C_{S,\,20} / \alpha (\beta C_{S,\,T,\,H} - C) (1.024^{20-T})$$

SOTR = Standard Rate of oxygen transfer (kgO2/hr)
AOTR = Actual Rate of oxygen transfer (kgO2/hr)
CS, 20 = oxygen concentration dissolved in saturation (mg/L)
$C_{S,\,T,\,H}$ = average oxygen concentration dissolved in saturation (mg/L)
α, β = Coefficients of ventilation

Settling Basins

$$M_{sludge/yr} = Q (TSS_i - TSS_e) (365j/Year)$$

$M_{sludge/yr}$ = Sludge mass produced per year (kg/yr)
TSSi = MES river (g/m3)
TSSe = MES effluent (g/m3)

$$VSS = 0.70 * TSS$$

VSS = solid volatile matter in suspension (g/m3)
TSS = solid matter in suspension (g/m3)

$$VSS_t = (0.70 + 0.4 (t-1)) * VSS$$

VSSt = Total volatile matter in suspension (g/m3)
VSS = volatile solid matter in suspension (g/m3)

$$TSS_t = VSS_t + FSS_t$$

TSSt = Total solid matter in suspension (g/m3)
VSSt = Total solid volatile matter in suspension (g/m3)
FSSt = Total fixed suspended solid matter (g/m3)

Sludge drying beds:

$$A = \frac{1.04\ S\ [\ (1-s_d)/s_d - (1-s_e)/s_e\ ] + (1000)(P)(A)}{(10)(k_e)(E_p)}$$

A: Bottom surface of bed m2
S: Annual quantity of sludge produced, kg
sd: Percentage of solid matter after settling
s_e Percentage of final solid matter required
P: Annual precipitation, m
Ke: Parameter of reduction of the rate of evaporation (sludge vs. water) (= 0.6)
Ep: Rate of evaporation (water surface) of the zone, cn/year

Maturation Ponds:

The principal objective of the maturation ponds is the elimination of the fecal coliforms. If we indicate by NI and Ne respectively the fecal numbers of coliforms exiting and entering the ponds per 100 ml, the equation of degradation is written as follows:

$$N_{ex} = \frac{N_e}{(1+K_{B\,(T)} \times T_{an}) \times (1+K_{B\,(T)} \times T_{fac}) \times (1+K_{B\,(T)} \times T_{mat})^N}$$

Where:

- KB(T): Coefficient of first order degradation of the fecal bacteria

- Tan, Tfac: residence time of the effluent in the anaerobic and secondary ponds, respectively

- Tmat: residence time of the effluent in the dewatering basins (1st basin 5 days, the others 3 days)

- N: number of dewatering basins in series

- The concentration of the fecal bacteria in raw water is generally on the order of E 10^7-10^8 per ml.

- The coefficient KB(T) is given by the Marais formula as follows:

$$K_{B\,(T)} = 2{,}6 * (1{,}19)^{(T-20)}$$

- The depth of the dewatering basins is 1 to 1.2 m.

A very important condition necessary to check during design is that the density of surface load of the first dewatering basin does not exceed 75% of the density of surface load of the secondary basin.

4.2.5 *Design criteria for collection and pumping stations*

4.2.5.1 Storm water Overflow

The design procedure for storm water over flows is as follows:

- Evaluation of the maximum capacity preserved at the downstream towards the wastewater treatment plant, according to an acceptable dilution at the station. This flow is about 3 to 4 times the dry-weather flow (5 to 6 to the maximum). The rate selected is 3.

- Determination of the value of the threshold of operation as well as the value of filling of the drain pipe, this last value determines the high full level.

- For the flows of the stormy event considered, one calculates then the length of the outfall by application of the formulas of threshold (function of the type of the work). The formula of POLENI can be used, it arises as follows:

$$Q = 2/3\ \mu\ LH\ (2gH)^{0,5}$$

Q: flow discharged (m3/s)
μ: coefficient of discharge
μ: 0.6 for a unilateral discharge
μ: 0.5 for a bilateral discharge

L: width of discharge (m)
H: head on the outfall (m)
G: acceleration of gravity (m/s²)

4.2.5.2 Pumping Stations

Discharge Flow:

The discharge flow of the pump station of Azemmour is equal to the diluted flow from the storm outfall and which is presented on the table above that is to say Qd = 183.16 l/s.

The discharge flow of the station of Sidi Ali is of 4.38 l/s.

Volume of the aeration tank:

The useful volume aeration tank of the station is given by the following formula:

V = Error!

Q: nominal capacity of a pump (m3/s)
N: numbers pumps
T: time tolerated between 2 successive starts (6 starts per hour)

Power absorbed by the pumping installation:

The power absorbed (in KW) by the pumping installation is calculated by the formula:

Pg = Error!

Q: back flow (l/s)
Hmt: total manometric head (m)
G: acceleration of gravity (9.81 m/s^2)
R: output of the pumping installation (0.6)

The total head Hmt is calculated by the formula:

Hmt = Hg + Ja + Jr

Hg: geometrical height (m)
Ja: pressure losses of aeration in m (negligible)
Jr: pressure losses of discharge (m) calculated by the Colebrook formula given below.

Energy Losses:

Annual energy loss is the product of the power loss by the number of hours (per year) of operation of the pumping installation.

The working installed capacity (in kcVa) is calculated by the formula.

$$P_i = \frac{Pg}{\cos\varphi} \times 1,2$$

Cos φ: power-factor installed

4.2.5.3 Discharge pipe

Pressure losses:

The discharge pipe is designed by calculating the linear pressure losses by means of the following formulas:

Darcy-Weisbach:

$$J = \frac{\lambda . V^2}{2.g.D}$$

Colebrook:

$$\frac{1}{\sqrt{\lambda}} = -2\log\left[\frac{k}{3.71D} + \frac{2.51}{\mathrm{Re}\sqrt{\lambda}}\right]$$

J: pressure loss (m/m)
λ : Loss coefficient of load
V: rate of flow (m/s)
G: acceleration of gravity (m/s^2)
K: coefficient of roughness (m)
K = 0.1 mm for the PVC conduits
K = 0.5 mm for the Pre-stressed Concrete conduits
D: diameter of pipe (m)
Re: Reynolds number of the flow

$$\mathrm{Re} = \frac{V \; . D}{\nu}$$

ν: kinematic viscosity of water (m^2/s)

The rate of flow in a discharge pipe will be limited between 0.5 and 2 m/s.

The diameter of pipe is that which corresponds to the minimum updated total cost (economic diameter).

4.2.5.4 Design of the collectors in combined system

The formula used for the calculation of a collector in a combined system is:

$$Q = 60. S. R_H^{3/4}. I^{1/2}$$

Q: flow conveyed by the drain (m3/s)
RH: hydraulic radius (ratio of the wetted surface to the wetted perimeter)
I: slope of the foundation of the drain (m/m)
S: wetted surface (m^2)

For the design of the ditches for rain water drainage, one will use the formula of **Manning Strickler:**

$$Q = K \cdot S \cdot R_H^{2/3} \cdot I^{1/2}$$

With:
K = 35 in the case of an earthen ditch
K = 70 in the case of a concrete gutter

4.2.5.5 Design of the collectors of waste water used in separate system

The formula used for the dimensioning of the waste water pipelines in a separate network is:

$$Q = 70 \cdot S \cdot R_H^{2/3} \cdot I^{1/2}$$

Q: flow conveyed by the drain (m3/s)
S: wetted surface (m²)
RH: hydraulic radius (m)
I: slope of the foundation of the drain (m/m).

4.2.5.6 Protection against water hammers

a. Determination of velocity

The velocity of the wave of propagation of the water hammer is a function of the nature and thickness of the pipe when the transported liquid is water. This celerity is given by the following formula:

$$a = \frac{9900}{\sqrt{48.3 + \frac{K.D}{e}}}$$

a: Celerity of the wave of propagation of the water hammer in m/s
D: Internal diameter of the pipe in m
E: Thickness of the pipe in m
K: Coefficient depend on the nature of the pipe;

Material	K
Steel	0.5
Concrete	5
PVC	33

b. Determination of high pressure and maximum vacuum

The value of high pressure or the maximum vacuum recorded at the time of a water hammer is given by:

$$H = \pm \frac{a.V_0}{g}$$

The sign: + for high pressure
- for vacuum

a: being the celerity of the wave in m/s
V0: initial speed of the flow in m/s
G: acceleration of gravity in m/s2
H: high pressure or maximum vacuum in m

c. Design of an anti-hammer tank

The design of an anti-hammer tank consists in determining the volume of this tank which, in the event of a water hammer, would be able to protect the installations against high pressure or a vacuum.

The volume of the anti-hammer tank is calculated using the following simplified formula:

$$V_t = \frac{Q.P_2.(16,4.L - T)}{4,2.(P_2 - P_1)}$$

Vt: total volume of the balloon in liters
Q: flow in l/s
L: length in km
T: downtime of the pump
P1: maximum pressure of control in rest (20 m)
P2: selected acceptable pressure (100 m).

4.3 DESIGN CALCULATIONS

The results of design of the operation of purification are presented below and are as follows:

4.3.1 Flow Distributor

At the entrance of the station, wastewater will be directed towards a diversion camber to distribute the flow amongs the aerated lagoons. The diversion chamber is equipped with valves and outfalls whose role is to equitably distribute the flow between the aerated lagoons.

Dimensions of the diversion chamber are:

- Length of the basin is equal to 2 m
- Width of the basin is equal to 2 m
- Depth of the basin is equal to 3 m.

4.3.2 Channel Flow meter

A Venturi channel will be installed upstream of the aerated lagoons in order to measure the flow entering the station. The Venturi will be prefabricated. It will be delivered with its accessories: probes ultrasonic, transmitting, and recording, support, etc...

4.3.3 Aerated lagoons

Three aerated lagoons are designed to treat wastewater of the towns of Azemmour and Sidi Ali, up to the year 2025.

The lagoons will be built on the ground with an impermeable bottom of clay (available in the area according to the geotechnical study). The dimensions of each lagoon are:

- Overall length: 112 m
- Total width: 47 m
- Depth: 3 m
- Over board: 1 m
- Width of the crest of the embankments: 4 m
- Slope of the embankments: 1V: 2H.

The lagoons will be equipped with floating mechanical aerators on the surface, which will be anchored to the embankments by cables:

- Number of aerators: 12 per basin
- Power of the motors: 20 CV/Unit.

4.3.4 Secondary settling basins

Three secondary settling lagoons (one in stand-by) are designed to treat water leaving the aerated lagoons for the design flow of year 2025.

The lagoons will be built in ground with an impermeable clay layer at the bottom. Dimensions of each lagoon are:

- Overall length: 165 m
- Total Width: 65 m
- Depth: 2, 5 m
- Width of the crest of the embankments: 4 m
- Slope of the embankments: 1V: 2H.

4.3.5 Maturation ponds

Four maturation ponds (in series of two) are anticipated to treat water leaving the secondary lagoons, for the design flow of year 2025.

The basins will be built out in the ground with an impermeable clay layer at the bottom. The dimensions of each basin are:

- Overall length: 160 m
- Total Width: 50 m
- Depth: 1, 2 m
- Width of the crest of the embankments: 4 m
- Slope of the embankments: 1V: 2H.

4.3.6 Sludge Drying Beds

Secondary sludge will be periodically pumped from secondary basins towards the sludge drying beds via mobile submarines pumps.

Dimensions and the number of the drying beds are indicated below:

- Number of drying beds: 10
- Length of the bed: 50 m
- Width of the bed: 30 m
- Height of the wall around the beds: 1.5 m.

4.3.7 Characteristics of the collection pipes

The results of the design of the collection pipes of Azemmour and Sidi Ali are summarized on the table below. The diameters of the force mains are calculated on the basis of rate of return of 8% and one amortization period of 40 years.

Table 4.5: Characteristics of the wastewater collection system

Town	Pipe	Flow (l/s)	Height of sill up-stream	Height of sill down-stream	Length. (m)	Diam (mm)	Observation
Azemmour	Extension CP3 (ANHI)	-	1.76	0.90	250	500	Gravitation in BP
	Discharge pipe	183	-1.1	17.25	705	500	Discharge in BP
	Extension of discharge pipe	183	16	11.05	285	500	Gravitation in BP
	Collection of evacuated purified WW towards wadi OeR	61	7.7	5	395	500	Gravitation in BP
Sidi Ali	Discharge pipe suspended on the OeR bridge	4,4	0.5	11	205	100	steel galvanized discharge
	Discharge pipe (buried)	4,4	-	-	270	110	discharge with PVC

4.3.8 Characteristics of the storm outfall

The characteristics of the storm outfall are:

- Flow upstream: 1.758 m3/s
- Flow downstream: 0.183 m3/s
- Flow diverted: 1.58 m3/s
- Height of the diversion edge: 0.5 m
- Width of the diversion sill: 3 m.

4.3.9 *Pumping stations*

4.3.9.1 Characteristics of the Pumping Stations

The characteristics of the pumping stations of Sidi Ali and Azemmour are summarized in the table below.

Station	Flow (ml/s)	Power (kw)	HMT (m)	Volume of the cover (m3)	Number of groups	Type of pump	Exit diameter pomp (mm)
Azemmour	183	59.13	19.76	27	2 + 1 reserve	Flygt CP 3300 – 280	350
Sidi Ali	4,4	1	13.23	1	1 + 1 reserve	Flygt CP 3085-5383500C	80

4.3.9.2 Protection anti-hammer

The design table for the protection against water hammer at the pump station of Azemmour is given below. The volume of the balloon anti-hammed calculated to protect the discharge pipe from the station of Azemmour is 630 L. Volume selected is 750 L.

The station of Sidi Ali whose wastewater is low and length of forcemain small requires only a low volume balloon anti-ram (10 L). The volume of balloon selected is 50 L.

Station	Value Blow Ram V0/g (m)	Maximum pressure H0+aV0/g (m)	Maximum vacuum H0-aV0/g (m)	Balloon volume anti-ram (liter)
Azemmour	95	113	-77	750
Sidi Ali	38	48	-27	50

4.3.9.3 Power supply

The electric power will be provided by an overhead line with a voltage of 22 Kv starting from the line passing by Sidi Ali.

A transformer is necessary to transform the average voltage into low voltage for the pumping station of Azemmour as well as of the wastewater treatment plant.

The calculation of the power of the transformer is made on the basis of consumption by the pumping installations (60KW/group X 2 = 120 KW) and by the aerators of the ventilated basins of the purification station (14.72 KW/aerator X 36 aerators = 530 KW). The total power is 120 + 530 = 650 KW. For a cos φ = 0.8 and one increase of 20%, the working installed capacity of the transformer is 1000 kcVa (interior type).

For the pumping station of Sidi Ali, we will use a pole-type transformer of 50 type kcVa.

4.3.10 Performance of the treatment plant

A simulation of the performance of the wastewater treatment plant was performed. The results of this simulation, summarized below, envision a purified effluent, which meets the effluent standards. One can note that quality is even better because of addition of the maturation ponds.

Parameter	Unit	Value
BOD5	mg/l	24
MES	mg/l	11
NTK	Mg/l	7

4.4 TECHNICAL SPECIFICATIONS

The design criteria that are applicable to this project are outlined in the following subsections. Applicable codes and standards are first identified followed by criteria for each major design discipline.

4.4.1 Design codes and standards

In general, the design will comply with all applicable Moroccan laws and regulations, with applicable local codes and ordinances and with the other codes and international standards referenced below. Unless otherwise stated, the latest edition of any cited code or standard in effect at the time of final design will be followed. In case of conflict between codes and or standards, the more stringent of the two shall apply unless conditions warrant following local Moroccan requirements.

- American Association of State Highway and Transportation Officials (AASHTO);
- American Concrete Institute (ACI);
- American Institute of Steel Construction (AISC);
- American Iron and Steel Institute (AISI);
- American National Standards Institute (ANSI);
- American Petroleum Institute (API);
- American Society of Civil Engineers (ASCE);
- American Society for Testing and Materials (ASTM);
- American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE);
- American Society of Mechanical Engineers (ASME);
- American Water Works Association (AWWA);
- American Welding Society (AWS);
- Antifriction Bearing Manufactures Association (AFBMA);
- Kingdom of Moroccan Code of Practice for the Use of Reinforced Concrete
- Asphalt Institute;
- Association of Edison Illuminating Companies (AEIC);
- Moroccan Code of Practice for Soil Mechanics and Foundation Engineering;
- Moroccan Standard Specifications for Roads and Bridges;
- Great Lakes-Upper Mississippi River Board of State Sanitary Engineers, Recommended Standards for Sewage Works (10-States Standards);
- Hydraulic Institute (HI);
- Illuminating Engineering Society (IES);
- Institute of Electrical and Electronics Engineers (IEEE);
- Instrument Society of America (ISA);
- Insulated Cable Engineers Association (ICEA);
- International Electrotechnical Commission (IEC)
- Manufacturing Standardization Society of the Valve and Fittings Industry, Inc. (MSS);
- National Association for Corrosion Engineers (NACE);
- National Electrical Code (NEC);

- National Electric Manufacturers Association (NEMA);
- National Electrical Safety Code (NESC);
- National Fire Protection Association (NFPA);
- Occupational Safety and Health Administration (OSHA);
- Pre-stressed Concrete Institute (PCI);
- Steel Joist Institute (SJI);
- Steel Structures Painting Council (SSPC);
- The Moroccan Code for Calculating Loads and Forces in Structural Building Works
- The Moroccan Code of Practice, Steel Structures and Bridges;
- The Minerals, Metals and Materials Society (TMS);
- Underwriters' Laboratory (UL);
- Uniform Building Code (UBC);
- Uniform Fire Code (UFC);
- Uniform Mechanical Code (UMC);
- Uniform Plumbing Code;
- United States Army Corps of Engineers (US ACOE); and
- Water Environment Federation/American Society of Civil Engineers, Design of Municipal Wastewater Treatment Plants – Manual of Practice No. 8 (WEF MOP 8).

4.4.2 Process criteria

The base alternative presented herein is illustrative of the minimum technical requirements for the project.

General Requirements:

In general, the treatment system must meet the following conditions:

1) Design is to follow state-of-the-practice industry wide standards, such as those published by the Water Environment Federation (WEF) or accepted wastewater treatment textbooks.
2) Process chosen must be well known, well proven and have operating references of the same size, loading conditions, climatic constraints and level of sophistication of the operating staff.
3) Climatic conditions at the site:
    a) Air Temperature (in shade):
        i) Maximum – 25 deg C
        ii) Mean – 18 deg C
        iii) Minimum – 11 deg C
    b) Water Temperature:
        i) Maximum – 25 deg C
        ii) Minimum – 12 deg C
    c) Relative Humidity:
        i) Average Yearly – 77%
        ii) Minimum – 39%
    d) Average Humidity:
        i) Summer – 61%
        ii) Winter – 74%

e) Precipitation–
   i) Maximum – 773 mm
   ii) Minimum - 132 mm
   iii) Annual Average - 423 mm.

4) Where ranges are given for specific design parameters, neither the minimum nor maximum values will be acceptable.

5) Design is to be in accordance with best modern practice and adapted to suit local conditions.

6) Design shall be such as to facilitate construction, operation, inspection and maintenance of all processes and equipment.

7) Civil and structural elements are to be designed based on a minimum 50-year service life.

8) Mechanical and electrical components are to be suitable for continuous 24-hour per day operation as well as for intermittent operation under all local climatic conditions and are to be designed based on a minimum 15-year service life.

9) Flow channels and conduits are to be deigned to avoid deposition of solids.

10) Where splitting of flow is required, design shall incorporate provisions to achieve an equal split of the flow between the operational units under all flow ranges.

11) Unless specifically noted, process tanks are to be designed to allow removal from service for cleaning and maintenance, including provisions for their easy dewatering and removal of any settled material.

12) Where floating material such as grease and oil can potentially accumulate, provisions are to be included for easy periodic removal by plant operational personnel.

Operation, safety and comfort is to be provided by the incorporation of the following elements into the design:

1) Good access
2) Equipment lifting devices
3) Separate storage facilities for chemicals
4) Lighting in all operating areas
5) Ventilation as required
6) Machinery guards
7) Stairs, hand-rails, cover, etc.
8) Referenced international design codes and standards

The facilities are to be designed with a high level of flexibility and reliability of all components.

1) All items controlling the process are to be designed with a sufficiently high degree of redundancy (indicative process monitoring and control considerations are described in Chapter III).

2) Reliability is to be achieved using spare capacity, spare equipment, unit bypasses, etc. to allow the plant to work satisfactorily and meet performance requirements even during maintenance and temporary malfunctioning of the main mechanical or electrical equipment.
3) To facilitate maximum flexibility, reliability and redundancy, the plant is to be designed under a modular concept.
4) System must also be readily expandable to meet the future design conditions without the need for taking the existing facilities out of service.

Following are specific requirements that must be applied to optional designs to the base option defined herein.

Preliminary Treatment:

1) Screening:
   a) Mechanically cleaned bar screen is to be provided, with a maximum bar spacing of 25 mm.
   b) A bypass channel containing a manually cleaned bar rack is to be provided.
   c) Provisions are to be provided to allow for collection and simple transfer of the screenings into a truck for removal from the site.
   d) The screening structure is to be sized to handle the future Year 2025 design flow without expansion of the structure.
2) Influent measurement and sampling:
   a) A flow-measuring device is to be incorporated into the preliminary treatment operation that provides for the measurement and recording of the raw wastewater entering the plant prior to any internal plant recycles being combined with the raw wastewater.
   b) Provisions are to be provided for the automatic collection of representative raw influent wastewater grab and composite samples.
   c) Collected samples are to be environmentally controlled prior to periodic removal from the sampler.

Aerated Lagoons:

1) The inlet structure to the aerated lagoons must provide for an equal splitting of the flow under all flow conditions between each unit in operation.
2) Inlet structure must include provisions for the equal splitting of influent flow once future units have been installed.
3) Inlet structure must include provisions for the periodic removal of any floating material that may accumulate in the structure.
4) Aerated lagoons are to achieve and maintain through mixing and suspension of solids during all periods of operation.
5) Acceptable biological treatment processes are limited to the following:

a) Aerated lagoons

6) The design of any biological treatment systems is to include all of the processes appurtenant systems such as aeration, return sludge pumping (if required), etc.
7) Mechanical aeration is the preferred method of aeration for systems utilizing the activated sludge process.

Facultative Settling Ponds:

1) Appropriately sized settling ponds are to be an integral component of proposed aerated lagoon system.
2) The inlet structures to the aerated lagoons and settling ponds must provide for an equal splitting of the flow under all flow conditions between each unit in operation.
3) Inlet structures must include provisions for the equal splitting of influent flow once future units have been installed.
4) Inlet structure must include provisions for the periodic removal of any floating material that may accumulate in the structure.
5) Settling ponds are to be provided with a means to remove sludge and scum.
6) Biological sludge removal from the settling ponds and wasting to the sludge processing facilities is to be accomplished using appropriately selected sludge pumping units.
7) Installed spare sludge pumps are to be incorporated into the design as well as provisions for installation of additional pumps for future biological treatment units.
8) Scum removal and transfer to the sludge processing facilities is to be accomplished using appropriately selected sludge pumping units.
9) Provisions are to be provided for the measurement and recording of sludge that is returned to the biological treatment system.
10) Provisions are to be provided for the measurement and recording of sludge that is transferred to the sludge processing facilities.

Disinfection:

1) Disinfection of the effluent prior to discharge to the R'bia River is required.
2) Chlorination (or maturation ponds) is the preferred disinfection method.
3) Chemical contact tank will be sized to handle the future Year 2025 conditions without the need for expansion.
4) Provisions are to be made to allow by-passing of the chlorine contact tank.
5) Plant service water system is to be incorporated into the design of the disinfection system.

Sludge Processing:

1) Sludge from secondary treatment systems and scum are to be blended before discharge to sludge dewatering area.
2) Paved sludge drying beds are recommended as an acceptable dewatering technology.
3) The sludge dewatering area is to be provided within the available site.
4) Recycle streams from the sludge processing operations are to be collected and pumped to the head end of the aerated lagoons.
5) Recycle flow sampling and measurement:
   a) A flow measuring device is to be incorporated into the recycle flow stream that provides for the measurement and recording of the recycle flow being returned to the main treatment process
   b) Provisions are to be provided for the automatic collection of representative recycle stream grab and composite samples
   c) Collected samples are to be environmentally controlled prior to periodic removal from the sampler.

4.4.3 Hydraulic criteria

The new Azemmour WWTP must be designed to allow the wastewater received at the plant from the central wastewater-pumping station to flow by gravity through the entire plant prior to discharge to the R'bia River.

A hydraulic profile for the base facility design has been developed and is presented in the drawings. The following hydraulic principles were used in developing this profile and subsequent sizing of the hydraulic components of the facility:

1) Profile is reflective of the longest flow path for each component;
2) All components will be capable of passing the peakhour flow, plus average secondary return sludge sub-natent as appropriate, with one unit out of service for each process and with a minimum 0.3-meter freeboard in the open channels and/or process tankage;
3) The following components have been sized to handle the future peakhour flow since no additional components are required to handle the future conditions:
   a) Inlet chamber;
   b) Screening structure;
   c) Flow meter;
   d) Aerated lagoon diversion structure;
   e) Combined aerated lagoon effluent chamber;
   f) Facultative settling pond diversion structure;
   g) Settling pond effluent chamber;
   h) Settling pond effluent pipeline;
   i) Chlorine contact tank inlet chamber;
   j) Chlorine contact tank outlet chamber; and
   k) Effluent pipeline.

4) Other pipelines have been sized to reflect their portion of the future peakhour flow with one associated process unit out of service;
5) Effluent weirs in the process tanks will be allowed to surcharge only under peakhour flow conditions with one process unit out of service;
6) When all units are in service, a minimum freefall depth of 100-mm between the top of the weir and downstream water surface will be maintained; and
7) The feed piping to the "A" basin of each aerated lagoon will be sized to handle the full peak flow to allow the aerated lagoons to operate in series.

4.4.4 Civil/site work criteria

The following data will be the basic design criteria for establishing design of the civil and site development components of the project.

4.4.4.1 Pavement

1) Pavement design will be in accordance with the requirements of the Moroccan Standard Specifications for Roads and Bridges.
2) Portland cement concrete will be used for all paving applications, including roadways, curbs and sidewalks.
3) Geometric parameters:
    a) Roadways:
        i) Maximum grade – 7.0%
        ii) Parabolic crown cross-section with minimum 2% slope
        iii) Minimum roadway width:
            (1) One-way traffic – 4.3 m
            (2) Two-way traffic – 7.5 m
        iv) Minimum turning radius:

Vehicle	Outside (m)	Inside (m)
Passenger Car	7.3	4.7
Single Unit Truck	12.8	8.6
Semi-Trailer Intermediate Truck	12.1	6.1
Combination Large Truck	13.7	6.0

    b) Parking areas:
        i) Minimum parking stall dimensions – 7.5 m wide, 4 m long
        ii) Maximum slope – 1%
    c) Sidewalks:
        i) Minimum width – 1.2 m
        ii) Desired cross slope – 25 mm/m

4.4.4.2 Outside Piping

1) Low Pressure Process Pipe, Potable Water Main and Sludge:

   a) Ductile iron:

      i) Thickness class per ANSI/AWWA C150/A21.50, minimum thickness:
         (1) Less than or equal to 300 mm – Pressure Class 350
         (2) Greater than 300 mm – Pressure Class 250
      ii) Coatings:
         (1) Interior:
            (a) Water & Wastewater – Cement mortar in accordance with AWWA C104
            (b) Sludge – Glass lined
         (2) Exterior (buried) – Asphalt coating per AWWA C151
      iii) Acceptable joints (per ANSI A21.11):
         (1) Push-on
         (2) Mechanical
      iv) Joints to be restrained at deflections or where soil conditions so warrant
      v) Bedding – Class B or C per AWWA/ANSI C150/A21.50
      vi) Truck loading – Single AASHTO H-20 truck with 7300 kg wheel load
      vii) Soil unit weight – Per geotechnical investigations
      viii) Internal pressure – Maximum calculated surge pressure or 1.5 times working pressure (whichever is greater)

   b) Hydraulic design:
      i) Friction losses based on Hazen-Williams formula, where C=100 for unlined pipe and 120 for cement or glass lined pipe and fittings
      ii) Minor losses computed as the product of the velocity head times an acceptable minor friction loss coefficient (from published hydraulic references)
      iii) Acceptable velocities:
         (1) 0.6-2.0 m/s for water/wastewater
         (2) 0.9-2.0 m/s for sludge
      iv) Minimum sludge pipe size:
         (1) Pump suction – 150 mm
         (2) Gravity withdrawal – 200 mm
         (3) Pump discharge – 100 mm

2) Gravity sewers:

   a) Reinforced concrete pipe:
      i) Pipe per ASTM C76
      ii) Gasketed joints per ASTM C443
      iii) Design conditions similar to process pipe
   b) Polyvinyl chloride pipe:
      i) 380 mm or less in diameter:
         (1) Per ASTM D3034
         (2) Gasketed joints per ASTM D3212
         (3) Minimum SDR 26 with minimum stiffness of 790 kPa
      ii) Greater than 380 mm:
         (1) Per ASTM F679 and AWWA C905
         (2) Gasketed joint conforming to ASTM D3212

(3) Minimum DR 25

iii) Design conditions similar to process pipe

c) Manholes:
   i) Precast reinforced sections per ASTM C478 and C443
   ii) Pipe connection to manhole to be flexible connections per ASTM C923
d) Hydraulic design:
   i) Sizing to be done using Manning Equation, where n=0.013
   ii) Acceptable velocities – 0.7-3.0 m/s
   iii) Minimum pipe slope according to requirements of 10-States Standards.

3) Valves & Gates:

   a) Gate Valves:
      i) 100 mm and larger - resilient seat per AWWA C509
      ii) Working pressure – 14 bar
      iii) Acceptable joints:
         (1) Push-on
         (2) Mechanical
      iv) Non-raising stem nut operator with cast-iron valve box
   b) Butterfly Valves:
      i) Conforming to AWWA C504
      ii) Class 150A
      iii) Mechanical joint body design
      iv) Non-raising stem nut operator with cast-iron valve box
   c) Non-Lubricated Eccentric Plug Valves:
      i) Conforming to ASTM A126
      ii) Working pressure – 12 bar
      iii) Mechanical
      iv) Acceptable valve seats:
         (1) Neoprene
         (2) Buna-N synthetic rubber
      v) Operators – non-raising stem with nut and cast-iron valve box
   d) Sluice Gates:
      i) Self-contained units conforming with AWWA C501 and ASTM A126, Class B
      ii) Floor stand or bench stand hand wheel or crank-operated gear box
   e) Slide Gates:
      i) Aluminum ASTM B211, Alloy 6061 T6
      ii) Minimum thickness – 6.5 mm, 9.5 mm if greater than 30".

4) Testing:

   a) All piping systems shall be pressure and leakage tested;
   b) All plugs, valves, pumps, connections, meters, gauges, and equipment are required for the testing;
   c) Piping will be required to hold pipe pressure rating pressure (not exceeding 150 psi) for one hour with no additional pumping;
   d) All leaks will be repaired at the Contractor's expense.

5) Disinfection:

   a) All potable water piping systems shall be disinfected;
   b) All plugs, valves, pumps, connections, meters, gauges, and equipment are required for the disinfecting;

c) Perform disinfecting in accordance with AWWA C651 Disinfecting Water Mains.

4.4.4.3 Storm Drainage

1) Given the climate in project area, a dedicated storm drainage system is to be installed.
2) Localize drainage system (drains and sumps returned to process stream) to be provided where run-off expected from process units such as within process buildings and their drainage areas.
3) Berms and swales to protect the site against a 100- year flood.

4.4.4.4 Landscaping

1) All open areas of the site to be finish graded.
2) All open areas and areas disturbed by construction areas to be seeded with grass.

4.4.5 Architectural criteria

The following data will be the basic design criteria for establishing design of the architectural elements of the project.

4.4.5.1 General Design Basis

1) Building design will be in compliance with the following standards:
   a) Uniform Building Code
   b) Kingdom of Moroccan Code of Practice for the Use of Reinforced Concrete
   c) The Moroccan Code of Practice, Steel Structures and Bridges
   d) National Fire Code
   e) National Fire Protection Association.

4.4.5.2 Materials

1) Pumping Stations and Chlorination Building:
   a) Structure:
      i) Reinforced concrete substructures
      ii) Reinforced concrete frame
      iii) Reinforced concrete stairways
      iv) Reinforced concrete roof
   b) Exterior:
      i) Facing brick
      ii) Anodized aluminum exterior doors, louvers, windows and their frames
      iii) Insulated exterior glazing
      iv) Aluminum railings
      v) Painted exterior ferrous equipment
   c) Interior:
      i) Painted concrete masonry unit interior walls
      ii) Hardened concrete floor finish
      iii) Painted equipment, pipes, conduits, etc.

iv) Aluminum or painted hollow metal doors.

4.4.6 Structural criteria

The following data will be the basic design criteria for establishing design of the Structural Components of the project.

4.4.6.1 General Design Criteria

1) Specific design codes/standards:
   a) General
      i) Uniform Building Code
      ii) Building loadings- ASCE Minimum Design Loads for Buildings and Other Structures
   b) Design and placement of structural concrete:
      i) Building Code Requirements for Structural Concrete ACI (318-99) and Commentary ACI (318R-99)
      ii) Kingdom of Moroccan Code of Practice for the Use of Reinforced Concrete
   c) Design and placement of concrete for liquid containment:
      i) Environmental Engineering Concrete Structures- ACI 350R-89
      ii) Kingdom of Moroccan Code of Practice for the Use of Reinforced Concrete
   d) Design, fabrication and erection of steel and steel components:
      i) Code of standard practice for steel buildings and bridges- AISC
      ii) Manual of Steel Construction- Ninth Edition- AISC
      iii) The Moroccan Code of Practice, Steel Structures and Bridges
      iv) AISI Specification of the Design of Light Gage Cold- Formed Steel Members
   e) Design and erection of masonry materials:
      i) ACI/ASCE/TMS Building Code Requirements for Masonry Structures
      ii) ACI/ASCE/TMS Specifications for Masonry Structures
   f) Miscellaneous:
      i) Welding procedures- AWS D1.1 Structural Steel Welding Code
      ii) Preparation of metal surfaces for coating- SSPC and NACE
      iii) Field and laboratory testing- ASTM
      iv) Specifications for materials:
         (1) American Society Testing and Materials
         (2) American National Standards Institute

Design Loads:

1) Live Loads:
   a) General areas - 4.8 kPa
   b) Mechanical equipment rooms - 14.5 kPa or equipment weight plus 4.8 kPa (whichever is greater)
   c) Electrical equipment rooms - 14.5 kPa or equipment weight plus 4.8 kPa (whichever is greater)
   d) Pump station slabs - 9.6 kPa or equipment weight plus 4.8 kPa (whichever is

greater)

i) Stairs and walkways - 4.8 kPa or 455 kg (whichever is greater)
ii) Truckways - AASHTO H20 or 12 kPa (whichever is greater)
iii) Roofs - 4.8 kPa or Ponding load (whichever is greater)
iv) Wind Speed - 36 m/s with adjustments for gusts
v) Seismic zone - Zone 3

2) Impact Loads:
   a) Hoists & cranes:
      i) Vertical - 25% of maximum static wheel
      ii) Horizontal-lateral - 20% of sum of rated hoist load plus that of hoist and trolley
      iii) Horizontal-longitudinal - 10% of sum of rated hoist load plus weight of hoist, trolley and bridge
   b) Lifting hooks - 1.5 times hoist capacity
   c) Hangers supporting floors and platforms - 33% of sum of dead and live loads
3) Liquid Loads:
   a) Operational depth without backfill
   b) Full of liquid, no backfill with 33% percent overstress
   c) Backfill with 100-year flood groundwater with structure empty with 33% overstress
   d) Any combination of tank cells full or empty
   e) Check for flotation minimum safety factor = 1.10
4) Lateral Earth Loads:
   a) Dry - 880 kg/sq meter
   b) Saturated - 1440 kg/sq meter
5) Foundation Requirements:
   a) Allowable soil bearing pressures per soil investigations
   b) Minimum depth of footings - 1.0 m
   c) Uplift:
      i) Utilize structure dead weight to resist uplift
      ii) Minimum safety factor of 1.10
6) Deflections:
   a) Monorails and cranes - L/800
   b) Floor plates and gratings - L/240 or 6.3 mm
   c) Supports for masonry - L/720 or 6.3 mm
   d) Roofs without ceilings - L/240
   e) Floors (concrete) - per ACI 318

Concrete Work:

1) Materials:
   a) Type I Cement - ASTM C150 (For General Construction)
   b) Type II Cement - ASTM C150 (For structures subject to sulfate attack)
   c) Air Entrainment - ASTM C260
   d) PVC Waterstop - CRDC 572
2) Design Strength:
   a) 280 kg/cm^2 compressive strength for all structural concrete and fill concrete

b) 210 kg/cm^2 compressive strength for mass concrete
c) Grade 60 reinforcing bars conforming to ASTM A615

3) Crack Control:
a) Conforming to ACI 350R-89

Masonry:

1) Load Bearing Walls:
a) Provide footing for all load bearing walls
b) Design based on ACI 530

2) Non-load bearing walls:
a) Provide lateral support as required
b) One story walls do not require separate footings of a thickened slab-on-grade unless required by foundation requirements
c) Design based on ACI 530

Metal Work:

1) Materials:
a) Structural Steel - ASTM A36
b) Stainless Steel - AISI Type 316,304 or 303
c) Cold formed tubing or pipe - ASTM A500
d) Aluminum, Structural Shapes and Plates - Alloy 6061-T6
e) Bolted Connections - ASTM A325, A490
f) Anchor Bolts - conforming to ASTM A307, A354

2) Usage:
a) Bolt Aluminum to Concrete with Stainless Steel Bolts
b) For Corrosive applications, use Type 316 Stainless Steel Bolts

4.4.7 Mechanical criteria

The following data will be the basic design criteria for establishing design of the mechanical components of the project.

General Requirements:

1) The Contractor shall design, detail, fabricate, furnish, install and test all equipment and appurtenances necessary to provide complete mechanical systems that meet the intent of the specifications.
2) Electrically driven equipment shall be complete with electric motor drives and mounted on a common, adequate raised structural foundation or base.
3) Electric motors, motor starters, and interconnecting electrical conduit and wiring for the equipment shall comply with the specifications for electrical work.
4) Anchor bolts for the equipment shall comply with the Structural Design Criteria.
5) Provide concrete housekeeping pads under all equipment not having a structural base. Housekeeping pads shall be a minimum of 100 mm thick.

6) All equipment shall be designed and detailed to fit into the space available with proper regard to accessibility, clearances around equipment, and handling for future maintenance.

7) Provide a minimum of one meter of clear space between adjacent equipment and pipe runs to three meters above the finished floor.

8) Provide access platforms for operation, inspection, and maintenance of equipment mounted two meters or more above the finished floor.

9) All equipment described herein shall be standard product of manufacturers regularly engaged in the production of the types of equipment specified. Where major items of equipment are similar in type and description, they shall be the product of a single manufacturer.

10) Equipment shall be painted with the manufacturer's standard finish unless otherwise specified.

11) Nameplates shall be affixed to mechanical equipment showing the serial number, equipment rating, and name of manufacturer. The nameplate of a distributing agent only will not be acceptable.

12) Materials not specifically designated herein shall be the most suitable for the purpose and shall as far as practicable, comply with the latest specifications of the ASTM, ANSI, or local equivalent standards, the most stringent shall apply.

13) All equipment shall be provided with spare parts and special tools as recommended by the equipment manufacturers to ensure satisfactory operation of the equipment for a period of not less than 2 years.

Piping Workmanship:

1) General:

   a) Pipe shall be cut accurately to dimensions established at the Site and shall be worked into place without springing or forcing.
   b) Pipe shall be installed as closely as possible to walls, ceilings, columns, etc., so as to occupy the minimum of space.
   c) Piping shall be run parallel with the lines of the building where practicable.
   d) All embedded piping shall be installed true to line and grade.
   e) Proper allowance shall be made for expansion and contraction of pipe.

2) Screwed Pipe:

   a) All pipes, after cutting and before threading, shall be reamed and all burrs removed.
   b) Pipe threads shall be cut and shall be free from torn or ragged surfaces.
   c) Screwed joints shall be made with lubricant applied to the male thread only.

3) Flanged and Welded Pipe:

   a) Flanged joints shall be made up with undamaged non-asbestos gaskets, and all bolts shall be drawn tight.
   b) Intersections and changes in direction shall be made with fittings.

4) Copper Tubing:

   a) All tubing shall be cut square, reamed, burred, and cleaned before fabrication.

b) The outside of the tubing and inside of fittings having soldered joints shall be cleaned with steel wool until metal is bright without trace of dirt or corrosion.
c) The application of flux, solder, and heat shall be in accordance with manufacturer's recommendations.
d) After the joint is complete, the excess solder shall be removed while the solder is in the plastic stage, leaving a fillet at the cup of the fitting.
e) A light anneal of the tubing used for making bends will be permitted, to return the tubing to its original hardness.

5) Plastic Pipe:

a) All plastic piping shall be furnished in stock lengths, cut to the best practicable advantage, and placed in a workmanlike manner.
b) All plastic piping shall be cut square, reamed, burred and cleaned before fabrication.
c) Installation shall be in accordance with the manufacturer's recommendations.
d) Every joint in plastic piping shall be made with approved fittings by either solvent or fusion welded connections, approved insert fittings and metal clamps and screws of corrosion resistant material, or threaded joints according to accepted standards.

6) Pipe Insulation:

a) Diesel engine exhaust piping installed inside buildings (including silencers), air compressor discharge piping from air compressors to air receivers or after coolers where provided, and all exposed water piping shall be insulated.
b) Insulation thickness, application and installation shall be in accordance with the manufacturer's recommended best practice.

7) Pipes Through Walls and Floors:

a) All pipes passing through concrete slabs, walls, or beams shall pass through galvanized steel pipe sleeves.
b) All exposed pipes passing through floors, finished walls or finished ceilings of offices, and toilet rooms, shall be fitted with chrome-plated brass plates on chrome-plated pipe or with enameled cast iron or steel plates on other pipes to close the openings around the pipes.
c) Where pipes are covered, plates shall fit over the covering.

8) Buried Pipe:

a) Buried pipe shall be run in cut trenches or placed in fill.
b) Piping in dug trenches shall be placed on a bed of sand and the trench shall be backfilled with sand and tamped; the pipe shall be held firmly in position and protected from damage during backfilling or subsequent fill placement.

9) Coordination with Other Work:

a) All piping work shall be coordinated with other work in the building so that all items may be installed in the most direct and workmanlike manner and so that interference between piping, equipment, and architectural and structural features will be avoided.
b) Damage to building, piping, wiring, or equipment as a result of cutting for installation shall be repaired by workers skilled in the trade involved.

10) Protection of Piping:

a) Metal, pipe, and fittings shall be inspected, and tested before being embedded in concrete and shall be held firmly in position and protected from damage while the concrete is being placed.
b) Care shall be taken to keep all pipes and fittings clean during the progress of the work; should any pipe become either partially or wholly clogged before final acceptance of the Work, it shall be cleaned.
c) To prevent clogging of drains and embedded pipes during the construction work, open ends of pipe shall be protected by cast iron plugs or other suitable closures; such closures shall be removed only when additional piping is added to the system and shall be immediately reinstalled at the end of the newly installed piping.

11) Hangers and Supports:

a) All interior piping shall be hung except that which can be supported from the floor or which can be racked adjacent to walls.
b) All materials not galvanized or cadmium plated shall be prime painted before installation.
c) The type and spacing of hangers, pipe rollers, and supports with inserts and expansion anchors and all anchor bolts necessary for properly securing all piping, machinery, and equipment shall be as required for proper fastening.
d) No perforated band hangers will be permitted.
e) Should dissimilar metals be utilized for piping and pipe supports, suitable insulation shall be provided to prevent galvanic action.

12) Unions and Nipples:

a) All piping shall be installed with unions located so that piping can be removed for repair or replacement without removing an excessive amount of pipe.
b) Unions on screwed steel pipe shall be malleable iron.
c) Unions in solder-joint copper tubing shall be of the ground joint type, commercial grade.
d) Nipples shall be of the same material, type, and grade as the pipe in the system where used.

Process Piping Systems

1) Process Piping:
   a) Ductile iron:
      i) Thickness class per ANSI/AWWA A21.50/C150, minimum thickness:

         (1) Flanged pipe:
            (a) Less than or equal to 300 mm – Pressure Class 350
            (b) Greater than 300 mm – Pressure Class 250
         (2) Groove or shouldered pipe – Pressure Class 350

      ii) Coatings:
         (1) Interior:

            (a) Wastewater – Cement mortar in accordance with AWWA C104
            (b) Sludge – Glass lined

(2) Exterior – None (to be painted)

iii) Acceptable joints:

(1) Flanged

(2) Grooved or shouldered

iv) Internal pressure – Maximum calculated surge pressure or 1.5 times working pressure (whichever is greater)

b) Hydraulic design:

i) Friction losses based on Hazen-Williams formula, where C=100 for unlined pipe and 120 for cement or glass lined pipe and fittings

ii) Minor losses computed as the product of the velocity head times an acceptable minor friction loss coefficient (from published hydraulic references)

iii) Acceptable velocities:

(1) 0.6-2.0 m/s for water/wastewater

(2) 0.9-2.0 m/s for sludge

iv) Minimum sludge pipe size:

(1) Pump suction – 150 mm

(2) Gravity withdrawal – 200 mm

(3) Pump discharge – 100 mm

2) Chemical:

a) Rigid, Type I, Grade I Schedule 80 PVC per ASTM D1784 and D1785

b) Fittings – Same as pipe

c) Acceptable Joints:

i) Socket-weld

ii) Flanged

iii) Union connections

3) Building services:

a) PVC:

i) Rigid, Type I, Grade I Schedule 80 PVC per ASTM D1784 and D1785

ii) Fittings – Same as pipe

iii) Acceptable Joints:

(1) Socket-weld

(2) Flanged

iv) Union connections

b) Galvanized Steel:

i) Schedule 40 per ASTM A120

ii) Fittings – ANSI B16.3

iii) Acceptable joints:

(1) Screwed

(2) Flanged

4) Pipe Supports:

a) Support pipe and appurtenances to prevent strain on equipment

b) Furnish and install supports to hold piping at desired lines and grades

c) MSS SP-58 Pipe Hangers and Supports, Materials Design and Manufacture

d) MSS SP-69 Pipe Hangers and Supports, Selection and Application

5) Valves:

a) Gate Valves:

- i) 100 mm and larger - resilient seat per AWWA C509
- ii) Working pressure – 14 bar
- iii) Joints – flanged (ANSI B16.1)

b) Butterfly Valves:
- i) Conforming to AWWA C504
- ii) Class 150A
- iii) Flanged short body design (ANSI B16.1)

c) Check Valves:
- i) Conforming to ASTM A126 Specifications for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
- ii) Working pressure – 12 bar
- iii) Joints – flanged (ANSI B16.1)

d) Non-Lubricated Eccentric Plug Valves:
- i) Conforming to ASTM A126 Specifications for Gray Iron Castings for Valves, Flanges and Pipefittings.
- ii) Working pressure – 12 bar
- iii) Joints – flanged (ANSI B16.1)
- iv) Acceptable valve seats:
  - (1) Neoprene
  - (2) Buna-N synthetic rubber

e) Operators – geared hand wheel

6) Testing:

d) All piping systems shall be pressure and leakage tested;
e) All plugs, valves, pumps, connections, meters, gauges, and equipment are required for the testing;
f) Piping will be required to hold pipe pressure rating pressure (not exceeding 150 psi) for one hour with no additional pumping;
g) All leaks will be repaired at the Contractor's expense.

7) Disinfection:

h) All potable water piping systems shall be disinfected;
i) All plugs, valves, pumps, connections, meters, gauges, and equipment are required for the disinfecting;
j) Perform disinfecting in accordance with AWWA C651 Disinfecting Water Mains.

Pumps:

1) Each pump shall be capable of delivering not less than the rated capacity against rated total head without encroaching on the service factor of the motor.
2) Pumps shall be capable of continuous operation over their operating ranges without the pump input power exceeding the nameplate rating of the motor at any point in the specified operating range.
3) The pumps shall be designed to operate throughout their respective head range without instability, without excessive vibration, and without excessive temperature build-up.
4) Pumps shall operate as near to its peak efficiency as practicable
5) Pumps shall be selected in accordance with the methods set forth in the Hydraulic Institute Standards

Gates, Cranes, Hoists, and Trash-racks:

1) Structural Members: Structural steel
2) Exposed surfaces of embedded parts: Corrosion resistant steel
3) Bolting: Bolting (including anchor bolts) submerged or exposed to weather shall be corrosion resistant steel with corrosion resistant steel washers and nuts. Corrosion resistant materials in contact shall be non-galling with respect to each other.
4) Shafts, Axles, and Pins for equipment: Corrosion resistant steel.
5) Allowable Stresses
   a) Stresses in Gate and Equipment Steel Structures
      i) The allowable stresses for structural steel under normal loading conditions will be 90% of those given in AISC "Specifications for the Design, Fabrication, and Erection of Structural Steels for Buildings" but will not be higher than the following percentages of the yield strength of the material used:

Tension on net section of holes:	36%
Bending (tension and compression on extreme fibers of Unsymmetrical members):	54%
Bending (tension and compression on extreme fibers of symmetrical members):	54%
Shear (on gross section of beam and plate girder webs):	36%
Bearing on contact area of machined surfaces:	72%

      ii) For overload conditions including seismic loading conditions, the allowable stresses given for normal loading conditions may be increased by 33.3% except that the bearing stress will not exceed 80% of the yield strength.
      iii) The equivalent stress resulting from combining bi-axial or tri-axial stresses may be 25% higher than the allowable monoaxial stress, but for all loading conditions not more than 80% of the yield strength of the material.

   b) Stresses in Mechanical Components

      i) The working stresses, bearing pressures, and other design criteria for mechanical components will be based on consideration of functional requirements, dynamic loadings, impact, and stress concentration effects.
      ii) Stresses computed for normal loading conditions (or rated capacity) in no case will exceed 1/5 of the ultimate strength or 1/3 of the yield point of the materials.
      iii) The working stresses for overload (for cranes under seismic load conditions) may be increased by 80% and those for overload caused by stalled conditions may be increase to 90% of the minimum yield strength or elastic limit of the materials used.

c) Embedded Parts

i) Embedded parts in concrete structure and parts bearing on the concrete structure shall be designed in accordance with the requirements of ACI 318 R-89 and based on a 28-day compressive strength of 3000 psi.
ii) A load factor of 1.7 shall be used for all water loads, and the combined factored dead and live loads shall be multiplied by a "Hydraulic Structural Factor HSF=1.3 to compute the required strength U.
iii) When loads from earthquake, overload operating forces, or wind are included, HSF shall be multiplied by 0.75.

4.4.7.1 Heating & Ventilating Systems

1) Design will be in compliance with the following specific codes:
   a) American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Handbooks and Standards
   b) National Fire Protection Association (NFPA) Codes, Standards, Recommended Practices, Manuals and Guides
   c) Uniform Building Code (UBC)
   d) Uniform Fire Code (UFC)
   e) Uniform Mechanical Code (UMC)
2) Design Conditions:
   a) Outdoor design criteria:
      i) In accordance with climatic design conditions defined under Process Criteria
   b) Minimum ventilation rates:
      i) Per WEF MOP 8, Chapter 7 (for applicable space classification)

Plumbing:

1) Design to conform to requirements of Uniform Plumbing Code (UPC)
2) Drainage System:
   a) Provided for all building floor and equipment areas:
      i) Standard cast-iron floor drains and soil pipe
      ii) Concrete sump and self-contained sump pump
3) Service Water:
   a) Provide backflow prevention
   b) Follow requirements for outside piping, low pressure process pipe, potable water main and sludge

4.4.8 Electrical design criteria

The following is the base criteria for the electrical work, which includes but is not limited to the following items:

General Requirements:

1) Outdoor and indoor medium voltage (15 kV) metal-clad load break disconnect switches and/or vacuum circuit breaker type switchgear as indicated and/or required.
2) Oil-filled, pad-mounted, compartment type, self-cooled, tamperproof, and weatherproof transformers as indicated and/or required.
3) 380 volt motor control and power distribution centers, as indicated and/or required.
4) Control and alarm cabinets.
5) Raceways and fittings.
6) Wire and cables.
7) Cable splices and terminations.
8) Power and Lighting Panel-boards.
9) Lighting systems.
10) Underground cable and duct systems.
11) System and Equipment Grounding systems.
12) Conduit, wire, control equipment, junction boxes, and field connections as required for all motors and equipment furnished.
13) Telephone System Expansion as required.
14) Communication System:
    a) Provide a totally integrated package for all new telephone handsets required; the new system shall be required in all new buildings.
    b) This Contract shall include all related peripheral equipment necessary for a complete and operational system capable of functioning independently of existing plant telephone installations.
    c) The Contractor shall provide all necessary interface wiring, hardware, and equipment for interconnection between the existing and new telephone systems.
    d) Provide a handset, interconnecting conduit and wiring, and a telephone outlet for each required telephone location. Minimum locations and minimum quantities as follows:
    e) One per room and defined area, except bathrooms, locker rooms and storage rooms.
    f) Two per each required desk in a room or defined area.
15) Provide a minimum of 25-percent spare capacity in all feeder cables, terminal cabinets, and exchange circuitry to ensure expansion capabilities.
16) Develop calculations for all aspects of the electrical design. These calculations shall support all design equipment selections and ratings. The calculations shall include the following, at a minimum:

a) load and short circuit studies,
b) coordination studies,
c) average lighting levels calculations,
d) power cable sizing (including voltage drop)
e) Harmonic studies of all new power distribution equipment and modified existing power distribution equipment, new buildings, and areas modified as required by this contract.

17) The load and short circuit studies shall include the new connected and operating loads and maximum short circuit levels at all distribution panels, motor control centers, switchboards, and switchgear.

18) All electrical equipment shall be manufactured to International Standards to provide BEGAWS access to spare parts in the local market place.

Service and Metering:

1) The power company serving this project is the Rural Electrification Authority herein referred to as the Power Company. The incoming service will be 10.5 kV, 3 phase , 50 HZ.

Special Jobsite Conditions:

1) Climatic Conditions:
   a) Ambient conditions are delineated in the basis of design report. All equipment, materials, and installation specified shall be suitable for the ambient temperature and the atmospheric conditions set forth.
2) Equipment Applications:
   a) All equipment used in hazardous areas shall be designed for Class I, Division 1, Group D locations. All installations shall be in strict accordance with the National Electrical Code for Class I, Division 1, Group D locations.
   b) Electrical equipment, electronic (PC) boards, and control panels shall be designed and/or coated to resist corrosion caused by H_2S. All equipment shall be marked by the manufacturer as being resistant to H_2S and corrosion.
   c) A controlled environment per the HVAC requirements shall serve all new electrical rooms and electrical buildings.
   d) Where required, existing electrical rooms and/or buildings shall be provided with controlled environments per the HVAC specified requirements.

Electric Motors:

1) The general design Specifications and criteria for electric motors shall be as specified herein.
   a) The following design parameters shall be considered:
      i) Environment
      ii) Voltage utilization and phases
      iii) Frequency
      iv) Kilowatt and starting requirements and limitations
      v) Motor type (synchronous, induction, dc, etc.) and construction
      vi) Power factor
      vii) Speed and direction of rotation

viii) Insulation
ix) Temperature limitations of winding insulation and enclosures
x) Duty cycle time
xi) Accessory devices
xii) Enclosure
xiii) Bearing construction, rating life of rolling elements, and external lube oil system for sleeve or plate bearings
xiv) Cooling requirements
xv) Ambient noise level and noise level for motor and driven equipment
xvi) Frame size
xvii) Termination provisions for power, earthling, and accessories
xviii) Installation, testing, and maintenance requirements
xix) Special features (shaft grounding, temperature, and vibration monitoring, etc.)

Tests and Settings:

1) Test all systems furnished and repair or replace all defective work, make all necessary adjustments to the systems, and provide instruction in the proper operation of the systems.
2) Make the following minimum tests and checks prior to energizing electrical equipment:
   a) Clean all new electrical equipment and all existing electrical equipment to be modified by this Contract. Cleaning shall be completed after all modifications are completed and before any testing is started.
   b) Mechanical inspection of all low voltage circuit breakers, disconnect switches, motor starters, control equipment, etc., for proper operation.
   c) Test grounding system as specified in the Grounding System section.
   d) Make all circuit breaker and protective relay adjustments and settings.
   e) Test 380-volt motor control centers as specified in the Motor Control Centers and Low Voltage and Medium Voltage Switchgear sections.
   f) Test wiring as specified in the Wires and Cables section.
   g) Check all wire and cable terminations for tightness.
   h) Field set all transformer taps as specified.
   i) Check motor nameplates for correct phase and voltage. Check bearings for proper lubrication. Check motor shaft rotation.
   j) Testing of protective relays and circuit breakers for calibration and proper operation. A tabulation of "As-Left" settings shall be provided to the Engineer after this test.
   k) High potential, insulation resistance, and shield continuity tests for medium voltage (8 and 15 kV) cables.
   l) Mechanical inspection of medium voltage (5 and 15 kV) vacuum circuit breakers and motor controllers to assure proper operation.
   m) Testing of 10.5 kV, 380 volt switchgear, 380 volt motor control centers, oil-filled transformers, and all other tests as described in other sections of these specifications.
   n) The Contractor shall obtain and pay for the services of an independent testing firm to perform the tests and checks described herein.
   o) Upon completion of the testing, a certified test report shall be submitted.

Protective Devices Coordination Study:

1) Provide services of an independent consultant for a complete study of fault current and coordination of all protective devices, including all new electrical equipment provided and all existing electrical equipment to be modified and the power distribution equipment directly feeding or being fed from the new or modified equipment. The studies shall include, but not be limited to, the following:
   a) Fault current available at each major equipment bus down to and including 380/220-volt lighting panels.
   b) A tabulation of all protective relay circuit breaker trip settings and recommended medium voltage fuse sizes and types.
   c) Motor starting profiles for 380 volt, 50 Hz motors. Note motors rated 25 HP and below shall be started across the line and 30 HP and above shall be started by Wye-Delta or reduced voltage starters.
   d) Transformer damage curves and protection evaluated in accordance with proposed ANSI protection guide C57.109-198X.
   e) Provide a complete set of coordination curves from the Power Company's protective devices down to the largest 380-volt branch circuit protective device.
   f) The final selection of all protective devices shall be based on a coordination study. All protective devices shall be adjusted, tested, and calibrated in the field, prior to energizing the equipment, per the settings listed in the study.

Power and Control Wiring

1) Design criteria for power and control wiring shall be as specified herein.
   a) Conductors shall be annealed and tin plated copper, compact stranded per ASTM B-496 and insulated in accordance with AEIC S-68-516 on the basis of a normal maximum conductor temperature of 90 C and a short-circuit temperature of 250 C. In areas with higher ambient temperatures, larger conductors shall be used or higher temperature rated insulation shall be selected.
   b) Conductor size and capacity shall be coordinated with circuit protective devices.
   c) Cable feeders from 10.5 kV and 0.4 kV power equipment shall be sized so a short-circuit fault at terminals of the load shall not result in damage to the cable prior to normal operation of fault interrupting devices.
   d) Cables for 10.5 kV service shall be shielded with the shield earthed at both ends, thereby accomplishing the following results:
      i) Confinement of the dielectric field within the cable
      ii) Obtaining a symmetrical radial distribution of voltage stress with the dielectric:
         (1) Reducing the hazard of shock to personnel
         (2) Prevention of charging current from being conducted by a surface contaminant
         (3) Allowing circuits to be dc high potential tested after installation
         (4) Limiting radio interference
         (5) Protecting cable from induced potentials
2) Instrument cable shall be shielded to minimize electrical noise as follows:
   a) Aluminum-polyester tape with 100 percent coverage and copper drain wire shall be used for shielding.
   b) Low-level analog signal cables shall be made up of twisted and shielded pairs.

c) Digital signal cables shall be twisted and shielded. Where physical proximity of terminations allows grouping, multi-pair cables with overall shields may be used.
d) Except where specific reasons dictate otherwise, cable shields shall be electrically continuous. When two lengths of shielded cable are connected together at a terminal block, a point on the terminal block shall be used for connecting the shields.
e) For multi-pair cables utilizing individual pair shields, the shields shall be isolated from each other.
f) To be effective, instrument cable shields should be connected to earth on one end as follows:
   i) The shield on digital signal circuits shall be earthed at the power supply end.
   ii) Shields on earthed and on thermocouple circuits, which are not earthed, shall be connected to earth at the thermocouple well.
g) Multi-pair cables used with thermocouples shall have individually isolated shields so that each shield will be maintained at the particular couple earth potential.
h) Each RTD (resistance temperature detector) system, one power supply and one or more RTDs, shall be connected to earth at only one point.
i) RTDs embedded in windings of transformers and rotating machines shall be connected to earth at the frame of the respective equipment.
j) The low or negative potential side of a signal pair shall be connected to earth at the same point where the shield is earthed. Where a common power supply is used, the low side of each signal pair and its shield shall be connected to earth at the power supply.
k) Any field made termination shall be re-tinned prior to connection.

Conductors: Design criteria for conductors shall be as specified herein.

1) Electrical conductors shall be selected with an insulation level applicable to the system voltage for which they are used and capacities suitable for the load being served.

2) Conductors shall be copper, tin-plated.

3) Maximum capacities for cable shall depend upon the worst case in which the cable will be routed (tray, conduit, duct, direct buried). Special requirements, such as voltage drop, fault current availability, and environment, shall be considered in sizing cable. All in accordance with the NEC.

4) Cable insulation shall be as follows:

   a) Cables installed in electrical cable tray systems shall have insulations and jackets, which have non-propagating and self-extinguishing characteristics. As a minimum, these cables shall meet the flame test requirements of IEC 332-3 Category C.
   b) Power cables with15 kV class insulation shall supply all 10.5 kV services and may be routed in tray, conduits, or direct buried. Cable shall conform to the requirements of ICEA Publication S-68-516.
   c) Conductor screen shall be extruded semi-conducting ethylene-propylene rubber.
   d) Insulation shall be ethylene-propylene rubber (EPR) meeting or exceeding ICEA S-68-516 and AEIC CS6.
   e) Insulation screen shall be extruded semi-conducting ethylene-propylene rubber.
   f) Insulation shield shall be bare copper wires or copper tape and rated for available short circuit current.

5) Conductor: stranded copper per ASTM B-3. Power cables to be furnished in the following quantities and sizes:

   a) 600 volt power cable insulated with extruded cross-linked polyethylene compound which meets or exceeds requirements of ICEA S-66-524, NEMA WC-7 and applicable UL standards. Listed by Underwriters Laboratories, Inc as type XHHW or equal, shall be used for 0.4 kV systems.
   b) Cables may be routed in trays, conduits, or direct buried. Insulation type XHHW or equal, minimum conductor size No. 12 AWG.
   c) Control cable with 1.0 kV class insulation shall be used for control, metering, and relaying. Minimum size shall be No. 14 AWG.
   d) Instrument cable shall be used for instrument circuits that require shielding to avoid induced currents and voltages.
   e) The type of cable used shall be determined by individual circuit requirements and individual equipment manufacturer's recommendations.
   f) Lighting and fixture cable with 1.0 kV insulation shall be used as follows:
      i) Circuit runs totally enclosed in conduit, XLPE insulation for use in all areas.
      ii) Circuit runs for roadway or outdoors area lighting enclosed in polyethylene tube, PVC insulation for direct burial.
      iii) Fixture wire, silicone rubber insulation, braided glass jacket.
      iv) Lighting and fixture cable designations and conductor sizes shall be identified on the drawings.
      v) Minimum size No. 14 AWG
   g) Earthing cable shall be insulated and uninsulated bare copper conductor, sized as required.
   h) Switchboard and panel cable shall be insulated to 1.0 kV with XLPE insulation.
   i) Special cable shall include cable supplied with equipment, prefabricated cable, coaxial cable, communication cable, and similar.
   j) If other types and construction of cable are required as design and construction of the unit progresses, they shall be designated and routed as required.

6) Preoperational tests shall be performed on all insulated conductors after installation.

   a) All insulated conductors with insulation rated 5.0 kV and above shall be given a field dc insulation test after installation as specified in applicable AEIC standards and Section 3 of IEC 502.
   b) Low voltage cables shall be tested for proper insulation resistance by applying a potential test of 1500 volts prior to connecting cables to equipment and functionally tested as part of the checkout of the equipment system.
   c) All insulated conductors shall be continuity tested for correct conductor identification and phase.

Protective Relaying:

Protective relays shall be provided for the protection of equipment in the power supply system and the electrical loads powered from these systems.

1) The following general requirements apply to all protective relay applications:

   a) The protective relaying scheme will be designed to remove and alarm any of the following abnormal occurrences:
      i) Over-current

ii) Under-voltage and over-voltage
iii) Frequency variations
iv) Over-temperature
v) Excessive pressure
vi) Open circuits and unbalanced current
vii) Abnormal direction of power flow

2) The protective relaying system shall be a coordinated application of individual relays.
3) For each monitored abnormal condition, there shall be a designated primary device for detection of that condition.
4) A failure of any primary relay shall result in the action of a secondary, overlapping scheme to detect the effect of the same abnormal occurrence.
5) Secondary relay may be the primary relay for a different abnormal condition.
6) Alternate relays may exist which detect the initial abnormal condition but which have an inherent time delay so that the alternate relays will operate after the primary and secondary relays. Similar to secondary relays, the alternate relays may be primary relays for other abnormal conditions.
7) All protective relays shall be selected to coordinate with protective devices supplied by manufacturers of major items and the thermal limits of electrical equipment, such as transformers and motors.
8) Secondary current produced by current transformers (CT) shall be in the 5-ampere range, and voltage signals produced by potential transformers (PT) shall be in the 220-volt range.

Switch-gear Bus and Incoming Main Breakers:

Where new switchgear is required:

1) Each incoming main breaker and common switchgear bus shall be provided with time over-current relays (Device 51) and time over-current earth detection relays (Device 51N).
   a) Device 51 would detect and trip the respective switchgear breaker for sustained overloads and short-circuit currents on the switchgear bus.
   b) Device 51N is residually connected to switchgear current transformers (CTs) and provides primary protection for earth faults on the switchgear bus and backup protection for earth faults in feeders emanating from the switchgear lineup.
2) Each medium voltage switchgear bus shall be provided with under-voltage relays, which shall, when bus voltage drops to a preset level, trip load feeder circuit breakers.

Switchgear Feeder Breaker:

Each switchgear feeder breaker shall be protected by a time over-current relay (Device 51) and a time over-current earth detection relay (Device 51G or 51N).

1) Device 51 protects the feeder circuit against sustained short-circuit currents and serves as backup protection for circuits farther downstream.
2) Device 51G or 51N protects the feeder circuit against sustained ground faults and provides backup protection for circuits farther downstream.

380 Volt Motor Control Centers:

Motor control centers are to comply with the following:

1) Motor control centers shall be protected by breakers having adjustable long-time and short-time solid-state trip device (SSTD) elements for phase protection.
2) Each magnetic starter within an MCC supplying power to a motor shall be equipped with a magnetic-only molded case circuit breaker and a bimetallic thermal overload element in the starter to protect motors against overload.
3) All motor starters shall be NEMA rated, minimum site NEMA 1.
4) Motors 30 HP and above shall have a reduced voltage starter. The reduced voltage starter shall be either a wye-delta or reactor type starter.
5) Certain loads shall be fed from MCC feeder circuit breakers. The breakers shall be thermal-magnetic molded case breakers sized to protect supply cable and individual loads.
6) A power monitor that will trip the motor off-line, if loss of phase, phase reversal, low voltage, or high voltage condition, shall protect each motor. The low and high voltage settings shall be adjustable and an adjustable time delay shall be provided for transient surges and voltage dip conditions.

380 Volt Power Panels: Power panels shall be supplied with a main breaker and thermal-magnetic circuit breakers sized to protect supply cable and individual loads.

Classification of Hazardous Areas:

1) The criteria for determining the appropriate electrical classifications are specified in IEC Publication 79-0 and 79-10 and NFPA 820.
2) Electrical equipment in areas classified as hazardous shall be constructed and installed in accordance with the requirements of NEC, Article 500, Hazardous (Classified) Locations.

Earthing (Grounding)

1) The earthing system shall be extended where required and shall be an interconnected network of bare copper conductor and copper-clad earth rods.
2) The system shall be provided to protect plant personnel and equipment from hazards that can occur during power system faults and lightning strikes.
3) New earthing systems shall be required at all new and relocated transformers, new buildings, new electrical rooms, and building additions.
4) All new earthing system shall be interconnected with any existing earthing systems available.
5) The earthing grid system shall meet the following requirements.
   a) Designed for adequate capacity to dissipate heat from earth current under most severe conditions in areas of high earth fault current concentrations, with grid spacing to maintain safe voltage gradients.

b) Bare conductors to be installed below grade shall be spaced in a grid pattern as required. Each junction of the grid shall be bonded together by an exothermal welding process.
c) In the plant area, earthing conductors shall be brought through the ground floor and connected to the building steel and selected equipment.
d) Equipment connections to earth shall conform to the following:
   i) Major items of electrical equipment shall have integral earth buses, which shall be connected to the Works earthing grid.
   ii) Electronic panels and equipment, where required, shall be earthed utilizing an insulated earth wire connected in accordance with the manufacturer's recommendations.
   iii) In some situations, a separate small grid and earth electrode, isolated from the main earth, shall be required. Where practical, electronics earth loops shall be avoided. Where this is not practical, isolation transformers shall be furnished.
   iv) Motor supply circuits to 380 volt motors, which utilize three-conductor cable with an earthing conductor in the interstices, shall utilize this conductor for the motor earth. For 380-volt motor supply circuits, which utilize three single-conductor cables, the earthing conductor shall be a separate conductor.
   v) All 5000 volt and higher voltage rated motors shall have a minimum of one 120 mm bare copper earthing conductor connected between the motor frame and the earthing grid.
   vi) An earthing conductor shall be routed parallel to conductors operating at or above 220 volts.
   vii) All earthing wires installed in conduit shall be insulated.
   viii) Remote buildings and outlying areas with electrical equipment shall be earthed by establishing local sub grade earthing grids and equipment earthing systems.
   ix) Remote grids, where practical, shall be interconnected with the earthing grid to reduce the hazard of transferring large fault potentials to the remote area through interconnecting instrumentation and communication cable shields.

6) Earthing materials shall be as described in the following:
   a) Earthing electrodes shall be copper-clad. Earthing electrode length and diameter shall be determined by soil resistivity and subsurface mechanical properties. Where required earthing electrode length exceeds the standard lengths, standard sections shall be exothermally welded together using a guide clamp.
   b) Cable shall be soft-drawn copper with Class B stranding or copper-clad steel.
   c) Exothermal welds shall use molds, cartridges, and materials as manufactured by Cadweld or equal.
   d) Clamps, connectors, and other hardware shall be made of copper.
   e) Earthing wires installed in conduit shall be soft-drawn stranded copper with green colored 1.0 kV PVC insulation.

Lighting:

Following are lighting system requirements.

1) The lighting system shall provide personnel with illumination for operation under normal conditions, means of egress under emergency conditions, and emergency lighting to perform manual operations during a power outage.

2) The permanent lighting system shall be used for construction lighting in areas where early installation is feasible. Temporary construction lighting shall be utilized in all other areas.
3) The power supply for the lighting system shall be from 220/380 volt, 3-phase, 4 wire lighting panel-boards.
4) Emergency lighting shall be provided with self-contained battery units.
5) Power used to supply outdoor roadway, emergency, and area lighting fixtures shall be at 220 volts.
6) The lighting system shall be designed in accordance with the Illuminating Engineering Society (IES) to provide illumination levels recommended by the following standards and organizations:
   a) ANSI/IES RP-7, Industrial Lighting
   b) ANSI/IES RP-8, Roadway Lighting
7) Luminance levels per the following:

Interior Location	Lux
Air-Conditioning Equipment Areas	100
Assembly Rooms	1000
Auxiliaries, Tanks, Compressors, Gauge Area	200
Control Room Main and Auxiliary Control Panels	300
Control Room Operator's Station	750
Control Room Emergency Lighting	200
Offices and Laboratories	1000
Switchgear and Motor Control Centers	300
Toilets	300
Telephone and Communications Equipment Rooms	500

Exterior Location	
General Areas	20
Building Entrances, Stairs, and Platforms	50
Roadway	
Between or Along Buildings	20
Not Bordered by Buildings	5
Parking by Buildings	20
Parking General	10
Switchgear	
Horizontal General Area	20
Vertical Tasks	50
Transformer Areas	
Horizontal General Area	20
Vertical Tasks	50

8) Light sources and luminaire selections shall be based on the applicability of the luminaries for the area under consideration.

9) Three types of lamps shall be used for the light sources in the lighting system including fluorescent, high-pressure sodium, and incandescent.

    a) Generally, fluorescent lamps shall be used in finished indoor, low ceiling enclosed areas
    b) High-pressure sodium lamps shall be used in high bay, and outdoor areas
    c) Incandescent lamps shall be used for emergency lighting.

10) All lamps shall be of Host Country manufacturer so that replacement parts are readily available.

11) For design purposes, lighting shall be categorized by the following areas:

    a) Indoor unfinished areas
    b) Indoor finished areas
    c) Outdoor areas
    d) High bay
    e) Roadway and area
    f) Egress and emergency
    g) Hazardous
    h) Control room
    i) Construction

12) The lighting categories listed above shall comply with the following criteria:

    a) Indoor areas include the indoor low bay areas (under 4 meters) as indicated and shall also include indoor areas in outlying structures such as electrical equipment rooms and warehouses. These areas shall generally be lighted using industrial fluorescent luminaries.
    b) High-pressure sodium luminaries shall be used in indoor high bay areas and areas where fluorescent luminaries are not suitable or cannot be installed due to physical or functional limitations.
    c) The outdoors category includes lighting of equipment located outdoors, outdoor platforms, and substations. High-pressure sodium fixtures suitable for use in wet locations shall be used.
    d) The indicated high bay areas shall be lighted using high bay luminaries with high-pressure sodium lamps.
    e) Roadway and area lighting shall be designed using high-pressure sodium light sources for the areas indicated. The lanterns shall be installed on aluminum columns. Columns shall generally be 9144 mm in height with outreach arm for roadway lighting.
    f) Egress and emergency lighting for buildings equipped with artificial illumination shall have approved adequate and reliable illumination provided for egress to exit facilities.
    g) Illumination for hazardous areas, dependent on the applicability of the luminaire, shall be provided with high-pressure sodium light sources installed in explosion-proof luminaries.
    h) Control room exit lighting shall be provided. Fluorescent luminaries shall provide control room general area lighting and control panel lighting with fluorescent dimmers to control the intensity. The emergency luminaries shall be used for

emergency lighting. The emergency light fixture shall be normally "off" and shall be automatically turned "on" upon loss of the plant reliable service.

i) Lighting during construction shall be for the benefit of all contractors engaged in work at the jobsite. In areas where construction restricts natural lighting from the sun and luminance levels approach 100 lux, construction lighting shall be placed in operation as soon as practicable and kept in continuous operation while any work is in progress. Temporary lighting shall be required for most enclosed areas during early construction before permanent panel boards, raceway, and luminaries are installed. Temporary lighting shall consist of portable cords and guarded lamps so it can be relocated and/or added by the Contractor to provide luminance levels for safe working conditions and clearances for piping and equipment installations.

13) Electric power to luminaries shall be switched with wall mounted light switches in areas where the light can be "off" when the area is not occupied. Wall mounted switches shall be provided at the entrance to rooms.

14) Electric power to luminaries located outdoors shall be switched with photoelectric controllers.

15) In areas below operating floors and areas that are congested with piping, raceway, and overhead equipment, the luminaries shall be supported from suspended continuous row prefabricated metal channel. In other areas, rigid steel conduit pendants shall support luminaries where they cannot be mounted directly on the underside of decks, on structural steel, or in finished ceilings.

16) Security lighting shall be designed using high-pressure sodium light sources. The lanterns shall be installed on aluminum columns approximately 6 meters above grade and above any adjacent walls. Grade lighting luminance level shall be not less than 5 lux at 10 meters from the column with beam patterns of adjacent fixtures intersecting at about 2 meters above grade. Lighting circuits will be connected to photo-cell controlled contactors located at each lighting transformer.

Wiring Devices:

Wiring devices are to comply with the following requirements:

1) Plug sockets shall be the European type three-pin socket outlets with earthing-contact rated at 13 amperes and 250 volts.
2) Socket outlets located outdoors shall have weatherproof covers.
3) Socket outlets shall be spaced to provide access to almost any point in the buildings with a 15-meter extension cord.
4) In hazardous locations, socket outlets shall be suitable for the hazardous area requirements.
5) Switches used throughout the plant shall be sized for the switched load and rated 250 volts ac with enclosures suitable for the location in which they are installed.

Raceway and Conduit:

Following are raceway and conduit criteria for the project.

1) The raceway and conduit systems used in supporting and protecting electrical cable shall be in accordance with the provisions of NEC.
2) Heavy wall rigid PVC plastic conduit shall be manufactured in accordance with NEMA TC-2 and WC-1094.
3) Individual raceway systems shall be established for the following services:
   a) 10.5 kV and higher power cables
   b) 380-volt power and control cables
   c) Special noise-sensitive circuits or instrumentation cables
4) Lighting and power branch circuits, telephone circuits, and communication circuits run indoors shall be routed in conduit. Exposed conduit shall be galvanized steel and conduit embedded in concrete can be heavy wall PVC.
5) Galvanized rigid steel conduit shall be used for all conduit containing Instrument cables encased in concrete and all exposed conduit.
6) All conduit not located in finished areas shall be routed in exposed runs parallel or perpendicular to dominant surfaces with right-angle turns made of symmetrical bends or fittings.
7) Conduit in finished wall and ceiling areas, such as offices, control rooms, and laboratory areas, shall be concealed.
8) Conduit shall be routed at least 150 mm from the insulated surfaces of hot water, steam pipes, and other hot surfaces. Where conduit must be routed parallel to hot surfaces, special high temperature cables shall be used.
9) All conduit systems shall be sized as follows:

Number of Cables	Maximum Percent Fill
1	53
2	31
3 or more	40

10) Raceway installed in classified areas shall be in accordance with the appropriate classification as discussed in Classification of Hazardous Areas article.
11) Pull and junction boxes shall be sized in accordance with the NEC as to minimum size.
12) Each 3-phase circuit shall be run in a separate conduit.
13) Conduit shall be run exposed except conduit shall be run concealed in finished areas including offices in buildings.
14) All necessary fittings and boxes shall be provided for a complete raceway installation.

15) Surface-mounted panel boxes, junction boxes, conduit, and similar items shall be supported by spacers to provide a clearance between wall and equipment.

Foundations:

1) Contractor shall design, furnish, and install steel reinforced concrete foundations for outdoor electrical equipment (switchgear, roadway or area lighting fixture poles, power distribution transformer, and similar items), meeting the structural design criteria requirements.

4.5 PROCESS MONITORING AND CONTROL

4.5.1 Control philosophy

The general control philosophy for the new facility is to provide a simple, manually controlled system. To keep the system simple, no central control panel is proposed. Instead, the majority of the new mechanical equipment will be manually controlled through local control panels. Provisions, however, will be made to allow for the future development of a more sophisticated automated and/or centralized control system.

4.5.2 Base control and monitoring system description

The following brief descriptions define the control and monitoring systems to be implemented under the base facility design for the Azemmour WWTP. Other control and monitoring systems will be accepted only if they conform to the process requirements described in Chapter II.

Main Pump-Station:

Because of the topography of the existing sewage collection system of Town of Azemmour, the proximity of the Village of Sidi Ali on the opposing bank of the Oum R'bia River , and the preferred location of the future wastewater treatment plant site, a lift station will be required to pump sewage collected at central wet- well to the head-works of the new wastewater treatment facility. A central wastewater pump station will be required. The proposed central pump station shall have an ultimate firm capacity of 120 l/s and shall provide one stand-by pump.

Preliminary Treatment:

The preliminary treatment phase will involve two processes: influent wastewater screening and influent sampling and metering. Following is a description of each process and its associated control and monitoring systems.

<u>Influent Wastewater Screening</u> Influent wastewater will be pumped to the treatment plant from the various in-system pumping stations where it will be received in an elevated inlet chamber. From the inlet chamber, the flow will be sent through one of the mechanical screening devices or through the bypass manual bar screen. Each screening channel will contain a manually operated inlet and outlet sluice gate to allow isolation of the screening for maintenance.

The supplier of the mechanical screen will be required to provide a local control panel mounted near each unit. The local control panel will provide the control and monitoring of the screen, including as a minimum the following features:

- Manual power on/off switch;
- Power on indicator light;
- Internal adjustable repeat cycle timer allowing screen to operate at set time intervals;
- Manual screen operate pushbutton, which will initiate one cleaning cycle; and

- Screen failure alarm light.

Influent Sampling and Metering: The influent wastewater will be sampled and metered. An automatic sampler will be installed on the inlet chamber/screening structure. The sampler will collect a sample downstream of the inlet chamber prior to the flow entering one of the screening channels. The sampler will contain an internal timer and an internal controller that will accept a flow signal from the influent flow meter and allow the sampler to operate in either a time based or volume based mode. The sampler device will contain the following control and monitoring features:

- Manual power on/off switch;
- Power on indicator light; and
- Sampler failure alarm light.

A magnetic flow meter will be installed in the influent chamber effluent pipeline in a below grade chamber prior to discharge to the aerated lagoon system. A flow transmitter will be installed in the metering chamber and will send the flow signal to a flow meter panel installed on the inlet chamber/screening structure adjacent to the influent sampler, to each of the settling pond sludge pumping systems, and the Chlorination Building. This panel will contain the following features:

- Meter operating status;
- Instantaneous flow indicator;
- Flow totalizer indicator;
- Flow recorder (strip chart or circular chart); and
- Meter failure alarm.

Secondary Treatment:

The secondary treatment phase will involve several principle processes: Aerated lagoons; facultative settling ponds; sludge pumping, chlorination, and effluent sampling. Following is a description of each process and its associated control and monitoring systems.

Aerated Lagoons: Effluent from the head-works will be conveyed to the aerated lagoon diversion chamber. Sludge filtrate will be introduced to this box and mixed with head-works effluent flow. The flow in the box will overflow even-length, broad-crested weirs into one of the initial phase compartments and then on to the aerated lagoon. A manually operated sluice gate will allow each aerated lagoon influent pipe to be shut-down to isolate the lagoon.

The aerated lagoon system will be sized hydraulically to operate in a parallel mode or in a series mode. In the parallel mode, the influent flow to the aerated lagoon system will be equally split between the lagoons. Flow would be discharged from each lagoon through its manually controlled outlet structure. In the series mode, all of the lagoon influent flow would be sent to the first lagoon. Manually operated sluice gates or gate valves would be opened to allow flow to be routed from the one lagoon to the next. Effluent would all be discharged from the last lagoon in series.

Mixing and aeration would be provided with surface mechanical aeration units specifically designed for use in aerated lagoon municipal wastewater treatment . Each lagoon would contain equally sized units. Operations staff would periodically monitor the dissolved oxygen (DO) level in each lagoon and manually start or stop aerators to either increase or reduce the lagoon's DO, respectively. A local control panel adjacent to each aerator, which would contain the following devices, would accomplish this:

- Manual power on/off switch;
- Power on indicator light; and
- Aerator failure alarm light.

Facultative Settling Ponds**:** Effluent flow from the aerated lagoons will be conveyed to the facultative settling pond diversion chamber. The flow in the chamber will overflow even length broad-crested weirs and into one of the four initial phase compartments and then on to the settling ponds. A manually operated sluice gate will allow each influent pipe to be shut-down to isolate the settling pond. Once in the pond, suspended solids settle to the bottom of the pond and the clarified effluent overflows a v-notched weir into an effluent launder for conveyance on to the disinfection system. The settled sludge in the pond system is withdrawn from the bottom of each pond as required by design then wasted to the sludge processing facilities.

The settling process will be controlled and monitored by, vendor supplied local control panels for each pond. The local control panel provided will include the following features:

- Collector mechanism power on/off switch;
- Collector mechanism power on indicator light;
- Collector mechanism high torque unit shut-down;
- Collector mechanism high torque shut-down alarm; and
- Collector mechanism failure alarm.

Chlorination: Effluent from the facultative settling ponds will be disinfected with chlorine prior to discharge from the plant. This will be accomplished by adding a chlorine solution to the effluent and passing it through a chlorine contact tank for sufficient contact time. The effluent will be conveyed from the facultative settling ponds to a small mechanically mixed chamber at the head end of the chlorine contact tank where the chlorine solution will be added. The mechanical mixer will be manually controlled by an on/off switch located adjacent to the unit.

The chlorine solution will be produced by passing chlorine gas through an injector, where water mixes with the gas forming the chlorine solution. Metric ton containers of chlorine gas will be used as the source of chlorine. A specially designed scale will be used to monitor the weight of the active gas containers. The gas flow will be metered through a chlorinator. A backup chlorinator will be provided, and provision will be made to add additional units to handle future higher dosage requirements.

The chlorine feed rate will be controlled manually or automatically through a local control panel in the Chlorination Building. The chlorinators will normally be operated in automatic mode. In the manual mode, the feed rate can be adjusted manually at each chlorinator process control unit. In the automatic mode, the operator will establish the desired chlorine dose. The chlorine feed rate will be dosed from the process control unit at the local control panel using the influent wastewater flow signal being transmitted to the Chlorination Building.

As a minimum, the local control panel would contain the following features:

- Chlorinator power on switch;
- Chlorinator power on indicator;
- Chlorinator process control unit (for each chlorinator);
- Chlorine gas flow rate indicator;
- Influent flow indicator;
- Active chlorine cylinder weight indicators;
- Loss of chlorine gas vacuum alarm;
- Low gas pressure alarm;
- No chlorine flow alarm; and
- Chlorine leak detector alarm.

Sludge Processing:

Sludge Pumping**:** Sludge that settles to the bottom of the facultative settling ponds will be pumped periodically as required to the sludge dewatering area by a sludge collection and pumping system engineered for this purpose. Manually operated valves and gates will provide flexibility in the system.

The sludge will be conveyed to the sludge dewatering area by a pipe that will contain a flow control valve that will allow operations staff to control the rate of sludge withdrawal from the clarifier. Operations staff will monitor the rate of sludge withdrawal and periodically open or close the motorized valve component of the rate of control unit from the local control panel to maintain equal sludge flow from each settling pond.

Mobile sludge pumps, with at least one standby pump, will be used for this purpose. A flow meter in the discharge line from the Sludge Pumping System will monitor the sludge pumped. Pipe pressure will be monitored and used to shut-off the pumps at a preset high pressure point.

As a minimum, the local control panel in the RAS/WAS Pumping Station would contain the following features associated with the WAS pumping system:

- Sludge pump on/off switch (for each pump);
- Sludge pump on indicator light (for each pump);
- Sludge pump failure alarm (for each pump);
- Sludge discharge flow indicator and totalizer; and
- Sludge pump high-pressure discharge shut-down alarm.

The sludge processing phase will involve sludge pumping; sludge drying beds; and sludge recycle flow pumping. Following is a description of each process and its associated control and monitoring systems.

Sludge Pumping: Sludge will be transferred from the facultative settling ponds to the sludge drying beds by the sludge pumping system. Ultimately three mobile sludge pumps will be utilized, one for each pond. The pumps will be connected to a common discharge header that will convey the sludge to the sludge drying beds. Manually operated valves will be used to direct the flow. Sludge pumping will be metered. To protect the pumps against a closed discharge valve high-pressure situation, the discharge pipe pressure will be monitored and the pumps shut down at a preset high-pressure level.

The sludge pumping system will be controlled and monitored by a local control panel. As a minimum, the local control panel provided will include the following features:

- Sludge pump on/off switch (for each pump);
- Sludge pump on indicator light (for each pump);
- Sludge pump failure alarm (for each pump);
- Sludge discharge flow indicator and totalizer (one for each dewatering system); and
- Sludge pump high-pressure discharge shut-down alarm.

Sludge Drying Beds: Sludge removed from the settling ponds will be pumped to the sludge drying beds. This operation will be a purely manual operation. Prior to initiating sludge pumping, the plant operators will determine which drying beds the sludge is to be applied to and which feed valves along the bed are to be opened. The appropriate valves will then be manually opened and the sludge pumping operation commenced.

Once the sludge has reached the desired solids content, the sludge will be removed from the beds. A wheeled front loader will be use to load the dried sludge onto trucks. The sludge will either be hauled to the on-site dewatered sludge storage area or directly off-site to an appropriate disposal location.

Effluent Monitoring:

Effluent Sampling: Prior to discharge from the plant, the plant effluent will be sampled. An automatic sampler located in the Chlorination Building will collect samples from the chlorine contact tank outlet box for this purpose. The sampler will contain an internal timer and an internal controller that will accept a flow signal from the influent flow meter (through the local control panel in the Chlorination Building) and allow the sampler to operate in either a time based or volume based mode. The sampler device will contain the following control and monitoring features:

- Manual power on/off switch;
- Power on indicator light; and
- Sampler failure alarm light.

To monitor effluent quality, an automatic sampler located in the Disinfection Building will collect samples from the Chlorine Contact Tank Outlet Box. The sampler will have a power-on indicator light and a sampler-failure alarm light.

A database will be established to document effluent quality monitoring results. The database will be used to keep track of the following parameters:

- BOD
- pH
- Nitrate-nitrogen
- Total phosphorous
- TSS
- Salinity
- Kjeldahl nitrogen
- Oil and grease
- Temperature
- Ammonia-nitrogen
- Total nitrogen
- Fecal coliform bacteria
- Enterococcus (fecal streptococci) bacteria
- Helminthic pathogens (e.g. Ascaris eggs)

4.6 SUPPORT FACILITIES AND SYSTEMS

4.6.1 Support facilities

This section covers the support facilities needed for the operation of the new Azemmour WWTP.

Operations Center:

A new Operations Center is to be included with the new Azemmour facilities. This new Operations Center will contain as a minimum the following building spaces:

- Operator office(s);
- Laboratory;
- Control room;
- Washroom and locker facilities; and
- Workshop.

The laboratory will be outfitted to handle only routine process monitoring and control testing. Mores elaborate tests, such as metals and organic pollutants, will need to be sent out to laboratories that specialize in these types of analyses.

Mobile Equipment:

In order to make the new facilities self-sufficient, certain new mobile equipment will be required, primarily associated with sludge disposal. The required mobile equipment will include:

- Small front-end loader or similar type vehicle;
- Larger front-end loader to transfer sludge to haul vehicles;
- Several small dump trucks to transfer sludge to on-site sludge storage facility; and to transport the dewatered sludge to off-site processing/disposal locations.

Access Roads:

As shown on the drawings, new plant access roads are proposed to be constructed along with the new wastewater treatment facilities to provide access to the new treatment facilities.

Power System:

A dual power feed will be rerouted from the new facility to a new metering/transformer structure on the site of the new plant. New on-site electrical generation facilities will then be installed along with the proposed wastewater treatment system. The new power system will be designed according to the criteria outlined above, section "Electrical Design Criteria".

Water Systems:

A potable water connection will be extended to the new Operations Center since this is the only facility that will require potable water.

Various process and clean-up operations, however, will require that a non-potable service water system be installed for the new facilities. This system will be installed in the new Disinfection Building and use final effluent from the chlorine contact tank as its source of water supply. Two 200 GPM pumps will pump the service water through a separate 100 mm diameter distribution piping system around the plant. Where possible, the system will be laid out in a loop with frequent isolation valves so repairs can be made without disrupting other sections of the plant. The primary uses for the service water will be as chlorine solution water, belt filter press wash water, and wash-down water for process tanks, but other uses such as site irrigation are possible.

Service water usage will be monitored and recorded regularly for each of the process systems and other major water-using equipment. Any faucets, hose bibs, sill cocks or hydrants associated with the service water system will be clearly and permanently labeled to indicate that the water is not safe to drink. No interconnections between service water and potable water systems will be allowed, and cross-connections will be prevented.

Wastewater Collection, Treatment and Disposal:

The only source of sanitary wastewater anticipated from the new facilities will be generated in the new Operations Center. The building plumbing will be connected to a small sanitary sump and a submersible grinder pump will be installed to transfer the sanitary waste to the new head-works facilities.

In addition to the sanitary system serving the new Operations Center, certain waste streams will be generated from several of the process units. These streams will be collected as recycle water and returned to the oxidation ditch system for treatment.

Landscaping and Green Area:

All open areas and areas disturbed by construction will be finish graded and seeded with grass. A security wall will be installed along the perimeter of the entire site (see "Security System" below).

Site Drainage System (Flood Control):

Given the Mediterranean climate in the project area, a storm drainage system is to be installed that will secure the proposed facility from the predicted 50 year flood. The site will be graded to insure flow of all surface water away from the structures to swales which will drain surface water off the site to acceptable drains or areas capable of receiving these surface flows.

Additionally, localized drainage systems (drains and sumps returning flow to process streams) will be provided where run-off is expected from process units, such as within process buildings and sludge dewatering facilities.

Fire and Safety Systems:

The fire and safety system will be designed according to the criteria outlined in above, section "Fire and Safety Design Criteria."

Communications Systems:

No extension of service beyond the Operations Center is planned for the proposed new treatment facilities.

Security System:

As shown on the drawings, a security fence will be constructed around the proposed new treatment facilities. Gates will be installed at the locations shown.

Heating and Ventilation System:

The heating and ventilation systems required will be designed according to the design criteria discussed in "Mechanical Design Criteria".

SECTION 5: ENVIRONMENTAL IMPACT ASSESSMENT

TABLE OF CONTENT

5.1 OBJECTIVE

The objective of Task 5 is to evaluate the environmental impact of the selected wastewater treatment alternative and define the appropriate remedial measures to reduce the impact.

5.2 DESCRIPTION OF THE PROJECT AREA

5.2.1 Geographical situation

The town of Azemmour is located on left bank of the Oum Er Rbia river, four kilometers to the south of the confluence with the Atlantic Ocean.

The center of Sidi Ali constitutes the urban development of the town of Azemmour on the right bank of Oum Erabia. This urban extension is located between the old Main road RP8 and its current deviation.

5.2.2 Administrative status

On the administrative level, the town of Azemmour is a municipality belonging to the Province of El Jadida (Wilaya of the Abda-Doukkala area).

Its zone of extension, which is Sidi Ali Ben Hamdouche, is the main center place of a rural district belonging to the town of Azemmour.

The town of Azemmour is made of six rural communes (Chtouka, Haouzia, Loghdira, Lamharza, Oueld Rahmoune and Sidi Ali Ben Hamdouche).

5.2.3 Physical data of the general area

5.2.3.1 Climatology

The town of Azemmour is marked by a mild climate following the moisture of the masses of air on the coast during the autumn and spring. Climate of the east zone is semi-arid and moderate in winter.

Annual average precipitation is important. It is approximately 423 mm.

The monthly average temperatures recorded for period 1988-1997 vary from 12.7°C to 23.1°C.

The winds are rather frequent, with a North-eastern dominant direction.

5.2.3.2 Geology

The town of Azemmour is located on the littoral edge which develops along the Atlantic Ocean from Rabat to Essaouira. It is located in the main geology called "Coastal Chaouia". The surveys carried out in the area of Azemmour revealed three types of distinct formations:

- The cretaceous base
- The consolidated quaternary
- The current quaternary

In the major part of coastal Chaouia, the Paleozoic base forms the substratum.

This base consists of impermeable and slightly permeable formations whose higher fringe is weathered.

The most dominant formations are Acadian schists or Ordovician and quartzite which sandstones join.

5.2.3.3 Hydrogeology

The town of Azemmour is located between two distinct hydro geologic zones: coastal Chaouia (zone ranging between Casablanca and Azemmour) and the Sahel. The Hydrogeology of coastal Chaouia is characterized by the existence of a ground water of general extension according to the places especially in the quaternary one, the cretaceous or the weathered primary.

5.2.3.4 Hydrology

The town of Azemmour and the center of Sidi Ali are located on two banks of the Wadi Oum er-Rbia.

5.2.3.5 Specific data at the site of the treatment plant

The Laboratory LABOSOL conducted a geotechnical study of the subsurface of the site by the execution of drillings and wells. The site of the project is characterized by the following features:

- ❖ Deltaic surface deposits made up of brownish fine sand with the presence of large pebbles of the Wadi heterogenic and hetero-metric.
- ❖ Conglomerates deposits.
- ❖ Layer of yellowish sand and gravel (with some small pebbles).
- ❖ Greenish marl substratum.

The details of the study are presented in the geotechnical report in appendix 3.

According to the readings taken at the drilling location, we could distinguish the following quasi homogeneous lithology:

Survey SM1:

- **0.00m - 0.40m**: Topsoil
- **0.40m - 2.70m**: Sands fine brownish
- **2.70m - 3.30m**: Alluvia: (pebbles) hetero-metric with brownish sandy matrix
- **To 3.30**: Conglomerates.

Level piezometric: None

Survey SM2:

- **0.00m - 0.50m**: Topsoil
- **0.50m - 2.30m**: Brownish fine Sands
- **2.30m - 3.30m**: Alluvia: pebbles hetero-metric with brownish sandy matrix
- **To 3.00**: Conglomerates.

Level piezometric: None

Survey SM3:

- **0.00m - 0.60m**: Topsoil
- **0.60m - 2.80m**: Brownish fine Sands
- **2.80m - 3.00m**: Hard tufaceous white sandstone.

Level piezometric: None

Survey SM4:

- **0.00m - 0.60m**: Topsoil
- **0.60m - 2.00m**: Brownish fine Sands
- **2.00m - 2.60m**: Alluvia: (pebbles) hetero-metric with brownish sandy matrix

Level piezometric: None

Survey SM5:

- **0.00m - 0.30m**: Topsoil
- **0.50m - 2.30m**: Brownish fine Sands
- **2.30m - 3.30m**: Alluvia: pebbles hetero-metric with brownish sandy matrix
- **To 2.00**: Conglomerates.

Water table level: Nothing

Survey SV1:

- **0.00m - 3.00m**: Brownish fine Sands
- **3.00m - 6.50m**: Conglomerates
- **6.50m - 9.00m**: Yellowish clayey sand with some gravels
- **9.00m - 10.00m**: Substratum: greenish marl

Water table level: Nothing

Survey SV2:

- **0.00m - 1.50m**: Brownish fine Sands
- **1.50m - 4.50m**: Alluvia: (pebbles) heterometric with brownish sandy matrix
- **4.50m - 7.50m**: Conglomerates
- **7.50m - 10.00m**: Yellowish clayey sand at some depth

Water table level: Nothing

Survey SV3:

- **0.00m - 1.00m**: Brownish fine sand
- **1.00m - 1.50m**: Sandstone hard
- **1.50m - 4.80m**: Conglomerates
- **4.80m - 9.00m**: Yellowish clayey sand with some gravels
- **9.00m - 10.00m**: Substratum: greenish marl

Water table level: Nothing

Survey SV4:

- **0.00m - 1.00m**: Brownish fine sand
- **1.00m - 1.50m**: Alluvium: pebbles hetero-metric with brownish sandy matrix
- **1.50m - 5.00m**: Conglomerates
- **5.00m - 8.00m**: Yellowish clayey sand with some gravel
- **8.00m - 10.00m**: Substratum: greenish marl

Water table level: 8.5m/TN

Moreover, two in-situ permeability tests were carried out on the features met on the level of the boreholes and the zone of the borrow pit. These tests are carried out by the method of **Porchet** on constant level. The results of the tests are given below:

Drilling #	Depth	Natural	Permeability K **(en m/s)**
SM_1	3.00m/TN	Alluvium: pebbles hetero-metric with brownish sandy matrix	$3 X 10^{-3}$
Zone of the borrow pit		multi-colored Clay	$0.1 X 10^{-8}$

5.2.4 *Demographic data*

The demographic data of the populations of the town of Azemmour and the center of Sidi Ali, resulting from the report of mission 1, are summarized in the table below for the design 2005, 2010, 2015, 2020 and 2025:

Year	2005	2010	2015	2020	2025
Azemmour (hab.)	41 241	45 533	49 781	54 426	58 632
Sidi Ali (hab.)	3 629	4 106	4 534	5 005	5 472
total Population (hab.)	44 870	49 639	54 315	59 431	64 104

5.2.5 *Industrial activities*

In the current industrial park of the town of Azemmour, only three factories are established:

- A preserve factory;
- A factory of congelation;
- A factory of mirror manufacture.

The two last factories are currently not functional. Only the preserve factory (SOVEM) is still functional. It manufactures the fruit juices per season and uses citrus fruits, the cutters and apricots. It uses the well water and rejects the used water directly in the wadi Oum er-Rbia.

A new industrial park is planned on the site of the current market of the town of Azemmour. Only two production facilities are currently built: A tannery which has not yet functional and the slaughter-houses of the town of Azemmour which is in operation.

5.2.6 *Tourism sector*

An important tourist project (Mazagan) is underway in the coastal zone of Hawzia. The future tourist station of Mazagan will be located along the sea between the mouth of the Oum Er-Rbia river and the current golf course of El Jadida. It will be built on a total surface of 476 Ha.

The goal of this tourism project is to create a tourist complex and recreation center to international standards, including specific installations enabling it to become a center for conferences, education, and sports training at a high level.

5.3 DESCRIPTION OF CURRENT WASTEWATER MANAGEMENT PRACTICES AND THEIR IMPACTS ON THE ENVIRONMENT

The existing wastewater network of the town of Azemmour is a combined type. It has a length of approximately 27 km. The wastewater network of Sidi Ali is a separated type. It is in an early state and has several effluents. In addition, the sewr networks of the town of Azemmour and the center of Sidi Ali do not cover the whole developed area.

The sewer lines of the wastewater network of the town of Azemmour are generally very old and insufficient for collecting rain water. Problems exist in the districts with mountainous sub basins whose system was installed without planning or control at the time of the construction.

The depth of the network is often low (varies between 0.25 m and 1.10 m), this situation thus generates problems of routing of wastewater of the dwellings which are often at a lower elevation than those of the collectors.

The Municipality of Azemmour completed rehabilitation work and renovations during the last few years. Work concerned the old médina, the Northwestern extensions, and the avenue Moulay Hassan. According to the Municipality of Azemmour, all this work permitted the elimination of the black spots and to ensure that the time of stagnation of water does not exceed half an hour.

Also, according to the municipality of Azemmour, the work carried out during the last few years relates to a linear distance of 11210 ml of renewed and rehabilitated collectors. As for the Médina, it should be noted that an interceptor (DN 500 mm, length: 700 ml) collecting wastewater along the wadi Oum Erbia, was installed by the ANHI.

Currently, the wastewater of the town of Azemmour is discharged without treatment in the Wadi Oum er-Rbia, as indicated in the figure below. This effluent joins the beach of Hawzia located approximately 2 km from the outfall. The organic matter carried by the water is of domestic origins.

The town of Azemmour and the center of Sidi Ali discharge daily more than 2500 m3 of wastewater in the Oum Erbia river. This flow is expected to increase and reach approximately 3000 m3/day in 2010 and 4200 m3/day in 2025. This wastewater flow generates nauseous odors and contributes to the pollution of the Oum er-Rbia river.

5.4 DESCRIPTION OF PROPOSED WASTEWATER TREATMENT SYSTEM

5.4.1 Type of treatment system

The wastewater treatment station for Azemmour and Sidi Ali will be built on a site which is located on the left bank of the Oum er-Rbia river at approximately 1km from the current wastewater outfall of the town of Azemmour and at 500 m at the east of the Oum Er – Rbia river.

The treatment process retained for the purification station consists of aerated lagoons followed by facultative lagoons and maturation ponds.

- The aerated lagoons allow a treatment without concern for the problem of the odors which can emanate from the other systems of treatment such as the simple lagoons or anaerobic lagoons. The aerated lagoons require less land area than the simple lagoons.

- The maturation ponds make it possible to obtain an effluent which can be used for irrigation and watering of the grounds and forests adjacent to the treatment plant.

The station will function in two parallel treatment trains. The number and configuration of the treatment units were selected so that these units can be disconnected individually for repair without requiring the complete shutdown of the whole station.

5.4.2 Description of the treatment units

Following is a description of the proposed wastewater treatment facility.

The selected wastewater treatment alternative will be an aerobic lagoon system capable of treated the combined wastewater generated by Azemmour and Sidi Ali through the year 2025. The selected technology will require design and construction of the following processes:

- A central sewage pump station
- A new influent structure to include mechanically cleaned bar screens, a manually cleaned bypass screen,
- New Aerated lagoons with mechanical surface aerators;
- Facultative Settling Ponds to remove suspended solids;
- A chlorination building with internal chemical storage area and disinfection contact tank;
- A sludge pumping facility to convey sludge from the settling ponds to the sludge dewatering area;
- Sludge dewatering and processing area;
- Site piping and flow splitting structures to accommodate the flows and facilities, and;

- Miscellaneous site work including roadway system, grading, seeding and landscaping, as well as a security barrier around the entire plant.

It should be stated that the base facility design considers that the minimum number of process units has to be based on taking all equipment, process lines, tanks, reactors, etc. out of operation one at a time for maintenance while still meeting effluent requirements and incorporates necessary process unity redundancy to meet this condition.

5.4.2.1 Pump Station

A pump station will be required to lift the sewage flow approximately 40 meters over a distance of 500 meters. The pump station will be located as near to the existing out fall as possible to minimize rerouting of the existing gravity collection system.

The station should be designed to handle peak hour wastewater flows of 60 l/s and 100 l/s for design years 2010 and 2025 respectively and shall have adequate standby capacity to run continuously without interruption. Pump station shall be equipped with standby power supply in the event of power failure. Lastly, the pump station should be equipped with a secondary discharge to by-pass excessive storm flows to the River.

Raw wastewater will be collected in a new wet-well to be constructed near to the existing Azemmour sewage outfall. Once collected, sewage will be pumped from a new central pumping station to the new treatment plant.

5.4.2.2 Pretreatment

At the head-works of the new facility, sewage will be received by an inlet chamber. A force main will be required from the pump station to this new inlet chamber. From the inlet chamber, flow will be directed to an above-grade screening facility.

The screening facility will contain a single mechanically cleaned bar screen with a bypass manual cleaned rack both situated in open concrete channels. Each channel will contain inlet and outlet gates to allow isolation of the screens. This facility will be sized to handle the initial design peak flow (with one screen out of service) as well as projected future peak flow without adding more screening channels. Screenings will be removed and hauled to an approved off-site disposal area. The design is to include provisions for removal of the screenings without manual lifting or physical contact by the operations staff.

Composite raw wastewater sampling and flow measurement equipment will be situated at the effluent end of the head-works, after the screening facility. Prior to discharge into the downstream units, the flow will be metered. The meter installation will be configured so as to allow removal and maintenance of the flow meter.

From the head-works, the screened flow will be collected in a common effluent channel from which it will be directed to aerobic lagoons.

5.4.2.3 Diversion chamber

At the aerated lagoon diversion chamber, screened wastewater will be split into multiple streams to feed the aerated lagoons. Flow will enter the center of the splitter box and flow upward and over a weir wall that drops the flow into one of the chambers of the box. Provisions are to be made (in this case, equal length weir walls) to ensure an even split of flow between the active lagoons. A gate will be installed in each of the chambers to allow isolation of the lagoon for removal from service. The splitter box will include weirs and isolation gates for the future lagoons. Vehicle access will also be provided to the box to allow periodic floating material removal from the box by a vacuum type truck. From the aerated lagoon splitter box, the flow will be directed to the Aerated Lagoons.

5.4.2.4 Channel Flow meter and Sampler

A Venturi flow meter will be installed upstream of the aerated lagoons in order to measure the flows entering the station.

5.4.2.5 Aerated lagoons

Initially a minimum of two lagoons will be required. Ultimately three lagoons are envisaged to accommodate ultimate design flows. Each lagoon will contain inlet and outlet gates to allow for isolation if necessary. Each will have a separate feed pipe from the aerated lagoon diversion chamber and an outlet weir structure to maintain adequate depth in each pond and to control flow discharged from the ponds. In addition, gates or valves are to be installed in each of the aerated lagoons to allow them to operate in both a series and parallel mode. As a result, the influent pipe feeding the each lagoon will be sized to handle the full flow. As mechanical surface aerators are historically applied in aerated lagoon systems, each pond will contain an appropriate number of mechanical surface aerators specifically designed and sized to meet anticipated maximum day oxygen demand in the unit and achieve thorough mixing of suspended solids. Alternately a compressed air system may be employed at the clients' discretion.

From the aerated lagoons, the aerated lagoon effluent will be combined at the aerated lagoon effluent chamber and transported to the facultative settling ponds. Provisions are to be made in the effluent chamber (for example, a downward acting sluice gate and scum box) to allow plant operators to remove floating grease and oil that may accumulate in this chamber. Vehicular access to the effluent collector area will be provided to allow periodic floating material removal from the area by a vacuum type truck.

5.4.2.6 Facultative settling ponds

From the aerated lagoon effluent chamber, flow will be directed to the settling ponds. Facultative settling ponds will receive effluent from the aerated lagoons via the facultative settling pond flow diversion chamber. At the facultative settling pond diversion chamber, the aerated lagoon effluent will be split into multiple streams to feed the proposed settling ponds. Flow will enter the center of the diversion chamber and flow upward and over a weir wall that drops the flow into cells feeding the settling ponds. Provisions are to be made (in this case, equal length weir walls) to ensure an even split of flow between the settling ponds. A gate will be installed in each of the chambers to allow isolation of each pond for removal from service. The diversion chamber will include weirs and isolation gates for the future settling ponds. Vehicle access will also be provided to the diversion chamber to allow periodic floating material removal from the chamber by a vacuum type truck.

Each pond would have a separate feed pipe from the facultative settling pond diversion chamber and an outlet weir structure to maintain adequate depth in each pond and to control flow discharged from the ponds. In addition, gates or valves are to be installed in each of the settling ponds to allow the ponds to operate in both a series and parallel mode. As a result, the influent pipe feeding the each pond is sized to handle the full flow.

Ponds will be sized to accommodate approximately 4 years of accumulated sludge and shall be designed for ease of sludge removal and dewatering. An additional standby lagoon will be constructed to facilitate this activity.

As previously indicated, an outlet weir would control indicated flow from each pond. Vehicular access to the effluent collector area will be provided to allow periodic floating material removal from the area by a vacuum type truck. The sedimentation pond effluent collected in the sedimentation lagoon effluent box will be piped to the chlorine tank inlet box, where it can be sent through the chlorine contact tank or bypassed around the tank.

5.4.2.7 Maturation ponds

Four maturation ponds (in a series of two) are planned for polishing the effluents resulting from the secondary lagoons.

The effluent of the secondary basins will be then directed towards a chamber which contains an automatic sampler before being forwarded to the outfall pipe towards the Oum Er-Rbia river (or towards the re-use).

5.4.2.8 Sludge handling

Secondary sludge will be collected in the facultative settling ponds. Sludge from the secondary treatment system will be periodically pumped from the settling ponds directly to a dedicated sludge dewatering area. The design is to include provisions for removal of the sludge without manual lifting or physical contact by the operations staff. Each settling pond will contain a sludge collection zone. Sludge collected in the secondary treatment system will be removed from the system by mobile sludge pumps designed specifically for this purpose. For redundancy purposes, an uninstalled spare mobile sludge pump shall be furnished as backup to the active units. Mobile sludge pumps will require submerged suctions; a sludge pumping arrangement requiring suction lift will not be allowed. These pumps would withdraw the required amount of sludge from settling ponds and discharge it to the sludge dewatering area. Flow meters will be installed in each of the sludge discharge pipelines to meter the amount of sludge pumped to the sludge dewatering area.

Given the space requirements associated with secondary sludge generated, sufficient space exists for dewatering all of the projected sludge utilizing paved sludge dying beds. The liquid fraction of filtrate will pass through an under-drain collection system will contain and collect dewatered sludge filtrate. Sludge filtrate return piping will include a return valve to allow return of sludge filtrate to the aerated lagoons. Alternately covered paved sludge drying beds may be constructed for this purpose.

The dewatered sludge will be removed from the site by wheeled front-end loader or similar smaller vehicle to a sealed bed dump truck. The dewatered sludge will be hauled to a small on-site dewatered sludge storage area prior to removal to an approved off-site disposal area or applied as an agricultural amendment as permissible under Moroccan Law.

5.4.2.9 Protection against flooding

The site of the purification station is in a non flooding zone.

The pump stations of Azemmour and Sidi Ali which are in a flooding zone will be protected by an embankment in order to avoid their flooding. They will be also surrounded by protective walls against the water rises of the Oum Er-Rbia.

For the protection of the pipes along the river against the floods, the construction of a protective embankment along the collector is planned.

5.4.3 Description of wastewater collection and pumping

The wastewater treatment plant is intended to treat wastewater of the town of Azemmour and of the center of Sidi Ali. It will be located on a higher level than the current discharge of wastewater.

Therefore, two pump stations are necessary to forward wastewater of Sidi Ali and Azemmour to the treatment plant. The first will be used to pump only wastewater of Sidi Ali to the main collector of Azemmour and the second will be intended to pump the combined flow of Azemmour and Sidi Ali towards the treatment plant.

The length of the force main for Sidi Ali is 475 m of which 205 m is suspended on the bridge above the Oum Er-Rbia river and 270 m buried in the ground.

Wastewater of Sidi Ali will join the existing collector CP3 (placed recently by the ANHI). This last section will be extended over a 250 m length in order to arrive to the projected Azemmour pump station.

The pump station of Azemmour will pump the flow along a force main 705 m long towards the treatment plant.

5.4.3.1 Sidi Ali

The center of Sidi Ali has a separated collection system that currently discharges untreated wastewater in Oum Er-Rbia not far from the existing bridge. To join the Azemmour pump station and treatment plant, this wastewater will be pumped by a pump station whose characteristics are:

- Pumped flow (peak daily output in 2025): 379 m3/d (4.38 l/s)
- Length of force main: 475 m
- Land requirement for the pump station: 200 m^2

For the crossing over the river, the forcemain will be installed on the bridge over a length of 205 m. The pipe will be galvanized steel with a diameter of 100 mm. It will then join the collector CP3 which is recently built by ANHI.

5.4.3.2 Azemmour

To convey wastewater of Sidi Ali and the medina to the pumping station of Azemmour, the existing collector CP3 (DN500mm) will be prolonged over a 250 m length.

The wastewater from Azemmour will be pumped to the treatment plant via a pump station with the following characteristics.

- Pumped flow is equal to 15825m3/d or 183.15 l/s.
- Length of the force main: 705 m
- Length of the gravity pipe towards the treatment plant: 285 m
- Land area for the pump station: 400 m2

A summary of the lengths of the collection pipes is given on the table below:

City	Pipe	Length (m)	Observation
Azemmour	Extension CP3 (ANHI)	250	Gravitational
	Discharge pipe	705	Force main
	Extension of discharge pipe	285	Gravitational
	Evacuation of purified waste water towards wadi OeR	395	Gravitational
Sidi Ali	Pipe discharge suspended on the bridge OeR	205	Suspended part of the pipe
	Discharge pipe (buried)	270	Buried part of the discharge pipe

5.4.4 Operation and maintenance requirements

Lagoon systems are typically not overly maintenance intensive when compared with conventional mechanical treatment facilities. Aerated lagoons will require more maintenance than other types of lagoons due to the requirement of aeration equipment. Preventative maintenance and occasional repair of surface aeration equipment will be required. Adequate spare parts to repair aerators and specialized operator training in the service and upkeep of this equipment is therefore recommended.

Debris must be removed from screens either mechanically or manually. Screening must be properly stored prior to off-site disposal. Daily flow monitoring and sampling and laboratory analysis of influent and effluent will be required. General yard-work and site maintenance will be necessary to maintain a good appearance. Occasional handling of chlorine cylinders will be necessary. Administrative oversight, accounting and record keeping will be necessary to insure smooth operation.

Periodic exercise of valves, weirs, and gates is required to insure smooth operation. Occasional adjustment of weirs, valves and gates will be required to handle changes in flow and loading. Removal of screenings and dewatered sludge from the site will be periodically required.

The operator must consuct measurements of accumulation of sludge at least once every three years. When the volume of sludge represents at least 10 % of the volume of the basin or that the level of sludge is at least one meter under the foundation raft of the exit conduit. Measurements must be taken at various points distributed in the basins and in particular in the settling zone of the last basin. The number of points of measurement recommended is 12 for the basins whose surface at the bottom is smaller than 2 000 m^2, and 15 when it is between 2 000 and 5 000 m^2 and 24 when it is larger than 5 000 m^2.

The quality of sludge must be analyzed every 3 years and during the year preceding a dewatering. A sampling consists of at least five specimens distributed inside a basin and homogenized to obtain a single sample representative of the basin. The parameters to be analyzed are the total solids and the total volatile solids in mg/L, the Kjeldahl nitrogen, the ammonia nitrogen, the nitrite-nitrates, total phosphorus, potassium, calcium, magnesium, aluminum, arsenic, boron, cadmium, cobalt, chromium, copper, iron, manganese, mercury, molybdenum, nickel, lead, selenium, zinc and the BPC in dry matter mg/Kg as well as the pH.

5.5 ENVIRONMENTAL IMPACTS AND COMPENSATORY MEASURES

The environmental impact assessment shows that the project presents some very important positive impacts.

One of those major positive impacts consist in treating wastewater of Azemmour and Sidi Ali before its discharge into the Oum Er-bia river and alleviating the pollution of this river where non-treated wastewater from these cities has been discharged from many years.

Furthermore, the re-use of treated effluent will allow safeguarding, at least partly, of water that can be used for irrigation of arable land.

Compensatory measures to protect the groundwater table (water proofing of the basins), elimination of the odors (aeration of the lagoons), and integration of the station in the neighboring landscape (plantings around the basins), etc. are envisaged.

The potential negative impacts are related to the nuisances during construction (excavations, sludge, etc) and from the nauseous odors emanating at the time of lagoon dewatering. These impacts, however, are generally of low importance and can be counterbalanced by the application of mitigation measures.

In addition, environmental monitoring and follow-up of the operations of the treatment plant can ensure the safeguarding of the environment.

A summary of environmental issues and compensatory measures related to these issue is shown in the following table.

Issue	Solution
Distance to population	The site is located at approximately 1 kilometer from the residential areas. The risk of odors is negligible due to the predominant wind direction which is NE and not towards the city. In addition the prescribed treatment process does not generate odors
Ownership of the site	The site is public domain currently owned by the Ministry of Water and Forestry, but the town can purchase it from the Ministry of water and forestry.
Access to the site	The access to the site is available through an existing dirt road which will be managed
Conveyance of raw sewage	The wastewater will be conveyed to the treatment plant via a pump station and force main.

Site physical characteristics	The site is covered by shrubs and small trees, which will be cleared prior to construction. The geotechnical investigation indicates that the geology of the site is mostly sand and gravel which will necessitate then the installation of a liner system underneath the ponds.
Risks of flooding	The site is located at an elevation above the flood plain. The collector and pump station will be protected by a berm against flooding
Risks of polluting groundwater	The ground water will be protected by the installation of an impermeable layer of clay underneath the ponds and sludge beds of the treatment plant
Reuse of treated effluent	The treated effluent will be used for irrigation of the adjacent forest.
Proximity to water extraction wells	The water table underneath the site is not useable due to the effect of salt intrusion. Therefore, there are no water wells in the proximity of the site.
Potential for plant expansion	Ample land is available at the site location for future expansion
Existing utilities	Electricity, water and telephone will be brought to the site from the nearby urban center at approximately 1 kilometer from the site. The sewer service will use the planned treatment plant.
Future land use plans	The site and adjacent land are located outside the development zone of the town of Azemmour

SECTION 6: IMPLEMENTATION PLAN

TABLE OF CONTENT

The objective of Task 6 is to identify the various modes of management of the project and to prepare an implementation plan for the construction and operation of the selected wastewater treatment alternative.

6.1 IMPLEMENTATION PLAN AND PROJECT MANAGEMENT

6.1.1 Project Financing

6.1.1.1 Private Public Participation

Budgetary constraints for Azemmour and Sidi Ali may lead them to seek alternative methods of financing this wastewater treatment project. Public private partnerships (PPP) have received widespread attention in several countries in recent years. These PPP initiatives have enabled the public sector to utilize private sector finance and expertise for the provision of public infrastructure through various schemes such as Design Build Finance and Operate (DBFO), Build Own Operate (BOO) and Build Operate and Transfer (BOT). This paper reviews these procurement systems and examines the relationship between these procurement systems and the financing of the project.

There is a range of options by which the city of Azemmour and the center of Sidi Ali can involve the private sector participation. These options vary with regards to ownership, operations and maintenance, financing, risk allocation and duration. A summary of these options can be viewed in Table 6.1. For purposes of brevity, only a short description of each of these options is provided hereafter.

Table 6.1: Allocation of key responsibilities under the main private sector participation options

Option	Asset ownership	Operations and maintenance	Capital investment	Commercial risk	Duration
Service contract	Public	Public and private	Public	Public	1-2 years
Management contract	Public	Private	Public	Public	3-5 years
Lease	Public	Private	Public	Shared	8-15 years
Concession	Public	Private	Private	Private	25-30 years
Build Operate Transfer	Private and Public	Private	Private	Private	20-30 years
Divestiture	Private or private and public	Private	Private	Private	Indefinite (may be limited by license)

Source: World Bank (1997)

6.1.1.1.1 Service contract

Under this option, the private sector performs a specific operational service for a fee, for example meter reading, billing and collection.

6.1.1.1.2 Management contract

In this option, the private sector is paid a fee for operating and maintaining a government-owned business and making management decisions.

6.1.1.1.3 Lease

Under the lease option, the private sector leases facilities and is responsible for operation and maintenance.

CIB World Building Congress, April 2001, Wellington, New Zealand Page 3 of 3 Paper number: 259

6.1.1.1.4 Concession

Under concessions, the private sector finances the project and also has full responsibility for operations and maintenance. The government owns the asset and all full use rights must revert to the government after the specified period of time.

6.1.1.1.5 Build own transfer (BOT) /Build own operate (BOO)

These are similar to concessions but they are normally used for new greenfield projects. The private sector receives a fee for the service from the users.

6.1.1.1.6 Divestiture

This option can take two forms – partial or complete divestiture. A complete divestiture, like a concession, gives the private sector full responsibility for operations, maintenance and investment, but unlike a concession, a divestiture transfers ownership of the assets to the private sector (World Bank, 1997).

6.1.1.2 Procurement Methods

The system suggested for the purification of wastewater of the town of Azemmour and Sidi Ali can be implemented as Turn-key, Build-Operate-Operate Transfer (BOOT), Build Operate Transfer (BOT), Lease Own Operate (LOO), etc. A brif description of each method is shown in the following table.

Table 6.2: project procurement structures

Contract type	Characteristics
Build Own Operate Transfer (BOOT)	- The service provider is responsible for design and construction, finance, operations, maintenance and commercial risks associated with the project. - The service provider owns the project throughout the concession period - The asset is transferred back to the government at the end of the term, often at no cost.
Build Own Operate (BOO)	- Similar to BOOT projects, but the service provider retains ownership of the asset in perpetuity. - The government only agrees to purchase the services produced for a fixed length of time
Design Build Operate (DBO)	- A design and construction contract linked to an operation and maintenance contract. - The service provider is usually responsible for financing the project during construction. - The government purchases the asset from the developer for a pre-agreed price prior to (or immediately after) commissioning and takes all ownership risks from that time.
Lease Own Operate (LOO)	- Similar to a BOO project but an existing asset is leased from the government for a specified time. - The asset may require refurbishment or expansion.

Source: Arndt (1999)

It should be noted that a system of "Turn-key" or "BOT" makes it possible to avoid design changes generating cost overruns and contractor's change orders and amendments. The contractor will be responsible for the whole project from the final design to startup and operation of the system.

It should be also noted that the recourse to "Turn-key" or "BOT" contracts with the stipulation of obligations of results with guarantees of performance is typical for projects of this type, because they constitute a fundamental aspect to acquire project financing.

The wastewater treatment plant, once built, can be operated and managed directly by the city, by affiliated utilities authorities, or by a private company.

The choice returns to the communes and will certainly be dictated by the financial and human capacities of the communes as well as by the presence already on the ground of actors experienced in the management of this type of service, in particular the Autonomous Water and Electricity Distribution Agency of El Jadida (RADEEJ) and the National Office of Drinking Water (ONEP).

6.1.1.3 Project Schedule

The wastewater treatment plant can be built in two phases. The first phase will be built to satisfy the requirements in wastewater treatment until the year 2010 and will consist of the construction of the pre-treatment works, two aerated lagoons, two secondary lagoons, and two maturation ponds.

The second phase will be built in 2010 to satisfy the needs for the year 2025 and will consist of the construction of the third aerated lagoon, the third secondary lagoon, and the last two maturation ponds.

Planning and the investment necessary for each phase are presented below.

Year	Phase	Amount of Investments DH
2006	Phase 1	**23,307,079**
2010	Phase 2	**10,978,829**

Operations	Cost of Phase I Dirhams	Cost of Phase II Dirhams	Total Cost of the Project Dirhams
Preparation of the Site	9,048,000		9,048,000
Operations buildings	870,000		870,000
Guard house	93,000		93,000
Startup work	74,296		74,296
Flow meters	300,000		300,000
Distributor 1	489,965		489,965
Ventilated Lagoons	1,849,263	3,698,525	5,547,788
Distributor 2	466,910		466,910
Secondary Lagoons	1,212,683	2,425,367	3,638,050
Distributor 3	20,510		20,510
Maturation ponds	1,008,378	3,025,133	4,033,510
Outfall Works	344,063		344,063
Treatment of sludge	2,749,500		2,749,500
Collection and distribution Sidi Ali	896,000		896,000
Collection and distribution Azemmour	2,927,750		2,927,750
Total Construction	**19,422,566**	**9,149,024**	**31,499,341**
Follow-up Work (5%)	971,128	457,451	1,574,967
Unforeseen (15%)	2,913,385	1,372,354	4,724,901
Grand Total	**23,307,080**	**10,978,829**	**37,799,209**

The schedule for the first phase is presented below. It should be noted in this planning, that the phases which require much more time include the bidding process (pre-selection, tender preparation, evaluation, award, etc.), the manufacture of the equipment and the period desired for the tests.

Designation	Duration Month	Designation	Duration Month
Preselection of Companies		**The Electromechanical Operation**	
Pre-Selection	1	Pumps	2
Evaluation of Qualifications	1	Aerators	2
Pre-Selection of Companies	1	Flowmeters /Sampler	1
Call For Bids and Award		**Works Of Control And Safety**	
Call For Bids On Performance	1	Control Panels	1
Preparation of Bids	2	Systems Of Control	1
Evaluation of Bids	1	Security Equipment	1
Negotiations	1	Surveillance Equipment	1
Award	1		
Preparation of Contract	1	**Startup**	
Realisation		**Trials**	
		Aerated Lagoon	1
Mobilisation	3	Secondary Lagoon	1
Field investigations	3	Maturation ponds	1
Final design	2		
Purchase of Equipment	2	**Calibration**	
Utilities, Electricity / Drinkable Water	2	Measuring Equipment	1
Construction		Equipment for Measuring and Control	1
Civil Engineering structures		Surveillance Equipment	1
Buildings	3		
Pumping Stations	3	**Startup**	
Access roads, parkings, etc	3	Treatment train 1	1
Fence and gates	3	Treatment train 2	1
Installation of the Basins, Water proofing, grading, excavation	5	**TRAINING**	2
Drains, pipes, connections	3		
Sludge Drying Beds	3		
Outfall Pipes for Effluent	3		
Diversion Ditch for Rain Water			
Permeability Tests			

6.2 VENDORS OF WASTEWATER EQUIPMENT

The following table gives a list of US wastewater equipment vendors who might be interested in providing equipment for this project.

A.R.I. USA, Inc.
4241 Jutland Drive
San Diego, CA 92117
Phone - (559) 269-9653 or (877) 536-6201
Fax - (858) 225-0894
www.arivalves.com

Acrison, Inc.
20 Empire Boulevard
Moonachie, NJ 07074
Phone - (201) 440-8300
Fax - (201) 440-4939
www.acrison.com

Air Liquide Industrial U.S. LP
2700 Post Oak Boulevard
#1800
Houston, TX 77056-5797
Phone - (713) 624-8000
Fax - (713) 624-8525

Applied Process Technology, Inc.
3333 Vincent Road
#222
Pleasant Hill, CA 94523
Phone - (925) 977-1811 or (888) 307-2749, ext. 0
Fax - (925) 977-1818

Atlantic Ultraviolet Corporation
375 Marcus Boulevard
Hauppauge, NY 11788
Phone - (631) 273-0500
Fax - (631) 273-0771
www.ultraviolet.com

Chlorinators Incorporated
1044 SE Dixie Cutoff Road
Stuart, FL 34994
Phone - (772) 288-4854
Fax - (772) 287-3238
www.regalchlorinators.com

Eden Equipment Company
1485 East 3rd Street
Pomona, CA 91766
Phone - (909) 629-5106 or (800) 842-5081
Fax - (909) 629-0243
www.edenequipment.com

Process Solutions, Inc.
560 Division Street
Campbell, CA 95008-6906
Phone - (408) 370-6540
Fax - (408) 866-4660

WC Equipment Sales, Inc.
3585 Lawrenceville Suwanee Road
#201
Suwanee, GA 30024

Phone - (678) 730-0997
Fax - (770) 614-5992

Aeration Industries Inc.
P.O. Box 59144
Minneapolis, MN 55459-0144
Phone: (952)448-6789
Fax: (952)448-7293
www.aero2.com

6.3 FINANCIAL INSTITUTIONS

The following list provides the names and addresses of financial organizations that could be interested in financing the project.

World Bank
1818 H Street, NW
Washington, DC 20433 USA
tel: (202) 473-1000
fax: (202) 477-6391
www.orldbank.org

Africain Development Bank
Rue Joseph Anoma
01 BP 1387 Abidjan 01
Côte d'Ivoire
Tel: (+225) 20.20.44.44
Fax: (+225) 20.20.49.59
www.afdb.org

Islamic Development Bank
P. Box. 5925
Jeddah 21432 Kingdom of Saudi Arabia
Telephone: (+9662) 6361400
Fax: (+9662) 6366871
Telex: 601 137 ISDB SJ
www.isdb.org

Japan International Cooperation Agency (JICA)
6th–13th floors,
Shinjuku Maynds Tower
2-1-1 Yoyogi, Shibuya-ku,
Tokyo 151-8558 Japan
Phone: +81-3-5352-5311/5312/5313/5314
www.jica.go.jp

KfW Bankengruppe
Palmengartenstrasse 5-9
60325 Frankfurt am Main
Phone: +49 69 7431-0
Fax: +49 69 7431-2944
www.kfw.de

Export-Import Bank of the United States
811 Vermont Avenue, N.W.
Washington, DC 20571
Tel: (202) 565-3946 (EXIM) or (800) 565-3946 (EXIM)
www.exim.gov

Overseas Private Investment Corporation
1100 New York Avenue, N.W.
Washington, D.C. 20527
www.opic.gov

ABU DHABI FUND FOR DEVELOPMENT
P.O. Box 814
United Arab Emirates
Telephone: [971](2)725-800
Facsimile: [971](2)728-890

SECTION 7: FINANCIAL ANALYSIS

TABLE OF CONTENT

The objective of Task 7 is to prepare a financial analysis for the realization and operation of the selected alternative of treatment.

7.1 FINANCIAL ANALYSIS

7.1.1. Project Cost

7.1.1.1 Capital costs

The capital costs include the cost of construction of civil structures, purchasing equipment and instrumentation and controls, the cost of studies, analyses, training and startup, and contingencies. The costs of the equipment include the following costs:

- Cost of the aerators
- Cost of the pumps
- Cost of the valves.
- Cost of the sludge drying beds
- Cost of the pipings
- Cost of the Flow-meters and Samplers.

The costs of construction include:

- Cost of basins
- Cost of buildings
- Cost of landscaping
- Costs of the structures of routing and water distribution.

The costs of instrumentation and control were estimated at approximately 10% of the total cost of acquisition of equipment and construction of buildings. The costs of follow-up and the costs of analyses were estimated at 5%, while the contingencies were estimated at 15% of the total cost of the project.

Table 7.1 below, presents the preliminary estimates of the capital cost for the water treatment plant.

Table 7.1: Preliminary estimates of the capital cost in DH

Work	Total cost in Dirhams
Preparation of the Site	9,048,000
Buildings	870,000
Guard house	93,000
Startup work	74,296
Flow meters	300,000
Distributor 1	489,965
Ventilated Lagoons	5,547,788
Distributor 2	466,910
Secondary Lagoons	3,638,050
Distributor 3	20,510
Maturation ponds	4,033,510
Outfall Works	344,063
Treatment of sludge	2,749,500
Collection for Sidi Ali	896,000
Collection for Azemmour	2,927,750
TOTAL CONSTRUCTION	**31,499,341**
Follow of Work (5%)	1,574,967
Contingency (15%)	4,724,901
Grand Total	**37,799,209**

7.1.1.2 Operation Costs

The operating costs are comprised of the following expenses:

- Energy expenses of the aeration system, the wastewater treatment plant, the sludge pumps, lighting, etc....
- Expenses of maintenance of the generators, the aerators and the electromechanical equipment.
- Maintenance costs.
- Expenses of the personnel.

Energy expenses

Tables 7.2a and 7.2b give an estimate of the quantities of energy necessary for the operation of the aerators and the pumps, also for the lighting of the buildings and the parking lots.

The aerators and the pumping station are supposed to function 24h/24h.

The power costs of lighting were estimated on the basis of use of an average of 25 bulbs of 100 Watts each 10 hours per day. The power costs of the aerators were estimated on the basis of 10 aerator of 20 horse power (HP) per basin.

Table 7.2a: Quantities of Energy Required by the Pump Stations

	Yearly Average Volume (m3)		Annual Energy Use (kwh)		Energy Cost DH/yr*	
	2010	**2025**	**2010**	**2025**	**2010**	**2025**
Pump station of Sidi Ali	69 715	110 595	3 684	6 285	3 684	6 285
Pump station of Azemmour	1 073 485	1 540 300	83 559	120 236	83 559	120 236
Total	**1 143 200**	**1 650 895**	**87 243**	**126 521**	**87 243**	**126 521**

Table 7.2b: Quantities of Energy required by the wastewater treatment plant

Equipment	Necessary Energy (kWhr /day)		Annual Cost (DH/year)*	
	2010	2025	2010	2025
Aerators	484	726	176660	264990
Lighting	25	30	9125	10950
Total Energy	509	756	185785	275940

* Unit price of 1 DH/kW

Expenses of the Personnel

The expenses of the personnel for the operation of the wastewater treatment plant are summarized on the Table 7.3.

Table 7.3: Expenses of the Personnel

Personnel/Fonction	Numbers	Annual Wages (DH/year)	Total Cost (DH/year)
Workman - Technician	1	100,000.00	100,000.00
Laboratory - Technician	1	60,000.00	60,000.00
Electrical engineer - Technician	1	60,000.00	60,000.00
Lagoons - Technician	1	60,000.00	60,000.00
Guardian - Laborer	1	40,000.00	40,000.00
Total wages			**320,000,00**

Maintenance expenses of the Equipment and the Civil Engineering

The maintenance costs are estimated at:

- 5% for the conduits
- 2% for the civil engineering
- 10% for the equipment

Operations	Total cost of investment (dh)	Annual cost of maintenance (dh/yr))
Equipment	11,964,000	1,196,400
Conduits	5,500,500	275,025
Civil Engineering	20,334,709	406,694

A financial analysis was carried out to establish the cost per cubic meter of treated water, which ensures a financial balance, under various scenarios of financing of the project and under the following assumptions:

- Amortization period of the civil structures is 40 years
- Amortization period of the power-lines is 20 years
- Amortization period of the equipment is 10 years
- The internal return rates are 5%, 8% and 12%
- The interest rate of financing is 3%
- The duration of loans was taken as 20 years
- The ratio Credit/Capital or Credit/Subventions is assumed to be 70% / 30%.

Calculations of cash flow under various scenarios of internal rates of return (5%, 8% and 12%) are presented in the report below.

A summary of the cost per cubic meter of treated wastewater under each scenario of financing is presented in Table 7.4.

Table 7.4: Summary of the Cost per Cubic meter of the Treated Wastewater

IRR / Year	Quantity of waste water m3	5%	8%	12%
		Cost Value DH/m3	Cost Value DH/m3	Cost Value DH/m3
2005	0.94	4.12	4.16	4.21
2006	0.95	4.12	4.16	4.21
2007	0.96	4.12	4.16	4.21
2008	0.97	4.12	4.16	4.21
2009	0.98	4.12	4.16	4.21
2010	0.99	4.12	4.16	4.21
2011	1.00	4.60	4.64	4.69
2012	1.01	4.60	4.64	4.69
2013	1.02	4.60	4.64	4.69
2014	1.03	4.60	4.64	4.69
2015	1.04	5.94	5.98	6.03
2016	1.05	5.94	5.98	6.03
2017	1.06	5.94	5.98	6.03
2018	1.07	5.94	5.98	6.03
2019	1.08	5.94	5.98	6.03
2020	1.09	5.94	5.98	6.03
2021	1.10	5.94	5.98	6.03
2022	1.11	5.94	5.98	6.03
2023	1.12	5.94	5.98	6.03
2024	1.14	5.94	5.98	6.03

7.1.1. Cost recovery analysis

Table 7.4 above gives an idea on the fees necessary to cover the costs of treatment. These fees appear high given the fact that the quantity of flow to be treated is small and that the level of treatment considered is tertiary to allow for the re-use of treated water.

However a comprehensive fee of treatment must be established within the framework of the master plan of wastewater treatment of the town of Azemmour and Sidi Ali. This fee will take into account the collection as well as the treatment of wastewater.

The determination of the fees will obviously take also into account the selected mode of management of the treatment plant.

In the event of direct management by the city, the tariff is established by taking into account all related payables and receivables. In the event of a delegated management, the fee includes:

- A fee for the operation and management of the treatment plant.
- A surtax to cover the cost of financing and construction of the treatment plant.

7.2 FINANCIAL INSTITUTIONS

The following list provides the names and addresses of financial organizations that could be interested in financing the project.

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1818 H Street, NW
Washington, DC 20433 USA
tel: (202) 473-1000
fax: (202) 477-6391
www.orldbank.org

Africain Development Bank
Rue Joseph Anoma
01 BP 1387 Abidjan 01
Côte d'Ivoire
Tel: (+225) 20.20.44.44
Fax: (+225) 20.20.49.59
www.afdb.org

Islamic Development Bank
P. Box. 5925
Jeddah 21432 Kingdom of Saudi Arabia
Telephone: (+9662) 6361400
Fax: (+9662) 6366871
Telex: 601 137 ISDB SJ
www.isdb.org

Japan International Cooperation Agency (JICA)
6th–13th floors,
Shinjuku Maynds Tower
2-1-1 Yoyogi, Shibuya-ku,
Tokyo 151-8558 Japan
Phone: +81-3-5352-5311/5312/5313/5314
www.jica.go.jp

KfW Bankengruppe
Palmengartenstrasse 5-9
60325 Frankfurt am Main
Phone: +49 69 7431-0
Fax: +49 69 7431-2944
www.kfw.de

Export-Import Bank of the United States
811 Vermont Avenue, N.W.
Washington, DC 20571
Tel: (202) 565-3946 (EXIM) or (800) 565-3946 (EXIM)
www.exim.gov

Overseas Private Investment Corporation
1100 New York Avenue, N.W.
Washington, D.C. 20527
www.opic.gov

ABU DHABI FUND FOR DEVELOPMENT
P.O. Box 814
United Arab Emirates
Telephone: [971](2)725-800
Facsimile: [971](2)728-890