The Republic of Tunisia
Office National de l'Assainissement (ONAS)

PREPARATORY SURVEY
ON
THE RURAL CITIES SEWAGE AND WATER ENVIRONMENT IMPROVEMENT PROJECT
IN
THE REPUBLIC OF TUNISIA

Final Report

(Main Report)

February 2012

Japan International Cooperation Agency (JICA)

INGEROSEC Corporation
HIDROPROJECTO, Engenharia e Gestao, S.A

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Abbreviations

AFD	Agence Française de Développement
AND	Autorité Nationale Désignée
ANGed	National Agency for Waste Management
ANME	Agence Nationale pour Maîtrise de l'énergie
ANPE	National Agency of Environmental Protection
B/D	Basic Design
CDM	Clean Deveropment Mechanism
CRC	Commission for Recognition and Conciliation
DNA	Designated National Authority
EIA	Environmental Impact Assessment / Energy Information Administration
EIB	European Investment Bank
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plans
E/N	Echange de Notes
EU	European Union
F/S	Feasibility Study
GCT	Groupe Chimique Tunisien
GDP	Gross Domestic Product
GES	Gaz à Effet de Serre
GNI	Gross National Income
GRP	Glass-fibre Reinforced Polystyrene

GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit
HDPE	High Density Polyethylene
IDB	Inter-American Deveropment Bank
IEE	Initial Environment Evaluation
IRR	Internal Rate of Return
IUCN	International Union for Conservation of Nature
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
KfW	Kreditanstalt für Wiederaufbau / Crédit pour la Reconstruction
MDCI	Ministère du Développement et de la Coopération Internationale
MDEAF	Ministère des domaines de l'état et des affaires foncières
MEDD	Ministère de l'Environnement et du Développement Durable
MDP	Mécanisme de Développement Propre
NIP	Note of Information on the Project
NT	Normes Tunisiennes
ODA	Official Development Assistance
O&M	Operation and Maintenance
ONAS	Office National de l'Assainissement
PIN	Project Idea Note
PDD	Project Design Document
PDES	Program for Economic and Social Development
RAP	Resettlement Action Plans

SMEs	Small and medium-sized enterprises
SONEDE	Société Nationale d'Exploitation et de Distribution des Eaux
STEG	Société Tunisienne de l'Electricité et du Gaz
TND	Dinar Tunisien
TORs	Terms of References
UNFCCC	United Nations Framework Convention Climate Change
UNCED	Conference of the United Nations on Environment and Development
UNDP	United Nations Development Program
UTAP	Union Tunisienne de l'Agriculture et de la Pêche
UTICA	Union Tunisienne de l'Industrie, du Commerce et de l'Artisanat
WB	The World Bank (Banque Mondiale)
WTO	World Trade Organization
WwTP	Wastewater Treatment Plant

Executive Summary

Executive Summary

1. GENERAL DESCRIPTION OF THE PROJECT

Introduction:

The Preparatory Survey (hereinafter referred to as “the Survey”) for the Japanese ODA (Official Development Assistance) loan project named “Rural Cities Sewage and Water Environment Improvement Project” (hereinafter referred to as “the Project”), aims to develop the existing sewage network in 10 governorates through rehabilitation and extension of relevant networks and of 5 waste water treatment plants (WwTPs).

The Survey was conducted by the Japan International Cooperation Agency (hereinafter referred to as “JICA”) and the Survey Team, which is composed of the Joint Venture (hereinafter referred to as “JV”) of Ingérosec Corporation (Japan), as leader, and HIDROPROJECTO, Engenharia e Gestao, S.A (Portugal), according to the request by the Government of the Republic of Tunisia and the agreed minutes between JICA and the Survey Team on December 4th 2010.

Background of the Project:

The annual average precipitations in the whole national territory being low, half of the land of Tunisia is semi-arid. At the same time, the precipitations and the annual usable surface water volume are geographically very biased, which makes recycling and the appropriate management of scarce water resources, together with the improvement of the hygiene environment, an extremely important development task. As a result of the efforts in recent years by the government of Tunisia, the penetration rate of sewage in the area administered by the Tunisian sewage public company (ONAS) has achieved 87% (as of 2006). In its "11th Socio-economic Development Plan (2007-2011)", the government of Tunisia set as preferential objectives to increase the sewage penetration rate to 91% and to offer a better sewage system service by 2011, so as to improve public hygiene and living conditions, preserve water resources and prevent environmental pollution. Furthermore, it is believed that the upgrade of the sewage and waste water treatment system, or in other words the improvement of the quality of treated water, will foster the reuse of treated sewage water in the irrigation sector, especially making the adoption of new technologies by suburban cities a central aspect of this sewage system maintenance and improvement policy. Since the execution plan enacted by ONAS places the reinforcement and improvement of the sewage sector as part of the creation of a platform for sustainable economic development and as a way for environmental protection, the present project benefits from a privileged position within the mentioned execution plan.

As the decrease in the performance and the aging of existing facilities continues in the target areas of the current project, contaminated water infiltrates the subterranean layer in some parts raising the possibility of polluting the water resources. Therefore, the necessity of reinforcement and rehabilitation of the waste and sewage water treatment system has been acknowledged, and the maintenance of wastewater treatment facilities and reinforcement of the existing ones has become an urgent task.

Under these circumstances, the Government of Tunisia has submitted the request for the yen loan named "The Rural Cities Sewage and Water Environment Improvement Project" to the Government of Japan.

Project Site:

a) Sewage treatment plant:

3 governorates (5 communes) : Tabarka, Béja, Jendouba, Medjez el Bab and Siliana

b) Sewage Pipeline and Pumping Station:

10 governorates (54 communes) : Sfax (12 towns), Bizerte (9 towns)[1], Zaghouan (3 towns), Béja (6 towns), El Kef (3 towns), Jendouba (5 towns), Kasserine (4 towns), Sidi Bouzid (1 town), Kébili (8 towns) and Siliana (3 towns)

Project Components (tentative):

This Japanese ODA loan project shall to include the following 5 major components:

Component	Summary
1. Waste-water Treatment Plants (WwTPs)	• Construction works for rehabilitation and extension of existing 5 WwTPs, (Tabarka, Béja, Jendouba, Medjez el Bab, Siliana) in 3 governorates
2. Sewage Networks	• Construction works for rehabilitation of existing sewage networks and extension of new sewage networks in 54 communes
3. Pumping Stations	• Construction works for rehabilitation of existing pumping stations and installation of new pumping stations in 54 communes
4. Consulting Services	• Detailed design • Supervision of the tender for selection of contractors • Supervision of the project execution
5. Other Technical Assistance (T/A) (if necessary)	• T/A for preparation of EIA report • T/A for preparation of Project Design Document (PDD)

1 Originally, the feasibility study of ONAS included 11 towns in the governorate of Bizerte. However, during the 2nd mission, ONAS has decided to exclude the 2 towns of Metline and Sedjnane.

2. DESIGN CRITERIA

Design of Networks:

The sewerage networks will use PVC and PVC/HDPE lined concrete pipes, according to the following table:

DN (nominal diameter)	Material
250	PVC
315	PVC
400	PVC
500	PVC
630	PVC
800	PVC/HDPE lined concrete
1,000	PVC/HDPE lined concrete
1,200	PVC/HDPE lined concrete

It is important to note that the nominal diameter corresponds to the exterior diameter for PVC and to the interior diameter for concrete pipes. The roughness coefficient K_S is 90 $m^{1/3}/s$.

The hydraulic-sanitary design of the networks was carried out according to the following criteria:

Table: Criteria for hydraulic-sanitary design of sewers

Criterion	Unit	Value
Minimum diameter	mm	250
Recommended minimum slope	m/m	0.005
Recommended maximum slope	m/m	0.150
Recommended capacity for sewers with diameter ≤ 500 mm (depth of flow / diameter)	—	h/D ≤ 0.50
Recommended capacity for sewers with diameter > 500 mm (h/D) (depth of flow / diameter)	—	h/D ≤ 0.75
Minimum speed of the flow in order to guarantee self-cleansing	m/s	0.6
Maximum speed of the flow	m/s	3.0
Average distance between man-holes	m	35
Recommended depth for establishment of sewers	m	$D_{(exterior)} + 1.2$

To estimate the cost of construction, we also estimated the number of connection boxes to be constructed, using the following criteria:

- Based on the length of the networks in urban areas:
  - in the more dense areas - 1 connection box / 10 m of sewer;
  - in the less dense areas - 1 connection box / 20 m of sewer;
- According to the number of houses visible on the drawings, considering one box per house.

All the recommendations of ONAS have been taken into consideration for design of the sewerage networks.

Design of the Pumping Stations:

The key design criteria for pumping stations are as follows:

- Minimum design flow 10 L/s (however in some cases an absolute minimum of 5 L/s was accepted)
- Screening (basket or mechanical)
- Submersible pumps
- Water hammer protection (hydro-pneumatic balloon or surge tank)
- Independent access to the wet well, valve chambers, screening room, electricity switchboard room.
- Ventilation of the wet well, access zones to the well and valve chambers
- Odor treatment of wet well and access zones to the well
- Emergency electricity generator

The proposed systems have been designed in order to minimize the pumping of raw wastewater, guaranteeing preventive and corrective measures in order to control the septicity of the wastewater.

Due to the sensitivity of the urban environment and the location planned for most of the pumping stations, it is necessary to adopt solutions that permit a highly reliable operation and which should guarantee a minimum of breakdown situations of the equipment items.

Six types of pumping stations have been taken into consideration for this study, according to the station capacity and equipment items: three capacity thresholds (up to 10 L/s; between 10 L/s and 150 L/s; and above 150 L/s); and two equipment levels (minimal solution and solution with mechanical screening, odor treatment and emergency electricity generator).

For capacities up to 10 L/s, compact pumping stations have been considered (of a prefabricated GRP type with a screening basket). According to the space available in order to implement the pumping station, two different options have been studied:

SP1A - Pumping stations with valves inside the well

SP1B - Pumping stations with valves in a valve chamber next to the well

For capacities between 10 L/s and 150 L/s, concrete pumping stations with two equipment levels have been considered:

SP2A -Vertical screening basket

SP2B-Vertical mechanical screen, odor treatment and emergency electricity generator

For capacities above 150 L/s, concrete pumping stations with two equipment levels have been considered:

SP3A-Screening basket in the channel

SP3B-Mechanical screen in the channel, odor treatment and emergency electricity generator

All the recommendations of ONAS have been taken into consideration for design of the pumping stations.

Design of Pumped Mains:

The pumped mains have been planned in HDPE, for the following diameters:

DN (nominal diameter)	Material
125	HDPE
160	HDPE
200	HDPE
250	HDPE
315	HDPE
400	HDPE
1,000	HDPE

HDPE was chosen to optimize technical, economic and public health aspects. Flexibility and security of the pumped mains were also taken into consideration. We should emphasize that the nominal diameters for the HDPE are exterior diameters.

The hydraulic design of the pumped mains respected the following criteria:

- Velocity higher than 0.65 m/s and lower than 1.5 m/s;
- Diameter of the rising main greater than 100 mm;
- Profile of the main preferably rising throughout the layout.

In complement, the pumped mains should be equipped with a set of maintenance and safety devices:

- Air-release valves (at the high points);
- Wash-out points (at the low points);
- Water hammer arrester (normally in the building of the pumping station, at the beginning of the rising main).

All the recommendations of ONAS have been taken into consideration for design of the pumped mains.

3. CRITERIA FOR ESTIMATION OF INVESTMENT COSTS

General Considerations:

The investment costs associated with the sewerage infrastructures (networks, pumped mains and pumping stations) are estimated using the following criteria:

- Economic criteria and unit costs recently used in similar studies;
- Consultations made with Tunisian companies;
- Indicators established using budgets for recent works and budgets for projects developed by the Study Team in relation to similar markets;
- Indicators and information supplied by ONAS.

Sewerage Networks:

The investment costs for the construction of a new sewerage network were determined in function of the piping material and network layout. The quantities of work for installation of the network were estimated using the following criteria:

- Width of the trench equal to Dext (exterior diameter) + 0.50 m;
- Trench with vertical walls ;
- Replacement of the road in a lane of width equal to the width of the trench plus 0.20m either side;
- Average cover over pipes equal to 1.2 m;
- Average distance between manholes = 35 m.

The material considered in the cost estimate is PVC for diameters up to 630 mm and lined with PVC/HDPE reinforced concrete for larger diameters. Construction costs of sewers were estimated using the following unit costs (which include pipes, earthworks, manholes and other associated structures), developed following consultation with ONAS and other local organizations:

The first Table presents the unit costs of purchase (material only, transport and installation excluded) while the second Table presents the unit costs of construction (all inclusive) of the linear of sewage network.

Table: Unit purchase costs of sewers pipes and manholes

Pipe	Nominal Diameter DN	Unit	Average purchase price (TND)
Gravity sewer in PVC (SN8)	250	ml	24
	315	ml	38,2
	400	ml	61,2
	500	ml	95,3
	630	ml	206,5
Gravity sewer in lined PVC / HDPE concrete	800	ml	300
	1000	ml	400
HDPE (PN10)	125	ml	10
	160	ml	16
	200	ml	25
	250	ml	40
	315	ml	63
	400	ml	102
	630	ml	259
	800	ml	452
	1000	ml	850

Manhole	Ductile cast iron cover - DN800	u	160
	Manhole in reinforced concrete, including inner and outer coatings - DN800	u	350
	Ductile cast iron cover – DN1000	u	180
	Manhole in reinforced concrete, including inner and outer coatings - DN1000	u	400
Connection box	Connection box in reinforced concrete, including inner and outer coatings	u	400

Table: Unit linear costs (TND/m) of sewers installed in trenches

Soil salinity	Pipe	Nominal Diameter DN	With removal and replacement of the road pavement		On natural terrain without pavement	
			On normal ground	On rocky ground	On normal ground	On rocky ground
Normal	Gravity sewer in PVC (SN8)	250	120	170	85	135
		315	130	180	95	145
		400	160	210	125	175
		500	205	255	165	215
		630	310	360	270	320
	Gravity sewer in lined PVC/HDPE concrete	800	450	500	410	460
		1,000	560	610	515	565
High salinity	HDPE (PN10)	600	445	495	405	455
		800	695	745	655	705
		1,000	975	1025	930	980

This study also considered a unit cost of connection boxes of 400 TND. This unit cost includes the box itself and the pipe which connects it to the sewer, including earthworks and removal and replacement of the road pavement.

Rehabilitation of Sewers

Pipes in asbestos or concrete that have more than 20 years are usually in bad structural conditions and replacement is imperative since rehabilitation is not possible.

The cost of rehabilitation of sewers was considered to be 120 % of the construction cost of a new sewer with the same characteristics, as indicated above, since the work must also include the demolition of existing structures (sewers and existing manholes) and guarantee the operation of the network during the rehabilitation.

Pumping Stations:

The costs for construction of pumping stations depends on the station capacity and the dynamic pumping heads, and are influenced by the conception method, the installations program and local constraints. The pumping stations considered in this study will be equipped with submersible pumps and will have a building for installation of various pieces of equipment e.g.: electricity switchboard, screening equipment, odor treatment, electricity generators, etc.

For capacities less than 10 L/s, the pumping station will be solely constituted by a pre-fabricated GRP wet well.

The following formulae, based on information provided by ONAS and other bodies, were used to estimate determine the initial investment costs of pumping stations:

Table: Formulae for Estimating the Investment costs of the Pumping Stations

Type	Description	Station capacity (L/s)	Total Construction Cost (TND)	Civil Engineering Cost (% Total Cost)	Cost of Equipment and Electrical Installations (%Total Cost)
SP1A	Compact with the valves inside the wells	< 10 L/s	80,000	50 %	50 %
SP1B	Compact with valve chamber	< 10 L/s	100,000	50 %	50 %
SP2A	Concrete with vertical basket screen	10 à 150 L/s	16,500 $Q^{0.65}$	40 %	60 %
SP2B	Concrete with vertical mechanical screen	10 à 150 L/s	23,500 $Q^{0.65}$	40 %	60 %
SP3A	Concrete with a basket screen in channel	> 150 L/s	16,500 $Q^{0.65}$	40 %	60 %
SP3B	Concrete with mechanical screen in a channel	> 150 L/s	23,500 $Q^{0.65}$	40 %	60 %

Note: Q = flow capacity of the pumping station (L/s);

Rehabilitation of Pumping Stations

The cost of rehabilitation of a pumping station was considered as a percentage of the construction cost of a new station, in function of the extent of rehabilitation required.

Pumped Mains:

The initial investment costs for the construction of pumped mains were estimated were determined in function of the piping material and pipe layout. The quantities of work for installation of the pumped mains were estimated using the following criteria

- Width of the trench is equal to Dext (exterior diameter) + 0.50 m;
- Trench with vertical sides;
- Replacement of the road in a lane of width equal to the width of the trench plus 0.20 m either side;
- Average cover of the pipes equal to 1.2 m;

Construction costs of pumped mains were estimated using the following unit costs (which include pipes, earthworks, air release valves, washout points and other associated structures), developed following consultation with ONAS and other local organizations:

Table: Cost (TND) per linear meters of the pumped mains installed in a trench

Pipe	Nominal Diameter DN	With stripping and re-establishment of the road		On natural terrain	
		On normal ground	On rocky ground	On normal ground	On rocky ground
Rising main in HDPE (PN10)	125	110	160	75	125
	160	120	170	85	135
	200	130	180	95	145
	250	150	200	115	165
	315	180	230	145	195
	400	230	280	195	245
	1,000	975	1025	930	980

Rehabilitation of a Rising Main

The cost of rehabilitation of a pumped main was considered to be 120 % of the construction cost of a new main with the same characteristics, as indicated above, since the work must also include the demolition of existing structures and guarantee the operation of the main during the rehabilitation.

4. CRITERIA FOR ESTIMATION OF OPERATION AND MAINTENANCE COSTS

General Considerations:

Itemized operating and maintenance costs have been established for each of the proposed sewerage infrastructures, as a percentage of the initial construction costs for the sewerage networks, rising mains and pumping stations.

For the pumping stations, electricity costs have also been considered.

Gravity Networks and Rising Mains:

The annual operating and maintenance costs were estimated as a percentage of the initial construction costs, according to the following table:

Table: Operation and maintenance costs of sewers and rising mains

	Annual operation and maintenance cost (% of initial construction cost)
Gravity sewers	3.00%
Rising mains	3.00%

Pumping Stations:

The annual operating and maintenance costs of pumping stations were estimated as a percentage of the initial construction costs in two subsets, civil engineering and equipment /electrical installations, according to the following table:

Table: Operation and maintenance costs for pumping stations

	Annual operation and maintenance costs	
	Civil engineering (% of initial construction cost)	Equipment and electrical installations (% of initial construction cost)
Pumping stations	1.50%	5.00%

Electricity consumption costs were also estimated, in function of the average annual flow to each pumping station, the dynamic head of the pumps, the efficiency of the pumps (considered to be 50 %) and the unit electricity cost.

The unit electricity cost taken into consideration is 0.125 TND/kWh.

In order to determine this cost, we calculated the cost of elevation of 1 m^3 at a height of 1 m, according to the following formula:

Cost of elevation of 1 m^3 at a height of 1 m = $(g / 3{,}600\ R)\ C_{kWh} = 5.67\times10^{-4}$ TND/m^3 m

Where:

g - Gravity (ms^{-2})
R - Efficiency of the pumps (50 %)
C_{kWh} - unit electricity cost (0.125 TND/kWh)

Project Summary for Networks and Pumping Stations:

Following Tables present a summary of the technical characteristics of the proposed interventions and a summary of the associated estimated investments.

Table: Summary of Technical Characteristics of Proposed Networks

Governorate	No. of towns	Gravity networks				Rising mains			Pumping Stations		
		Laterals	Rehabilitation	Extension	Total	Rehabilitation	Extension	Total	Rehabilitation	Extension	Total
		(un.)	(km)	(km)	(km)	(km)	(km)	(km)	(no.)	(no.)	(no.)
Béja	6	4,217	38.3	7.2	45.5	0.1	0.8	1.0	1	5	6
Bizerte	9	8,540	70.7	14.7	85.5	6.8	2.8	9.6	8	7	15
Jendouba	5	4,040	28.7	32.9	61.7	1.4	4.7	6.0	5	6	11
Kasserine	4	5,885	30.4	48.7	79.1	0.0	2.4	2.4	0	4	4
Kébili	8	10,013	9.6	121.0	130.6	0.8	27.9	28.6	2	15	17
Kef	3	2,140	20.6	5.0	25.6	0.8	0.8	1.6	4	2	6
Sfax	12	27,886	73.8	454.5	528.3	1.6	5.4	6.9	3	5	9
Sidi Bouzid	1	1,472	15.1	9.8	24.9	0.9	0.4	1.3	0	1	1
Siliana	3	1,834	20.0	3.2	23.2	0.0	0.0	0.0	0	1	1
Zaghouan	3	6,285	61.5	4.2	65.7	0.0	2.7	2.7	0	4	4
Total	**54**	**72,312**	**368.6**	**701.3**	**1,069.9**	**12.3**	**47.8**	**60.1**	**23**	**50**	**73**

Table: Summary of Investment Costs (TND)

Governorate	Rehabilitation					Extension					Total Rehabilitation + Extension
	Gravity networks	Rising mains	Pumping stations		Total	Gravity networks	Rising mains	Pumping stations		Total	
	Civil works	Civil works	Civil works	Equipment and electrical installations		Civil works	Civil works	Civil works	Equipment and electrical installations		
Béja	9,693,332	15,732	5,750	28,750	9,743,564	1,151,426	96,796	241,500	241,500	1,731,222	11,474,785
Bizerte	17,712,542	1,554,501	489,093	1,886,866	21,643,002	2,592,043	390,770	425,423	609,385	4,017,621	25,660,622
Jendouba	7,916,923	250,832	315,751	530,369	9,013,875	4,833,657	561,636	345,000	345,000	6,085,293	15,099,168
Kasserine	8,100,338	0	0	0	8,100,338	7,664,173	296,579	230,000	230,000	8,420,753	16,521,090
Kébili	2,475,852	124,200	119,584	199,307	2,918,944	20,008,785	3,287,413	817,573	938,859	25,052,629	27,971,573
Kef	4,986,161	168,360	65,194	163,957	5,383,672	855,698	83,835	115,000	115,000	1,169,533	6,553,205
Sfax	17,179,046	1,223,612	171,191	347,028	18,920,877	68,509,439	4,779,021	276,000	276,000	73,840,460	92,761,337
Sidi Bouzid	3,086,107	137,834	0	0	3,223,941	1,278,693	37,346	57,500	57,500	1,431,039	4,654,980
Siliana	4,133,692	0	0	0	4,133,692	466,157	431	46,000	46,000	558,588	4,692,280
Zaghouan	15,548,633	0	0	0	15,548,633	725,679	424,638	232,897	597,596	1,980,809	17,529,441
Total	**90,832,624**	**3,475,072**	**1,166,563**	**3,156,279**	**98,630,537**	**108,085,749**	**9,958,465**	**2,786,893**	**3,456,839**	**124,287,946**	**222,918,483**

5. PROPOSED SOLUTIONS FOR WASTEWATER TREATMENT PLANTS

Design Data:

Domestic Users

The connected population in each municipality has been established taking into consideration the results of the population censuses of 1994 and 2004 and the geometric growth rate between these two census years, assuming a connection rate to the sewerage network of 95 %. The results of this estimate are presented in the following table:

Table: Estimated connected population, by year

Municipalities	Census		Growth rate	Connected population (inhab.)				
	1994	2004		2009	2011	2020	2025	2029
Béja and Maagoula	60,361	64,367	1,00% [1]	67,650	65,560	71,701	75,359	78,419
Medjez El-Bab	18,141	20,308	1,13%	20,700	20,113	22,264	23,556	24,644
Jendouba	39,731	43,997	1,03%	55,785	54,088	59,288	62,389	64,988
Tabarka	12,599	15,634	2,18%	21,412	21,239	25,793	28,731	31,322
Siliana	21,341	24,243	1,28%	25,984	25,322	28,401	30,270	31,855

[1] Based on information from ONAS, supplied during the meeting of 25 May 2011.

Tourist Users

In the communes of Béja, El Maagoula, Medjez El-Bab, Jendouba and Siliana, the contribution of tourist users was not taken into account for the purposes of the estimate of sewage production, due to the weak capacity of the existing hotels and the low level of tourism in these communes - according to forecasts provided by the Tourism Real Estate Agency (AFT).

By contrast, it is necessary to consider significant tourism activity in the town of Tabarka. The following table provides projections of the number of beds for the town of Tabarka.

Table: Estimated connected population for different time horizons

Municipalities	Number of beds	
	2009	2029
Tabarka	5,304 [1]	9,400 [2]

[1] Tabarka WwTP's annual operating report (2009), [2] The Tourism Real Estate Agency (AFT).

Industrial Users

For the estimation of industrial effluents, this study considers the industrial users currently connected to the WwTP and also evaluates the capacity of the sewage treatment structures to accept connections from the new industrial zones planned in each town.

The industrial zones accepted in each WwTP are presented in the following table.

Table: Industrial zones for each WwTP

Municipalities	Surface (ha)	
	2011	2029
Béja	-	85
Medjez El-Bab	-	46
Jendouba	-	100
Tabarka	-	14.2
Siliana	-	16.3

The amounts listed above result from the meetings organized with ONAS and have been established in view of the document entitled «The Future Strategy of ONAS».

Specific Consumption of Drinking Water:

Domestic Users

The specific consumption of domestic users, adopted for each town, has been evaluated on the basis of data from the Société Nationale d'Exploitation et de Distribution des Eaux (SONEDE – the national water distribution company). The following table presents the specific water consumption levels for 2009.

Table: Specific consumption of drinking water in 2009

Municipalities	Specific consumption per year 2009 (L/capita/d)
Béja	110
Medjez El-Bab	120
Jendouba	110
Tabarka	110
Siliana	100

Source: SONEDE, Volume distributed, volume consumed (2008-2009)

For the projections of the levels of specific consumption of drinking water in the communes in question, a constant growth rate of 1.5 % was considered for the period 2009-2029. The consumption levels thereby obtained are presented in the following table.

Table: Estimated specific consumption of drinking water for different time horizons

Municipalities	Specific consumption of drinking water (L/capita/d)					
	2009	2011	2015	2020	2025	2029
Béja et El Maagoula	110	113	120	130	140	148
Medjez El-Bab	120	124	131	141	152	162
Jendouba	110	113	120	130	140	148
Tabarka	110	113	120	130	140	148
Siliana	100	103	109	118	127	135

Tourist Users

The consumption of drinking water considered for tourist users is 500 L/bed/day, according to information provided by ONAS during the meeting of 25 May 2011.

The consumption of drinking water for tourist users was considered to be constant during the course of the project's time horizon (i.e. 0 % growth rate).

Industrial Users

The consumption of drinking water by industrial users will not be taken into account, as a result of the production of wastewater.

The water flow considered for the industrial zones will be 40 m^3/ha/day.

<u>Discharge Rate:</u>

The discharge rate assumed for domestic-use water will be 80 %. The discharge rate assumed for tourist-use water will be 90 %.

<u>Specific Production of Polluting Flows:</u>

Domestic and Tourist Users

The following table provides an estimate of the specific production of polluting flows for domestic and tourist users, in the communes analyzed in the study. These amounts are considered to be constant during the course of the project's time horizon.

<u>Table: Specific Production of Polluting Flows</u>

Municipalities	BOD_5 (g/capita/d)	N_T (g/capita/d)	P_T (g/capita/d)
Béja et El Maagoula	60 [2]	8,0	1,5
Medjez El-Bab	60 [1]		
Jendouba	40 [2]		
Tabarka	60 [2]		
Siliana	45 [1]		

[1] Based on information from ONAS, supplied during the meeting of 25 May 2011.
[2] Based on the operating reports (2008-2010) and the results of the chemical analyses implemented by the consulting team.

Industrial Users

As agreed with ONAS, this project will be developed assuming that all the new industrial zones to be connected to the WwTP will have pre-treatment and that their discharges will respect the norm on the discharge rate to the public sewerage networks (NT 106.02, 1989).

6. SOLUTIONS FOR EACH WWTP

<u>WwTP of Béja:</u>

<Solution 1>

The treatment line of Solution 1 for the rehabilitation of the WwTP of Béja includes the following stages:

- Preliminary treatment
  - Grit retention in tank (new);
  - Screening consisting of 2 mechanical bar screens in parallel, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);
  - Flow measurement in a Venturi channel using an ultrasonic level meter (existing);
- Biological treatment
  - Oxidation of the organic matter in 5 treatment lines (4 existing and 1 new), each one with 5 aeration tanks (existing) aerated by a new air diffused system supplied by blowers equipped with variable speed (new);
  - Settling of sludge in 5 secondary rectangular plant clarifiers (4 existing and 1 new), equipped with a suction scraper bridge (existing);
  - Sludge elevation by three pumping stations (new);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
  - Excess sludge elevation towards thickeners and flow measurement using an electromagnetic flow meter (new);
- Tertiary treatment
  - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
  - Dosage of aluminium sulfate for the chemical precipitation de phosphorus and in order to increase the transmittance of the effluent, thus benefiting the disinfection stage;
  - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
  - Excess activated sludge thickening in 3 thickeners of square plant (2 existents and 1 new), equipped with a scraper bridge (existing);

  - Temporary storage of the thickened sludge in a tank upstream of the dewatering (new);
  - Dewatering of the thickened sludge in the decanter centrifuge machine with addition of polymer (new); in the event of recourse, dewatering of the thickened sludge in drying beds (existing);
  - Storage of dewatered sludge in containers (new);
  - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are returned through a pumping station to the biological treatment facility;
- Treatment of odors
  - Treatment of the contaminated air, extracted from the grit retention chambers, from the preliminary treatment building, thickeners, thickened sludge storage tank and from the dewatering building, using a bio filter (new).

<Solution 2>

The treatment line of Solution 2 for the rehabilitation of the WwTP of Béja includes the following stages:

- Preliminary treatment
  - Grit retention in tank (new);
  - Screening consisting of 2 mechanical bar screens in parallel, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);
  - Flow measurement in a Venturi channel using an ultrasonic level meter (existing);
- Primary treatment
  - Primary settling in 4 rectangular plant clarifiers, with bottom and surface scrapers bridge (new);
  - Feeding of floats into the thickeners (new);
  - Extraction of primary sludge for the thickeners (new);
- Biological treatment
  - Oxidation of the organic matter in 2 treatment lines, each one with 5 aeration tanks (existing) aerated by a new air diffused system supplied by blowers equipped with variable speed (new);
  - Settling of sludge in 4 secondary rectangular plant clarifiers, equipped with a suction scraper bridge (existing);
  - Sludge directing for two pumping stations (new);

  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
  - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (new);

- Tertiary treatment
  - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
  - Dosage of aluminium sulfate for the Chemical precipitation of phosphorus and in order to increase the transmittance of the effluent, thus benefiting the disinfection stage (existing);
  - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
  - Thickening of the primary sludge, in excess and physicochemical, in 4 thickeners of square plant, with scraper bridge (2 existing and 2 new);
  - Mesophilic anaerobic stabilization of thickened sludge (new);
  - Storage of biogas in a gasholder (new);
  - Biogas energy recovery by a motor generator with production of thermal and electrical energy (new);
  - Heating of sludge in digestion with heat produced by cogeneration (new);
  - Burning the biogas in excess and the bad quality biogas in the flare (new);
  - Dewatering of the digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
  - Storage of dewatered sludge in containers (new);
  - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are returned through a pumping station to the biological treatment facility;
- Treatment of odors
  - Treatment of the contaminated air, extracted from the grit retention chambers, the preliminary treatment building, thickeners and dewatering building using a biofilter (new).

<Solution 3>

The treatment sector of solution 3 of rehabilitation of the Béja wastewater treatment plant encompasses the following stages:

- Pre-treatment of the yeast wastewater
    - equalization of the wastewater in a tank (new) ;
    - anaerobic treatment of the wastewater in a UASB-type reactor (new) ;
    - introduction of the pre-treated effluent in the headwork (new) ;
    - combustion in the torch of the biogas produced (new) ;
- Preliminary treatment
    - grit retention in tank (new);
    - screening constituted by 2 mechanical screens in parallel with spacing between the bars of 6 mm, a conveyor belt and a towline (existing) ;
    - extraction of grit and oil in a double aerated channel, equipped with a scraper bridge (existing) ;
    - measurement of the flow of the wastewater in a Venturi channel with the aid of an ultrasonic level meter (existing) ;
- Biological treatment
    - oxidation of the organic materials in 4 lines (existing) each with 5 tanks, aerated by a new system of diffused air supplied by the compressors equipped with a speed control (existing) ;
    - sedimentation of the sludge in 4 rectangular-shaped secondary clarifiers supplied with a suction scraper bridge (existing) ;
    - conveying of the sludge via two pumping stations (new) ;
    - recirculation of the sludge towards the beginning of the aeration tanks and measurement of the flow using an electro-magnetic flow meter (new) ;
    - extraction of the excess sludge towards the thickeners and measurement of the flow using an electro-magnetic flow meter (new) ;
- Tertiary treatment
    - Biological elimination of the materialized nitrogen through recirculation of compressed nitrate after exiting from the nitrifying tank (final compartments) towards the beginning of the anoxic tank (first compartments) ; measurement of the recirculated flow using an electro-magnetic flow meter (new) ;
    - dosage of aluminium sulfate for the Chemical precipitation of phosphorus and in order to increase the transmittance of the effluent, in order to benefit the disinfection stage (existing);
    - Disinfection by ultraviolet radiation preceded upstream by a filtering operation (new) ;
- Treatment of the sludge
    - thickening of the excess and physical-chemical primary sludge, in 3

square-shaped thickeners, equipped with a scraper bridge (2 existing and 1 new) ;

  - dewatering of the thickened sludge in a centrifugal decanter with addition of polymers (new) ; in case of emergency, dewatering of the thickened sludge on drying beds (existing) ;
  - storage of the dewatered sludge in containers (new) ;
  - the supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are returned through a pumping station to the biological treatment facility;

- Treatment of odors
  - Treatment of the contaminated air, extracted from the grit retention chambers, from the preliminary treatment building, thickeners, thickened sludge storage tank and from the dewatering building using a bio filter (new).

WwTP of Medjez el Bab:

<Solution 1>

The treatment line of Solution 1 for the rehabilitation of the WwTP of Medjez el-Bab presents the following stages:

- Preliminary treatment
  - Grit retention in tank (new);
  - Water rising by 2 Archimedean screws (existing);
  - Screening consisting of 1 mechanical bar screen in parallel, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);
  - Flow measurement in a Venturi channel using an ultrasonic level meter (existing);
- Biological treatment
  - Oxidation of the organic matter in 2 treatment lines, each one with 3 aeration tanks (existing) aerated by a new air diffused system supplied by blowers equipped with variable speed (new);
  - Settling of sludge in 2 secondary rectangular plant clarifiers, equipped with a suction scraper bridge (existing);
  - Sludge directing for a pumping station (new);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);

    - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (new);

- Tertiary treatment
    - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
    - Chemical precipitation of phosphorus with aluminum sulfate dosing;
    - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
    - Excess activated sludge thickening in 1 thickener of square plant, equipped with a scraper bridge (existing);
    - Temporary storage of the thickened sludge in a tank upstream of the dewatering (new);
    - Dewatering of the thickened sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
    - Storage of dewatered sludge in containers (new);
    - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are returned through a pumping station to the biological treatment facility;
- Treatment of odors
    - Treatment of the contaminated air, extracted from the grit retention chambers, from the preliminary treatment building, thickeners, thickened sludge storage tank and from the dewatering building using a bio filter (new).

<Solution 2>

The treatment line of Solution 2 for the rehabilitation of the WwTP of Medjez el-Bab includes the following stages:

- Preliminary treatment
    - Grit retention in tank (new);
    - Water rising by 2 Archimedean screws (existing);
    - Screening consisting of 1 mechanical bar screen in parallel, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
    - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);
    - Flow measurement in a Venturi channel using an ultrasonic level meter

(existing);

- Primary treatment
  - Primary settling in 2 rectangular plant clarifiers, with bottom and surface scrapers bridge (new);
  - Extraction of floating residue towards the thickeners (new);
  - Extraction of primary sludge for the thickeners (new);
- Biological treatment
  - Oxidation of the organic matter in 2 treatment lines, each one with 3 aeration tanks (existing), aerated by a new air diffused system supplied by blowers equipped with variable speed (new);
  - Settling of sludge in 2 secondary rectangular plant clarifiers, equipped with a suction scraper bridge (existing);
  - Sludge directing for the pumping station (new);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
  - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (new);
- Tertiary treatment
  - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
  - Chemical precipitation of phosphorus with aluminum sulfate dosing;
  - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
  - Thickening of the primary sludge, excess sludge and physicochemical sludge, in 2 thickeners of square plant, with scraper bridge (1 existing and 1 new);
  - Mesophilic anaerobic stabilization of thickened sludge (new);
  - Storage of biogas in a gasholder (new);
  - Biogas energy recovery by a motor generator with production of thermal and electrical energy (new);
  - Heating of sludge in digestion with heat produced by cogeneration (new);
  - Burning the biogas in excess and the bad quality biogas in the flare (new);
  - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);

  - o Storage of dewatered sludge in containers (new);
  - o The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility (new).

- Treatment of odors
  - o Treatment of the contaminated air, extracted from the grit retention chambers, from the preliminary treatment building, thickeners and from the dewatering building using a bio filter (new).

<Solution 3>

The treatment line of Solution 3 for the rehabilitation of the WwTP of Medjez el-Bab includes the following stages:

- Preliminary treatment
  - o Grit retention in tank (new);
  - o Water rising by 2 Archimedean screws (existing);
  - o Screening consisting of 1 mechanical bar screen in parallel, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
  - o Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);
  - o Flow measurement in a Venturi channel using an ultrasonic level meter (existing);
- Primary treatment
  - o Primary settling in 2 rectangular plant clarifiers, with bottom and surface scrapers bridge (new);
  - o Feeding of floats into the thickeners (new);
  - o Extraction of primary sludge for the thickeners (new);
- Biological treatment
  - o Oxidation of the organic matter in 1 treatment line, with 3 aeration tanks (existing) aerated by a new air diffused system supplied by blowers equipped with variable speed (new);
  - o Settling of sludge in 2 secondary rectangular plant clarifiers, equipped with a suction scraper bridge (existing);
  - o Sludge directing for the pumping station (new);
  - o Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
  - o Feeding of excess sludge into the thickeners and flow measurement using an

electromagnetic flow meter (new);

- Tertiary treatment
    - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
    - Chemical precipitation of phosphorus with aluminum sulfate dosing;
    - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
    - Thickening of the primary sludge, excess sludge and physicochemical sludge, in 2 thickeners of square plant, with scraper bridge (1 existing and 1 new);
    - Mesophilic anaerobic stabilization of thickened sludge (new);
    - Storage of biogas in a gasholder (new);
    - Heating of sludge in digestion with heat produced by the boiler (new);
    - Burning the biogas in excess and the bad quality biogas in the flare (new);
    - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
    - Storage of dewatered sludge in containers (new);
    - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility;
- Odor treatment
    - Treatment of the contaminated air, extracted from the grit retention chambers, from the preliminary treatment building, thickeners and from the dewatering building using a bio filter (new).

WwTP of Tabarka:

<Solution 1>

The treatment line of Solution 1 for the rehabilitation of the WwTP of Tabarka shows the following stages:

- Preliminary treatment
    - Grit retention tank (new);
    - Screening consisting of 1 mechanical bar screen, with bars spacing of 12 mm, a conveyor hopper and a trailer (existing);

    - Manual bar screen installed in the recourse channel (existing);
    - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing).

- Biological or secondary treatment
    - Oxidation of the organic matter in 2 treatment lines, with a total volume of approximately 7,762 m^3 aerated by a new air diffused system supplied by blowers equipped with variable speed (one existing and one new);
    - Settling of sludge in 2 secondary rectangular plant clarifiers, with a total surface of 700 m^2, equipped with a suction scraper bridge (one existing and one new);
    - Conveying of the biological sludge towards two pumping stations, one pumping station for each treatment line (new);
    - Sludge directing for a pumping station (new);
    - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
    - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (new);
    - Extraction of the floating sludge towards the thickeners (new);
    - Measurement of treated effluent flow (new);
- Tertiary treatment
    - Biological removal of nitrogen in each line through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
    - Chemical precipitation of phosphorus with aluminum sulfate dosing (new);
    - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
    - Excess activated sludge thickening in 2 thickeners of square plant, equipped with a scraper bridge (existing);
    - Temporary storage of the thickened sludge in a tank upstream of the dewatering (new);
    - Dewatering of the thickened sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
    - Storage of dewatered sludge in containers (new);
    - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are returned through a pumping station to the biological treatment

facility (new).

- Treatment of odors
    - Treatment of the contaminated air, extracted from the grit retention tank, preliminary treatment building, thickeners, thickened sludge storage tank and dewatering building, by bio filter (new).

<Solution 2>

Thus, the treatment line of Solution 2 for the rehabilitation of the WwTP of Tabarka includes the following stages:

- Preliminary treatment
    - Elevation of the raw wastewater, due to the raise of the coping of the pre-treatment structures (new);
    - Grit retention tank (new);
    - Screening consisting of 1 mechanical bar screen, with bars spacing of 6 mm, a conveyor hopper and a trailer (existing);
    - Manual bar screen installed in the recourse channel (existing);
    - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing).
- Primary treatment
    - Primary settling in 1 clarifier, of rectangular plant, with bottom and surface scrapers bridge (new);
    - Feeding of floats into the thickeners (new);
    - Extraction of primary sludge for the thickeners (new);
- Biological treatment
    - Oxidation of the organic matters in the existing treatment line (by using a total volume of 2,462 m^3 at year zero and of 3,693 m^3 in the project planning year), aerated by a new air diffused system supplied by blowers equipped with variable speed (new);
    - Settling of sludge in 2 secondary rectangular plant clarifiers, equipped with a suction scraper bridge, with a total surface of 700 m^2;
    - Sludge directing for the pumping stations (new);
    - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
    - Feeding of floats into the thickeners (new);
    - Rise of excess sludge to the thickener (new);
    - Measurement of the treated water flow;

- Tertiary treatment
    - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
    - Chemical precipitation of phosphorus with aluminum sulfate dosing (new);
    - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
    - Thickening of the primary sludge, excess sludge and physicochemical sludge in 2 thickeners provided with a scraping bridge(new);
    - Mesophilic anaerobic stabilization of thickened sludge (new);
    - Storage of biogas in a gasholder (new);
    - Biogas energy recovery by a motor generator with production of thermal and electrical energy (new);
    - Heating of sludge in digestion with heat produced by cogeneration (new);
    - Burning the biogas in excess and the bad quality biogas in the flare (new);
    - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
    - Storage of dewatered sludge in containers (new);
    - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filters, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility (new).
- Treatment of odors:
    - Treatment of the contaminated air, extracted from the preliminary treatment building, thickeners and dewatering building, by bio filter (new).

<Solution 3>

The treatment line of Solution 3 for the rehabilitation of the WwTP of Tabarka includes the following stages:

- Preliminary treatment
    - Elevation of the raw wastewater, due to the raise of the coping of the pre-treatment structures (new);
    - Grit retention in tank (new);
    - Screening consisting of 1 mechanical bar screen, with bars spacing of 6 mm, a conveyor hopper and a trailer (existing);

    - Manual bar screen installed in the recourse channel (existing);
    - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing).
- Primary treatment
    - Primary settling in 1 clarifier, of rectangular plant, with bottom and surface scrapers bridge (new);
    - Feeding of floats into the thickeners (new);
    - Extraction of primary sludge for the thickeners (new);
- Biological treatment
    - Oxidation of the organic matters in the existing treatment line (by using a total volume of 2,462 m^3 at year zero and of 3,693 m^3 in the project planning year), aerated by a new air diffused system supplied by blowers equipped with variable speed (new);
    - Settling of sludge in 2 secondary rectangular plant clarifiers, equipped with a suction scraper bridge, with a total surface of 700 m^2;
    - Sludge directing for the pumping stations (new);
    - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
    - Feeding of floats into the thickeners (new);
    - Rise of excess sludge to the thickener (new);
    - Measurement of the treated water flow;
- Tertiary treatment
    - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
    - Chemical precipitation of phosphorus with aluminum sulfate dosing (new);
    - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
    - Thickening of the primary sludge, excess sludge and physicochemical sludge in 2 thickeners, of square plant, provided with a scraper bridge (new);
    - Mesophilic anaerobic stabilization of thickened sludge (new);
    - Storage of biogas in a gasholder (new);
    - Heating of sludge in digestion with heat produced by the boiler (new);
    - Burning the biogas in excess and the bad quality biogas in the flare (new);

  - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
  - Storage of dewatered sludge in containers (new);
  - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filters, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility (new);

- Treatment of odors:
  - Treatment of the contaminated air, extracted from the preliminary treatment building, thickeners and dewatering building, by bio filter (new).

WwTP of Jendouba:

<Solution 1>

The treatment line of Solution 1 for the rehabilitation of the WwTP of Jendouba shows the following stages:

- Preliminary treatment
  - Grit retention tank (new);
  - Water rise by 3 Archimedean screws (existing);
  - Manual bar screen installed in the recourse channel (existing);
  - Screening consisting of 1 mechanical bar screen in parallel, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);
  - Flow measurement in a Venturi channel using an ultrasonic level meter (existing);
- Biological or secondary treatment
  - Oxidation of the organic matter in the existing treatment lines, with a total volume of approximately 11,928 m^3 aerated by a new air diffused system supplied by blowers equipped with variable speed (existing);
  - Settling of sludge in the existing secondary rectangular plant clarifiers, equipped with a suction scraper bridge (existing);
  - Sludge directing for a pumping station (new);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
  - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (new);

  - o Extraction of supernatant sludge towards the thickeners (new) ;

- Tertiary treatment
  - o Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
  - o Chemical precipitation of phosphorus with aluminum sulfate dosing (existing);
  - o Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
  - o Excess activated sludge thickening in two thickeners, equipped with a scraper bridge (one existing and one new);
  - o Temporary storage of the thickened sludge in a tank upstream the dewatering (new);
  - o Dewatering of the thickened sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
  - o Storage of dewatered sludge in containers (new);
  - o The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are returned through a pumping station to the biological treatment facility (new).
- Treatment of odors
  - o Treatment of the contaminated air, extracted from the grit retention tank, preliminary treatment building, thickeners, thickened sludge storage tank and dewatering building, by bio filter (new).

<Solution 2>

Thus, the treatment line of Solution 2 for the rehabilitation of the WwTP of Jendouba includes the following stages:

- Preliminary treatment
  - o Grit retention tank (new);
  - o Water rise by 3 Archimedean screws (existing);
  - o Screening consisting of 1 mechanical bar screen in parallel, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
  - o Manual screen installed in the channel of recourse (existing);
  - o Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);

- Flow measurement in a Venturi channel using an ultrasonic level meter (existing).

- Primary treatment
  - Primary settling in 2 rectangular plant clarifiers, with bottom and surface scrapers bridge (new);
  - Feeding of floats into the thickeners (new);
  - Extraction of primary sludge for the thickeners (new);

- Biological treatment
  - Oxidation of the organic matter in half of the existing treatment line, totaling 5,964 m^3, aerated by a new air diffused system supplied by blowers equipped with variable speed (existing);
  - Settling of sludge in the existing secondary settling tanks, of rectangular plant, provided with a suction scraper bridge (existing);
  - Sludge directing for the pumping station (new);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
  - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (new);

- Tertiary treatment
  - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
  - Chemical precipitation of phosphorus with aluminum sulfate dosing (existing);
  - Disinfection by ultraviolet radiation served upstream by a filtration (new);

- Sludge treatment
  - Thickening of the primary sludge, excess sludge and physicochemical sludge, in 2 thickeners of square plant, with scraper bridge (1 existing and 1 new);
  - Mesophilic anaerobic stabilization of thickened sludge (new);
  - Storage of biogas in a gasholder (new);
  - Biogas energy recovery by a motor generator with production of thermal and electrical energy (new);
  - Heating of sludge in digestion with heat produced by cogeneration (new);
  - Burning the biogas in excess and the bad quality biogas in the flare (new);
  - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of recourse, dewatering of the thickened sludge in

drying beds (existing);

- Storage of dewatered sludge in containers (new);
- The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility (new).

- Treatment of odors :
  - Treatment of the contaminated air, extracted from the grit retention tank, from the preliminary treatment building, thickeners and dewatering building, by biofilter (new).

<Solution 3>

The treatment line of Solution 3 for the rehabilitation of the WwTP of Jendouba includes the following stages:

- Preliminary treatment
  - Grit retention tank (new);
  - Water rise by 3 Archimedean screws (existing);
  - Screening consisting of 1 mechanical bar screen in parallel, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
  - Manual screen installed in the channel of recourse (existing);
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);
  - Flow measurement in a Venturi channel using an ultrasonic level meter (existing);
- Primary treatment
  - Primary settling in 2 rectangular plant clarifiers, with bottom and surface scrapers bridge (new);
  - Feeding of floats into the thickeners (new);
  - Extraction of primary sludge for the thickeners (new);
- Biological treatment
  - Oxidation of the organic matter in half of the existing treatment line, totaling 5,964 m^3, aerated by a new air diffused system supplied by blowers equipped with variable speed (existing);
  - Settling of sludge in the existing secondary settling tanks, of rectangular plant, provided with a suction scraper bridge (existing);
  - Sludge directing for the pumping station (new);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement

  using an electromagnetic flow meter (new);

  - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (new);

- Tertiary treatment
  - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
  - Chemical precipitation of phosphorus with aluminum sulfate dosing (existing);
  - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
  - Thickening of the primary sludge, excess sludge and physicochemical sludge, in 2 thickeners of square plant, with scraper bridge (1 existing and 1 new);
  - Mesophilic anaerobic stabilization of thickened sludge (new);
  - Storage of biogas in a gasholder (new);
  - Heating of sludge in digestion with heat produced by the boiler (new);
  - Burning the biogas in excess and the bad quality biogas in the flare (new);
  - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
  - Storage of dewatered sludge in containers (new);
  - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility (new).
- Treatment of odors :
  - Treatment of the contaminated air, extracted from the grit retention tank, the preliminary treatment building, thickeners and dewatering building, by bio filter (new).

<u>WwTP of Siliana:</u>

<Solution 1>

The treatment line of Solution 1 for the rehabilitation of the WwTP of Siliana shows the following stages:

- Preliminary treatment
  - Grit retention tank (new);
  - Screening consisting of 1 mechanical bar screen, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
  - Manual bar screen, with bars spacing of 10 mm, installed in the recourse channel (existing);
  - Rotating sieve for micro filtering the grease from the grit and grease removal operation and from the secondary clarifier scum (existing);
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing).
  - Flow measurement in a Venturi channel using an ultrasonic level meter (existing).
- Biological or secondary treatment
  - Oxidation of the organic matter in the 2 existing treatment lines, with a volume of approximately 7,800 m^3 (existing);
  - Settling of sludge in the two secondary circular clarifiers, equipped with a scraper bridge (existing);
  - Transport of biological sludge for a pumping station (existing);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (existing);
  - Elevation of excess sludge into the thickener and flow measurement using an electromagnetic flow meter (existing);
  - Scum extraction from the secondary clarifiers via a sludge pump (installed on the rotating scraper bridge) to the rotating sieve (existing);
- Tertiary treatment
  - Nitrogen biological removal, materialized in the oxidation ditch (existing);
  - Chemical precipitation of phosphorus with aluminum sulfate dosing (existing);
  - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
  - Excess activated sludge thickening in a thickener, equipped with a scraper bridge (existing);

  - o Temporary storage of the thickened sludge in a tank upstream the dewatering (new);
  - o Dewatering of the thickened sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
  - o Storage of dewatered sludge in containers (new);
  - o The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are returned through a pumping station to the biological treatment facility (new);
- Treatment of odors
  - o Treatment of the contaminated air, extracted from the grit retention tank, preliminary treatment building, thickener, thickened sludge storage tank and dewatering building, by bio filter (new).

<Solution 2>

Thus, the treatment line of Solution 2 for the rehabilitation of the WwTP of Siliana includes the following stages:

- Preliminary treatment
  - o Grit retention tank (new);
  - o Screening consisting of 1 mechanical bar screen, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
  - o Manual bar screen, with bars spacing of 10 mm, installed in the recourse channel (existing);
  - o Rotating sieve for micro filtering the grease from the grit and grease removal operation and from the secondary clarifier scum (existing);
  - o Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing).
  - o Flow measurement in a Venturi channel using an ultrasonic level meter (existing).
- Primary treatment
  - o Primary settling in 1 clarifier, of circular plant, with bottom and surface scrapers bridge (new);
  - o Rise of floats towards the thickeners (new);
  - o Extraction of primary sludge for the thickeners (new);
- Biological or secondary treatment
  - o Oxidation of the organic matter in 1 treatment line, with a volume of approximately 1,900 m^3 (existing);

  - Settling of sludge in the two secondary circular clarifiers, equipped with bottom and surface scraper bridge (existing);
  - Sludge directing for a pumping station (existing);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (existing);
  - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (existing);
  - Scum extraction from the secondary clarifier via a sludge pump (installed on the rotating scraper bridge) to the rotating sieve (existing);
- Tertiary treatment
  - Nitrogen biological removal materialized in the aeration tank;
  - Chemical precipitation of phosphorus with aluminum sulfate dosing (existing);
  - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
  - Thickening of the primary sludge, excess sludge and physicochemical sludge in two thickeners, of circular plant, provided with a scraping bridge (one existing and one new);
  - Mesophilic anaerobic stabilization of thickened sludge (new);
  - Storage of biogas in a gasholder (new);
  - Biogas energy recovery by a motor generator with production of thermal and electrical energy (new);
  - Heating of sludge in digestion with heat produced by cogeneration (new);
  - Burning the biogas in excess and the bad quality biogas in the flare (new);
  - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
  - Storage of dewatered sludge in containers (new);
  - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility (new);
- Treatment of odors :
  - Treatment of the contaminated air, extracted from the grit retention tank, from the preliminary treatment building, thickeners and dewatering building, by bio filter (new).

<Solution 3>

The treatment line of Solution 3 for the rehabilitation of the WwTP of Siliana includes the following stages:

- Preliminary treatment
  - Grit retention in tank (new);
  - Screening consisting of 1 mechanical bar screen, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
  - Manual bar screen, with bars spacing of 10 mm, installed in the recourse channel (existing);
  - Rotating sieve for micro filtering the grease from the grit and grease removal operation and from the secondary clarifier scum (existing);
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing).
  - Flow measurement in a Venturi channel using an ultrasonic level meter (existing).
- Primary treatment
  - Primary settling in 1 clarifier, of circular plant, with bottom and surface scrapers bridge (new);
  - Rise of floats towards the thickeners (new);
  - Extraction of primary sludge for the thickeners (new);
- Biological or secondary treatment
  - Oxidation of the organic matter in 1 treatment line, with a volume of approximately 1 900 m^3 (existing);
  - Settling of sludge in the two secondary circular clarifiers, equipped with a bottom and surface scraper bridge (existing);
  - Sludge directing for a pumping station (existing);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (existing);
  - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (existing);
  - Scum extraction from the secondary clarifier via a sludge pump (installed on the rotating scraper bridge) to the rotating sieve (existing);
- Tertiary treatment
  - Nitrogen biological removal, materialized in the new aeration tank;
  - Chemical precipitation of phosphorus with aluminum sulfate dosing (existing);

    - Disinfection by ultraviolet radiation served upstream by a filtration (new);

- Sludge treatment
    - Thickening of the primary sludge, excess sludge and physicochemical sludge in two thickeners, of circular plant, provided with a scraping bridge (one existing and one new);
    - Mesophilic anaerobic stabilization of thickened sludge (new)
    - Storage of biogas in a gasholder (new);
    - Heating of sludge in digestion with heat produced by the boiler (new);
    - Burning the biogas in excess and the bad quality biogas in the flare (new);
    - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
    - Storage of dewatered sludge in containers (new);
    - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility (new).

- Treatment of odors :
    - Treatment of the contaminated air, extracted from the grit retention tank, from the preliminary treatment building, thickeners and dewatering building, by bio filter (new);

7. COST ESTIMATION

Base Cost for WwTP:

Following Table shows the base cost for WwTP (in 2011):

Table: Base Cost of each Solution (WwTP)

Béja		Solution 1	Solution 2	Solution 3
Civil Works(TND)		2,326,879	3,422,392	2,307,241
Equipment and Electrical(TND)		5,883,472	9,811,845	5,540,939
Total	**(TND)**	**8,231,851**	**13,234,237**	**7,848,180**
	(Million JPY)	**485**	**779**	**462**
Jendouba		Solution 1	Solution 2	Solution 3
Civil Works(TND)		1,918,721	2,973,907	2,943,992
Equipment and Electrical(TND)		4,685,661	8,055,684	5,795,291
Total	**(TND)**	**6,604,382**	**11,029,592**	**8,739,283**
	(Million JPY)	**389**	**650**	**514**
Medjez el Bab		Solution 1	Solution 2	Solution 3
Civil Works(TND)		1,031,921	1,634,061	1,613,223
Equipment and Electrical(TND)		3,089,487	5,457,232	4,010,507
Total	**(TND)**	**4,121,408**	**7,091,293**	**5,623,729**
	(Million JPY)	**243**	**418**	**331**
Tabarka		Solution 1	Solution 2	Solution 3
Civil Works(TND)		1,708,172	2,185,946	2,171,621
Equipment and Electrical(TND)		3,199,741	5,685,285	4,158,181
Total	**(TND)**	**4,907,913**	**7,871,231**	**6,329,802**
	(Million JPY)	**289**	**464**	**373**
Siliana		Solution 1	Solution 2	Solution 3
Civil Works(TND)		1,058,431	1,773,057	1,760,280
Equipment and Electrical(TND)		2,105,601	4,444,947	3,086,948
Total	**(TND)**	**3,164,032**	**6,218,004**	**4,847,228**
	(Million JPY)	**186**	**366**	**286**

Source: Study Team

Base cost for each WwTP (Selected Solution):

Following Table shows the base cost for selected solution for each WwTP (in 2011):

Table: Base cost for each WwTP (Selected Solution)

Béja (Solution3)		
Civil Works(TND)		2,307,241
Equipment and Electrical(TND)		5,540,939
Total	**(TND)**	**7,848,180**
	(Million JPY)	**462**
Jendouba (Solution 1)		
Civil Works(TND)		1,918,721
Equipment and Electrical(TND)		4,685,661
Total	**(TND)**	**6,604,382**
	(Million JPY)	**389**
Medjez el Bab (Solution 1)		
Civil Works(TND)		1,031,921
Equipment and Electrical(TND)		3,089,487
Total	**(TND)**	**4,121,408**
	(Million JPY)	**243**
Tabarka (Solution 1)		
Civil Works(TND)		1,708,172
Equipment and Electrical(TND)		3,199,741
Total	**(TND)**	**4,907,913**
	(Million JPY)	**289**
Siliana (Solution 1)		
Civil Works(TND)		1,058,431
Equipment and Electrical(TND)		2,105,601
Total	**(TND)**	**3,164,032**
	(Million JPY)	**186**

Source: Study Team

Shortlist of Interventions (Networks and Pumping stations) for the Project:

Prior to the establishment of shortlist of interventions, following conditions are considered:

- Basically, the criteria and Types of intervention (A, B and C) established in the Chapter II shall be applied in order to identify the priority of each intervention;
- Three (3) sets (cases) of interventions are simulated considering the Type of operation and annual amount of past Japanese ODA financing to Tunisia;
- All interventions are grouped commune by commune and the shortlist is established at commune basis, because interventions in the same commune are associated each other and they function as an unique system;
- Several communes, which interventions on sewage network are already financed, were excluded;

- In addition to above, the interventions classified as Type C which cost exceeds 1,000 TND/capita are re-classified individually considering economic efficiency;
- In the end, the interventions of the five (5) communes in the Sfax governorate connected to the WwTP Sfax Sud (Sfax Ville, Sfax Sud, Gremda, El Ain and Tyna) are excluded from the shortlist by JICA. JICA considered the fact that Sfax Sud WwTP has already been rehabilitated in 2006 under finance by JICA and that it has problematic issues on its operation since short term after the rehabilitation. Thus JICA decided that the solution for the WwTP shall be studied prior to the financing of the interventions connected to the WwTP.

The shortlist is established by simulating following 3 cases:

a) Case 1

The case includes the communes which networks are connected to the 5 WwTP of the project (Béja, Medjez el Bab, Jendouba, Tabarka and Siliana) and the communes which consist of the Type A interventions, with serious environmental problems to be improved. Selected communes also include some Type B interventions (rehabilitation) and Type C interventions (extensions).

b) Case 2

The case includes the communes which consist of the Type B interventions (rehabilitation). Each commune will be classified according to economic efficiency with prioritization of cost per capita. Selected communes also include some Type C interventions (extensions).

c) Case 3

The case includes the communes which consist of only Type C interventions (extensions).

Table: List of subprojects for each case

Case	Type	Governorate	Commune	Commune code	A Investment cost (Type A) (TND)	B Investment cost (Type B) (TND)	C Investment cost (Type C) (TND)	A Population served (Type A) (hab)	B Population served (Type B) (hab)	C Population served (Type C) (hab)	A Cost par capita (Type A) (TND/hab)	B Cost par capita (Type B) (TND/hab)	C Cost par capita (Type C) (TND/hab)	Civil works costs (TND)	Equipment cost (TND)	Total cost (TND)	Total population served (hab)	Average cost par capita (TND)	Total length of intervention on network (m)	Number of Pumping Station (Rh)	Number of Pumping Station (Ex)	Total Number of Pumping Station (Rh +Ex)	Necessary Land Acquisition L/A (m2)	Remarks
1	STEP	Beja	Medjez el Bab	Med	0	873,148	0	0	7,450	0	0	117	0	844,398	28,750	873,148	7,450	117	3,713	1	0	1	0	
		Jendouba	Tabarka	Tab	0	1,434,428	654,896	0	6,110	821	0	235	798	2,060,575	28,750	2,089,325	6,931	301	12,718	1	0	1	0	w/o Cité Malloula, JEN-Tab-RS-Ex-2, JEN-Tab-SP-EX-1, JEN-Tab-SP-EX-2
		Beja	Beja	Bej	170,304	3,957,440	0	560	12,319	0	304	321	0	4,127,743	0	4,127,743	12,879	321	17,008	0	0	0	0	
		Jendouba	Jendouba	Jen	0	7,274,190	594,941	0	28,923	1,077	0	252	552	7,310,011	559,119	7,869,131	30,000	262	26,539	4	1	5	100	including transfer pipe
		Siliana	Siliana	Sil	0	1,139,213	0	0	2,773	0	0	411	0	1,139,213	0	1,139,213	2,773	411	5,159	0	0	0	0	
	A+B+C	Sidi Bouzid	Sidi Bouzid	Sid	1,448,692	2,336,173	870,115	8,460	24,310	2,030	171	96	429	4,597,480	57,500	4,654,980	34,800	134	26,243	0	1	1	100	
		Siliana	Krib	Kri	2,484,544	0	0	8,000	0	0	311	0	0	2,484,544	0	2,484,544	8,000	311	12,171	0	0	0	0	
		Kebili	Kebili	Keb	443,092	1,681,944	476,928	4,000	4,000	1,000	111	420	477	2,345,156	256,807	2,601,964	9,000	289	10,375	2	1	3	100	
		Bizerte	Raf Raf	Raf	1,774,199	0	0	5,000	0	0	355	0	0	1,548,754	225,445	1,774,199	5,000	355	6,750	0	2	2	800	
		Kef	Tajerouine	Taj	216,775	2,059,604	159,965	225	5,600	400	963	368	400	2,378,844	57,500	2,436,344	6,225	391	10,990	1	1	2	100	
		Zaghouan	Hammam Zriba	Ham	925,631	5,900,018	0	1	10,700	0	925,631	551	0	6,377,711	447,938	6,825,649	10,701	638	24,500	0	1	1	400	special for spa
		Beja	Nefza	Nef	225,130	28,118	84,157	260	125	215	866	225	391	291,404	46,000	337,404	600	562	1,572	0	1	1	100	w/o Cité Erriadh, Cité Saada, Cité Ezzouhour, BEJ-Nef-RS-Ex-2, BEJ-Nef-RS-Ex-3, BEJ-Nef-RS-Ex-5, BEJ-Nef-RS-Ex-6, BEJ-Nef-RS-Ex-8, BEJ-Nef-RS-Ex-9, BEJ-Nef-SP-Ex-2
		Zaghouan	Zaghouan	Zag	117,760	5,367,678	0	50	12,225	0	2,355	439	0	5,393,280	92,158	5,485,438	12,275	447	23,745	0	2	2	500	w/o Cité Hanaya, ZAG-Zag-RS-EX-2, ZAG-Zag-SP-EX-3
		Jendouba	Ghardimaou	Gha	246,977	965,200	517,041	548	1,466	458	451	658	1,129	1,671,718	57,500	1,729,218	2,472	700	8,695	0	1	1	100	
		Beja	Testour	Tes	227,861	640,734	395,871	240	1,072	462	949	598	857	1,218,466	46,000	1,264,466	1,774	713	5,320	0	1	1	100	
		Kebili	Jemna	Jem	3,345,872	0	0	4,000	0	0	836	0	0	3,291,946	53,926	3,345,872	4,000	836	22,850	0	1	1	400	
2	B+C	Kef	Kef	Kef	0	2,210,947	579,025	0	44,191	1,000	0	50	579	2,582,889	207,082	2,789,972	45,191	62	10,600	2	1	3	100	
		Kebili	Douz	Dou	0	793,908	1,082,685	0	25,000	2,000	0	32	541	1,819,093	57,500	1,876,593	27,000	70	8,274	0	1	1	100	
		Bizerte	Alia	Ali	0	450,743	0	0	3,500	0	0	129	0	450,743	0	450,743	3,500	129	1,950	0	0	0	0	
		Kasserine	Kasserine	Kas	0	7,088,039	1,756,298	0	59,760	4,900	0	119	358	8,844,337	0	8,844,337	64,660	137	39,176	0	0	0	0	including transfer pipe
		Sfax	Mahres	Mah	0	2,086,774	1,824,245	0	18,325	2,750	0	114	663	3,819,019	92,000	3,911,019	21,075	186	21,541	1	1	2	100	
		Zaghouan	El Fahs	Fah	0	4,842,535	0	0	17,700	0	0	274	0	4,842,535	0	4,842,535	17,700	274	18,450	0	0	0	0	
		Sfax	Sakiet Ezzit	Sae	0	874,506	3,338,965	0	7,795	6,024	0	112	554	4,213,471	0	4,213,471	13,819	305	27,575	0	0	0	0	
		Sfax	Chihia	Chi	0	988,625	2,577,811	0	6,529	3,963	0	151	651	3,566,436	0	3,566,436	10,491	340	23,153	0	0	0	0	
		Beja	Maagoula	Maa	0	125,051	0	0	300	0	0	417	0	67,551	57,500	125,051	300	417	30	0	1	1	100	
		Kasserine	Sbeitla	Sbe	0	1,012,299	315,215	0	2,950	1,025	0	343	308	1,327,514	0	1,327,514	3,975	334	6,725	0	0	0	0	
		Siliana	Bouarada	Bou	0	1,068,523	0	0	2,569	0	0	416	0	1,022,523	46,000	1,068,523	2,569	416	5,860	0	1	1	100	
		Sfax	Sakiet Eddaier	Sak	0	2,664,276	17,152,112	0	13,340	29,565	0	200	580	19,816,388	0	19,816,388	42,905	462	129,367	0	0	0	0	
		Beja	Teboursouk	Teb	0	3,968,560	261,476	0	5,688	300	0	698	872	4,184,036	46,000	4,230,036	5,988	706	16,032	0	1	1	100	
		Jendouba	Fernana	Fer	0	687,651	527,204	0	1,142	425	0	602	1,240	1,157,354	57,500	1,214,854	1,567	775	6,295	0	1	1	100	
3	C	Kebili	El Golaa	Gol	0	0	387,109	0	0	750	0	0	516	387,109	0	387,109	750	516	3,065	0	0	0	0	
		Sfax	Agareb	Aga	0	0	1,381,400	0	0	3,000	0	0	460	1,323,900	57,500	1,381,400	3,000	460	8,095	0	1	1	100	
		Kebili	Kebili Nord	Ken	0	0	6,814,930	0	0	14,080	0	0	484	6,564,239	250,691	6,814,930	14,080	484	39,368	0	4	4	700	
		Kebili	Kebili Sud	Kes	0	0	3,633,540	0	0	7,500	0	0	484	3,501,948	131,592	3,633,540	7,500	484	22,945	0	2	2	200	
		Jendouba	Bousselem	Bss	0	0	629,375	0	0	724	0	0	869	571,875	57,500	629,375	724	869	4,033	0	1	1	100	
		Sfax	Jebeniana	Jeb	0	0	1,785,950	0	0	2,350	0	0	760	1,785,950	0	1,785,950	2,350	760	10,000	0	0	0	0	
		Kebili	Douz Sud	Dos	0	0	2,230,196	0	0	3,000	0	0	743	2,172,696	57,500	2,230,196	3,000	743	17,319	0	1	1	100	
		Sfax	Hencha	Hen	0	0	1,938,900	0	0	2,850	0	0	680	1,938,900	0	1,938,900	2,850	680	12,000	0	0	0	0	
		Beja	Nefza	Nef	0	0	223,112	0	0	90	0	0	2,479	177,112	46,000	223,112	90	2,479	1,211	0	1	1	100	Cité Erriadh, Cité Saada, Cité Ezzouhour, BEJ-Nef-RS-Ex-2, BEJ-Nef-RS-Ex-3, BEJ-Nef-RS-Ex-9, BEJ-Nef-SP-Ex-2
		Zaghouan	Zaghouan	Zag	0	0	375,820	0	0	200	0	0	1,879	318,320	57,500	375,820	200	1,879	1,630	0	1	1	100	Cité Hanaya, ZAG-Zag-RS-EX-2, ZAG-Zag-SP-EX-3
		Jendouba	Tabarka	Tab	0	0	1,567,266	0	0	314	0	0	4,991	1,452,266	115,000	1,567,266	314	4,991	9,413	0	2	2	200	Cité Malloula, JEN-Tab-RS-Ex-2, JEN-Tab-SP-EX-1, JEN-Tab-SP-EX-2
Communes connected to the WwTP Sfax Sud	B+C	Sfax	Sfax Ville	Sfv	0	21,220,910	3,624,869	0	217,990	6,700	0	97	541	24,487,251	358,528	24,845,779	224,690	111	102,332	2	1	3	100	including transfer pipe
		Sfax	Sfax Sud	Sfs	0	4,061,923	4,992,539	0	10,915	4,655	0	372	1,073	8,996,962	57,500	9,054,462	15,570	582	50,551	0	1	1	100	
	C	Sfax	Gremda	Gre	0	0	12,570,236	0	0	20,705	0	0	607	12,570,236	0	12,570,236	20,705	607	86,272	0	0	0	0	
		Sfax	El Ain	Ain	0	0	6,538,526	0	0	10,680	0	0	612	6,538,526	0	6,538,526	10,680	612	44,890	0	0	0	0	
		Sfax	Tyna	Tyn	0	0	3,138,770	0	0	4,220	0	0	744	3,081,270	57,500	3,138,770	4,220	744	19,427	0	1	1	100	
Communes excluded from the Project (Financed by other donors)	A+B+C	Bizerte	Tinja	Tin	458,274	1,287,031	733,795	2,000	9,900	2,100	229	130	349	2,161,197	317,903	2,479,100	14,000	177	10,740	1	2	3	800	
	B+C	Bizerte	Zarzouna	Zar	0	3,006,958	0	0	21,300	0	0	141	0	2,114,097	892,861	3,006,958	21,300	141	7,890	3	0	3	0	comprenant conduite de transfert
		Bizerte	Mateur	Mat	0	924,389	0	0	15,000	0	0	62	0	661,989	262,400	924,389	15,000	62	2,800	2	0	2	0	
		Bizerte	Menzel Jamil	Jam	0	2,288,172	0	0	30,000	0	0	76	0	1,888,886	399,286	2,288,172	30,000	76	6,830	1	1	2	0	
		Bizerte	Menzel Abderahmen	Abd	0	1,464,951	0	0	18,700	0	0	78	0	1,170,252	294,699	1,464,951	18,700	78	4,410	1	0	1	0	
		Bizerte	Bizerte	Biz	0	5,919,763	1,164,375	0	34,500	2,500	0	172	466	7,026,638	57,500	7,084,138	37,000	191	29,420	0	1	1	100	>2,500 TND/Log (>500 TND/hab)
		Bizerte	Menzel Bourguiba	Men	0	5,691,293	496,680	0	28,500	400	0	200	1,242	6,141,815	46,158	6,187,973	28,900	214	24,250	0	1	1	400	>2,500 TND/Log (>500 TND/hab)
		Kef	Dahmani	Dah	0	1,283,782	43,108	0	4,515	125	0	284	345	1,312,515	14,375	1,326,890	4,640	286	5,524	1	0	1	0	
	C	Kebili	Souk Lahad	Sou	0	0	7,081,368	0	0	15,000	0	0	472	6,751,219	330,149	7,081,368	15,000	472	34,990	0	5	5	800	
		Kasserine	Thala	Tel	0	0	2,858,613	0	0	5,950	0	0	480	2,743,613	115,000	2,858,613	5,950	480	12,665	0	2	2	200	
		Kasserine	Feriana	Fei	0	0	3,490,627	0	0	4,950	0	0	705	3,375,627	115,000	3,490,627	4,950	705	22,962	0	2	2	200	
Unnecessary Interventions	D	Beja	Nefza	Nef	0	0	0	0	0	0	0	0	0	293,825	0	293,825	675	435	1,612	0	0	0	0	BEJ-Nef-RS-Ex-5, BEJ-Nef-RS-Ex-6, BEJ-Nef-RS-Ex-8
Total (ONAS F/S)					0	0	0	0	0	0	0	0	0	216,305,365	6,613,118	222,918,483	922,458	242	1,130,021	23	50	73	7,900	

<u>Base cost for Networks and Pumping Stations in each Case:</u>

Following table presents a project summary including all interventions of networks and pumping stations, such as the length of networks and the number of pumping stations in each case.

<u>Table: Base cost for Networks and Pumping Stations in each Case</u>

Case	Total Length of Network (m)	Number of Pumping Stations	Total cost for Civil works (TND)	Total cost for Equipment (TND)	Total Cost (TND)	Total Cost (M JPY)
Case 1	218, 349	22	47,081,244	1,957,394	49,038,638	2,888
Case 2	533,377	32	104,795,134	2,520,976	107,316,110	6,321
Case 3	662,456	45	124,989,448	3,294,260	128,283,708	7,556

<u>Cost Estimation for Consulting Services:</u>

General Condition for Consulting Services

Some consulting services during execution period will be required for executing both WwTPs and Networks.

For WwTPs, considering advanced facilities which will be installed into each WwTP, experienced international consultants and local consultants will be both required. Thus, in order to ensure the required performance, the consultants shall be selected through shortlist process.

General Terms of References for Consulting Services

The general terms of references for consulting services corresponding to each component is summarized as follows:

- WwTP
    - To Prepare the Detailed Design (DD), tender documents for bidding of contractors and Environmental Impact Assessments (EIA) for 5 WwTPs;
    - To supervise the execution plan prepared by contractor and construction work, and to check the performance of the WwTP;
    - To provide quality inspection after completion of construction;
    - To assist the start-up of each WwTP.
- Networks and Pumping Stations
    - To Prepare the Detailed Design (DD), tender documents for bidding of contractors.

<u>Men-Month Required for the Consulting Services:</u>

The number of Men-Month required for the consulting services of Detailed Design, preparation of Tender Documents and EIA is calculated considering a fixed number of 110 MM for the WwTP and 21 MM/Lot for the Networks basically.

WwTP

The distribution of Men-Months for experts on WWTP is as follows.

Table: Consulting services for Detail Design of WwTP

Detail Design: International Consultant		
Title	Initial Scope of Works	M/M
Project Manager (WwTP Engineer)	Planning of WwTP, Estimation, Construction Planning	3.0×5WwTP = 15
Process Engineer	Examination and design of treatment process	3.0×5WwTP = 15
Civil Engineer	Examination and design of civil works	3.0×5WwTP = 15
Equipment/ Instrumentation Expert	Examination and design of mechanical and electric equipment	3.0×5WwTP = 15

Table: Consulting services for EIA of WwTP

EIA: International Consultant		
Title	Initial Scope of Works	M/M
Environmental Considerations Specialist	Assessment of environmental impacts and preparation of EIA report	3.0×5WwTP = 15
Social Considerations Specialist	Assessment of social impacts and preparation of EIA report	2.0×5WwTP = 10

Table: Consulting services for Tender Document of WwTP

Tender Documents: International Consultant		
Title	Initial Scope of Works	M/M
Project Manager (WwTP Engineer)	Preparation of general and administrative clause for the tender	1.0×5WwTP = 5
Civil Engineer	Preparation of technical clause for civil works	2.0×5WwTP = 10
Equipment/ Instrumentation Expert	Preparation of technical clause for equipment	2.0×5WwTP = 10

Table: Consulting services of Supervision (International) of works of WwTP

Supervision: International Consultant		
Title	Initial Scope of Works	M/M
Project Manager (WwTP Engineer)	Technical supervision of general construction works	8.0
Equipment/ Instrumentation Expert	Technical supervision of installation of machineries	8.0
Electrical Engineer	Technical supervision of electric works	2.0

Table: Consulting services of Supervision (Local) of works of WwTP

Supervision: Local Consultant		
Title	Initial Scope of Works	M/M
Civil Engineer	Technical supervision of civil works	4.0
Environment and Social Considerations	Monitoring of the environmental management plan (EMP)	3.0

Networks and Pumping Station

The lots shall be divided governorate by governorate as detailed in the following table and a consultant shall be procured for each lot. The distribution of Men-Months for experts on Networks and Pumping Stations is as follows.

Table: Consulting services of Detail Design and Tender Document of Networks and Pumping Stations

Detailed Design and Tender Documents: Local Consultant		
Title	Initial Scope of Works	M/M
Project Manager (Sewage Planning)	Planning of sewage system and preparation of general and administrative clause for the tender	12.0/Lot
Civil Engineer (Sewage)	Examination , design and preparation of technical clause for pipe and civil works	6.0/Lot
Equipment/ Instrumentation Expert	Examination, design and preparation of technical clause for equipment of pumping station, etc.	2.0/Lot
Cost Estimation	Estimation of construction cost and preparation of bill of quantities	1.0/Lot

Regarding the estimation of consulting services MM for networks and pumping stations, although 21.0 MM is applied on per lot basically, total length of network shall be also considered as an indicator of variation.

The distribution of MM for each case in all the governorates is presented in the following table.

Table: Consulting services M/M for each Case (Networks and Pumping Stations)

Governorate	Consulting services M/M for each Case			ONAS responsible department
	Case 1	Case 2	Case 3	
	M/M	M/M	M/M	
BEJA	14	21	21	Projects Department (North Regional Department) Project Department (Béja Regional Department)
BIZERTE	3	3	3	Projects Department (North Regional Department) Project Department (Bizerte Regional Department)
JENDOUBA	21	21	21	Projects Department (North Regional Department) Project Department (Jendouba Regional Department)
KASSERINE / SIDI BOUZID	14	21	21	Projects Department (Central Regional Department) Project Department (Kasserine & Sidi Bouzid Regional Departments)
KEBILI	14	21	42	Projects Department (South Regional Department) Project Department (Kébili Regional Department)
KEF / SILIANA	14	21	21	Projects Department (North Regional Department) Project Department (Kef & Siliana Regional Departments)
SFAX	0	36	36	Projects Department (South Regional Department) Project Department (Sfax Regional Department)
ZAGHOUAN	21	21	21	Projects Department (North Regional Department) Project Department (Zaghouan Regional Department)
Total	**101**	**165**	**186**	

Base Cost for Consulting Services (WwTP + Network):

Cost for international and local consultants

Topographic and Geotechnical Survey cost for each case is detailed in following Tables:

Table: Consulting Services Cost (Case1)

Category	Monthly Cost (M JPY)	Total (Month)	Total Cost (M JPY)
International Consultants Staff	2.591	128	331.6
Local Consultants Staff	1.80	108	194.4
Total		**236**	**526.0**

Table: Consulting services Cost (Case 2)

Category	Monthly Cost (M JPY)	Total (Month)	Total Cost (M JPY)
International Consultants Staff	2.591	128	331.6
Local Consultants Staff	1.80	172	309.6
	Total	**300**	**641.2**

Table: Consulting services Cost (Case 3)

Category	Monthly Cost (M JPY)	Total (Month)	Total Cost (M JPY)
International Consultants Staff	2.591	128	331.6
Local Consultants Staff	1.80	193	347.4
	Total	**321**	**679.0**

Topographic and Geotechnical Survey Cost

Topographic and Geotechnical Survey cost for each case is detailed in following Tables:

Table: Topographic and Geotechnical Survey (Case1)

Category	Unit	Unit Price (TND)	Quantity	Total Cost (TND)
Topographic Survey (WwTP)[1]	Ha	650	10	6,500
Geotechnical Survey (WwTP)[2]	Unit	10,000	5	50,000
Topographic Survey (Networks)[3]	Km	300	218	65,400
Topographic Survey (New Pumping Station)[1]	Unit	500	13	6,500
Geotechnical Survey (New Pumping Station)[2]	Unit	2,000	13	26,000
			Total	**154,400**

[1] Topographic surveys used to measure the perimeter and the ground levels

[2] Geotechnical studies allowing the characterization and the bearing capacity of soils

[3] Topographic surveys used to measure the longitudinal profile and cross section of sewage pipes

Table: Topographic and Geotechnical Survey (Case2)

Category	Unit	Unit Price (TND)	Quantity	Total Cost (TND)
Topographic Survey (WwTP)	Ha	650	10	6,500
Geotechnical Survey (WwTP)	Unit	10,000	5	50,000
Topographic Survey (Networks)	Km	300	533	159,900
Topographic Survey (Pumping Station)	Unit	500	20	10,000
Geotechnical Survey (Pumping Station)	Unit	2,000	20	40,000
			Total	**266,400**

Table: Topographic and Geotechnical Survey (Case3)

Category	Unit	Unit Price (TND)	Quantity	Total Cost (TND)
Topographic Survey (WwTP)	Ha	650	10	6,500
Geotechnical Survey (WwTP)	Unit	10,000	5	50,000
Topographic Survey (Networks)	Km	300	662	198,600
Topographic Survey (Pumping Station)	Unit	500	33	16,500
Geotechnical Survey (Pumping Station)	Unit	2,000	33	66,000
			Total	**337,600**

Price Escalation:

Annual price escalation is considered to cover a rise in prices of the construction materials, equipment and labor. Annual price escalation rates are estimated both for foreign currency portion and local currency portion as summarized below:

- Foreign currency potion : 1.6 %
- Local currency potion : 0.9 %

Physical Contingency:

Under the present conditions for the planning of the projects, there exist many unknown factors. For example, the route of Networks, which occupy the biggest portion of the construction cost, will be determined precisely by topographic survey and engineering consideration in the Detail Design and therefore length of Networks as well as construction cost of Networks will change to a certain extent. Prospective beneficiary population will determine locations and number of service points through the sensitization program. Therefore, 5.0 % for the physical contingency is provided for estimating the project cost.

Non-eligible Portion for Japanese ODA Loan

Land Acquisition and Compensation cost:

The cost for land acquisition and compensation may not be considered for WwTP. On the other hand, for new pumping stations, the cost of land acquisition and compensation shall be considered.

Land Acquisition and Compensation Cost is estimated, on a tentative base cost of $1m^2$=100 TND, as shown in following Table:

Table: Land Acquisition and Compensation Cost

	Area (m^2)	Total Cost (TND)	Total Cost (M JPY)
Case 1	2,800	280,000	16.5
Case 2	3,500	350,000	20.6
Case 3	5,100	510,000	30.0

Administration Expenses by Executing Agency:

Administration expenses for the executing agency; ONAS, required for the Project implementation is estimated at 3.0 % of the base cost.

Tax and Duties:

To all the goods and labor costs in project except imported equipment, 18 % of VAT (Value Added Tax) is applied. In case of imported equipment, 12 % of import tax is charged before 18 %VAT.

8. TOTAL INVESTMENT COST

The cost estimated is shown in following Table:

Table: Investment Cost (Case1)

	Cost		
	F/C (TND)	L/C (TND)	Total (M JPY)
A. Eligible potion Construction Cost			
Civil Works	0.0	55,105,730.0	3,245.7
Equipment	20,578,823.0	0.0	1,212.1
Price Escalation	2,338,327.0	3,286,422.7	331.3
subtotal	**22,917,150.0**	**58,392,152.7**	**4,789.1**
Physical Contingency	**1,145,857.5**	**2,919,607.6**	**239.5**
Consulting Services			
Personnel Cost	5,630,696.1	3,300,509.3	526.0
Topo&Geo	0.0	154,400.0	9.1
Price Escalation	310,551.1	124,255.7	25.6
Physical Contingency	297,062.4	178,958.3	28.0
subtotal	**6,238,309.5**	**3,758,123.3**	**588.8**
Subtotal A	**30,301,317.1**	**65,069,883.7**	**5,617.4**
B. Non-Eligible potion			
Land Acquisition	0.0	280,000.0	16.5
Administration Cost	909,039.5	1,952,096.5	168.5
Subtotal B	**909,039.5**	**2,232,096.5**	**185.0**
Total before Tax (A+B)	31,210,356.6	67,301,980.2	5,802.4
Tax and Duty	6,292,007.9	12,114,356.4	1,084.1
Interest during construction	1,702,420.6	3,423,058.9	301.9
Total	**39,204,785.1**	**82,839,395.5**	**7,188.4**

Table: Investment Cost (Case2)

	Cost		
	F/C (TND)	L/C (TND)	Total (M JPY)
A. Eligible potion Construction Cost			
Civil Works	0.0	112,819,620.0	6,645.0
Equipment	21,142,405.0	0.0	1,245.3
Price Escalation	2,399,758.4	6,752,909.8	539.1
subtotal	**23,542,163.4**	**119,572,529.8**	**8,429.5**
Physical Contingency	**1,177,108.2**	**5,978,626.5**	**421.5**
Consulting Services			
Personnel Cost	5,630,696.1	5,256,366.7	641.2
Topo&Geo	0.0	266,400.0	15.7
Price Escalation	310,551.1	193,339.2	29.7
Physical Contingency	297,062.4	285,805.3	34.3
subtotal	**6,238,309.5**	**6,001,911.2**	**720.9**
Subtotal A	**30,957,581.1**	**131,553,067.4**	**9,571.9**
B. Non-Eligible potion			
Land Acquisition	0.0	350,000.0	20.6
Administration Cost	928,727.4	3,946,592.0	287.2
Subtotal B	**928,727.4**	**4,296,592.0**	**307.8**
Total before Tax (A+B)	31,886,308.5	135,849,659.5	9,879.6
Tax and Duty	6,428,279.8	24,452,938.7	1,818.9
Interest during construction	1,734,952.0	6,828,614.1	504.4
Total	**40,049,540.3**	**167,131,212.3**	**12,202.9**

Table: Investment Cost (Case3)

	Cost		
	F/C (TND)	L/C (TND)	Total (M JPY)
A. Eligible potion Construction Cost			
Civil Works	0.0	133,013,934.0	7,834.5
Equipment	21,915,689.0	0.0	1,290.8
Price Escalation	2,484,047.7	7,965,847.0	615.5
subtotal	**24,399,736.7**	**140,979,781.0**	**9,740.9**
Physical Contingency	**1,219,986.8**	**7,048,989.1**	**487.0**
Consulting Services I			
Personnel Cost	5,630,696.1	5,898,132.4	679.0
Topo&Geo	0.0	337,600.0	19.9
Price Escalation	310,551.1	218,502.9	31.2
Physical Contingency	297,062.4	322,711.8	36.5
subtotal	**6,238,309.5**	**6,776,947.1**	**766.6**
Subtotal A	**31,858,033.0**	**154,805,717.1**	**10,994.5**
B. Non-Eligible potion			
Land Acquisition	0.0	510,000.0	30.0
Administration Cost	955,741.0	4,644,171.5	329.8
Subtotal B	**955,741.0**	**5,154,171.5**	**359.9**
Total before Tax (A+B)	32,813,774.0	159,959,888.6	11,354.4
Tax and Duty	6,615,256.8	28,792,780.0	2,085.5
Interest during construction	1,779,587.9	8,016,925.7	577.0
Total	**41,208,618.7**	**196,769,594.3**	**14,016.9**

9. ECONOMIC ANALYSIS

FIRR at Base Scenario:

FIRR is as per following Table.

This figure is based on the treatment price at 0.7 TND/m^3, but in future, if this price is discussed among relevant bodies and a different price may be decided, this FIRR may change accordingly.

Table: FIRR at base scenario in each case

Project	Case 1	Case 2	Case 3
Treatment capacity (m^3/day)	54,102	85,391	89,574
Sales capacity (m^3/day)	49,774	78,560	82,408
Total capital requirement (million TND)	164.0	256.4	289.4
JICA Cost (million TND)	**89.0**	**152.4**	**175.1**
GoT Cost (million TND)	60.9	81.7	88.6
Revenue (million TND/year)	12.7	20.1	21.1
Profit (*) (million TND/year)	0.2	1.5	0.6
FIRR before Tax (%)	1.59	2.36	1.88
Benefit population （person）	326,074	586,814	621,672

Source: Study Team, (*1) incl. Depreciation, (*2) Profit before TAX

EIRR:

In this section, from viewpoints of social development and infrastructure improvement, economic by this F/S Project to Tunisia is reviewed and studied. Following items are assumed to be benefit and expenditure in this study.

- Expenditure
  - Total investment cost
  - Operation and Maintenance cost for the facility
- Benefit
  - Activation of agriculture industries by reusing of treated water
  - Reduction of medical expenditure and social cost of diarrhea by improving sanitary conditions

Total benefit is summarized in the following Table:

Table: Total benefit by the project

Unit: Million TND

Items	Case 1	Case 2	Case 3
Revenue by WwTP operation	12.7	20.1	21.1
Benefit from Agriculture	0.2	0.2	0.2
Decrease of medical expenditure	0.5	0.9	1.0
Decrease of Children mortality cost	3.2	5.8	5.9
Total	16.6	27.0	28.2

Considering above benefits, total economic impact and EIRR in base scenario, with 20 years project life for each case is calculated as following Table:

Table: EIRR

	Case 1	Case 2	Case 3
Revenue (million TND)	16.6	27.0	28.2
EIRR (%)	5.7	6.8	6.2

Source: Study Team

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Quantitative impact:

Quantitative impacts by the project are summarized in following table:

Table: Quantitative Impact

a) WwTP

Indicator	WwTP	Design Capacity (Existing WwTP)	Actual (2011)	Completion Year (2020)	Project Target Year (2029)
Number of beneficiaries served by the Project (hab)	Béja	–	65,560	71,990	78,419
	Medjez el Bab	–	20,113	22,379	24,644
	Tabarka	–	21,239	26,281	31,322
	Jendouba	–	50,088	57,538	64,988
	Siliana	–	25,322	28,589	31,855
BOD5 processing of the 5 WwTP (kg/ day)	Béja	7,800	6,484	7,550	8,615
	Medjez el Bab	2,000	1,368	1,872	2,376
	Tabarka	1,825	1,664	2,168	2,671
	Jendouba	3,400	2,251	3,226	4,200

	Siliana	2,450	1,233	1,464	1,694
Average daily flow of 5 WwTP for wastewater treatment (m^3/ day)	Béja	14,000	6,244	9,619	12,994
	Medjez el Bab	4,500	2,391	3,910	5,429
	Tabarka	5,500	4,491	6,501	8,510
	Jendouba	8,000	5,123	8,413	11,703
	Siliana	4,530	2,321	3,203	4,084
BOD5 concentration of the 5 WwTP on discharge water (mg/l)	Béja	30	20-31 (*1)	≦30 (NT 106.002)	
	Medjez el Bab	30	25 (*1)		
	Tabarka	30	21-25 (*1)		
	Jendouba	30	22-24 (*1)		
	Siliana	30	27-56 (*1)		

(*1) ONAS: Annual Report (2008-2010)

b) Network (3 Cases)

Indicator	Case	Actual (2011)	Completion Year (2020)	Project Target Year (2029)
Length of new networks (Extension) (km)	Case 1	—	71.1	
	Case 2	—	287.1	
	Case 3	—	416.1	
Number of beneficiaries of networks (hab)	Case 1	119,082	136,981	154,880
	Case 2	327,631	371,626	415,620
	Case 3	327,631	389,055	450,478

c) Network (Each commune)

Governorate	Commune	Length of new networks (Extension) (km)	Number of beneficiaries (hab)		
		Completion Year (2020)/ Project target Year (2029)	Actual (2011)	Completion Year (2020)	Project target Year (2029)
Béja	Medjez el Bab	0.7	7,450	7,450	7,450
	Béja	1.0	12,319	12,599	12,879
	Nefza	4.3	385	538	690
	Testour	0.7	1,312	1,543	1,774
	Maagoula	0.0	300	300	300
	Teboursouk	1.3	5,448	5,718	5,988
Bizerte	Raf Raf	0.3	0	2,500	5,000

	Alia	0.0	3,500	3,500	3,500
Jendouba	Tabarka	18.8	6,110	6,678	7,245
	Jendouba	5.1	28,923	29,462	30,000
	Ghardimaou	4.6	2,014	2,243	2,472
	Fernana	5.0	1,142	1,355	1,567
	Boussalem	4.0	0	362	724
Kasserine	Kasserine	13.2	59,760	62,210	64,660
	Sbeitla	2.3	2,950	3,463	3,975
Kébili	Kébili	2.5	8,000	8,500	9,000
	Jemna	22.9	500	2,250	4,000
	Douz	5.8	25,000	26,000	27,000
	El Golaa	3.1	0	375	750
	Kébili Nord	39.4	0	7,040	14,080
	Kébili Sud	22.9	0	3,750	7,500
	Douz Sud	17.3	0	1,500	3,000
Kef	Tajerouine	2.0	5,825	6,025	6,225
	Kef	3.6	44,191	44,691	45,191
Sfax	Mahres	18.7	18,325	19,700	21,075
	Sakiet Ezzit	122.8	7,795	10,807	13,819
	Chihia	19.2	6,529	8,510	10,491
	Sakiet Eddaier	24.1	13,340	28,123	42,905
	Agareb	8.1	0	1,500	3,000
	Jebeniana	10.0	0	1,175	2,350
	Hencha	12.0	0	1,425	2,850
Sidi Bouzid	Sidi Bouzid	10.3	32,770	33,785	34,800
Siliana	Siliana	0.0	2,773	2,773	2,773
	Krib	3.2	0	4,000	8,000
	Bou Arada	0.0	2,569	2,569	2,569
Zaghouan	Hammam Zriba	2.3	10,701	10,701	10,701
	El Fahs	0.0	17,700	17,700	17,700
	Zaghouan	4.6	0	6,238	12,475
Total		**416.1**	**327,631**	**389,055**	**450,478**

Assessments of financial feasibility:

Based on the previous analysis, following conclusions could be assessed.

Project Profitability

From general view point of investment study, this FIRR is very low. This comes from public project which is difficult to charge its cost to users.

But based on the above study, Case 2 shows the highest financial result, with a total capital requirement of 234.1 million TND, and achieves an FIRR of 2.36 % at a base tariff of 0.7 TND/m3; if current tariff of 0.5 TND/m3 is applied; FIRR is less than zero, in which FIRR is not calculated. Further DSCR (Debt Service Coverage Ratio) for the 1st year of repayments and years afterward shows more than one (1), which is theoretically healthy cash flow.

Sewage Tariff

The sales price is assumed to be increased. In this study, all cases show healthy financial economics when the base scenario is applied, but if people cannot accept this base scenario tariff, the idea of a subsidy is recommended to be applied by the GoT.

Economic Efficiency

EIRR of the project is estimated to be 5.7 % in the Case 1, 6.8% in the Case 2, and 6.2 % in the Case 3, which are not high, but it might be conducted that the investment will be positive from the viewpoint of development of the project.

10. IMPLEMENTATION SCHEDULE

Progress rate of construction:

Progress rate of construction will be each year from 2015 to 2020 shown in following Table:

Table: Progress rate of construction

Case	2015	2016	2017	2018	2019	2020
1	7%	17%	24%	24%	21%	7%
2	8%	18%	22%	23%	21%	8%
3	8%	19%	22%	22%	21%	8%

Implementation Schedule for WwTP:

The facilities will be implemented according to the implementation Schedule shown in the Figure -1. The first task would be selected the International Consultants. Next task would be selected the Contractor on 2016 at lot by lot in total 4lots. WwTP construction will be built from 2016 to 2019. While the civil and electrical works are carried out, the mechanical and electrical equipment would be procured and installed. The construction works would be completed and WwTP would begin operation by 2020.

Implementation Schedule for Pumping station and Networks:

The facilities will be implemented according to the implementation Schedule shown in the Figure -2 Local Contractor selections will be held each year from 2014 to 2017 in total three times.

NO	Task	Start	End
1	JICA Procedure, E/N, L/A of ODA Loan,etc	2012/01/01	2012/09/30
2	Loan period	2012/10/01	2021/12/31
3	Preparation of shortlist	2012/07/01	2012/09/30
4	Tender for shortlisted consultants	2012/10/01	2013/03/31
4-1	Evaluation and selection of consultants	2013/04/01	2013/09/30
4-2	Approval of Contract (Japan and Tunisia)	2013/10/01	2013/12/31
5	Detail design, EIA, Preparation of Tender Document	2014/01/01	2014/12/31
6	Construction Supervision	2016/04/01	2019/12/31

Figure: Project Implementation Schedule for consulting services

NO	Task	Start	End
1	JICA Procedure, E/N, L/A of ODA Loan,etc	2012/01/01	2012/09/30
2	Loan period	2012/10/01	2021/12/31
3	Tender for contractors Lot 1 - Lot 4 (ICB)	2015/01/01	2016/12/31
3-1	Evaluation and selection of contractors by ONAS	2015/07/01	2017/06/30
3-2	Approval of Contract	2016/01/01	2017/09/30
4	Construction period: Lot 1 (Beja)	2016/10/01	2018/06/30
4-1	Topo and geotechnic survey	2016/04/01	2016/09/30
4-2	Civil works	2016/10/01	2017/09/30
4-3	Equipement and electric works	2017/07/01	2018/03/31
5	Construction period: Lot 2 (Medjez el Bab)	2017/04/01	2018/12/31
5-1	Topo and geotechnic survey	2016/10/01	2017/03/31
5-2	Civil works	2017/04/01	2018/03/31
5-3	Equipement and electric works	2018/01/01	2018/09/30
6	Construction period: Lot 3 (Tabarka,Jendouba)	2017/10/01	2019/06/30
6-1	Topo and Geotechnic Survey	2017/04/01	2017/09/30
6-2	Civil works	2017/10/01	2018/09/30
6-3	Equipement and electric works	2018/07/01	2019/03/31
7	Construction period: Lot 4 (Siliana)	2018/04/01	2019/12/31
7-1	Topo and geotechnic survey	2017/10/01	2018/03/31
7-2	Civil works	2018/04/01	2019/03/31
7-3	Equipement and electric works	2019/01/01	2019/09/30
8	Guarantee period	2018/07/01	2021/12/31

Figure: Project Implementation Schedule for WwTP

NO	Task	Start	End
1	JICA Procedure, E/N, L/A of ODA Loan, etc	2012/1/1	2012/9/30
2	Loan Period	2012/10/1	2021/12/31
3	Tender for Consultants (LCB)	2012/7/1	2013/12/31
3-1	Tender evaluetion and approval of contract	2012/10/1	2014/3/31
4	Detail design, Preparation of Tender Document	2013/7/1	2016/6/30
5	Land acquisition and compensation for new pumping stations	2013/10/1	2016/8/31
6	1st Tender for Contractors (LCB)	2014/4/1	2015/3/31
6-1	Tender evaluetion and approval of contract	2014/10/1	2015/3/31
6-2	Topo and geotechnic survey	2015/4/1	2015/9/30
6-3	Civil works	2015/10/1	2017/6/30
6-4	Equipement and electric works	2017/10/1	2018/6/30
7	2nd Tender for Contractors (LCB)	2015/4/1	2016/3/31
7-1	Tender evaluetion and approval of contract	2015/10/1	2016/3/31
7-2	Topo and geotechnic survey	2015/4/1	2016/9/30
7-3	Civil works	2016/10/1	2018/6/30
7-4	Equipement and electric works	2018/1/1	2019/6/30
8	3rd Tender for Contractors (LCB)	2016/4/1	2017/3/31
8-1	Tender evaluetion and approval of contract	2016/10/1	2017/3/31
8-2	Topo and geotechnic survey	2017/4/1	2017/9/30
8-3	Civil works	2017/10/1	2019/6/30
8-4	Equipement and electric works	2019/1/1	2020/6/30
9	Tender for material supplyers	2014/4/1	2017/3/31
9-1	Tender evaluetion and approval of contract	2014/10/1	2017/6/30
10	Construction period	2015/4/1	2020/9/30
11	Guarantee period	2020/10/1	2021/12/31

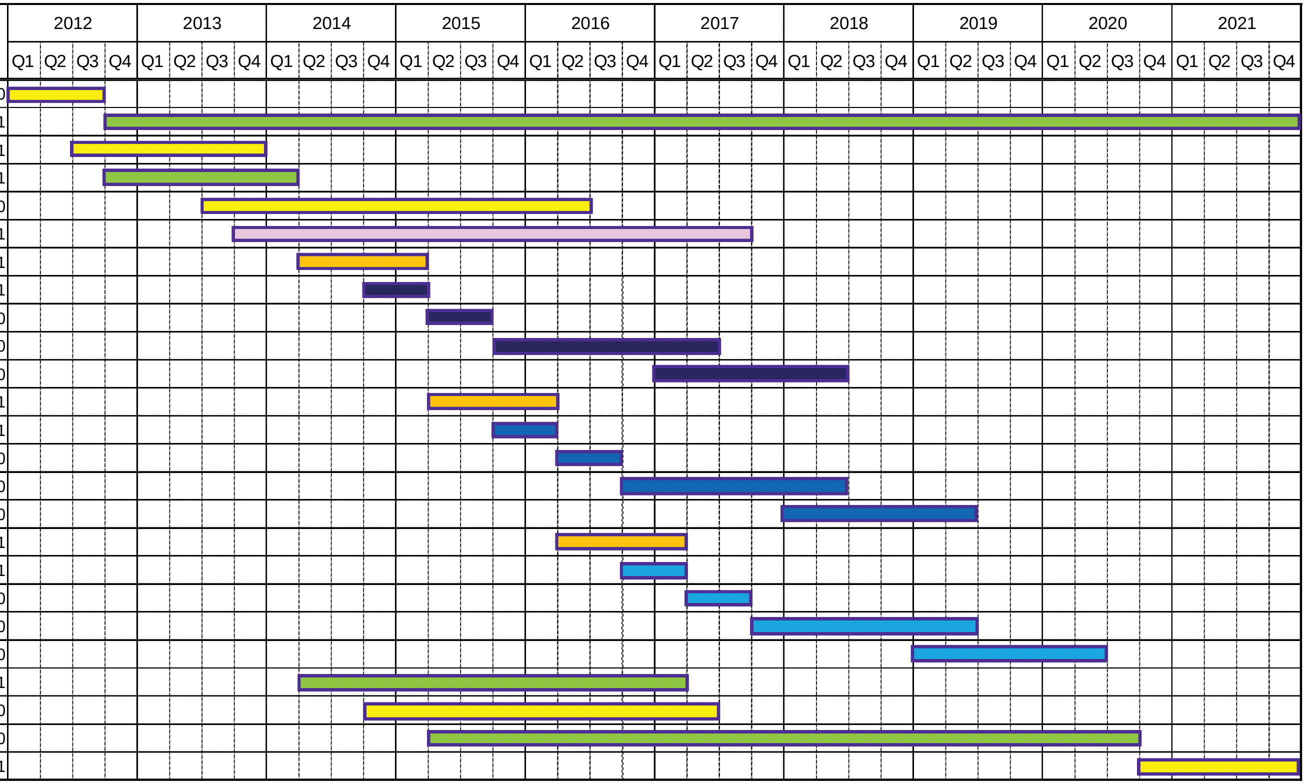

Figure: Project Implementation Schedule for Pumping station and Networks

11 RECOMMENDATIONS FOR ENSURING PROJECT SUSTAINABILITY

Short Term:

Sludge Management

In 5 WwTPs of the project, sludge has been stocked at drying bed and temporary dump inside the WwTP without any protection against pollution since several years.

To ensure the project sustainability, it is an urgent matter that ONAS find a controlled dumping station and it seems to be a serious risk and will be a bottleneck for the approval of EIA report by ANPE.

ONAS has already tackled this issue by taking various approaches, such as pilot projects for reutilization of sludge for agriculture, creation of ONAS's own dumping station, etc., especially in the greater Tunis areas.

It should be stressed that ONAS shall develop necessary institutional and legal arrangement concerning sludge management in national level and enhance them to regional level as soon as possible.

Mid Term:

Operation and Maintenance for WwTP

The WwTP of the Project shall be operated adequate manner in compliance with Tunisian standards. Main equipment, such as inlet pumps, scrapers used in primary sedimentation tanks and thickeners, scrapers used in secondary sedimentation tanks and thickeners and mechanical dewatering devices, shall be maintained periodically by checking its performance through monitoring the quality of treated water, odor, sludge, etc.

Operation and Maintenance for Sewage Networks

Sewage Networks are important to the community to improve living conditions by removing sewage from dwellings and commercial premises. Sewage shall be treated and discharged into public water areas in compliance with Tunisian standard.

The task for operation and maintenance of sewage networks include the following items:

- Inspection : Inlet chambers and manholes are visually checked. Detailed inspection of the inside of manholes and connection pipes is undertaken;
- Cleaning : Networks and Manholes are cleaned using high-pressure jet cleaners, mud suction vehicles and water tankers. Deposits in Networks are collected at manhole locations and are sucked up by mud suction vehicles and disposed;
- Repair : The Packer method is used (cement milk injection) is applied to decayed parts of Networks. The number of annual repairs is estimated by the Survey Team.

Others

Considering daily operation and maintenance of WwTP and networks, some amount of following materials shall be reserved in ONAS regional direction level for daily operations and maintenances:

- Chemical products : Chemicals are required for disinfection, coagulation treatment, and dewatering and water quality analysis;
- Spare parts : Lubricant and spare parts are required for daily maintenance of the mechanical and electrical equipment;
- Inspection & cleaning : Inspection devices and cleaning equipment such as CCD cameras, vehicles for jet cleaning, vehicles for the suction of deposits, and equipment and materials may be necessary for daily maintenance of network.

Long Term:

Financial Sustainability

As described in the Chapter I, financial deficit of ONAS increased an average of 18% per year between 2005 and 2009. On the other hand, thanks to increasing state subsidies from 41 M TND in 2005 to 76 M TND in 2009, ONAS is able every year to break even. These subsidies increased by an average of 16.5% per year in the same period.

Although service cost has increased annually, the tariff has been freeze since 2003 and it caused high deficit.

The state subsidies compensate financial deficit of ONAS, however it is not obvious how much the state has disbursed for covering the deficit. ONAS's financial sustainability now highly depends on the state subsidies not only for periodic investment and rehabilitations but also daily operation and maintenance. Although, when tariff are not sufficient to recover the service cost, state subsidies should be disbursed, it is always the risk for ONAS to secure required interventions, such as maintenance, rehabilitation and replacement.

Thus, the GoT shall address the consequences of the tariff freeze for ONAS and take some actions to ensure the ONAS's financial sustainability by modifying the tariff system.

CHAPTER I

GENERAL INFORMATION ON THE PROJECT

CHAPTER I. GENERAL INFORMATION ON THE PROJECT

1.1 OUTLINE OF THE PROJECT

1.1.1 Introduction

The Preparatory Survey (hereinafter referred to as “the Survey”) for the Japanese ODA (Official Development Assistance) loan project named “Rural Cities Sewage and Water Environment Improvement Project” (hereinafter referred to as “the Project”), aims to develop the existing sewage network in 10 governorates through rehabilitation and extension of relevant networks and of 5 waste water treatment plants (WwTPs).

The Survey was conducted by the Japan International Cooperation Agency (hereinafter referred to as “JICA”) and the Survey Team, which is composed of the Joint Venture (hereinafter referred to as “JV”) of Ingérosec Corporation (Japan), as leader, and HIDROPROJECTO, Engenharia e Gestao, S.A (Portugal), according to the request by the Government of the Republic of Tunisia and the agreed minutes between JICA and the Survey Team on December 4th 2010.

This report presents the results of the Survey.

1.1.2 Background of the Survey

The annual average precipitations in the whole national territory being low, half of the land of Tunisia is semi-arid. At the same time, the precipitations and the annual usable surface water volume are geographically very biased, which makes recycling and the appropriate management of scarce water resources, together with the improvement of the hygiene environment, an extremely important development task.

As a result of the efforts in recent years by the government of Tunisia, the penetration rate of sewage in the area administered by the Tunisian sewage public company (ONAS) has achieved 87% (as of 2006). In its "11th Socio-economic Development Plan (2007-2011)", the government of Tunisia set as preferential objectives to increase the sewage penetration rate to 91% and to offer a better sewage system service by 2011, so as to improve public hygiene and living conditions, preserve water resources and prevent environmental pollution.

Furthermore, it is believed that the upgrade of the sewage and waste water treatment system, or in other words the improvement of the quality of treated water, will foster the reuse of treated sewage water in the irrigation sector, especially making the adoption of new technologies by suburban cities a central aspect of this sewage system maintenance and improvement policy.

Since the execution plan enacted by ONAS places the reinforcement and improvement of the sewage sector as part of the creation of a platform for sustainable economic development and as a way for environmental protection, the present project benefits from a privileged position within the mentioned execution plan.

As the decrease in the performance and the aging of existing facilities continues in the target areas of the current project, contaminated water infiltrates the subterranean layer in some parts raising the possibility of polluting the water resources. Therefore, the necessity of reinforcement and rehabilitation of the waste and sewage water treatment system has been acknowledged, and the maintenance of wastewater treatment facilities and reinforcement of the existing ones has become an urgent task.

Under these circumstances, the Government of Tunisia has submitted the request for the yen loan named "The Rural Cities Sewage and Water Environment Improvement Project" to the Government of Japan.

1.1.3 Objectives of the Survey

The objective of this survey is to prepare a F/S of the expansion and rehabilitation of 5 existing sewage treatment plants in the target areas [starting of operation: Tabarka (1993), Béja (1994), Jendouba (1994), Medjez el Bab (1994), Siliana (2000)], as well as to review the F/S (currently under elaboration by ONAS) concerning the expansion and rehabilitation of the existing sewage networks, check their actual condition, check for the required facilities, the operation expenses and the implementation scheme and schedule, and to foster the constitution of the Japanese ODA loan project for expansion and rehabilitation of the sewage system. At the same time, a study will be conducted to determine the potential reduction in greenhouse effect gases originating from the sewage treatment plants.

1.1.4 Outline of the Project

1.1.4.1 Project Site

a) Sewage treatment plant:

3 governorates (5 communes)	:	Tabarka, Béja, Jendouba, Medjez el Bab and Siliana

b) Sewage Pipeline and Pumping Station:

10 governorates (54 communes)	:	Sfax (12 towns), Bizerte (9 towns)[(1)], Zaghouan (3 towns), Béja (6 towns), El Kef (3 towns), Jendouba (5 towns), Kasserine (4 towns), Sidi Bouzid (1 town), Kébili (8 towns) and Siliana (3 towns)

[1] Originally, the feasibility study of ONAS included 11 towns in the governorate of Bizerte. However, during the 2nd mission, ONAS has decided to exclude the 2 towns of Metline and Sedjnane.

1.1.4.2 Scope of the Project (tentative)

This Japanese ODA loan project shall to include the following 5 major components:

Component	Summary
1. Waste-water Treatment Plants (WwTPs)	• Construction works for rehabilitation and extension of existing 5 WwTPs, (Tabarka, Béja, Jendouba, Medjez el Bab, Siliana) in 3 governorates
2. Sewage Networks	• Construction works for rehabilitation of existing sewage networks and extension of new sewage networks in 54 communes
3. Pumping Stations	• Construction works for rehabilitation of existing pumping stations and installation of new pumping stations in 54 communes
4. Consulting Services	• Detailed design • Supervision of the tender for selection of contractors • Supervision of the project execution
5. Other Technical Assistance (T/A) (if necessary)	• T/A for preparation of EIA report • T/A for preparation of Project Design Document (PDD)

1.2 CURRENT SOCIO-ECONOMIC SITUATION OF TUNISIA

1.2.1 Territorial administration of Tunisia

Tunisia is divided into 24 governorates which are subdivided into 264 delegations and 264 municipalities. The smallest administrative division is the sector or Imada, whose number amounts to 2073.

- Governorate: The governorate (*wilaya* in Arabic) is the administrative division headed by a governor, appointed by the president, who is the "custodian" of the authority of the State. Three institutions help him to perform its tasks: the local development council, the rural council and the neighborhood committee.

- Delegation: The delegation (*mutamadiyah* in Arabic) is an intermediary administrative district between the governorate and the sector (Imada). The representative of the State in each delegation is the delegate. He is appointed by the Minister of Interior and Local Development and under the supervision of the governor. The delegate operates the local administration and chairs the local development council, an advisory body. The Delegations are consistent geographically and demographically. Indeed, the delegation covers an area of limited extent which will enable the populations of cities to access easily public and private services.

- Commune: The municipality or urban commune in Tunisia is an area of several hundred hectares including urban and rural areas generally organized around a major city.

- Imada: The Imada is the smallest administrative division in Tunisia. It is similar to zone or locality. It is headed by an *omda*.

1.2.2 Demography and population

Tunisia counts as of 2009 10.4 million people, with an annual growth rate of 1.19% and an average life expectancy of 74.3 years(2). If we compare these figures with the values of 1960, namely 4.2 million, a growth rate over 2% and a life expectancy of 50 years, we see that Tunisia has undergone the demographic transition in the past 50 years.

Remarkably, during this period of time, the population has almost tripled, but the number of children per woman has gone down from 7.15 to 2.0, the lowest among the Arab countries(3).

Noteworthy is also the fact that 1.1 million Tunisians (10.5% of the country's population) are residing abroad, 55% of them in France(4).

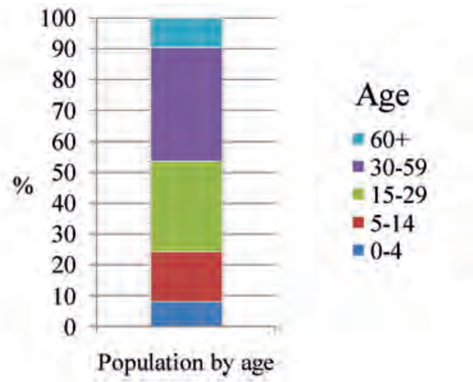

Figure 1.2-1: Age distribution of the population of Tunisia in 2008 (source: World Bank)

Even though the population today is relatively young, as shows Figure 1.2-, the demographic transition has entailed a population aging process that is developing extremely fast, when compared with the time it took in nowadays developed nations. Indeed, it took 115 years to France to see the percentage of the population in the age bracket of 65+ years go from 7% to 17%, but it will only take Tunisia 30 years to complete the same process: in 2008, the percentage of the population 65 years and above was 9%; in 2029, it will have doubled, but not so the total population, which is projected to have reached 12.4 million(3).

[2] National Institute of Statistics of Tunisia (www.ins.nat.tn)
[3] "Transition des structures par âge et vieillissement en Tunisie", A. Ben Brahim, CICRED Seminars, Paris 2004
[4] Office des Tunisiens à l'étranger (www.ote.nat.tn)

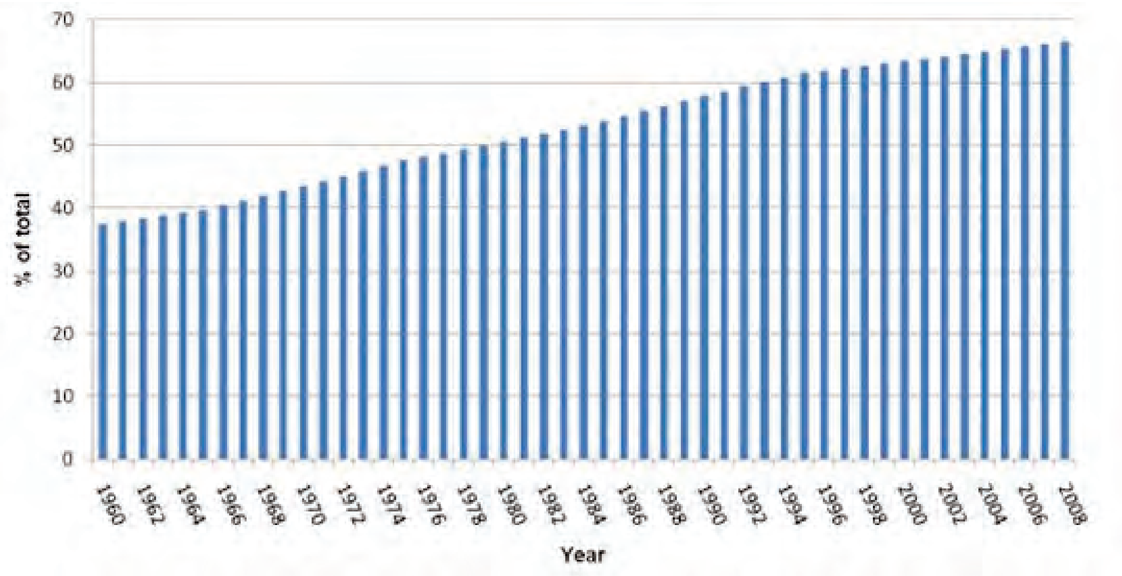

Figure 1.2-2: Evolution of urban population in Tunisia from 1960 to 2008

35% of the population is rural, but this percentage varies drastically, with 100% of the population being urban in the governorate of Tunis and only 24% in the governorate of Sidi Bouzid(2).The graph on Figure 1.2- shows that the percentage of urban population in Tunisia has increased from 37.5% in 1960 to 66.5% in 2008, with an almost steady growth that has been slowed down to around 1.7% per year since 1996(5).

The distribution of the population is uneven, with 67% of the population concentrated on the coastal region, especially the northeast coast, as show Figure 1.2-3 and Figure 1.2-4. This same coastal region concentrates 90% of industrial activities(6).

[5] World Bank

[6] "Bilan commun de pays" (Tunisie), New York, United Nations, 2001.

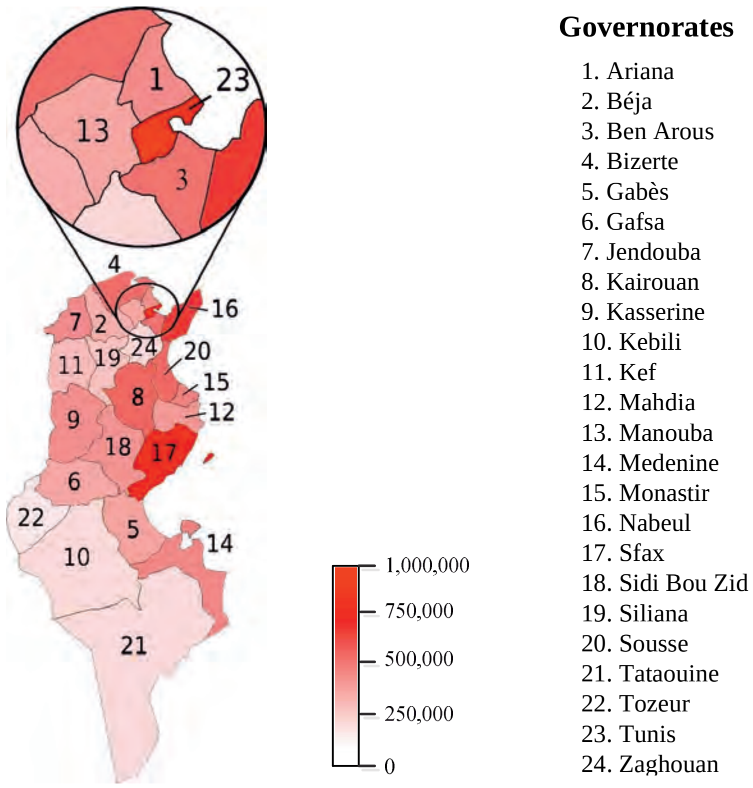

Figure 1.2-3: Population of Tunisia by governorate

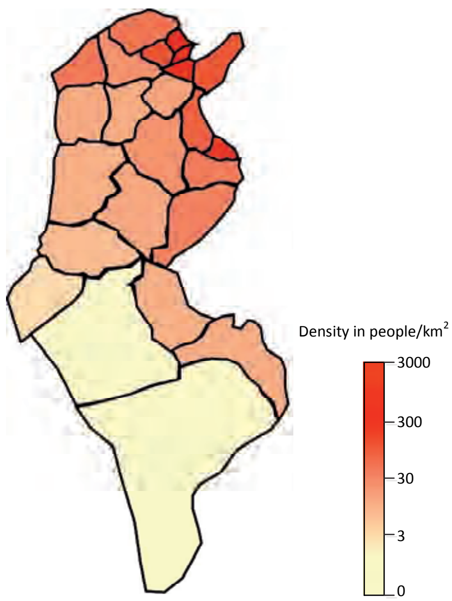

Figure 1.2-4: Population density of Tunisia

The area of Grand Tunis, comprising Tunis, Ben Arous, Manouba and Ariana, is the most populated of the country, concentrating 23% of the total population in an area representing 2% of the country's total area. Its population is still growing today, attracting people from the northwest governorates that move to Grand Tunis, especially to the governorate of Tunis, in search of a job, for access to higher education or because of marriage.

The ratio of women to men today is 1.0, despite the fact that women have a life expectancy 4 years higher than men (76.3 versus 72.4)[(2)].

1.2.3 Family structure

In Tunisia there are 2.9 million dwelling units. Each dwelling unit has an average of 1.03 household, accounting 4.33 persons. The size of the households varies depending on the governorate, with values ranging from 4.03 for Tunis to 5.32 for Tataouine. These values are for the urban population, with the values for the rural portion being slightly higher.

The dwellings are in their majority traditional Arab houses (65.9%), the remaining being modern dwelling units. It is interesting to see that the part of traditional Arab houses attained its minimum of 54.1% in 2004, and experienced an increase in popularity since then. On the contrary, the part of modern dwelling units peaked at 45.1% in 2004 and has since then decreased to 34.1%[(2)].

1.2.4 Poverty

In contrast to most African or Arab states, Tunisia has a strong middle class to which an estimated 80% of the population belongs[(7)]. This reflects the continued efforts the government has made to promote social equity and to eradicate poverty. Indeed, Tunisia has managed to drastically decrease the percentage of the population below the poverty line[(8)] during the last 40 years. In 1967, 33% of the population was poor, whereas this figure had been reduced to 3.8% by 2005 (see Figure .2-5). The objective under the Millennium Development Goals promoted by the United Nations is to further reduce this percentage to 2% by 2015.

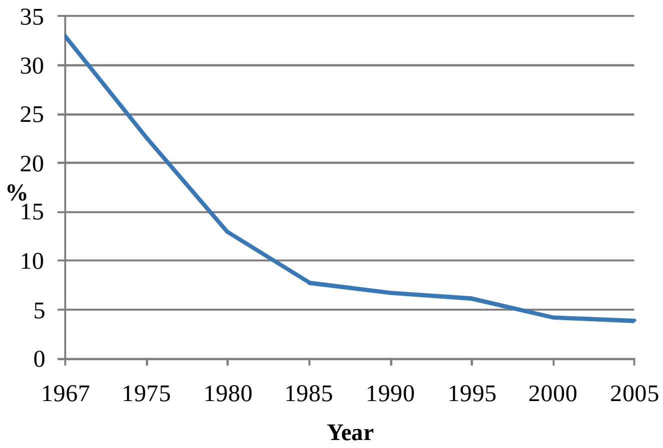

Figure 1.2-5: Evolution of the percentage of the population under the poverty line

Although the majority of the poor population, 62.3%, remained rural until 1980, this tendency started to reverse around that year, and today the proportion has been inversed: 75% of the poor population was urban in 2000[(9)].

[7] "Baisse du taux de pauvreté, hausse de la classe moyenne en Tunisie", J. Arfaoui, Magharebia, 2007

[8] The poverty line is established by the National Institute of Statistics at 400 TND per year (i.e. 0.75 USD per day)

[9] "Évolution de la pauvreté et développement durable en Tunisie", R. Bechir, M. Sghaier, S.M. Dhifallah, 2010

The unemployment rate is relatively high, being at 14.1% in 2007, with a considerable gap between sexes: women's unemployment peaked at 17.8% that year against men's unemployment, which bottomed at 12.8%[(10)].

The GNI per capita was 3,480 USD against 38,130 USD per year for Japan in 2008, the 10th highest of the African continent, and the GINI index was 0.40 in 2005.

1.2.5 Public Health

Tunisia's health system is efficient despite modest resources. The public sector provides 66% of consultations and 90% of hospitalizations, but it is less effective at regional hospitals. Communicable diseases, such as malaria, neonatal tetanus and poliomyelitis have disappeared or are in the eradication or pre-eradication phase, and maternal and child health have greatly improved, but regional disparities persist[(11)].

Tunisian government dedicates 6.5% of the total government expenditure to public health to operate 174 hospitals with capacity for 18,771 beds[(2)], but the government's financial contribution has remained almost steady while household contributions have increased.

Infant mortality rate is very low, being at 18.4 per 1,000 births, a value very close to that of developed countries. It steeply decreased from 173 deaths in 1960 to 23 deaths in 2000, and has since then slowly gone down (see Figure 1.2-6), which proves the efficiency of the efforts the Tunisian government has put in improving the health system and making it accessible to everyone.

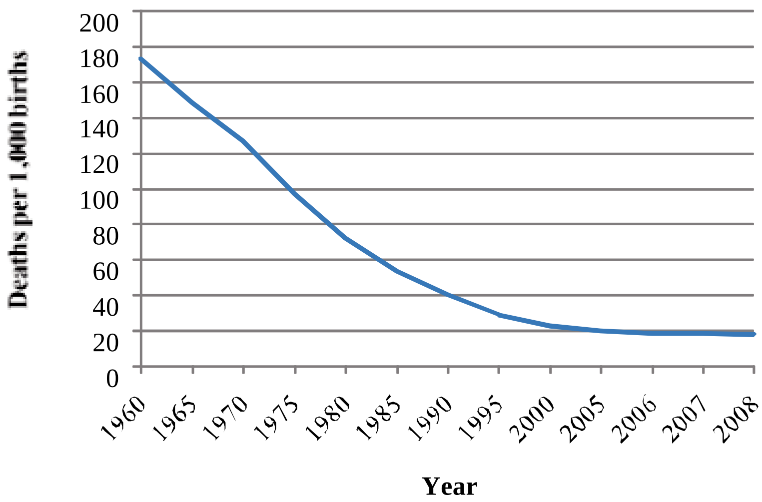

Figure 1.2-6: Infant mortality per 1,000 live births

Access to improved drinking-water sources is virtually universal in urban areas, and has increased in rural areas during the last 20 years from 20% to 84% today. On the other hand, the proportion of population using improved sewage facilities is still low in rural areas: only 64%. This may have a negative impact on health, and particularly threatens children's survival as a

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[10] "Evolution du marché de l'emploi en Tunisie", Ministère de l'Emploi et de l'Insertion Professionnelle des Jeunes, République Tunisienne, 2008

[11] "Country cooperation strategy at a glance", World Health Organization, April 2006

faecally-contaminated environment is directly linked to diarrheal disease, one of the biggest killers of infants under the age of five. A clean environment is very difficult to ensure if open defecation, resulting from the lack of sanitation equipment, is practiced even by a minority (14%) of the population.

Urban areas have achieved almost universal usage of improved sewage facilities[(12)].

1.2.6 Economy and Industry

Tunisia has enacted several laws to encourage foreign investment in order to promote economic growth, narrow existing trade imbalances and increase exports. These incentives have been available since the seventies, but some of the major recent steps taken by the Government of Tunisia in this direction are the establishment of the Investment Incentives Code, effective in 1994; the Association Agreement with the EU, signed in 1995, which lead to the entrance in a free trade area with the latter in 2008; the Agadir Agreement with Egypt, Morocco and Jordan, signed on February 2004, which commits all parties to removing all tariffs on trade between them and to harmonizing their legislation with regard to standards and customs procedures; a free trade agreement with Turkey and EFTA; and a bilateral agreement with Libya.

Tunisia's GDP was of 96.43 billion USD in 2009, which placed the country 70nd in the world. In the same year, GDP real growth was 3.7% (rank 106), and GDP per capita 9,400 USD[(13)].

10.6% of the economic activity is based on agriculture. The main agricultural products are olives, olive oil, grain, tomatoes, citrus fruit, dates, almonds, beef and dairy products[(14)], whose export represents 10% of the total exports of the country. 80% of the water withdrawals went to the agricultural sector in 2009[(15)].

34.6% of the economic activity is concentrated in the industrial sector, the main industries being oil and mining (particularly phosphate, whose deposits are the most important in the world, and iron ore).

Finally, 49.8% of the economic activity goes for the services sector, clearly dominated by tourism. See 1.2.1.7 for a detailed overview of this sector.

1.2.7 Tourism

Tourism is the first source of revenues of Tunisia and the main sector of investment. The "Travel & Tourism Industry", defined as including direct spending tourism goods and services by residents, incoming tourists, business and government travelers, as well as government expenditure on tourism infrastructure, amounted to an estimated 9.4% of the country's GDP of 2001 (the average percentage figure for North Africa is only 5.6% and for the EU only 4.8%). An

[12] "Progress on sanitation and drinking-water 2010 update", World Health Organization, 2010

[13] "Travel and Tourism in Tunisia", Macy Marvel, June 2002

[14] "The World Fact Book", CIA

[15] "Project appraisal document on a proposed loan in the amount of US$36.10 million and a proposed grant from the global environmental facility trust fund grant in the amount of US$9.73 million to the Republic of Tunisia for a second natural resources management project", World Bank, May 2010.

estimated 232,300 Tunisians (7.1% of the work force) were employed in the travel and tourism industry in 2001[(13)].

6.9 million tourists visited Tunisia in 2009, staying 5 days in average for a total of 35 million nights[(2)]. A remarkable fact is that, contrary to what one could think, the part of North African tourism is not negligible compared to European tourism: 39.4% of tourists come from Maghreb against 58.1% that come from European countries.

Tunisia has developed its hotel network since the sixties in coordination with private investment, when tourism already represented the first source of foreign exchange with 2 million USD. After expanding rapidly during the 1990s, the Tunisian tourism industry has experienced a leveling off in its growth rate, which was apparent even before the September 11th terrorist attacks%[(13)]. As a result, tourist accommodation capacity has increased from 4,000 beds in 1962 to 235,000 today, and the number of entries from 52,000 to 6.9 million a year. Despite a significant drop in visits in 2011 resulting from the concern of tourists regarding safety and political stability following the events of January, the demand for travel and tourism should meet an increase of 5,4% per annum until 2020[(16)].

Over 90% of Tunisian tourism consists of beach-orientated package tours. Consequently, most lodging capacity is located in resort areas of the east coast, which also enjoy the best occupancy rates in the country (between 50% and 60%)[(13)]. Tunisian bed space is increasing at a present rate of 3% to 4% per year, with growth concentrated in upscale accommodation. There is substantial additional capacity in the pipeline, which presents a certain "supply risk" over the coming years, as it is highly possible that demand growth will not keep up. Speaking of the latter, the WTO forecasted an annual growth rate in Tunisian arrivals for the period 1995-2020 of 3.1%.

The seasonality of Tunisian tourism is acute, with higher arrivals in the spring and summer months than in the winter (see Figure 1.2-7).

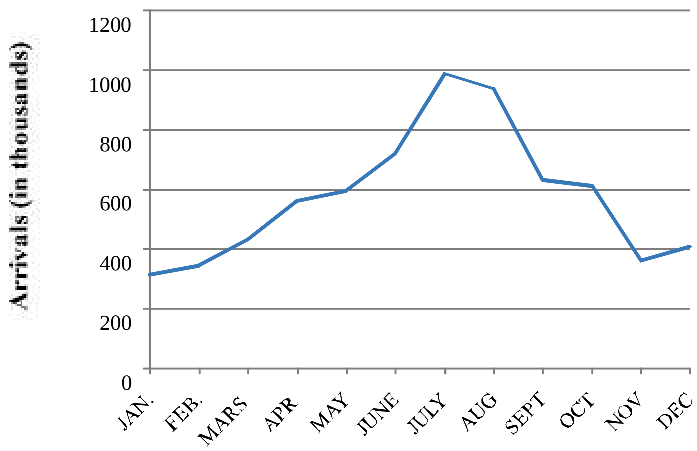


Figure 1.2-7: Evolution of the number of arrivals in Tunisia in 2009

[16] "Travel & Tourism economic impact 2010 – Tunisia", World Travel and Tourism Council, 2010

1.3 CURRENT SITUATION OF THE SEWAGE SYSTEM IN TUNISIA

1.3.1 Current Situation of the Wastewater Collecting System

1.3.1.1 Current Situation of the System of Purification and Wastewater Collection

The Office National de l’Assainissement (ONAS) was created under the terms of Law No. 37/74 dated on August 3, 1974, with the mission of ensuring the management of the sanitation sector. The law establishing ONAS was amended by Law N°93/41 dated April 19, 1993, under which ONAS, manager of the sewage network, has become the dominant player in the protection of the water environment and the fight against all sources of pollution.

ONAS is a public entity for commercial and industrial purposes provided with a legal personality and financial autonomy. It belongs to the Ministry of Agriculture and Environment (MAE).

The fields of action of ONAS are as follows:

- Sewage master plans of cities and governorates, feasibility studies, prospective studies and also implementation studies relating to sewage networks, wastewater treatment plants and pumping stations;
- Development of sanitation projects and control of projects carried out by other intervening parties such as real estate promoters, either public or private;
- Operation and maintenance of the sewage networks and sanitation infrastructures: ONAS operates fully and directly in all the areas supported by decree;
- Technical assistance: ONAS provides technical assistance and advice to the local communities and other public or private entities in the field of control of water pollution.

According to information provided by ONAS in the document “Statistics of subscribers of ONAS”, by the end of year 2009, the number of communes covered by ONAS was 160.

Table 1.3-1: Coverage of ONAS according to the size of the communes

	Communes		Communes covered by ONAS		Covering Rate	
Size of the commune	Number	Population in 2009 (thousands)	Number	Population in 2009 (thousands)	(%)	Population (%)
< 5 000	49	169	4	16	8.2	9.5
5 000 - 10 000	72	520	28	218	38.9	41.9
10 000 - 50 000	110	2,633	96	2,409	87.3	91.5
50 000 - 100 000	23	1,621	22	1,561	95.7	96.3
> 100 000	10	1,979	10	1,979	100	100
Total	**264**	**6,922**	**160**	**6,183**	**60.6**	**89.3**

This table explains the historical evolution of ONAS. During the seventies, the communes covered by ONAS included the cities of more than 50.000 inhabitants (in particular Great Tunis, Sfax, Nabeul, Sousse, Kairouan, and Bizerte). During the eighties, the population of the communes covered by ONAS varied between 10.000 and 50.000 inhabitants. Since the nineties, ONAS started covering small size communes (less than 10.000 inhabitants) while continuing the efforts in the other medium size communes.

The population covered by ONAS represents about 89% of the total urban population and almost 61% of the total population of Tunisia.

In the areas covered by ONAS (160 communes), some cities are not provided with a wastewater treatment plant (WwTP). In 2009, 16 communes were not provided with a WwTP. The volume discharged and collected by ONAS's sewage networks in these communes amounts to 5.7 million m^3. The 144 remaining communes are connected to a wastewater treatment system. The volume collected and treated amounts to 238.5 million m^3.

1.3.1.2 Connection rate

At the end of year 2009, the population connected to the public sewage network in ONAS's operation areas amounted to approximately 5.5 million inhabitants.

The rate of connection to the sewage network is 88.7% in the cities covered by ONAS and 56.9% for the whole country.

In 2009, the rate of household connection to the WwTP was 85.0% in the cities covered by ONAS and connected to the sewage network.

1.3.1.3 Water Consumption

Water consumption during the period 1975-2009 increased regularly.

In 2009, the water consumption by ONAS subscribers amounted to 256.3 million m^3. The distribution of the volume of consumed water by level of consumption is given below:

- Approximately 31% of the total volume is consumed by subscribers of the lower level [0-20] and [21-40] m^3/quarter;
- Nearly 29% of the total volume corresponds to subscribers consuming more than 150 m^3/quarter;
- The remaining part, which is approximately 40%, is consumed by subscribers of the intermediate levels [41-70] and [71-150] m^3/quarter.

For the same year, the distribution of the volume of consumed water by use is given below:

- Approximately 67% of the total water consumption corresponds to domestic users;
- Nearly 26% of the total water consumption corresponds to industrial users and others;
- Approximately 8% of the total water consumption corresponds to tourism.

As far as the evolution of water consumption is concerned, the effect of the global financial crisis in 2009, resulted in a decrease in water consumption in certain economic sectors despite the general increase in the number of subscribers, especially the tourism and industry sectors (to be precise, the industrial users of medium pollution level).

1.3.2 Tariff of Drinking Water and Wastewater

1.3.2.1 Current Situation of the Sewerage tariff

The Office National de l'Assainissement (ONAS) is authorized by Decree n° 75-492 of 26, July1975 to collect the sewerage tariffs in the areas under its responsibility, as part of the invoices of the Société Nationale d'Exploitation et de Distribution des Eaux (SONEDE).

According to information available from ONAS, the system of sewerage tariffs is based on the concept of one tariff, estimated upon the drinking water consumption, divided into a fixed and a variable tariff. In the same manner, the tariffs vary according to the type of use of the subscriber:

i) Domestic use;

ii) Tourist use;

iii) Industrial, commercial, professional use, or others, conforming to wastewater standard or not (ministerial decision of July 2010).

The last tariff modulation took place on 24, July 2010 by ordinance of Ministry of Finances and Ministry of Environment and Sustainable Development. The sewerage tariffs that are currently in force are set as specified in Table 1.3-2.

Table 1.3-2: Sewerage tariffs in Tunisia

Class / Criteria	Fixed tariff	Variable tariff
1 – Domestic use		
1.1 – User connected to the drinking water supply public network and to the sewage public network		
A – Drinking water consumption ≤ 20 m^3 per quarter	1.310 TND per quarter	0.017 TND per m^3 of consumed water
B – Drinking water consumption > 20 m^3 and ≤ 40 m^3 per quarter	1.310 TND per quarter	Consumed water ≤ 20 m^3: 0.028 TND per m^3 Consumed water > 20 m^3: 0.170 TND per m^3
C – Drinking water consumption > 40 m^3 and ≤ 70 m^3 per quarter	3.860 TND per quarter	Consumed water ≤ 20 m^3: 0.170 TND per m^3 Consumed water > 20 m^3: 0.269 TND per m^3
D – Drinking water consumption > 70 m^3 and ≤ 150 m^3 per quarter	7.600 TND per quarter	Consumed water ≤ 70 m^3: 0.269 TND per m^3 Consumed water > 70 m^3: 0.445 TND per m^3
E – Drinking water consumption > 150 m^3 per quarter	7.820 TND per quarter	Consumed water ≤ 70 m^3: 0.269 TND per m^3 Consumed water > 70 m^3: 0.545 TND per m^3

Class / Criteria	Fixed tariff	Variable tariff
1. 2 – **User connected to the drinking water supply public network and not connected to the sewage public network**		
The provisions of User 1 are applied unless the impossibility of connection to the public sewage network through a special connection is proven by ONAS services	None	None
1.3 – **User access to drinking water by means of tanks, wells that are not equipped or others, and discharging or not effluents into a public sewage network**		
Drinking water consumption	None	None
2 – **Tourist use**		
Drinking water consumption	7.880 TND per quarter	0.979 TND per m^3 of consumed water
3 – **Industrial, commercial, professional use, or others**		
3.1 – **Industrial use or other polluting activities**		
3.1.1 – User whose effluent complies with the standards for discharge into the public sewage network	7.880 TND per quarter	0.720 TND per m^3 of consumed water
3.1.2 – The user is provided with a pre-treatment facility or other means of treatment and the discharges are in compliance with the standards for discharge into the natural environment		
If the user is connected to the public sewage network	7.880 TND per quarter	0.560 TND per m^3 of consumed water
The impossibility of connection to the public sewage network through a special connection is proven by ONAS services	None	None
3.1.3 – User whose effluent does not comply with one or some elements of the standards for discharge into public sewage network, but within limits, and not detrimental to the sewerage infrastructure or affecting the quality of treated water.	7.880 TND per quarter	0.720 TND per m^3 of consumed water plus 0.355 TND per kilogram of pollution exceeding the quantity of chemical demand for oxygen (COD) set in the above-mentioned standards for discharge for each m^3 of consumed water
3.1.4 – The user is unable to discharge his effluents into the public sewage network (if this is proven by ONAS services) or he has been refused the connection to the public network due to the level of pollution of his effluents	7.880 TND per quarter	0.560 TND per m^3 of consumed water

Class / Criteria	Fixed tariff	Variable tariff
3.2 – Commercial, professional use or others		
3.2.1 – Commercial or professional user (excluding the special cases)		
A – Drinking water consumption ≤ 10 m^3 per quarter	7.880 TND per quarter	0.521 TND per m^3 of consumed water
B – Drinking water consumption > 10 m^3 per quarter	7.880 TND per quarter	0.650 TND per m^3 of consumed water
3.2.2 – Administrative user (excluding the special cases)		
Drinking water consumption	7.880 TND per quarter	0.720 TND per m^3 of consumed water
3.2.3 – Special cases		
The quality of the effluent of this category of users exceeds the discharge standards into the public sewage network	7.880 TND per quarter	0.720 TND per m^3 of consumed water plus 0.355 TND per kilogram of pollution exceeding the quantity of chemical demand for oxygen (COD) set in the above-mentioned standards for discharge for each m^3 of consumed water
The user is unable to discharge his effluents into the public sewage network as proven by ONAS services or he has been refused the connection to the public network due to the level of pollution of his effluents	7.880 TND per quarter	0.560 TND per m^3 of consumed water

Source: ONAS

For industrial users, ONAS may exceptionally and temporarily accept effluents from some industrial units that do not comply with standards for discharge into the public sewage network, after having sent a notice inviting them to propose a schedule for the installation of a pre-treatment facility or the rehabilitation of an existing one, provided that:

- The public network and the wastewater treatment plants have enough capacity to accept the flow of the effluents to be discharged;
- The quality of the effluents to be discharged causes no damage to the sewage infrastructures and does not affect the quality of treated water.

In this case, the tariff class 3.1.3 in the Table 1.3-2 will be applied.

Evolution of the sewerage tariff (constant prices 1990 = 100) since 1979 is analyzed in the document "ONAS Subscriber Statistics, 2009". The sewerage tariff grew on a regular basis until 1994. From 1995, a decrease of 8.8% was recorded, caused mainly by the decrease of water consumption. In 1996, this decline has been overtaken by a series of tariff adjustments that could boost the increase rate of sewerage tariffs. From 2005, the increase rate experienced a delay that became more important in 2008 and 2009, leading to negative rates of 1.2% and 1.4% respectively.

In spite of the increase in the number of subscribers and the volume of water consumed as well as the uneven tariff modifications operated during the period of 1979-2009, the sewerage tariff could not resist the price inflation (average estimated rate of inflation over this period of approximately 6.0%), and recorded low and even negative real growth rates, especially for the years 1984, 1986, 1988, 1995, 2008, and 2009.

For year 2009, the situation of the distribution of the revenues from the sewerage tariff per level of consumption is as follows:

- About 16% of the total revenues from the sewerage tariff comes from the subscribers of the lower levels [0-20] and [21-40] m^3/quarter;
- Nearly 49% of the total revenues from the sewerage tariff comes from the subscribers who consume more than 150 m^3/quarter;
- The remaining, nearly 35% comes from the subscribers of the intermediate levels [41-70] and [71-150] m^3/quarter.

For the same year, the situation of the distribution of the revenues from the sewerage tariff per user is as follows:

- About 39% of the revenues from the sewerage tariff come from the household subscribers;
- Nearly 43% of the revenues from the sewerage tariff come from the industrial subscribers and others;
- Approximately 18% of the revenues from the sewerage tariff come from the tourist subscribers.

According to a document from ONAS, it is important to mention that the industrial users causing a strong pollution and the tourist users showed a reduction in the revenues they generated from the sewerage tariff of 8.2% and 0.6% respectively, due to a decrease in their water consumption.

Finally, we can summarize the data as follows:

- The household users representing 88.2% of the total number of ONAS's subscribers consume 66.6% of the total volume and generate 39.2% of the total revenues from the sewerage tariff;
- The industrial users and others, representing 11.3% of the total number of subscribers, consume 25.7% of total volume and generate 42.7% of the total revenues from the sewerage tariff;
- The tourist users, representing 0.5% of the total number of subscribers, consume 7.7% of total volume and generate 18.1% of the total revenues from the sewerage tariff.

1.3.2.2 Process of revision of sewage tariff

The process of revision and fixation of the sewage tariff in Tunisia is conducted as follows.

a) Preparation of the tariff adjustment file by ONAS

First of all, ONAS prepares a tariff adjustment file based on the financial situation in order to reduce the gap between the cost of sanitation and the current average tariff and to adjust the financial balances of ONAS. This file is composed of four parts, which we will detail by taking the example of the last tariff adjustment file (still at the stage of preparation).

a-1) Overview of changes in ONAS' activities

In this part, ONAS insists on the significant changes that occurred in previous years (period 2003-2010 in our example), such as the increase of the amount of annual investment (from 97 million TND in 2003 to 147 million TND in 2010), the increase of the number of treatment plants (from 70 to 109), the increase of the capacity of wastewater treatment (from 208 million m^3 to 300 million m^3), the development of network length (from 11,000 km to 15,000 km) and evolution of the number of subscribers.

a-2) Causes of deterioration of ONAS' financial situation

In the light of this situation, ONAS explains the causes of the deterioration of its financial situation by involving particularly the freezing of rates since 2003 and the increase in operating expenses.

a-3) Projection of ONAS' financial situation

Thus, ONAS conducts a projection over 6 years of the rate of cost recovery through sewerage tariff, as presented in the following table.

	2010	2011	2012	2013	2014	2015	2016
Total resources (MTND)	206.8	226.9	242.2	256.6	272.2	289.4	309.5
Total operating expenses (MTND)	197.9	218.1	231.2	242.0	256.9	273.9	293.3
Recovery rate of expenditure by the sewerage tariff (%)	56.3	49.5	52.9	52.2	51.0	49.3	47.8

a-4) Proposals and impacts

Based on these projections, ONAS proposes some tariff adjustments such as the increase of 5% of the rate for all users (to reinforce the polluter pays principle) and the increase of connection fee (from 130 to 200 TND for social housing and from 260 to 440 TND for other users).

These adjustments intend to limit the cash deficit (26 million TND in 2012 instead of 34 million without adjustment) and to improve the recovery rate, up to 61% in 2016, as presented in Table following.

	2010	2011	2012	2013	2014	2015	2016
Total resources (MTND)	206.8	226.9	242.2	256.6	272.2	289.4	309.5
Total operating expenses (MTND)	197.9	218.1	231.2	242.0	256.9	273.9	293.3
Recovery rate of expenditure by the sewerage tariff (%)	56.3	51.3	55.5	57.4	58.9	59.8	60.9

b) Validation by the Council of Ministers

The tariff adjustment file is then transmitted to the parent ministry (Ministry of Environment) which commits to present it to the Council of Ministers composed essentially of Ministers of Finance, Regional Development and Planning, and Industry and Commerce.

c) Promulgation in the Official Journal and entry into force

Once the file is approved by the Council of Ministers, the tariff adjustment is promulgated in the Official Journal of Republic of Tunisia (JORT) by an interministerial decree signed jointly by the Minister of Environment and Minister of Finance. The new tariff becomes effective from the date of publication in the JORT. The last Tariff revision occurred on July 24, 2010 by decree of Ministry of Finance and Ministry of Environment and Sustainable Development, published in the JORT on July 27 of the same year.

The Société Nationale d'Exploitation et de Distribution des Eaux (SONEDE) applies the new rates and carries out fee collection.

1.3.2.3 Cost of Household Connections

Decree No. 79-768 dated September 8, 1979, prescribes the requirements for connection and discharge of the effluents into the public sewage network within community perimeters or other areas provided with public sanitation facilities.

Regarding the Law, the connection fees, performed by the sanitation service, shall be charged to the users. For each connection request, a quotation for the connection fees shall be established by this service.

The works will be undertaken only after the user has paid the amount indicated in the quotation above and after the public sanitation utility has obtained the authorization of the road department for crossing the roadway. The user has a deadline of three-months to settle the payment of the quotation.

The cost includes the following items:

- If the works are to be undertaken by ONAS, the expenses are calculated according to the real expenditure increased by 10% for overheads;
- The expenses associated with the repairing of the roadway established on the basis of prices charged by the concerned service.
- A contribution of the user for the construction expenses of the sewers calculated according to the applicable regulation.

From 2004, a fee is paid by the user with a tariff for social areas and a tariff for wealthy areas. Today, and according to the information provided by ONAS, the subscribers pay currently 260 TND per house paid over 8 years for the connection expenses (130 TND for the social housing).

1.3.2.4 Affordability for the poor and water tariff

1.3.2.4.1 National policy for improvement of affordability

In the various plans for the improvement of the living conditions in Tunisia, a special attention was given to sanitation. An example of this is the implementation of the “Programme national d’amélioration des conditions de vie du citoyen”, namely a presidential sanitation program established in 1989.

This program aims at the promotion and improvement of the living conditions of the inhabitants of the low income residential areas, the eradication of the sources of diseases and the preservation of the citizens’ health, as well as the protection of the environment and groundwater against the dangers of the pollution provoked by the uncontrolled discharge of wastewater into the natural environment.

The impact of the implementation of the program on the health of the poor has been deep (disease prevention, eradication of odors, sources of insects and vectors).

Beyond the positive impacts on the economy and the protection of the natural resources, the program also improves the socio-economic efficiency, the fight against poverty and the level of income.

In what concerns the sewerage tariffs in Tunisia, reference is not made to any category based on socio-economic criteria to provide the poor with low-cost services. The only distinction found was related to the connection fees, which are lower (of 50%) in the case of social housing.

1.3.2.4.2 Evaluation of affordability in Tunisia

The survey results on household expenses, conducted by the National Institute of Statistics in 2000, showed that the invoice for water consumption would represent 0.93% of total expenses per person, which is well below the normally accepted standards (3% of the income).

However, this cost is based not only on the average Tunisian salary, but also and mainly for income of modest households. As such, the calculation took the guaranteed inter-professional minimum wage (SMIG) as the reference.

$$X = W_s / Y * 100$$

X: Part of the potable water and sanitation costs in the income of modest Tunisian households.

W_s: Average potable water and sanitation costs.

Y: Average salary of modest Tunisian households.

The guaranteed inter-professional minimum wage (SMIG) and the guaranteed agricultural minimum wage (SMAG) are instituted by decree No. 73-247 of 26th May 1973. This wage includes the transport allowance of five dinars established in July 1986 by decree 86-691 (JORT No. 41 of 18th-22nd July 1986). The number of working hours per month for the 40 hours/week system is 173.333 hours and 208 hours for the 48 hours/week system.

Table 1.3-3: Average wage of modest Tunisian households

System of guaranteed monthly minimum wage	Hourly wage (TND)	Working hours per week (hours)	Average monthly wage (TND)
S.M.I.G system for 40 Hours/week	1.299	173.333	225.156

Source: National Institute of Statistics (INS)

Table 1.3-4: Average monthly sanitation costs

Average domestic consumption (m^3/subscriber/quarter)		Sanitation charge (TND/subscriber/quarter)							Proportion (TND/ subscriber / month)
		Fixed charge (TND)	Variable charge (TND)					Total	
			Charge variation		Q^{ty} (m^3)	Price (TND)	Total		
Urban area	31.7	1.310	<20m^3	0.028	20	0.560	2.549	3.859	1.286
			>20m^3	0.170	11.7	1.989			
Rural area	28.6		<20m^3	0.028	20	0.560	2.022	3.332	1.111
			>20m^3	0.170	8.6	1.462			

Source: ONAS Statistical Report (2009)

Table 1.3-5: Average monthly potable water costs

Average domestic consumption (m^3/subscriber/quarter)		Potable water charge (TND/subscriber/quarter)							Proportion (TND/ subscriber / month)
		Fixed charge (TND)	Variable charge (TND)					Total	
			Charge variation		Q^{ty} (m^3)	Price (TND)	Total		
Urban area	31.7	3.500	<20m^3	0.140	20	2.800	5.608	9.108	3.036
			>20m^3	0.240	11.7	2.808			
Rural area	28.6		<20m^3	0.140	20	2.800	4.864	8.364	2.788
			>20m^3	0.240	8.6	2.064			

Source: Potable water fees (SONEDE - 2010)

Table 1.3-6: Portion of sanitation and potable water costs in the income of modest Tunisian households

<table>
<tr><th rowspan="2">Average monthly wage (TND)</th><th colspan="4">Average monthly potable water and sanitation costs (TND/subscriber/month)</th><th rowspan="2">Portion of sanitation and potable water costs in the income of modest Tunisian households</th></tr>
<tr><th colspan="2">Sanitation</th><th>Potable water</th><th>Total</th></tr>
<tr><td rowspan="2">225.156</td><td>Urban area</td><td>1.286</td><td>3.036</td><td>4.322</td><td>1.9 %</td></tr>
<tr><td>Rural area</td><td>1.111</td><td>2.788</td><td>3.899</td><td>1.7 %</td></tr>
</table>

The Portion of sanitation and potable water costs in the income of modest Tunisian households vary between 1.7% in the rural area and 1.9% in the urban area. This result is clearly higher than that gathered by the survey on household expenses (0.93%), but remains highly satisfactory based on normally accepted standards (3%) and in comparison with other countries (between 1.1% (Sweden, Netherlands, Italy), 5.3% in Slovakia, 9.0% in Poland and 10.3% in Turkey).

1.3.3 Wastewater Management System

1.3.3.1 Policies and Development Plans for the Wastewater Sector

The policy of environmental protection undertaken by GoT has always been based on the programs to improve conditions and quality of life in urban and rural areas and targeted operations for rational management and conservation of natural resources. An example is the process conducted at national, sector and governorate (regional) scale, which allowed, at a first stage, to prepare the guidance document for the 11th Development Plan (2007-2016) and for the decade (2007-2016). This process was conducted in two phases:

- The first phase allowed the preparation of regional action programs for the environment and sustainable development. It consists in 24 programs, one per each administrative region of the country. These programs were examined and adopted by the regional councils of development.
- The second phase included a regional consultation process (conducted through the organization in each governorate) which helped highlight the main concerns of citizens and stakeholders regarding the improvement of the quality of life, the preservation of natural resources, and social advancement.

The document of 11th Plan and the decade 2007-2016, incorporates the concerns of the implementation of sustainable development by focusing on traditional economic sectors (agriculture, industry, mining, tourism, transport) and encouraging them to promote production systems that are based on stricter management methods, thus guaranteeing economical profits while preserving the integrity of natural environments and ecosystems.

The sanitation sector is in the last instance responsible of the state of the environment by contributing to the protection of public health and preservation of water and marine environments. Sanitation affects many areas of economic activity such as tourism, agriculture, industry and fisheries. This sector is particularly important on the coastline and clean beaches and water quality of the sea are depending on it.

The sanitation sector has increasingly faced challenges in both technical performance and operational efficiency at the level of cost control. While pursuing further investment, the sector will have to rehabilitate old structures and to renew equipment, to develop further treatment where necessary, to establish a treatment line for sustainable management of sludge, to control odors and promote the reuse of treated wastewater.

ONAS benefits from a large number of funding agencies and foreign borrowers who take part in the financing of its projects, among which we can mention the World Bank, KfW, EIB, AFD, JBIC, and JICA.

The following table presents the sanitation projects in progress or planned per governorate at the study:

Table 1.3-7: Sanitation projects in progress or planned by each governorate

Projects	Communes	Estimated cost (in 1000 TND)	Progress report
Sidi Bouzid			
4th Sanitation project of the low income residential areas - Part 1	Sidi Bouzid and Jelma	3,900	Works in progress
4th Sanitation project of the low income residential areas - Part 2	Sidi Bouzid, Jelma, Sidi Ali Ben Aoun, Bir Elhfai, Regueb, Sebbala, Menzel Bouzaine, Ouled Haffouz and Mezouna	11,000	Works in progress
5th Sanitation project of the low income residential areas	Sidi Ali Ben Aoun, Bir Elhfai, Regueb and Mezouna	5,500	Planned
Master plan of the governorate of Sidi Bouzid	Whole governorate	100	Planned
Rural sanitation Program - Part 2	Sidi Bouzid	450	Study in progress
Extension and rehabilitation project of the sewage networks and capacity building of ONAS (PRERERC1)	Sidi Bouzid	700	Tendering process
Sanitation project of small and medium-size cities (6 cities)	Meknassy	5,600	Tendering process
Extension and rehabilitation Project of the SIDI Bouzid WwTP	Sidi Bouzid	7,200	Study in progress
Kébili			
4th Sanitation project of the low income residential areas - Part 2	Douz and Golaa	1,600	Study in progress
5th Sanitation project of the low income residential areas	Kébili and Jemna	2,500	Planned
Master plan of the governorate of Kébili	Whole governorate	100	Planned

Projects	Communes	Estimated cost (in 1000 TND)	Progress report
Rural sanitation program - Part 2	Sabria ghrib	2,500	Study in progress
Management program of the WwTP sludge	Kébili	400	Study in progress
Sfax			
4th Sanitation project of the low income residential areas - Part 2	Sfax, Hencha, Chihia, El Ain, Mahres, Sakiet Eddaier, Jebeniana and Sakiet Ezzit	2,800	Study in progress
5th Sanitation project of the low income residential areas	Sfax, Hencha, Mahres, Sakiet Eddaier, Gremda, Tyna and Agareb	5,000	Planned
Development of cogeneration in the Northern Sfax WwTP	Sfax	9,000	Planned
Master plan of the governorate of Sfax	Whole governorate	150	Planned
Sanitation program of industrial parks	Sfax	20,000	Feasibility study in call for tenders
Rural sanitation program - Part 2	Hzag, Khazenet, El Amra and Ellouza	6,800	Study in progress
Management program of the WwTP sludge	Sfax	6,900	Study in progress
Extension and rehabilitation project of the sewage networks and capacity building of ONAS (PRERERC1)	Sfax	5,400	Study in progress
“ONAS VI” Sanitation Project	Kerkenah	4,200	Works in progress
Extension and rehabilitation project of the Mahres WwTP	Mahres	3,400	Study in progress
National project of sanitation of the town of Kerkenah	Kerkenah	17,000	Study in progress
Rehabilitation of the ventilation system of the Northern Sfax WwTP	Sfax	3,000	Planned
Kasserine			
4th Sanitation project of the low income residential areas - Part 1	Kasserine and Thala	900	Works in progress
4th Sanitation project of the low income residential areas - Part 2	Kasserine, Sbiba, Feriana, Foussana and Thala	2,700	Study in progress
5th Sanitation project of the low income residential areas	Telepte and Feriana	1,500	Planned
Master plan of the governorate of Kasserine	Whole governorate	100	Planned
Rural sanitation program - Part 2	Hassi el frid and El Ayoun	1,600	Study in progress

Projects	Communes	Estimated cost (in 1000 TND)	Progress report
Extension and rehabilitation project of the sewage networks and capacity building of ONAS (PRERERC1)	Kasserine	500	Tendering process
Upgrade project of 12 WwTP	Sbeitla	6,000	Planned
Rehabilitation project of the Kasserine WwTP	Kasserine	8,500	Study in progress
Kef			
4th Sanitation project of the low income residential areas - Part 2	El Kef, Jerissa and Tajerouine	600	Works in progress
5th Sanitation project of the low income residential areas	El Kef	400	Planned
Master plan of the governorate of El Kef	Whole governorate	100	Planned
Management program of the WwTP sludge	El Kef	700	Study in progress
Sanitation project of 10 medium size cities	Tajerouine, Dahmani and El Ksour	10,500	Study in progress
Project of sanitation of small and medium size cities (6 cities)	Jerissa and Sers	14,000	Works in progress
Upgrade project of 12 WwTP	El Kef	5,000	Planned
Jendouba			
4th Sanitation project of the low income residential areas - Part 1	Jendouba	1,000	Works in progress
4th Sanitation project of the low income residential areas - Part 2	Jendouba, Ain Drahem and Ghar Dimaou	900	Tendering process
Master plan of the governorate of Jendouba	Whole governorate	100	Planned
Sanitation project of Ain Drahem	Ain Drahem	2,200	Works in progress
Management program of the WwTP sludge	Jendouba and Tabarka	2,900	Study in progress
5th Sanitation project of the low income residential areas	Ain Drahem	200	Planned
Siliana			
4th Sanitation project of the low income residential areas - Part 2	Rouhia	200	Study in progress
Master plan of the governorate of Siliana	Whole governorate	100	Planned
Management program of the WwTP sludge	Siliana	1,100	Study in progress
Sanitation project of small and medium size cities (6 cities)	Bou Arada and Makther	15,200	Works in progress

Projects	Communes	Estimated cost (in 1000 TND)	Progress report
Béja			
4th Sanitation project of the low income residential areas - Part 2	Béja and Medjez El Bab	1,100	Works in progress
5th Sanitation project of the low income residential areas and the rural areas	Hammam Sayala	900	Planned
Master plan of the governorate of Béja	Whole governorate	100	Planned
Sanitation program of industrial parks	Medjez El Bab	15,000	Feasibility study in call for tenders
Rural sanitation program - Part 1	Testour	1,600	Works in progress
Rural sanitation program - Part 2	Béja Testour and Medjez El Bab	5,200	Study in progress
Management program of the WwTP sludge	Béja, Medjez El Bab and Teboursouk	7,000	Study in progress
Extension and rehabilitation project of the sewage networks and capacity building of ONAS (PRERERC1)	Béja	400	Works in progress
Upgrade project of 12 WwTP	Teboursouk	2,000	Planned
Renewal of the Bouzegdem Channel	Béja	1,000	Study in progress
Zaghouan			
4th Sanitation project of the low income residential areas - Part 2	Zaghouan and Bir Mchergua	3,000	Study in progress
5th Sanitation project of the low income residential areas	Djebel El Oust	200	Planned
Master plan of the governorate of Zaghouan	Whole governorate	100	Planned
Rural sanitation Program - Part 2	El Fahs (locality of Khniguet Magra)	600	Study in progress
Bizerte			
4th Sanitation project of the low income residential areas - Part 2	Bizerte, Metline, Ras Djebel and Menzel Bourguiba	600	Works in progress
5th Sanitation project of the low income residential areas	Menzel Bourguiba, El Alia and Metline	800	Planned
Development of cogeneration in the Bizerte WwTP	Bizerte	10,000	Planned
Development of cogeneration in the Menzel Bourguiba WwTP	Menzel Bourguiba	4,500	Planned
Master plan of the governorate of Bizerte	Whole governorate	100	Planned
Sanitation program of industrial parks	Bizerte and Utique	34,000	Feasibility study in call for

Projects	Communes	Estimated cost (in 1000 TND)	Progress report
			tenders
Rural sanitation program - Part 2	Ras Djebel (locality Blessed Atta)	600	Study in progress
Management program of the WwTP sludge	Bizerte and Menzel Bourguiba	3,500	Study in progress
Extension and rehabilitation program of the pumping stations	Bizerte and Menzel Jamil	1,000	Study in progress
Sanitation project of Grand Bizerte (upgrade of the Bizerte WwTP)	Bizerte	4,600	Works in progress
Sanitation project of the towns of Mateur, Raf Raf, Ras Djebel and El Alia	Mateur, Raf Raf, Ras Djebel, Aousja, Ghar El Melh and El Alia	30,000	Works in progress
Rehabilitation of the aeration system of the Bizerte WwTP	Bizerte	3,500	Planned
Rehabilitation of the aeration system of the Menzel Bourguiba WwTP	Menzel Bourguiba	1,500	Planned

Source: ONAS

Finally, we can summarize in figures the planned projects as follows:

- Ongoing studies at a cost of approximately 138,550,000 TND
- Planned projects at a cost of approximately 62,550,000 TND
- Ongoing works at a cost of approximately 91,300,000 TND

Today, ONAS is supported by other partners, especially by the private sector, whenever it can be efficient. ONAS is very interested in proceeding with new projects on the basis of Build-Operate-Transfer (BOT). This corresponds to a form of concession with private groups funding and carrying out a project, taking charge of its operation during a period comprised between 15 and 25 years and then, if necessary, transferring the property of the facilities to the Owner.

1.3.3.2 Institutional Framework

Responsibility for the management of the sanitation sector belongs to ONAS, which is under the Ministry of Agriculture and Environment. ONAS is a public industrial and commercial company with legal personality and financial autonomy.

The focal areas of ONAS include:

i) Studies, such as sanitation master plans of cities and governorates, feasibility studies, prospective studies and detailed studies related to sewerage, wastewater treatment plants and pumping stations;

ii) Execution of sanitation projects;

iii) Operation and maintenance of sewage networks and sanitation infrastructures;

iv) Technical assistance to local governments and other public or private entities in the field of water pollution control.

1.3.3.3 Legal Framework

1.3.3.3.1 Rules and Standards for the Management of Wastewater Quality

Wastewaters discharged into public sanitation networks must respect the quality requirements established in the homologated Tunisian standard NT 106.02 (1989) - edition of September 1998 (see Table 1.3-8).

Discharges of treated wastewater in the receiving environment, including the public maritime and hydraulic domains, is regulated by Decree n° 85-56 of January 2, 1985, and by the Tunisian standard NT 106.02 (1989) - September edition 1998.

Wastewater discharged into the receiving environment must comply with the discharge standards set by the rules provided by these legal documents, in particular in the NT 106.02, which are listed in Table 1.3-8.

Table 1.3-8: Water discharge standards as described in NT 106.02 (1989)

Parameters (units)	Public maritime domain	Public hydraulic domain	Public sewerage system	Assay method
Temperature (ºC)	35ºC	25ºC	35	
pH	6.5 < pH < 8.5	6.5 < pH < 8.5	6.5 < pH < 9.0	NT 09.05 and 09.06
TSS (mg/L)	30	30	400	NT 09.21
Decantable solids (ml/L)	0.3	0.3	-	
COD (mg/L O2)	90	90	1000	NT 09.23
BOD_5 (mg/L O2)	30	30	400	NT 09.20
Chlorides	-	600	700	NT 09.77
Active chlorinate (mg/L Cl_2)	0.05	0.05	1	NT 01.31
Dioxide chlorine (mg/L)	0.05	0.05	0.5	
Sulfate (mg/L)	1,000	600	400	NT 09.78
Magnesium (mg/L)	2,000	200	300	NT 09.09
Potassium (mg/L)	1,000	50	50	NT 09.65 and 09.66
Sodium (mg/L)	-	300	1000	NT 09.65 and 09.66
Calcium (mg/L)	-	500	case-by-case	NT 09.09 and 09.10
Aluminium (mg/L)	5	5	10	
Boron (mg/L)	20	2	2	
Iron (mg/L)	1	1	5	NT 09.25
Copper (mg/L)	1.5	0.5	1	NT 09.07
Tin (mg/L)	2	2	2	
Manganese (mg/L)	1	0.5	1	NT 09.28
Zinc (mg/L)	10	5	5	NT 09.07
Molybdenum (mg/L)	5	0.05	5	
Cobalt (mg/L)	0.5	0.1	0,5	NT 09.07
Active brominate (mg/L)	0.1	0.05	1	
Barium (mg/L)	10	0.5	10	
Silver (mg/L)	0.1	0.05	0.1	
Arsenic (mg/L)	0.1	0.05	0.1	NT 09.08
Beryllium (mg/L)	0.05	0.01	0.05	
Cadmium (mg/L)	0.005	0.005	0.1	NT 09.35
Cyanide (mg/L)	0.05	0.05	0.5	NT 09.41
Chromium VI (mg/L)	0.5	0.01	0.5	
Chromium III (mg/L)	2	0.5	2	

Parameters (units)	Public maritime domain	Public hydraulic domain	Public sewerage system	Assay method
Antimony (mg/L)	0.1	0.1	0.2	
Nickel (mg/L)	2	0.2	2	NT 09.07
Selenium (mg/L)	0.5	0.05	1	NT 09.36
Mercury (mg/L)	0.001	0.001	0.01	NT 09.37
Lead (mg/L)	0.5	0.1	1	NT 09.07
Titanium (mg/L)	0.001	0.001	0.01	
Pesticides (mg/L)	0.005	0.001	0.01	
Faecal Coliform (/100mL)	2,000	2,000	-	NT 16.21 and 16.22
Faecal streptococcus (/100mL)	1,000	1,000	-	NT 16.23 and 16.24
Salmonellas (/500mL)	-	-	-	
Cholera (/500mL)	-	-	-	
Color (mg/L)	100	70	case-by-case	NT 09.16
Sulphides (mg/LS)	2	0.1	3	
Dissolved Fluoride (mg/LF)	5	3	3	
Nitrate (mg/L NO_3)	90	50	90	NT 09.30
Nitrite (mg/L NO_2)	5	0.5	10	
Organic nitrogen and ammonia (mg/L)	30	1	100	NT 09.18
Phosphorus or total P	0.1	0.05	10	
Phenols and phenolic compounds (mg/L)	0.05	0.002	1	
Saponifiable fats and oils (mg/L)	20	10	30	
Total aliphatic hydrocarbons (mg/L)	10	2	10	
Chlorinated solvents (mg/L)	0.05	0	0.1	
Anion detergents of the type of alkyl-benzene sulfanate (ABS) (mg/L)	2	0.5	5	NT 09.26

It should be noted that for some parameters other limit values than those in Table 1.3-8 can be agreed with the competent authorities, and that the standard provides for some parameters higher tolerance limits.

With respect to the microbiological parameters imposed for the public maritime and hydraulic domains, the achievement of 2,000/100 mL of fecal coliforms and of 1,000/100 mL of fecal streptococcus implies the integration of a final disinfection stage of the effluent, regardless of the use made by the receiving party. On the other hand, the imposition of concentrations of organic nitrogen and ammonia below 30 mg/L and 1 mg/L, respectively for the water and marine environments, and 90 mg/L and 50 mg/L NO_3 for the nitrates, implies removal of nitrogen for nitrification of ammonium and nitrate de-nitrification. Thus the maximum concentration of 0.1 and 0.05 mg/L of total phosphorus requires a major effort to remove phosphorus from the effluent, only possible through physico-chemical process.

These legal documents are currently under review. The draft of a new decree has been provided by ONAS. Despite this new document, not yet in force and subject to modifications until its publication, it is important to know the main changes that are under consideration, which are as follows:

- The definition of sensitive receiving environment. The sensitive receptors will be fixed by joint decree of the Minister of Agriculture and Environment and of the Minister of Public Health ;

- Different discharge standards for the sensitive receiving environments and other receiving environments. It modifies the limits of total Kjeldahl nitrogen and total phosphorus on discharges, while allowing the possibility of establishing a limit for the discharge of these parameters based on a percentage reduction compared to the concentration in raw wastewater ;

- Limit values for microbiological parameters, including faecal coliforms, faecal streptococci, salmonella, cholera and intestinal nematode eggs, apply only to discharges in sensitive areas ;
- Standards for effluent discharge from industrial facilities, by industrial sector.

The reuse of treated wastewater in agriculture is regulated by Decree n. º 89-1047 of July 28th 1989, and by the Tunisian standard NT 106.03 (1989), which defines the physico-chemical and biological characteristics of reused wastewater. According to these legal documents, reuse of treated wastewater for agricultural purposes must be authorized by the Minister of Agriculture and Environment, issued after approval of the Minister of Public Health and advice of the National Agency for Protection Environment (ANPE).

Decree n. º 89-1047 of July 28th 1989, which title is "setting the conditions for use of treated wastewater for agricultural purposes," explains in its first article that "the use of treated wastewater for agricultural purposes needs an authorization from the Minister of Agriculture, delivered after approval of the Minister of Public Health and notices of the National Agency of Environmental Protection.

The reuse of treated wastewater in agriculture may be authorized only after proper treatment in a sewage treatment plant to comply with the quality framework imposed by the NT 106.03 (1989) and presented in Table 1.3-9.

Table 1.3-9: Framework of quality of the NT 106.03 (1989)

Parameters	Maximum concentration	Assay method
pH	6.5 ≤ pH ≤ 8.5	NT 09.06 or NT 09.07
Conductivity	7, 000 µS/cm	NT 09.34
DCO	90 mg/L O_2 (average of 24 hr)	NT 09.23
DBO_5	30 mg/L O_2 (average of 24 hr)	NT 09.20
MES	30 mg/L	NT 09.21
Chlorides	2, 000 mg/L	NT 09.77
Fluorides	3 mg/L	
Organochlorinated	0.001 mg/L	
Arsenic	0.1 mg/L	NT 09.08
Boron	3 mg/L	NT 09.06
Cadmium	0.01 mg/L	NT 09.35
Cobalt	0.1 mg/L	NT 09.07
Chromium	0.1 mg/L	
Copper	0.5 mg/L	NT 09.07
Iron	5 mg/L	NT 09.25
Manganese	0.5 mg/L	NT 09.26
Mercury	0.001 mg/L	NT 09.37
Nickel	0.2 mg/L	NT 09.07
Lead	1 mg/L	NT 09.07
Selenium	0.05 mg/L	NT 09.36
Zinc	5 mg/L	NT 09.07
Arithmetic mean of eggs of intestinal nematodes	≤ 1/1,000 mL	

The use of treated wastewater for irrigation of crops and vegetables is forbidden. The direct grazing in plots irrigated with treated wastewater is also forbidden.

1.3.3.3.2 Water Quality Management and Monitoring System

The management of the quality of the water treated in the WwTP is ensured by a monitoring system that includes the water sampling and the analytical control of the quality of wastewater and treated water.

The monitoring system includes the analytical control of raw water and treated water and is performed twice a week in the laboratories of ONAS and once a month in one external and independent laboratory. The analytical control of the quality of the dewatered sludge is produced twice a year and includes bacteriological and heavy metal analysis.

Meanwhile, the operation team of each WwTP carries on a set of analysis in the WwTP's own laboratory, mainly the physical parameters, as well as certain simple laboratory tests to control the operation of the aeration tanks.

Regarding the measurement of the quality of treated water in natural environments such as rivers, lakes or the sea, no standard exists in Tunisia. Nevertheless, from the point of view of environmental management system in Tunisia, the water quality for natural hydraulic environment (receiving environment) is controlled by discharge standard in compliance with the NT 106. 02 associated with the Decree No. 85-56 of 2^{nd} January 1985 which regulates the pollutants by the "Regulation of discharge to the receiving environment".

1.3.3.3.3 Framework of Sludge Final Disposal

According to studies carried out by ONAS, dewatered sludge in Tunisia may have three destinations: green sector – use in agriculture; red sector – incineration; black sector – conveying towards controlled landfill. In the areas surrounding the studied wastewater treatment plants, there are no incinerators, and therefore dewatered sludge can either be used in agriculture or conveyed towards an appropriate landfill. The dewatered sludge must present a dry solids content higher than 30% (minimum value accepted by ANGed) in order to be admitted to a landfill.

The Tunisian standard NT 106.20 (2002) has been subject to setting technical specifications for sludge from wastewater treatment plants for urban wastewater, the conditions of their use as fertilizing materials and restrictions on use of such sludge when metallic elements-traces and pathogenic agents are present. Implementation of this standard is currently in a trial period.

Sludge to be reused must come mainly from household sewage treatment (where its characteristics measured on an average sample taken 24 hours before pre-treatment and decanted for 2 hours are such that the ratio of its COD to BOD5 is lower or equal to 2.5, the COD is less than or equal to 1,000 mg/L, the Kjeldahl nitrogen is less than 100 mg/L).

According to this standard, sludge must be subjected to methods of treatment using biological, chemical or thermal processes or any other suitable method to reduce its fermentability and health hazards in their use.

Standard NT 106.20 (2002) establishes the following maximum allowable levels for certain trace elements in sludge:

Table 1.3-10: Maximum allowable levels for certain trace elements in sludge: Norm NT 106.20

Parameters	Maximum concentration (mg/kg ms)	Assay method
Cadmium	20	Atomic absorption spectrometry or emission spectrometry (AES) or Emission spectrometry (ICP) coupled with mass spectrometry or fluorescence spectrometry (for Hg)
Chromium	500	
Copper	1,000	
Mercury	10	
Nickel	200	
Lead	800	
Zinc	2,000	

Regarding the microbiological quality of sludge, it must present a faecal coliform concentration below 2 * 106 CR expressed in MPN/g DM. Control of the analytical quality of sludge should be carried out at least once every six months.

We should note that the polymer used for sludge dewatering does not interfere with the normal development of crops and in no manner prevents human consumption of agricultural products.

1.3.4 Capacity Assessment of Relevant Agencies

1.3.4.1 Financial Situation of ONAS

By December 2005, total investments had reached 1,138 MTND (millions of Tunisian dinars) since 1974. During the 2000-2005 period, investment totaled 624 MTND, representing an annual rate of increase of 4.3%. The utility has therefore been able to extend sewerage services to about 86% of all urban areas of Tunisia.

Investments are programmed annually through GoT's (Government of Tunisia) five-year plans. GoT provided direct financing for about 35% of the investments in 2008, and guarantees the loans and grants financing the balance, except for a small portion of the working capital and the self-financing.

GoT subsidies cover ONAS operational losses, repayment of principal, investment and foreign exchange losses.

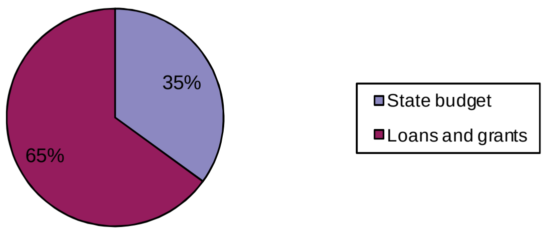


Figure 1.3-1: Investments financing of ONAS in 2008

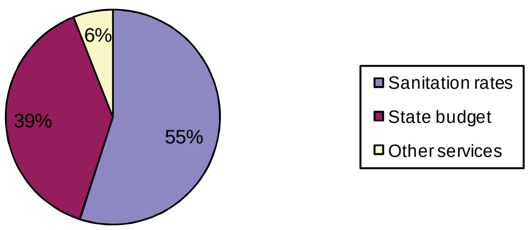


Figure 1.3-2: Operating costs financing of ONAS in 2008

1.3.4.2 Financial Performances of ONAS

ONAS sales are increasing more slowly than its expenses, so the profit before tax is more and more negative. Between 2005 and 2009, total income increased by an average of 3% per year, whereas total expenses increased by an average of 7.5% per year. The deficit increase is about +5 MTND per year, but fastened in 2008 (+25 MTND), then came back to its original trend by the end of 2009; this represents an average of 18% of deficit increase per year.

Thanks to increasing balancing modifications (subsidies) from 41 MTND in 2005 to 76 MTND in 2009, ONAS is able every year to break even. These State subsidies increased by an average of 16.5% per year in the same period. Accounting modifications relate to changes in norms or in accounting estimates and to mistakes corrections in previous financial statements.

The working capital ratio (current assets / current liabilities) was 1.323 in 2007 and 1.233 in 2008. The quick ratio ((current assets – stocks) / current liabilities) is also over 1.0 : 1.267 in 2007 and 1.177 in 2008. The debt ratio (debts / total capital) was only 0.352 in 2007 and 0.335 in 2008. Finally, the capital ratio increased from 0.651 to 0.683 between 2005 and 2009.

Table 1.3-11: ONAS financial data

(1 000 TND)

	Dec. 2005	Dec. 2006	Dec. 2007	Dec. 2008	Dec. 2009
Current assets			160,939	155,488	
Stocks			6,753	6,998	
Total assets	1,245,018	1,305,389	1,371,346	1,403,643	1,414,675
Capital	703,715	770,289	788,270	818,446	826,669
Others	106,190	110,311	127,056	139,597	139,265
Total capital	809,905	880,600	915,326	958,043	965,934
Current liabilities			121,658	126,107	
Debts			321,814	320,839	
Provisions			438	1,515	
Total liabilities	430,664	410,678	443,910	448,461	447,849
Total capital and liabilities	1,240,569	1,291,278	1,359,236	1,406,504	1,413,783
Working capital ratio			1,323	1,233	
Quick ratio			1,267	1,177	
Debt Ratio			352	335	
Capital ratio	651	675	667	683	683
Sales and State subsidies	113,988	119,996	121,367	124,858	127,832
Sales cost	17,427	18,627	18,332	23,718	22,766
Overheads	126,960	135,321	140,712	155,641	165,313
Gross profit	- 30,399	- 33,952	- 37,677	- 54,501	- 60,247
Non-operating income	4,258	5,945	9,794	7,787	5,749
Non-operating expenses	10,827	13,939	17,745	23,752	20,830
Profit before tax	- 36,968	- 41,946	- 45,628	- 70,466	- 75,328
Balancing modifications	41,418	56,057	57,738	67,605	76,220
Net profit	4,450	14,111	12,110	-2,861	892
Accounting modifications	- 4,684	- 7,418	3,057	4,146	
Net profit after modifications	- 234	6,693	15,167	1,285	892

Sources: Auditor's report, 2005-2009

Cumulated operational losses for the period 2000-2005: 156 MTND (average of 26 MTND per year); operational losses: 34 MTND in 2006; 37.7 MTND in 2007; 54.5 MTND in 2008; 60.2 MTND in 2009. The average revenues from the sewerage tariff for the 2000-2005 period could only cover 96% (excluding depreciation) of the average cost, and 64% including depreciation, even if the annual rate of increase for O&M expenses was lowered from 16% in 2001 to 2% in 2005.

In 2009, total assets of ONAS of the table 1.3-11 (3rd line) included the different elements presented in Table 1.3-12.

Tableau 1.3-12: Total assets of ONAS (2009)

Elements	Amount after depreciation
Intangible fixed assets (mainly software acquired by ONAS)	77,839 TND
Property and equipment (including in particular lands, networks, treatment facilities, equipment, materials and buildings of ONAS)	991,488,100 TND
Fixed assets in progress (Work Expenditure and equipment under construction)	209,915,561 TND
Financial assets (shares owned by ONAS in the capital of other companies, credit facilities on connecting and non-current bank deposits)	29,319,379 TND
Other non-current assets (foreign currency translation on foreign currency loans)	36,068,731 TND
Inventories (raw materials and other supplies)	6,668,625 TND
Receivables and related accounts (sewerage fees invoiced but not yet been received from individuals and administrations)	52,317,032 TND
Other current assets (advance payments made by suppliers, work on behalf of the state and other administrations)	27,616,165 TND
Investments and other financial assets	13,078,409 TND
Cash and financial equivalents	48,125,676 TND
TOTAL	**1,414,675,517 TND**

Accounting modifications of table 1.3-11 (last line but one) may reflect changes in accounting policies, changes in accounting estimates or corrections of errors in financial statements.

For example, in the case of ONAS, the rate of depreciation for fixed assets has changed during the year 2008, thus changing their residual value (Notes to Financial Statements - 2009, ONAS). The line "accounting modifications" allows rectifying the balance sheets of previous years in order to present results on the same accounting basis, allowing their comparison.

Table 1.3-13: ONAS O&M annual amount increase

(1,000) TND

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010 (est.)
O&M annual amount	78,302	85,182	92,488	94,95	96,004	99,155	104,925	116,674	125,017	133,563

The ONAS operational income, aside from income from water charges and piping work, consists of two major groups: subsidies from the State and miscellaneous operating income.

1.3.4.2.1 Investment subsidies:

At the end of each fiscal year, ONAS distributes the donations granted to it by the State for financial operations based on four sections:

a) State balance subsidy (supplement of sanitation charge);

This subsidy is calculated based on the volume of water consumed by subscribers, at 0.230 TND per cubic meter. The amount of the subsidy varies from year to year. It is decided upon each year through a letter issued by the Ministry of Finance.

b) State balance subsidy (exchange rate lost for loans transferred by the State);

For the loans undertaken by the State with investors and transferred to other public, semi-public or private companies, reimbursement is made in foreign currency and according to the retrocession agreement that defines the exchange rate in which the reimbursement must be made. If the exchange rate fluctuates, ONAS may suffer a loss. This exchange rate loss however may be reduced through financial advantages of the State in the retrocession. The retrocession rate must be set by mutual agreement between the State and the investor.

c) Operations for the account of the State;

These are services for the State, particularly, projects for rainwater networks, dredging for wadis and sanitation infrastructures built in areas not under the responsibility of ONAS, as well as all work conducted outside its intervention field.

d) Donations for the State (donation funds).

These are donations and subsidies granted to the State then transferred to ONAS in the form of funds, studies or work.

1.3.4.2.2 Other operational income:

Aside from State subsidies, ONAS may rely on three other operational incomes:

a) Mechanism 41;

Under the “Mechanism 41” program, for the purpose of promoting employment by enlarging the scope of small and medium enterprises, a subsidy is given to public establishments which include ONAS, in order to motivate them to sign agreements with small enterprises. The latter are subsidized by 100% the first year, 75% the second year, 50% the third year, and 25% the fourth. From the fifth year, ONAS will take in charge the totality of the agreement.

b) Common funds portion;

The common funds portion represents the amounts annually paid to ONAS as a counterpart for services provided by it for local communities. The amount is set through a decree by the Ministry of Finance.

c) Technical assistance and services.

Technical assistance and services represent income for dredging and clearing activities for individuals, studies and technical assistance to third parties, particularly real estate promoters in sanitation, household connection or industrial projects.

1.3.4.2.3 Non-operating income:

Non-operating income mainly relates to investment income and other ordinary gains.

a) Investment income;

Investment income represents the financial products earned on loans for connections, as well as other financial products.

b) Other ordinary gains;

Other ordinary gains represent the penalties for late payment of sewage fees, the gain on sale of tender files and the sales by public auction.

1.3.4.2.4 Non-operating expenses:

Non-operating expenses mainly relate to net financial expenses, exchange losses and provisions, and other ordinary losses.

a) Net financial expenses;

Net financial expenses (which means after deduction of investment products) that pertain to assets under construction and financed by loans, represent generally interest expenses, commissions on loans, and interest expense on CCB (Frozen Current Account).

b) Exchange losses and provisions;

Exchange losses and provisions represent the difference between losses and the gains made following foreign currency exchange in purchases to suppliers.

c) Other ordinary losses;

Other ordinary losses represent mainly losses on pipe stocks readjustments, losses related to downgrading of fixed assets.

1.3.4.3 Projected financial performance (2009-2029)

It is possible to draw a financial forecasting from these data for the period 2009-2029. Two scenarios can be considered.

1.3.4.3.1 Scenario 1

ONAS goes on with its 3% sales increase and 7.5% expense increase per year. Subsidies increase by an average of 11.8% per year, so that the GoT goes on financing the average of all ONAS losses (the cumulated 2009-2029 net profit is -1.332 MTND).

Table 1.3-14: Financial forecast (Scenario 1)

	2009	2014	2019	2024	2029
Sales	127,832	148,192	171,796	199,158	230,879
Others	5,749	6,665	7,726	8,957	10,383
Total income	133,581	154,857	179,522	208,115	241,262
Total expenses	208,909	299,916	430,568	618,136	887,414
Profit before tax	- 75,328	- 145,059	- 251,046	- 410,021	- 646,152
GOT Subsidies	76,220	133,131	232,534	406,159	709,423
Net profit	892	- 11,928	- 18,512	- 3,862	63,270

In this case, the part of subsidies in total resources increases from 36.3% (2009) to 74.6% (2029).

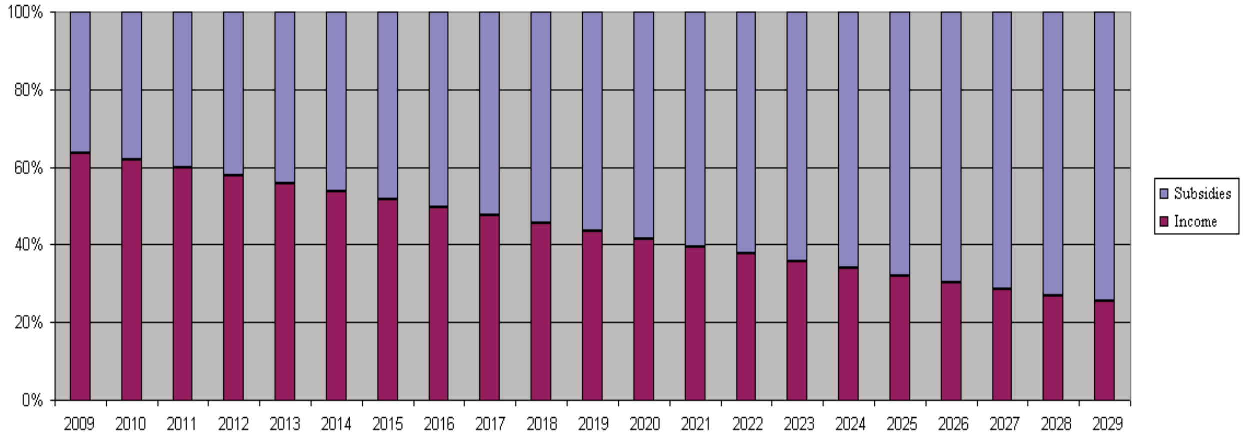


Figure 1.3-3: Part of subsidies and revenues in total resources (Scenario 1)

1.3.4.3.2 Scenario 2

The GoT stops increasing its subsidies from 2009, remaining at its 76.22 MTND level. ONAS goes on with its 7.5% expense increase per year but has to increase its sales income by 10.0% per year so that the cumulated 2009-2029 net profit is positive (12.897 MTND).

Table 1.3-15: Financial forecast (Scenario 2)

	2009	2014	2019	2024	2029
Sales	127,832	205,875	331,563	533,986	859,990
Others	5,749	6,665	7,726	8,957	10,383
Total income	133,581	212,539	339,289	542,943	870,373
Total expenses	208,909	299,916	430,568	618,136	887,414
Profit before tax	- 75,328	- 87,377	- 91,279	- 75,193	- 17,041
GOT Subsidies	76,220	76,220	76,220	76,220	76,220
Net profit	892	- 11,157	- 15,059	1,027	59,179

In this case, the part of subsidies in total resources decreases from 36.3% (2009) to 8.1% (2029).

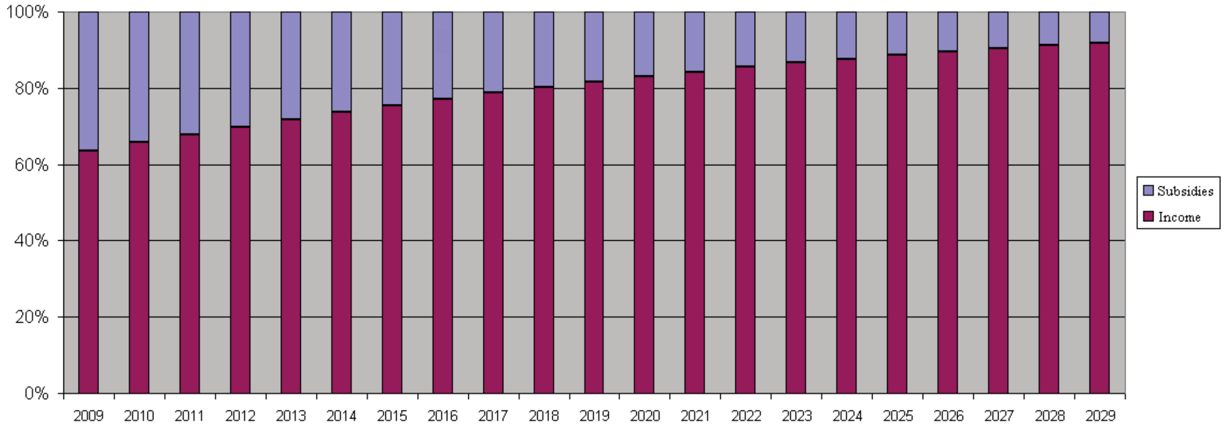


Figure 1.3-4: Part of subsidies and revenues in total resources (Scenario 2)

Sources:
ONAS – Financial statements, Auditor's report, 2005-2009
ONAS – Balance sheet and income statement, 2007-2008
ONAS – Annual Report, 2008
World Bank – Project appraisal document on a proposed loan to the ONAS, June

1.3.4.4 Asset Management by ONAS

ONAS was established by Law N° 73-74, dated August 3rd 1974. Its missions are:

- To combat all forms of water pollution and to contain its sources ;
- To manage, operate, maintain, rehabilitate and construct all sanitation facilities in ONAS action zones, of which, in particular, wastewater treatment plants, pumping stations and sea outlets ;
- To promote the sector of distribution and commercialization of treated wastewater and sludge ;
- To conduct sanitation studies and works on behalf of the State or local government ;
- To plan and implement integrated projects.

The general structure of the organization is given in Figure 1.3-5. As for 2010, ONAS staff accounts for 4,660 individuals, distributed as indicated in Table 1.3-16.

Table 1.3-16: Distribution of ONAS staff by job and regional area

	Engineers	Technicians	Operation staff	Other	Total
Headquarters	79	48	205	370	702
Grand Tunis region	58	139	864	207	1268
North region	40	133	709	178	1060
Centre region	55	130	603	189	977
South region	41	102	391	119	653
Total	**273**	**552**	**2,772**	**1,063**	**4,660**

ONAS, August 2010

The maintenance framework of ONAS is established at the governorate level. Each Regional Department of ONAS in each governorate employs several working teams dedicated to the dredging of pipes and connected structures.

A yearly dredging plan for sewage networks is set up at the beginning of each year and revised every month. In addition, when a maintenance problem is localized in a local ONAS office, for example after the claim of a client, the supervising Regional Department is contacted for an intervention of the maintenance teams.

The teams are equipped with mechanized equipment (suction and water pressure clearing trucks, suction-trucks), mobile units for camera inspection, small equipment and transportation vehicles.

Table 1.3-17 presents as example the maintenance resources for the three Regional Departments of the governorates of Kef, Kasserine and Sidi Bouzid.

Table 1.3-17: Maintenance system for the sanitation piping network

Governorate	Number of employees required per day for dredging	Detailed composition of teams according to the type of dredging equipment		Number of dredging days per month	Piping meters cleared by dredging (m)
Kef	8 workers 3 drivers	Hydro dredger 1	2 workers 1 driver	22 days	490 m
		Hydro dredger 2	2 workers 1 driver		
		Manual dredging equipment	4 workers 1 driver		
Kasserine	4 workers 2 drivers	Hydro dredger	2 workers 1 driver	22 days	440 m
		Manual dredging equipment	2 workers 1 driver		
Sidi Bouzid	4 workers 2 drivers	Hydro dredger	2 workers 1 driver	23 days	390 m
		Manual dredging equipment	2 workers 1 driver		

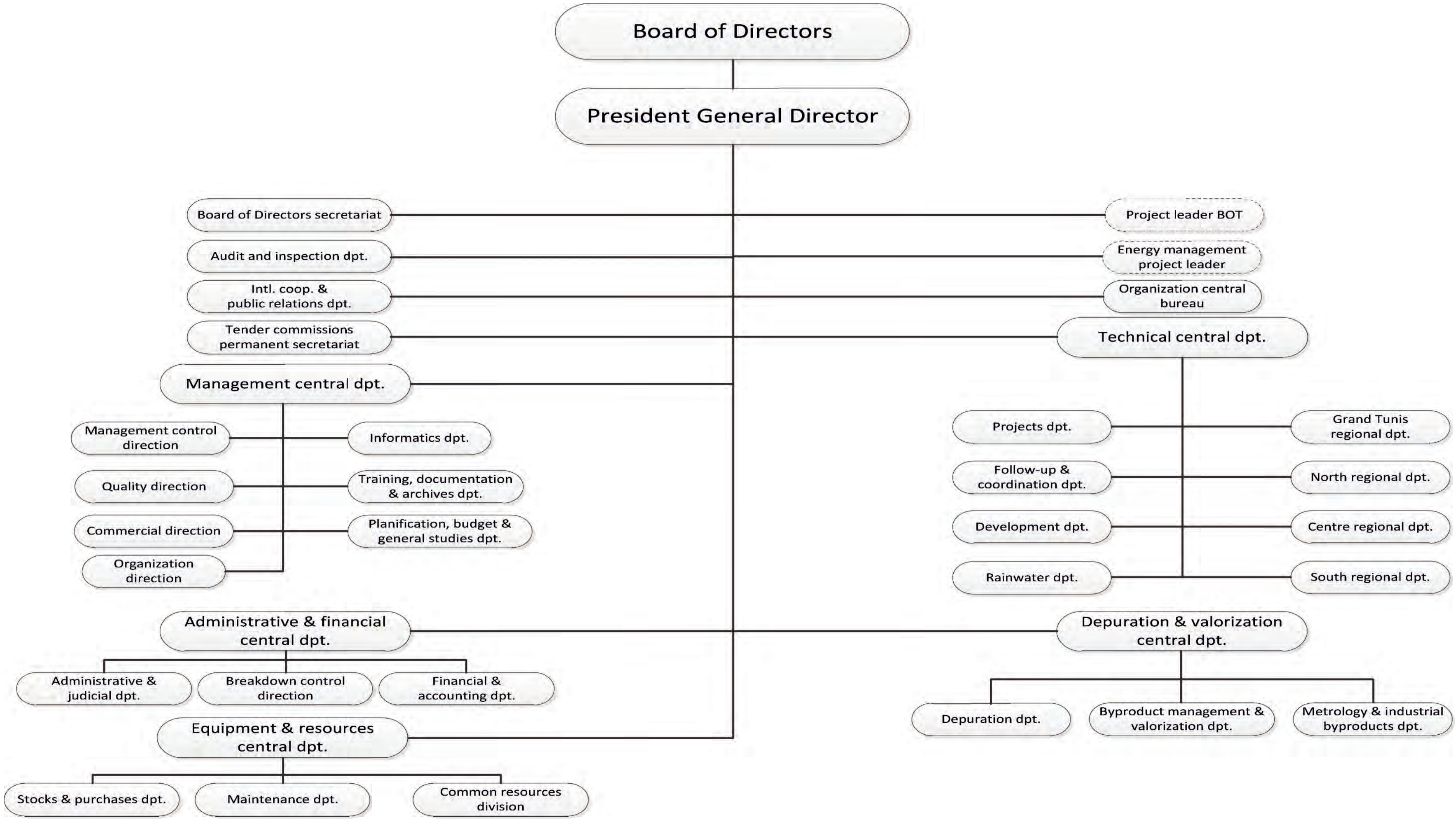


Figure 1.3-5: General structure of ONAS

As for the WwTP, the personnel costs of 5 WwTP under the North regional department in 2009 are given in Table 1.3-18 (values given in TND).

Table 1.3-18: Personnel costs of 5 WwTP under the North regional department

STEP	Staff	Staff salary (total)	Staff salary (monthly average)
Medjez el Bab	6	61,391	5,115
Tabarka	7	61,898	5,158
Siliana	9	56,037	4,669
Béja	8	90,594	7,549
Jendouba	7	66,860	5,572

1.4 ASSISTANCE BY DONORS ON WATER SECTOR

External partners have played a major role in the development of the water and sanitation sector in Tunisia. The French Development Agency AFD, the African Development Bank, the European Investment Bank, the German development bank KfW and the World Bank are among Tunisia's major external partners in the water sector.

1.4.1 Water supply

The following table summarizes the main international cooperation projects that have been undertaken in Tunisia in the field of water supply.

Table 1.4-1: International cooperation projects in the field of water supply

Implementing body	Project	Amount (in million USD)	Loan/Grant	Period
JICA	Rural Water Supply Project (Phase-2) in the Republic of Tunisia	53	Loan	2003-2010
	Jendouba Rural Water Supply Project	63.8	Loan	2006-2012
	Rural Water Supply Project (Phase-1) in the Republic of Tunisia	39.5	Loan	1999-2003
	Rural Electrification Using Solar Panels and Water Supply	24.4	Loan	2005-2012
	Water Supply &Sewage System Improvement Project in South-Tunisia	89.3	Loan	1996-2004
	Water Pipeline construction project in Northern Tunisia	94.5	Loan	2004-2011
	Project for Desalination of Groundwater in Southern Region	11.8UNS	Grant	2010-2012
AFD	Programme d'alimentation en eau potable du milieu rural du X^{ème} Plan de développement	41.9	Loan	2003- ?
	Water Sector Investment Loan Project Phase II (PISEAU II)	61	Loan	2009-2014

Implementing body	Project	Amount (in million USD)	Loan/Grant	Period
WB	Urban Water Supply Project	38.03	Loan	2005-
	Water Sector Investment Loan Project (PISEAU)	103	Loan	2000-2007
	Water Sector Investment Loan Project Phase II (PISEAU II)	31	Loan	2009-2014
	Water Supply and Sewerage Project	58	Loan	1994-2003
	Seventh Water Supply Project	50	Loan	1983-1993
	National Rural Water Supply Project	30.5	Loan	1982-1987
	Nationwide Water Supply Expansion Project	25	Loan	1979-1983
	Fourth Water Supply Project	21	Loan	1977-1984
	Third Water Supply Project	23	Loan	1974-1980
	Second Water Supply Project	10.5	Loan	1970-1976
	First Water Supply Project	15	Loan	1968-1976
KfW	Water Sector Investment Loan Project (PISEAU)	17.5	Loan	2000-2007
	Water Sector Investment Loan Project Phase II (PISEAU II)	1.2	Loan	2009-2014
AfDB	Water Sector Investment Loan Project Phase II (PISEAU II)	31.3	Loan	2009-2014
	Etude dessalement eau de mer de Zaarat	0.6	Loan	2010-
	Amélioration des taux d'approvisionnement en eau potable Bizerte et Béja	0.5	Loan	2010-

The total amount of loan and grant aids from international organizations to the GoT up to 2010 in the field of water supply is 1,095 million TND and the contribution by organization is as follows:

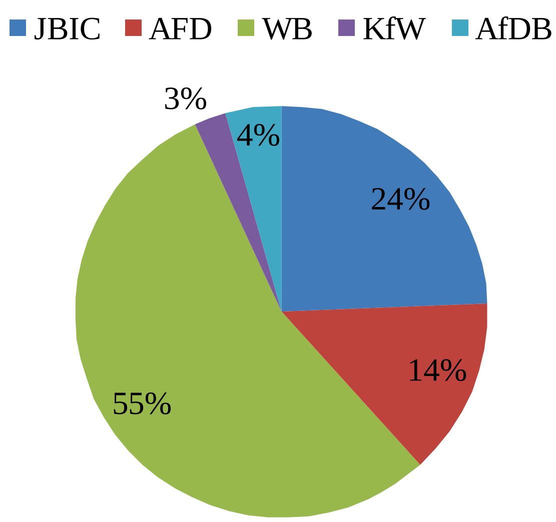


Figure 1.4-1: Percentage of cooperation by organizations to ONAS

1.4.2 Sewage

The following table summarizes the main international cooperation projects that have been undertaken in Tunisia in the field of water sanitation.

Table 1.4-2: International cooperation projects in the field of water sanitation

Implementing body	Project	Amount (M USD)	Loan / Grant	Period
WB	Sanitation of Greater Tunis (1st)	31.5	Loan	1975-1982
	Sanitation of Greater Tunis (2nd)	31.5	Loan	1978-1984
	Greater Tunis Sewage and Water Reuse	81	Loan	1998-2005
	Sanitation of Korbes, Mrissa, Agareb	8.9	Loan	2003-2009
	Sewage of Western Tunis	70.6	Loan	2006-2011
KfW	Sewage system in 11 cities of Medjerda river basin	78.8	Loan	1990-2008
	Sewage system in Sousse, Kairouan and Nefza	58.9	Loan	2002-2011
	Sewage in Greater Bizerte	26.7	Grant	1995-2007
	Sewage system in Boussalem, Jedeida-Siliana, Tebourba, Teboursouk, Testour-Gaff, Ghardimaou	43.8	Loan	1993-2010
	Sewage system in Raf Raf, Mateur, Ras Jebel, Alia	22.2	Grant	1996-2010
	Sewage system in Kairouan, Nefza-Sousse	23.5	Loan	1998-2010
	Sewage system in medium and small cities	0.26	Loan	1999-2010
	Sewage system in Sousse	5.2	Loan	2005-2011
	Sewage system in small and medium cities	31.4	Loan	2005-2011
	Rehabilitation and extension of 19 WwTPs and 130 pump stations	72	Loan	2008-2015
JICA	Sewage system in 4 cities in the south	61.6	Loan	1996-2006
	Water Supply &Sewage System Improvement Project in South-Tunisia	89.3	Loan	1996-2004
EIB	Sewage system in small and medium cities	85.7	Loan	1998-2007
		52.3	Loan	2006-2011
AFD	3rd project for sewage of popular quarters and rural areas (I)	23.2	Loan	1998-2004
	3rd project for sewage of popular quarters and rural areas (II)	25.3	Loan	2001-2007
	4th project of sanitation of popular quarters – First bid package	41	Loan	2004-2008
	4th project for sewage of popular quarters and rural areas (PNAQP4)	44.5	Loan	2004-2010
	PRERERC: rehabilitation and extension of 7 cities (Tunis, Ariana, Manouba, Ben Arous, Nabeul, Kairouan, Tozeur) and rehabilitation of WwTPs of Meliane and Sousse.	104.7	Loan	2007-2012
	Rehabilitation and extension of 19 WwTPs and 130 pump stations	24.2	Loan	2008-2015
IDB	Extension of 2 treatment plants	30.1	Loan	2005-2007
Belgian Gov.	Sanitation of El Kef	6.5	Grant	1996-2008
	Sanitation of Zaghouan	2.75	Grant	1999-2009
Swiss Gov.	Sanitation of northern Sousse	1.36	Loan	2008-2009
Austrian Bank	Sanitation of northern Sousse	3	Loan	2008-2009
EU	Rehabilitation and extension of 19 WwTPs and 130 pump stations	3.9	Loan	2008-2015

Source : ONAS, World Bank “Project appraisal document for the Tunis West Sewerage Project”, other

(yellow) : Target projects of “Program of rehabilitation and extension of networks of sewage system and pump stations» of ONAS (July 2009)

The total amount of loan and grant aids from international organizations to ONAS from its foundation to 2008 in the field of sewage is 1,082 million TND and the contribution by organization is as follows:

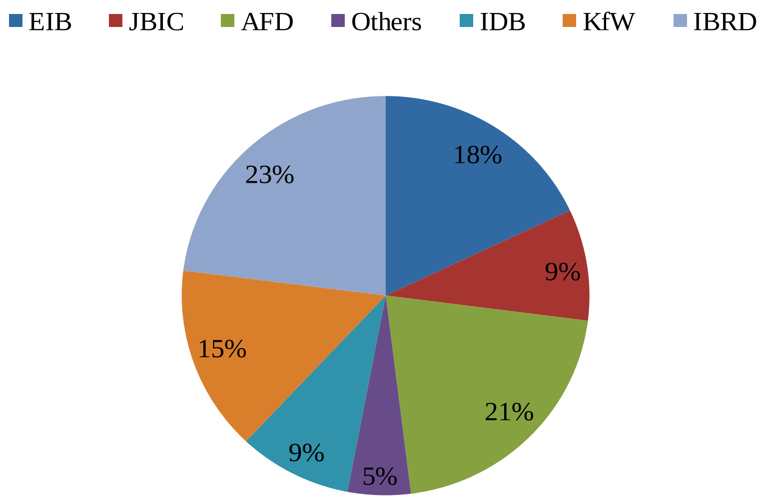


Figure 1.4-2: Percentage of cooperation by organizations to ONAS

CHAPTER II

PROPOSED SOLUTIONS FOR SEWERAGE NETWORKS AND PUMPING STATIONS

CHAPTER II: PROPOSED SOLUTIONS FOR SEWERAGE NETWORKS AND PUMPING STATIONS

2.1 CURRENT SITUATION OF SEWERAGE NETWORK IN EACH GOVERNORATE

2.1.1 Project Objectives for the Sewage Networks and Pumping Stations

The main objectives of the project for the Sewage Networks and Pumping Stations are the improvement of the living conditions of the citizens, the leveling of the sanitation infrastructures and the protection against water and soil pollution. In order to satisfy an increasingly pressing request of the sanitation services, to make the infrastructures under operation profitable, and to ensure the quality of service, extension and rehabilitation interventions in pumping stations and sewage networks will be proposed. The expected rehabilitation interventions shall allow to avoid the phenomena of breaking and cracking which become increasingly frequent in spite of the efforts of the annual programs undertaken by ONAS.

The specific objectives of rehabilitation are as follows:

- Reduction of the harmful effects caused by the collapses and water leak;
- Improvement of the services provided to the customer;
- Optimization of the operation costs.

The main objectives for networks and pumping station extensions (construction of new pumping stations) are as follows:

- Optimization of the profitability of the primary sanitation infrastructures and especially the wastewater treatment plants ;
- Increase of the ONAS financial resources through the increase in the sanitation clients (increase of the connection rate currently recorded in the governorates).

2.1.2 Intervention Area

From the 24 Governorates of Tunisia, the intervention area extends to the North and Centre of Tunisia and includes ten Governorates from Bizerte Governorate in the North to the Governorate of Kébili in the South. The other governorates included in the intervention area are Béja, Jendouba, Kasserine, El Kef, Sfax, Sidi Bouzid, Siliana and Zaghouan.

Of these, Sfax is the most populated Governorate (with 923,000 inhabitants), and is also that where the highest number of interventions (61) is proposed in this study. It is also the Governorate with the highest number of communes included in this study (12). In contrast, Sidi Bouzid Governorate has only one commune in this study. The Governorates of El Kef, Siliana and Zaghouan have three communes each, Kasserine four, Jendouba five, Béja six, Kébili eight and Bizerte nine. Figure 2.1-1 shows the intervention area with the governorates location and the communes included in the present study.

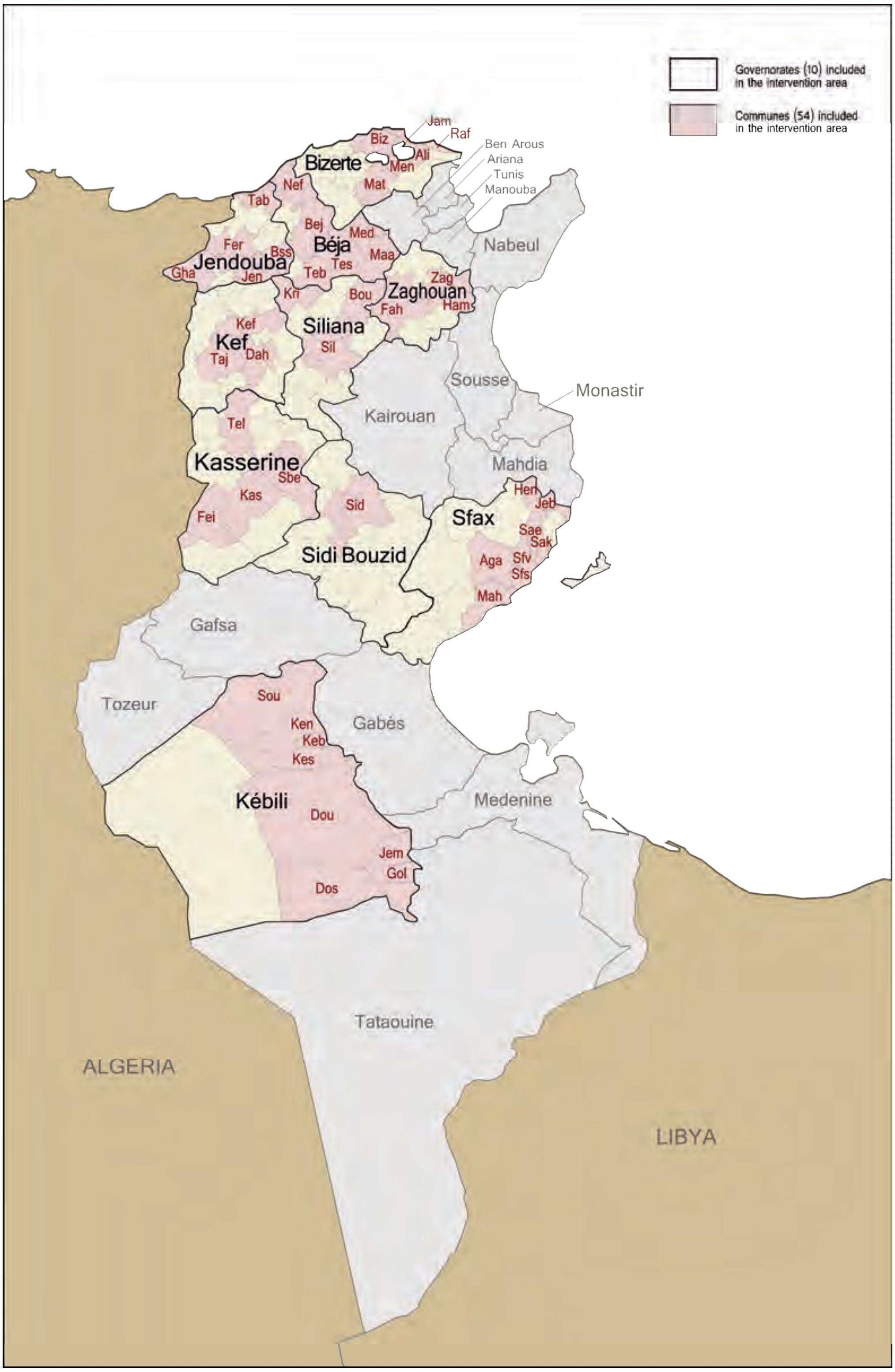


Figure 2.1-1: Intervention Area: Governorates and Communes

A total of 303 interventions are proposed for the 54 communes included in the present study, covering the rehabilitation and extension interventions of sewerage networks and pumping stations, as shown in the Table 2.1-1.

Table 2.1-1: Summary of interventions

Intervention	Networks	Pumping station	Total
Rehabilitation	124	24	148
Extension	106	49	155
Total	**230**	**73**	**303**

The distribution of the interventions planned for each Governorate is as follows (Table 2.1-2):

Table 2.1-2: Planned Interventions for each Governorate

Governorate	Communes	Rehabilitation		Extension		Total
		Network	Pumping station	Network	Pumping station	
Béja	6	18	1	16	5	40
Bizerte	9	16	9	6	6	36
Jendouba	5	6	5	8	6	25
Kasserine	4	14	0	9	4	27
Kébili	8	2	2	12	15	31
Kef	3	11	4	5	2	22
Sfax	12	15	3	38	5	61
Sidi Bouzid	1	9	0	6	1	16
Siliana	3	8	0	1	1	10
Zaghouan	3	25	0	5	4	34
Total	**54**	**124**	**24**	**106**	**49**	**302**

These various types of interventions will get the following codes: Rh= rehabilitation, Ex= extension, RS= sewage network, SP= pumping station. The code type refers to the principal work involved, but it can also include additional minor interventions. For example, an “SP” (pumping station) intervention may include some construction or rehabilitation of a gravity network (for example, the connection between the network and the pumping station, or the gravity sewer following the pumped main). In the same way, a rehabilitation intervention may involve some extension. Also some “SP” (Pumping Station) interventions do not include any work on a pumping station, but only on a pumped main.

The following sections present general characteristics and information of each governorate (geography, economy, climate, population, etc.) and indicators of sanitation. The information comes from several sources and is generally reliable. The figures showing the location of the governorates come from Tunisian “*Centre National de la Cartographie and de la Télédétection – CNCT*”.

The statistical data referring to the year 2004 are based on the last census of the population in that year, having been obtained from at the National Institute of Statistics of the Ministry of Planning and International Cooperation of the Republic of Tunisia.

The population estimates for the years 2009 and 2010 were provided by ONAS during the first mission in Tunisia.

Finally, with the exception of some calculated indicators, the Infrastructure indicators and planned interventions were obtained through the Sanitation Program of 10 Governorates, provided by ONAS.

2.1.3 Béja Governorate

2.1.3.1 Geographical and demographic context

Béja governorate is bordered by the Mediterranean in the North, the Siliana Governorate in the South, the governorate of Jendouba in the West, the governorate of Ariana in the East, and the Zaghouan Governorate in the South-East.

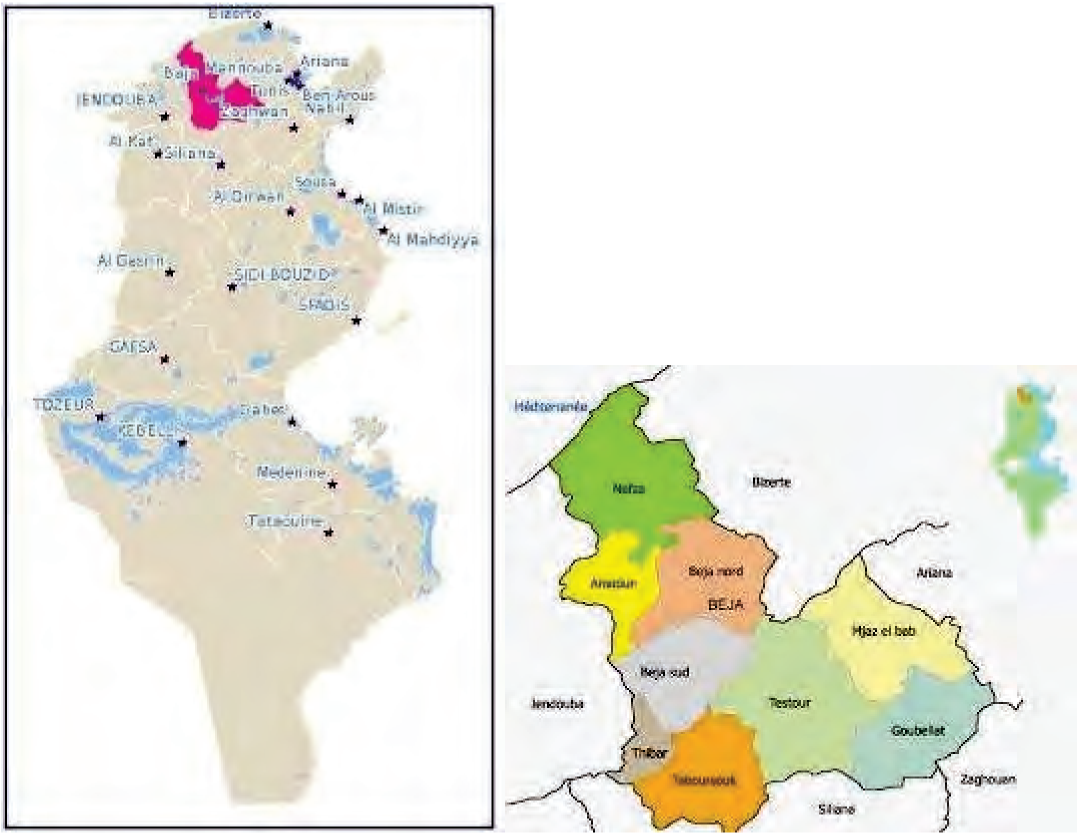


Figure 2.1-2: Maps of location and of delegations of Béja governorate

The Béja governorate had a population of 304,051 inhabitants in 2004 corresponding to 3.14% of the population of Tunisia. The same year, the number of households was 68,584 units and the dwellings were 72,058.

In this governorate, the communes which belong to this study are: Béja, Maagoula, Medjez El Bab, Nefza, Teboursouk and Testour.

The Béja commune is located at the Western border of the Béja Wadi alluvial plain, at around 105 km from Tunis and around a hundred km from the administrative centers of other Northern governorates in Tunisia.

Medjez El Bab town, the administrative center of the Béja governorate delegation, is located in the upper part of the low Medjerda valley, 60km from Tunis. It developed along the main roads RN5 main roads connecting Tunis to Kef town and RN6 which connects Tunis to Béja and Jendouba.

The town of Nefza - the administrative center of one of the delegations of the Béja governorate - is located 15 km from the Mediterranean Sea (Chott Zouaraa). It has developed around the intersection between the RN7 road, that connects Tunis to Tabarka and the RR52 road that links Nefza to the town of Béja.

The town of Teboursouk, the administrative center of one of the delegations of the Béja governorate - is located 100 km to the Southwest of Tunis and 50 km from the town of Béja, on the RN5 road. The roman ruins in Dougga, located 3 km southwest of the town, are an important tourism attraction.

The town of Testour - the administrative center of one of the delegations of the Béja governorate - is located on the right bank of the wadi Medjerda, 5 km downstream from the Sidi Salem dam and 80 km from Tunis. It is crossed by the RN5 road, which connects Tunis to the town of El Kef.

These communes correspond to the six communes taken in charge by ONAS. According to the 2004 census, we can observe the following figures per commune taken in charge:

Table 2.1-3: Population, Households and Dwellings for the communes taken in charge in Béja governorate (2004)

Communes	Population	Households	Dwellings
Béja	56,677	14,126	15,698
El Maagoula	7,690	1,710	1,640
Nefza	6,039	1,457	1,631
Teboursouk	10,987	2,644	3,039
Testour	12,732	2,907	3,193
Medjez El Bab	20,308	4,810	4,934
Total	**114,433**	**27,654**	**30,135**

2.1.3.2 Physical context

Topography

The main topographical characteristics for the communes of this governorate are given hereafter.

The Béja town is characterized by a mainly mountainous but low relief, between 300 and 600 m in altitude, with many plains and valleys.

The relief of Medjez-El Bab consists of a very mild slope towards the Medjerda wadi, the natural terrain level varying between 50 to 60 m NGT, except in the South where a hilly headland ascends up to 75 m NGT.

The town of Nefza is located at the foot of the slopes of the Abiod and Essiouf mountains that border the town - to the South and East respectively.

The natural slope of the land of the town of Teboursouk enables good irrigation towards the wadi Barbari. The elevation of the natural terrain varies between 528 m NGT and 350 m NGT.

The town of Testour is nestled on small hills that border the right bank of the wadi Medjerda. Topographically, the town has a general natural slope in direction towards the wadi Medjerda.

The elevation of the natural terrain varies between 130 m NGT and 70 m NGT (at the level of the wadi).

Geology

The main geological characteristics for the communes of this governorate are given hereafter.

In the town of Béja, the soil is composed of limestone and marl towards the South, marked Qs on the map below (old soils).

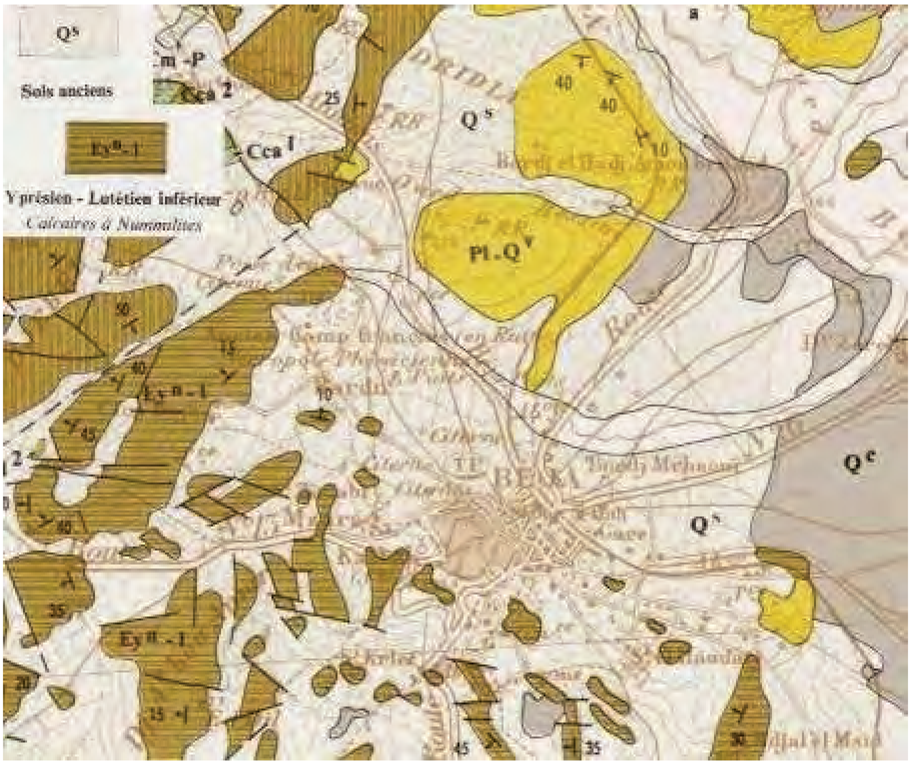


Figure 2.1-3: Geological map of Béja

In Medjez El Bab town, the encountered quaternary series are:

- Grayish to brownish sandy clay of the Medjerda plains: Holocene (Qh on the figure) ;
- Fine silt in the floodable zone and fine silt from sebkhas (sQ on the figure) ;
- Sandy clay with carbonated concretions and foliated calcareous crust (Qc on the figure).

Figure 2.1-4: Geological map of Medjez El Bab

In Nefza low-lying areas, there are alluvial soils on the side of the wadi Maâden, and clay-marl soils on the side of the mountains.

In Teboursouk, the nature of the soil varies between rock formations and clay soil.

Hydrology – Hydrogeology

The main hydrological and hydrogeological characteristics for the communes of this governorate are given hereafter.

The town of Béja is bordered by a range of mountains and crossed by several « chaâbets » (small wadis), where the river bed is often deviated during housing estate operations. Downstream from the town, all these wadis flow into the wadi Bouzegdem, a tributary of the wadi Béja.

The analysis of the ramifications of the river system shows that there are many winding bends of the wadi Medjerda when crossing Medjez El Bab. The only tributary of significance is the wadi Bourdim, which flows into the wadi Medjerda in the town center. Slightly downstream and to the North of the town, a second tributary, the wadi Meziz, crosses under the railway line, before rejoining the wadi Medjerda.

To the North, the town of Nefza is bordered by the plains of the wadi Maâden, the main watercourse that crosses the town and which is partly supplied by waters flowing from the Sidi El Barrak dam. Nefza is also crossed by many other smaller watercourses, of which the most important is the Chaâbet El Agoues which borders the communal domain of Nefza to the West and then rejoins further downstream the wadi Maâden.

2.1.3.3 Climate

The climate is heterogeneous, with an average temperature of 18.4ºC and four distinct bioclimatic zones, namely:

- Lower wet zone in the North with 800 to 1,200 mm/year of rainfall (26.7% of the governorate);
- Sub-wet zone in the delegations of Northern Béja, Southern Béja and part of Teboursouk, with 600 mm/year of rainfall (21.4% of the governorate);
- Higher semi-arid zone in the delegations of Medjez el Bab, Testour, Thibar and part of Teboursouk (35% of the governorate);
- Average semi-arid zone in the areas of Goublat, at the East of the delegation of Medjez-el-Bab and at the South of the delegation of Testour (17.1% of the governorate).

The average annual precipitation recorded in 31 years of observation (1976-2006) in the weather stations of Béja Inrat, Nefza and Teboursouk are 635 mm, 905 mm and 567 mm per annum.

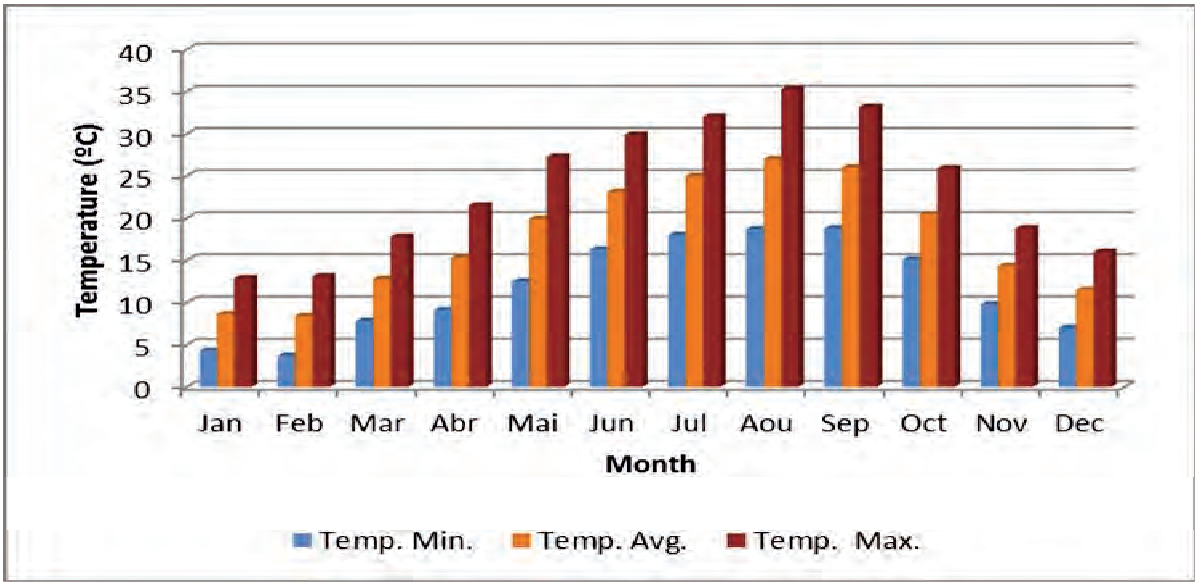


Figure 2.1-5: Minimum, average and maximum temperatures for Béja

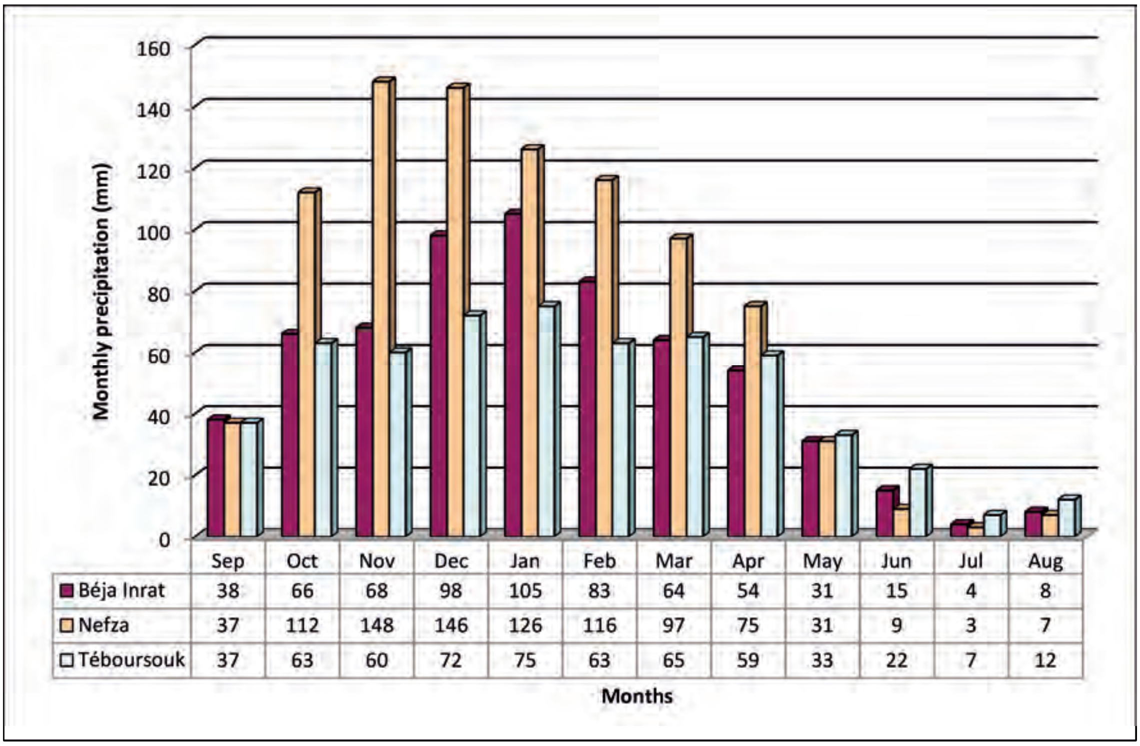


Figure 2.1-6: Annual rainfall in Béja (Source: INM)

2.1.3.4 Economic activities

The main economic activities of the governorate are agriculture and food processing industry. Nonetheless, there are also industrial estates and hotels located throughout the governorate. Based on ONAS' annual operating reports, the following table indicates the number of hotels and industrial units per commune as well as the water consumption of the industrial units connected to ONAS' network.

Table 2.1-4: Tourist Data and Industrial Data per commune

Commune	Tourist Data		Industrial Data	
	Number of hotels	Number of beds	Number of units	Consumption (m^3/j)
Béja	8	160	4	391
Medjez El Bab	1	46	2	335
Nefza	-	-	-	-
Testour	1	20	-	-
Teboursouk			-	-
El Maagoula	-	-	-	-
Total	**10**	**226**	**6**	**726**

Source: Tunisian Hotel Business Federation – 2010 and ONAS 2010

2.1.3.5 Sanitation service indicators

The following table summarizes the key indicators that have been estimated for the Béja Governorate. The indicators refer to the service of wastewater sanitation and were divided by territorial and demographic indicators, service levels indicators, infrastructure indicators and operational indicators. The estimation of these indicators takes into account the latest data provided by the entities consulted during this study.

Table 2.1-5: Indicators of sanitation service for the Béja governorate

Indicator category	Indicators	Unit	Value
Territorial and demographic indicators	Communes taken in charge by ONAS	un.	6
	Population taken in charge by ONAS in 2004	inhabit.	114,433
	Estimated population taken in charge by ONAS in 2010	inhabit.	117,668
	Households in the communes taken in charge by ONAS in 2004	un.	27,654
	Dwelling in the communes taken in charge by ONAS in 2004	un.	30,135
	Inhabitants per dwelling in 2004	inhabit.	3.8
	Growth rate of the number of dwelling	%	6.52
	Governorate area	km^2	3,558
	Estimated population density of the administrative center commune (Béja) in 2004	$inhabit./km^2$	4,497
Level of Service Indicators	Estimated connected population (2010)	inhabit.	116,256
	Number of installations connected to ONAS 2009 (*)	u.	32,850
	Connection rate in 2010	%	98.8
	Connection rate expected in 2029	%	99.2
	House sewer connections in 2010	un.	22,839
Infrastructure indicators	Linear length of the sewage networks	km	344
	Pumping stations	un.	19
	Wastewater treatment plants	un.	6
	Estimated length of the sewage networks to be rehabilitated	km	30,2
	Estimated length of the sewage networks to be extended	km	8,4
	Estimated new house sewer connections	un.	900
	Pumping stations to be rehabilitated	un.	1
	Pumping stations to be built	un.	5
Operational Indicators	Estimated drinking water consumption in 2010 (domestic, industrial, commercial/collective and tourist users) (1)	m^3/day	17,792
	Estimated infiltration into sewer	m^3/day	889
	Estimated wastewater flow	m^3/day	18,681

(1) Main source of drinking water supply data: SONEDE

Large-scale water consumers: Yeast manufacturing company of Béja, sugar factories, carbonated drink factories, SICAM factories.

(*) - Data not available for 2010

The average specific consumption of drinking water in the governorate is 104 L per capita per day and has been estimated on the basis of data from SONEDE (annual volume consumed and the served population in 2009). For each commune, the specific consumption of drinking water is indicated below:

Table 2.1-6: Specific consumption of drinking water (2009)

Commune	Specific consumption of drinking water 2009 (L per capita per day)
Béja	110
Medjez El Bab	120
Nefza	85
Testour	85
Teboursouk	85

The interventions proposed for each commune of Béja governorate are summarized in the following table:

Table 2.1-7: Planned Interventions by commune for the Governorate of Béja

Communes	Rehabilitation		Extension	
	Networks (u.)	Pumping stations (u.)	Networks (u.)	Pumping stations (u.)
Béja	5	0	2	0
Maagoula	1	0	0	1
Medjez El Bab	7	1	0	0
Nefza	2	0	10	2
Teboursouk	2	0	2	1
Testour	1	0	2	1
Total	**18**	**1**	**16**	**5**

2.1.4 Bizerte Governorate

2.1.4.1 Geographical and demographic context

Bizerte governorate, whose southern limit is located at about thirty kilometers from the capital Tunis, includes the most northern point of Africa. It is bordered by the Mediterranean Sea in the North (250 kilometers of coast), by Béja governorate in the South-West, and by the governorates of Manouba and Ariana in the South-East.

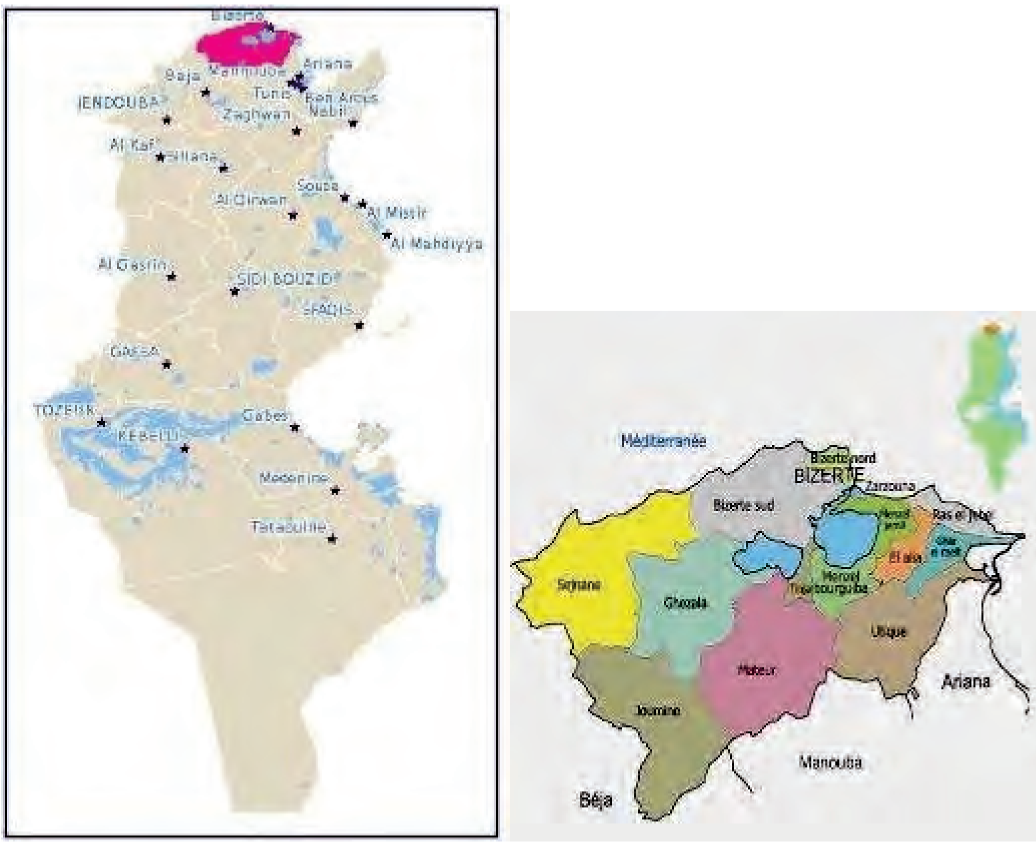


Figure 2.1-7: Maps of location and of delegations of Bizerte governorate

The Bizerte Governorate had a population of 524,128 inhabitants in 2004 which corresponded to 5.29% of the population of Tunisia. The same year, the total number of households was 119,976 and the dwellings were 137,176.

In this governorate, the following communes are considered in this study: Alia, Bizerte, Mateur, Menzel Abderrahmen, Menzel Bourguiba, Menzel Jamil, Raf Raf, Tinja and Zarzouna.

The city of Bizerte is located 60 kilometers to the Northwest of Tunis and 5 kilometers from Cap Blanc, the northernmost point in Africa. The town is located Southeast of an isthmus on the north bank of the Bizerte canal, connecting the sea to Lake Bizerte. It is linked by a mobile bridge to the rest of the urban area, that is located on the south bank of the canal, formed by the town of Zarzouna and the towns of Menzel Jamil and Menzel Abderrahmane.

The town of Menzel Bourguiba is located around 15 km to the South of Bizerte. It is the second largest town in the Bizerte governorate, after Bizerte itself (administrative center of the governorate).

The commune of Tinja belongs to the delegation of Menzel Bourguiba in the Bizerte governorate. It is bordered to the East by the town of Menzel Bourguiba, to the Northwest by the Djebel Tinja mountain and to the West by Lake Ichkeul.

The town of Raf Raf - a commune of the delegation of Ras Djebel - is located 5 km from Ras-Djebel in a farming region.

The town of El Alia is located around 20 kilometers South East from Bizerte. It is perched on a slope of the Djebel Touabine mountain, whose peak stands at 295 m above sea level.

According to the 2004 census, we can observe the following records by commune and district taken in charge:

Table 2.1-8: Population, Households and Dwellings for the communes and districts taken in charge in Bizerte Governorate (2004)

Communes Districts	Population	Households	Dwellings
Bizerte	114,371	29,260	34,817
Bizerte Medina	25,432	6,888	8,561
Zarzouna	24,428	6,563	6,876
Aïn Mariam	46,060	11,536	14,731
Hached	18,451	4,273	4,649
Mateur	31,345	7,339	7,604
Mateur	18,944	4,656	4,972
Cité El Omrane	12,401	2,683	2,632
Menzel Bourguiba	47,742	11,383	12,458
Menzel Bourguiba	12,631	3,288	3,864
Cité Etthaoura	11,003	2,654	2,845
Cité En-Najah	24,108	5,441	5,749
Tinja	17,454	4,009	4,611
Menzel Jamil	18,344	4,368	6,712
Menzel Abderrahmen	16,824	3,805	4,768
El Alia	16,819	3,531	4,210
Raf Raf	9,839	2,522	4,867
Raf Raf	7,883	2,040	2,624
Raf Raf Plage	1,956	482	2,243
Total	**272,738**	**66,217**	**80,047**

2.1.4.2 Physical context

Topography

The main topographical characteristics for the communes of this governorate are given hereafter.

The outcrops of Upper Cretaceous, Ypresien and Oligocene constitute the principal frame of the reliefs of Bizerte governorate. From the West and to the East, the altitudes are reduced from 300m (Jebels Hadida, Loubera, and Zoukar) to 150 to 200m (Jebels Ed Dib, Rhezlane, Et Touila, Beni Moslem and Ali Ben Trad).

Plateaus, often quite vast (Henchir Ez Zafta, El Mouajène, Zebboudje, El Metline, Ben Aouf, etc…), are crossed by wadis, the biggest of which are: Wadi El Mechra, Wadi El Merazig and Wadi Damous.

In Tinja, general topography of the city is almost flat in the center, with an elevation of 9 m NGT for a zone located between the Mateur road and the train station. Each side of this zone, the elevations fall to 5 m NGT, both to the North and to the South.

Raf Raf is perched on the spur of the Northern point of the Djebel Boukornine mountain belonging to Tunisian Ridge. It is located on a small area of level change within the mountain slope.

The town of El Alia is located at an altitude between 70 m and 140 m NGT above sea level, and is around 10 km from the sea. It has steep slopes, some with gradients of more than 15 %.

The town of Mateur is located on very gently sloping plain, bordered by a terrain with rugged relief to the East, South and West.

Geology

The main geological characteristics for the communes of this governorate are given hereafter.

The Quaternary soils of Bizerte town and its surroundings are composed of:

- Qp^c on the figure 2.1-8: Sandy to silty sand colluvium and brown limestone
- O on the figure 2.1-8: Sandy and glauconitic clay and sandstone (Djebel Sébaa Facies)

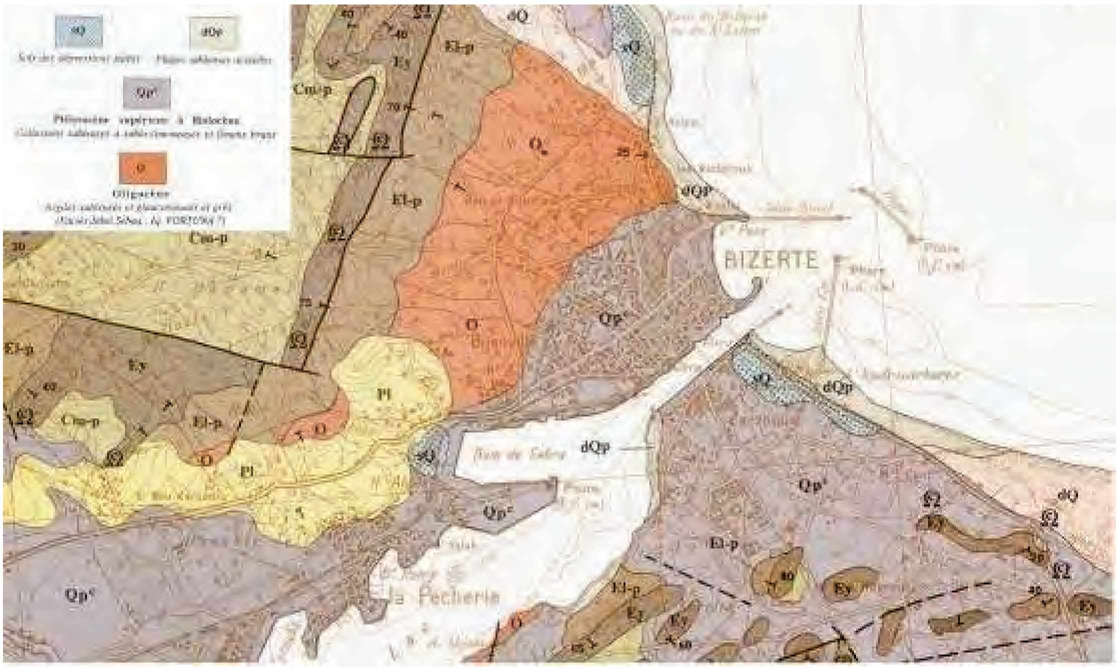


Figure 2.1-8: Geological map of Bizerte

Hydrogeology - Hydrology

The main hydrological and hydrological characteristics for the communes of this governorate are given hereafter.

Bizerte town is crossed by the « Bizerte canal » connecting the Mediterranean sea and the Bizerte Lake. From the geological map given above, we may note the existence of salty depressions (sQ), lakes created by the proximity of the sea and not by non-existent rain flows (wadis).

The region of Menzel Bourguiba is characterized by the presence of Bizerte Lake, which is supplied in water by the wadi Tinja and the Ichkeul water basin. The lake, with a surface area of 120 km² and a maximum depth of 12 m, occupies a rift which has served for all times as an excellent refuge for sailors.

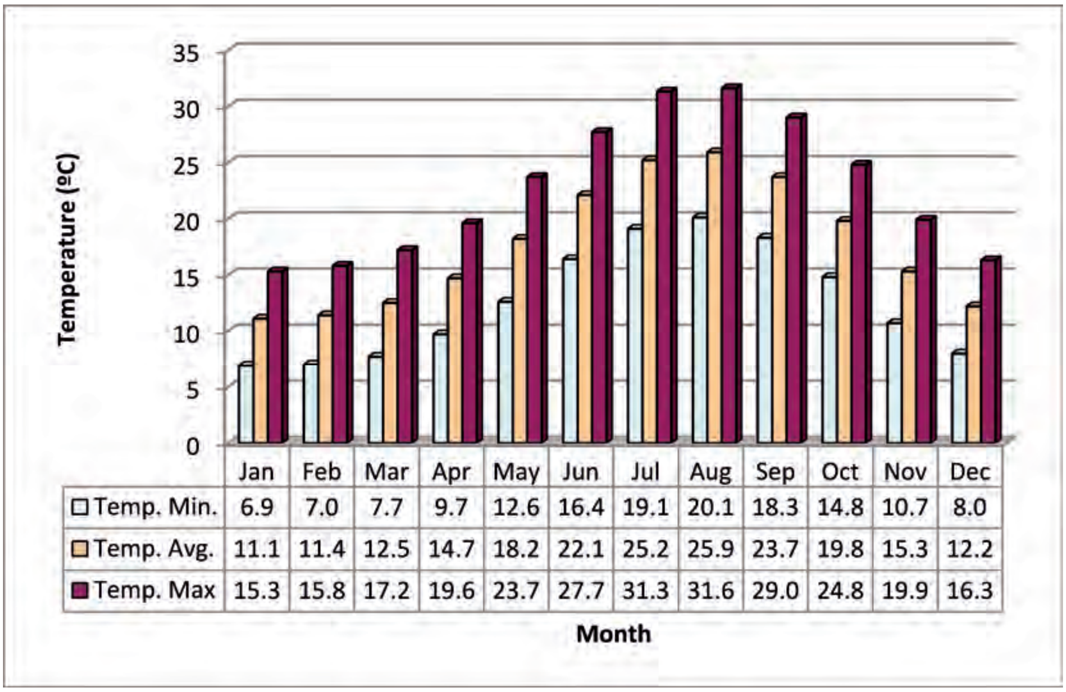
The town of Raf Raf is principally crossed by the wadi Ain Bled and the wadi El Mâa which channel rainwater from the dominant water basins of the Djebel Nadhour mountain and Sidi Brahem.

In the town of El Alia, rainwater from the Djebel Touabine mountain partly flows across the town before flowing into the wadi Zorhba and the wadi El Melah, located to the East and West of the town respectively. After heavy rainfall, this causes silting-up of the road RR70, thus creating serious problems for the municipality.

The town of Mateur is crossed by the wadi Tine and the wadi Joumine, which flow into Ichkeul Lake.

2.1.4.3 Climate

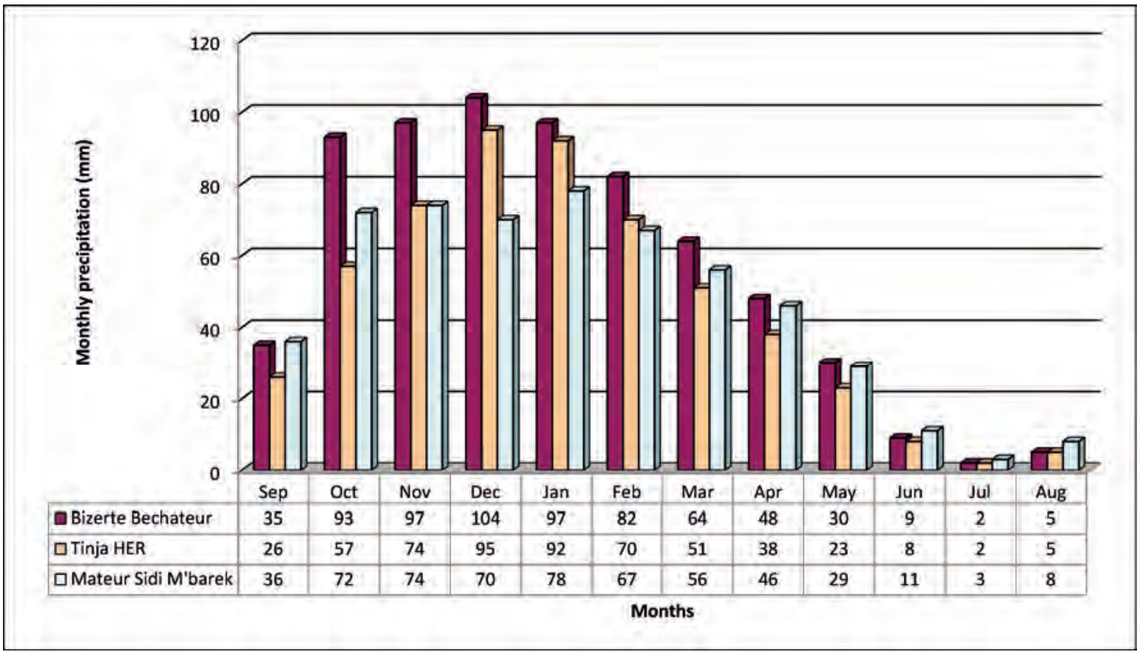
The climate of the Bizerte region is semi-humid, influenced by its proximity to the sea. The daily and seasonal variations of temperature are mild and there is almost no risk of frost. The following figure summarizes the average temperatures recorded by the weather station for the Bizerte region (1965- 1990).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp. Min.	6.9	7.0	7.7	9.7	12.6	16.4	19.1	20.1	18.3	14.8	10.7	8.0
Temp. Avg.	11.1	11.4	12.5	14.7	18.2	22.1	25.2	25.9	23.7	19.8	15.3	12.2
Temp. Max	15.3	15.8	17.2	19.6	23.7	27.7	31.3	31.6	29.0	24.8	19.9	16.3

Figure 2.1-9: Minimum, average and maximum temperatures for Bizerte

The average annual precipitation levels recorded in 31 years of observation (1976-2006) in the weather stations of Bizerte Bechateur, Tinja HER and Mateur Sidi M' barek are 663 mm, 539 mm and 549 mm per annum.



	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Bizerte Bechateur	35	93	97	104	97	82	64	48	30	9	2	5
Tinja HER	26	57	74	95	92	70	51	38	23	8	2	5
Mateur Sidi M'barek	36	72	74	70	78	67	56	46	29	11	3	8

Figure 2.1-10: Annual rainfall in Bizerte (Source: INM)

The city of Tinja is located in a relatively rainy region, receiving average annual rainfall higher than 600 mm.

The town of Menzel Bourguiba is located in a relatively rainy region, receiving average annual rainfall higher than 600 mm. The temperature is high in the summer and mild in the winter. The temperature gap may rise to 40°C.

The region of Raf Raf is characterized by its relatively humid climate. Average annual rainfall is 600 mm and average annual temperature is 18°C.

In terms of the local climate, the average annual rainfall recorded in the region of El Alia – Bizerte is 625 mm, distributed across 113 days. The average annual temperature is 18°C and the average minimum temperature is 6°C.

The town of Mateur is located in a relatively rainy region, receiving average annual rainfall higher than 600 mm. The temperature is high in the summer and low in the winter. The temperature gap may rise to 40°C.

2.1.4.4 Economic activities

The main economic activities of Bizerte governorate are agriculture, fishing, food-processing and mechanical industry. Numerous efforts have been pursued in the agriculture sector, in particular in some fields: hydro-agricultural developments, land settlement, protection of the natural environment, support for small- and medium-sized enterprises and intensification of production. Food processing activities have been developed in this region, which produces 25% of Tunisia's milk production.

For the other economic sectors, port-based industrial activities constitute one of the main sectors of the Bizerte governorate.

There are several hotels throughout the governorate. On the basis of ONAS' annual operating reports, the following tables present the number of hotels and of the industrial units per commune as well as the water consumption of the industrial units connected to ONAS' network.

Table 2.1-9: Tourist Data and Industrial Data per commune

Commune	Tourist Data		Industrial Data	
	Number of hotels	Number of beds	Number of units	Consumption (m^3/j)
Bizerte	10	692	85	814
Zarzouna	-	-	6	40
Tinja	-	-	6	16
Menzel Bourguiba			3	74
Raf Raf	2	42	-	-
Menzel Jamil	-	-	2	21
Menzel Abderrahmane	-	-	-	-
Alia	-	-	-	-
Mateur	-	-	25	178
Total	**12**	**734**	**127**	**-**

Source: Tunisian Hotel Business Federation – 2010 and ONAS 2010

2.1.4.5 Sanitation service indicators

The following table summarizes the key indicators that have been estimated for the Bizerte Governorate. The indicators refer to the service of wastewater sanitation and were divided by territorial and demographic indicators, service levels indicators, infrastructure indicators and Operational Indicators.

Table 2.1-10: Indicators of sanitation service for the Bizerte governorate

Indicator category	Indicators	Unit	Value
Territorial and demographic indicators	Communes taken in charge by ONAS	un.	10
	Population taken in charge by ONAS in 2004	inhabit.	284,845
	Estimated population taken in charge by ONAS in 2010	inhabit.	301,145
	Households in the communes taken in charge by ONAS in 2004	un.	68,939
	Dwelling in the communes taken in charge by ONAS in 2004	un.	83,315
	Inhabitants per dwelling in 2004	inhabit.	5
	Growth rate of the number of dwelling	%	N/A
	Governorate area	km^2	3,685
	Estimated population density of the administrative center commune (Bizerte) in 2004	$inhabit./km^2$	3,364
Level of Service Indicators	Estimated connected population 2010	inhabit.	295,423
	Number of installations connected to ONAS 2009 (*)	u.	60,562
	Connection rate in 2010	%	98.1
	Connection rate expected in 2029	%	99.5
	House sewer connections in 2010	un.	53,080
Infrastructure indicators	Linear length of the sewage networks	km	714
	Pumping stations	un.	46
	Wastewater treatment plants	un.	3
	Estimated length of the sewage networks to be rehabilitated	km	67.3
	Estimated length of the sewage networks to be extended	km	26.5
	Estimated new house sewer connections	un.	2,000
	Pumping stations to be rehabilitated	un.	10
	Pumping stations to be built	un.	6
Operational Indicators	Estimated drinking water consumption in 2010 in 2010 (domestic, commercial/collective and tourist users) (1)	m^3/day	65,075
	Estimated infiltration into sewer	m^3/day	N/A
	Estimated wastewater flow	m^3/day	39,030

N/A - No Data Available
(1) Source of the drinking water supply: SONEDE from dams and deep wells
SONEDE Subscribers in 2009: (98,682 domestic, 9,197 industries, 55 touristic)
12 large-scale consumers (the quarterly consumption exceeds 500 m^3).
(*) – Data not available for 2010

The average specific consumption of drinking water in the governorate is 102 L per capita per day and has been estimated on the basis of data from SONEDE (annual volume consumed and the served population in 2009). For each commune, the specific consumption of drinking water is indicated as follows:

Table 2.1-11: Specific consumption of drinking water (2009)

Commune	Specific consumption of drinking water 2009 (L per capita per day)
Bizerte	120
Zarzouna	110
Tinja	85
Menzel Bourguiba	100
Raf Raf	160
Menzel Jamil	80
Menzel Abderrahmane	80
Alia	85
Mateur	80

The specific consumption in the town of Raf Raf is high due to the high consumption of water during the summer season, as a result of its use as a tourism resort.

The interventions proposed for each commune of Bizerte governorate are summarized in the following table:

Table 2.1-12: Planned Interventions by commune for the Bizerte Governorate

Communes	Rehabilitation		Extension	
	Networks (u.)	Pumping stations (u.)	Networks (u.)	Pumping stations (u.)
Bizerte	6		1	1
El Alia	1			
Mateur		2		
Menzel Abderrahmane	1	1		
Menzel Bourguiba	2		2	1
Menzel Jamil	2	2		
Raf Raf	1			2
Tinja	2	1	3	2
Zarzouna	1	3		
Total	**16**	**9**	**6**	**6**

2.1.5 Jendouba Governorate

2.1.5.1 Geographical and demographic context

The governorate of Jendouba is located at the North-Western end of Tunisia, at 150 kilometers from the capital Tunis. It is bordered by the governorates of El Kef and Siliana to the South, and the Béja governorate in the East. It has 135 kilometers of border with Algeria in the West and is bordered by the Mediterranean Sea in the North, with a 25 kilometer long coast.

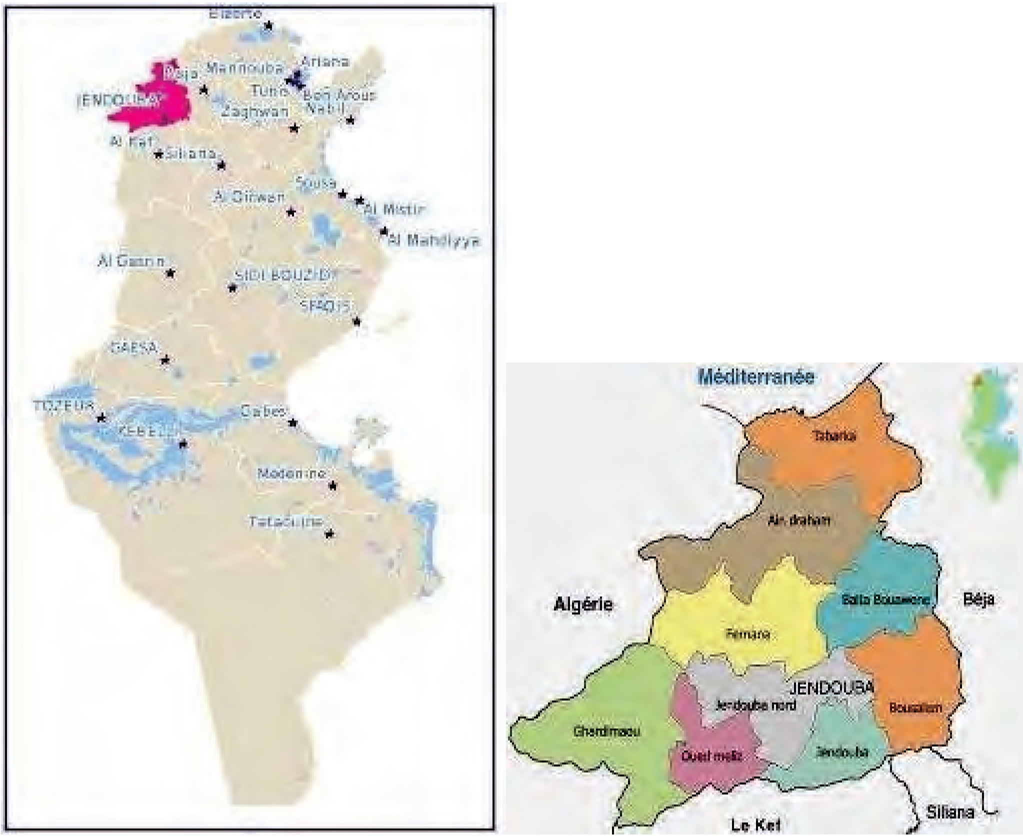


Figure 2.1-11: Maps of location and of delegations of Jendouba governorate

The Governorate of Jendouba had a population of 416,608 inhabitants in 2004 which corresponded to 4.20% of the population of Tunisia. The same year, the total number of households was 92,877 and the dwellings were 103,244.

In this Governorate, the communes which are part of this study are the following: Jendouba, Boussalem, Tabarka, Fernana, and Ghardimaou.

Jendouba town, the administrative center of the governorate, is located at 155km from Tunis on the RN6 road and 40km from the Tunisian-Algerian border. It represents an important communication hub on the North-South main roads (El Kef – Tabarka) and East-West (Tunis – Algeria). It is also crossed by the Tunis – Algeria railroad. Jendouba extends to the interior of a big meander of the Medjerda wadi. The urban extension crosses the wadi and goes to the west up to the foothills dominating the town.

The town of Boussalem, a delegation of the Jendouba Governorate, is located in the middle of the alluvial plain of the upper section of the wadi Medjerda. It is located on the left bank of the wadi Medjerda, between the wadi Bou Hertma and the wadi Kasseb. It is crossed by the RN6 road and by the railway line.

The town of Ghardimaou, a delegation of the Jendouba Governorate, is located in the Northwest zone of Tunisia, 190 km from Tunis and several kilometers from the Algerian-Tunisian border, at the end of the upper valley of the Medjerda. It is crossed by the RN6 road and by the railway line. The town has been built up around the Train station. It is divided in the middle by the river bed of the wadi Medjerda.

Tabarka town, administrative center of a delegation of the Jendouba governorate, is located at the coastline. The region is part of the Kroumirie Tell massif.

According to the 2004 census, we can observe the following records by commune and district taken in charge:

Table 2.1-13: Population, Households and Dwellings for the communes and districts taken in charge in the Governorate of Jendouba (2004)

Communes Districts	Population	Households	Dwellings
Jendouba	43,997	10,515	12,031
Jendouba	31,167	7,597	8,720
El Hédi Ben Hassine	12,830	2,918	3,311
Boussalem	20,098	4,769	5,518
Tabarka	15,634	3,831	5,926
Fernana	2,395	557	645
Ghardimaou	19,688	4,562	5,764
Total	**101,812**	**24,234**	**29,884**

2.1.5.2 Physical context

Topography

The main topographical characteristics for the communes of this governorate are given hereafter.

The Jendouba region covers two very different morphological areas:

- In the South, a relatively vast mountainous region, represented by Djebel Goraa and Djebel Ghozlane which are separated by the Hammam Biadha plain.
- The Boussalem – Thibar plain in the North.

The Djebel Goraa constitutes the most important orographic feature in the region. It extends SW-NE for more than 30 km. The crests are highest at the Eocene Synclinal basin.

The entire area of Tabarka is composed of sharp reliefs, including sometimes mountains. The slopes are very steep and the valley flanks are subject to intense runoff due to significant rainfall and the impermeable nature of soil.

Geology

The main geological characteristics for the communes of this governorate are given hereafter.

The town of Jendouba is located in the middle valley of Medjerda, an alluvial plain occupying a vast synclinal bottom with the accumulation of thick sedimentary layers. The alluvial soils are often quite dense, thus providing excellent wheat fields.

Figure 2.1-12: Geological map of Jendouba

The Tabarka region constitutes a structural unit formed by detrital deposits (sandstone, marl and clay). These sandstone or sandstone-clayey outcrops have essentially led to the development of brown soils, characterized by an average to fine texture (silty-sandy or clayey-sandy) which is almost impermeable.

The extreme Northwest region is dominated by an outcropping of a huge flysch mass dating from the Oligocene period.

This monotonous series is composed of alternating sandstone layers and clayey layers. The frequency of sandstone banks generally determines the highest topographical points.

Almost all the wadis cross the flysch zone for a major portion of their course. The softness and heterogeneity of this formation has led to the digging of wide and deep thalwegs.

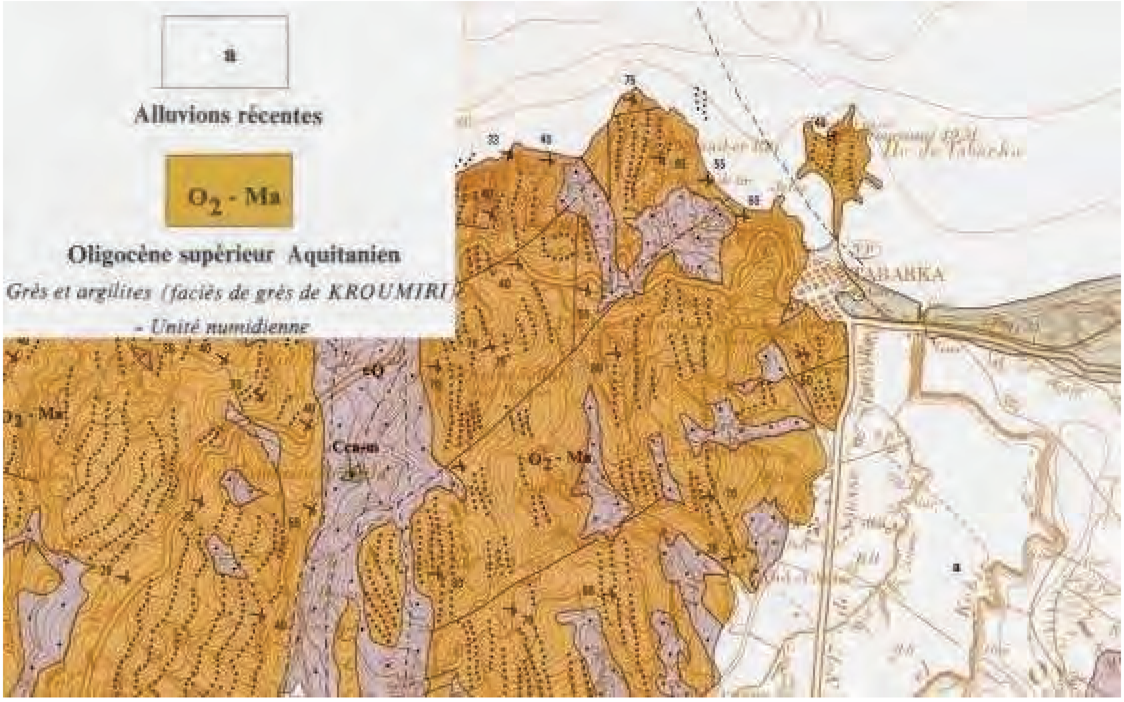


Figure 2.1-13: Geological map of Tabarka

Hydrogeology - Hydrology

The main hydrological and hydrogeological characteristics for the communes of this governorate are given hereafter.

The town of Jendouba is located in the middle of the valley of the wadi Medjerda. The hydrogeological importance of the Eocene limestone and its location in the perched synclinal of Djebel Goraa makes a veritable water saturated basin which supplies the different sources in the region (Ain Seyala, Ain Midoun, and Ain Dinar).

The Tabarka plain was found to have a single thin aquifer ground water table, with an open air surface close to the eastern border of the valley, and which is captive west and downstream under the clay cover. This ground water flow is estimated at 180l/s. It is not used today to provide potable water to the Tabarka town since its water is too ferruginous and is presently only used to irrigate small plots.

The town of Boussalem is located in a long, shallow basin, which impedes water from flowing towards the wadi Medjerda.

Ghardimaou is bordered to the South by a mountain range, which creates major problems of flooding in the town.

2.1.5.3 Climate

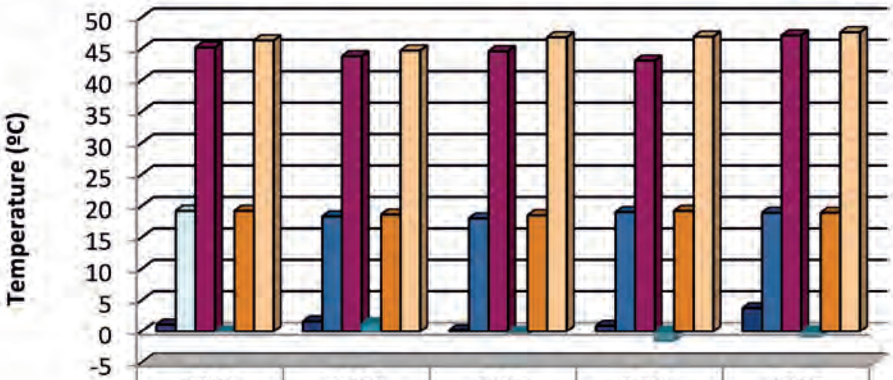
This governorate is characterized by a continental climate, the rainiest in the country. This climate is rigorous and severe with annual precipitations reaching 405.6 mm/year in average value and 1,000 millimeters on the littoral. For the governorate, the annual average temperature is 17.7 ºC.

The town of Jendouba and Boussalem have a slightly semi-arid climate typical of the basin of the wadi Medjerda, with very hot summers. The average annual rainfall is 450 mm, and the average annual temperature is 17°C.

The Ghardimaou region has a rainy Mediterranean climate. The average annual rainfall is 1,000 mm. Temperatures are moderate.

Tabarka is characterized by its humid climate with mild winters. Annual average rainfall is 1,048 mm. Average annual temperature is 18°C, with very high maximum values recorded in August.

The following figure presents the minimum, average and maximum temperatures, supplied by the weather stations of Tabarka and Jendouba between 2003 and 2007.

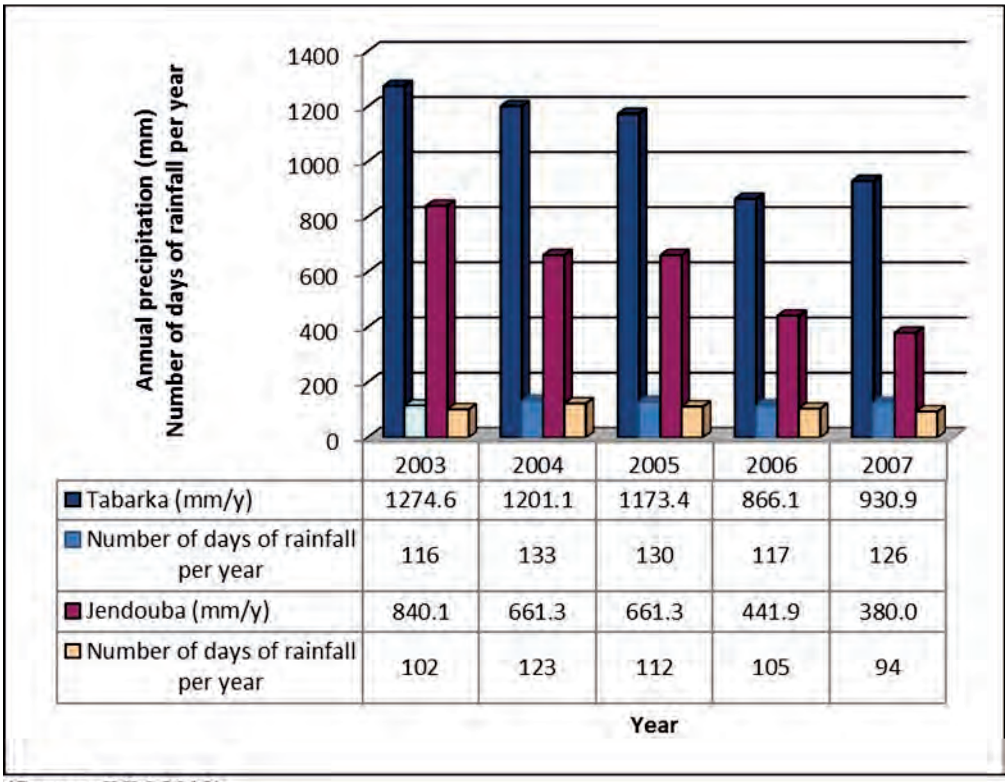


	2003	2004	2005	2006	2007
Tabarka Min.	1.1	1.6	0.2	0.9	3.7
Tabarka Avg.	19.2	18.3	18	19	18.9
Tabarka Max.	45.2	43.8	44.6	43.1	47.1
Jendouba Min.	0.0	1.3	-0.5	-1.5	-0.8
Jendouba Avg.	19.2	18.6	18.5	19.2	18.9
Jendouba Max.	46.3	44.7	46.8	46.9	47.6

Year

Figure 2.1-14: Minimum, average and maximum temperatures for Tabarka and Jendouba (Source: INM 2010)

The following figure shows the annual rainfall, as well as the number of days of rainfall per year, for Tabarka and Jendouba.



(Source: INM 2010)

Figure 2.1-15: Annual rainfall in Tabarka and Jendouba

2.1.5.4 Economic activities

The main economic activities of the governorate are agriculture, food processing industry and also tourism, essentially in Tabarka which is a touristic town renowned for its underwater diving activity (seabed well stocked with fish where fishing of grouper or lobster is done) and for coral used in jewelry.

Based on ONAS' annual operating reports, the following table presents the number of hotels and industrial units per commune as well as the water consumption of the industrial units connected to ONAS' network.

Table 2.1-14: Tourist Data and Industrial Data per commune

Commune	Tourist Data		Industrial Data	
	Number of hotels	Number of beds	Number of units	Consumption (m^3/j)
Jendouba	3	86	9	396
Tabarka	20	5,304	6	314
Boussalem	-	-	5	112
Ghardimaou	1	26	2	34
Fernana	-	-	1	14
Total	**24**	**5,416**	**23**	**870**

Source: Tunisian Hotel Business Federation – 2010 and ONAS 2010

2.1.5.5 Sanitation service indicators

The following table summarizes the key indicators that have been estimated for the Jendouba Governorate. The indicators refer to the service of wastewater sanitation and were divided by territorial and demographic indicators, service levels indicators, infrastructure indicators and operational indicators. These indicators have been estimated taking into account the latest data provided by the entities consulted for this study.

Table 2.1-15: Indicators of sanitation service for the governorate of Jendouba

Indicator category	Indicators	Unit	Value
Territorial and demographic indicators	Communes taken in charge by ONAS	un.	5
	Population taken in charge by ONAS in 2004	inhabit.	101,812
	Estimated population taken in charge by ONAS in 2010	inhabit.	106,877
	Households in the communes taken in charge by ONAS in 2004	un.	24,234
	Dwelling in the communes taken in charge by ONAS in 2004	un.	29,884
	Inhabitants per housing in 2004	inhabit.	3.6
	Growth rate of the number of dwelling	%	2
	Governorate area	km^2	3,102
	Estimated population density of the administrative center commune (Jendouba) in 2004	inhabit./km^2	4,458
Level of Service Indicators	Estimated connected population 2010	inhabit.	97,258
	Number of installations connected to ONAS 2009 (*)	u.	29,615
	Connection rate in 2010	%	91
	Connection rate expected in 2029	%	92
	House sewer connections in 2010	un.	21,000
Infrastructure indicators	Linear length of the sewage networks	km	307
	Pumping stations	un.	37
	Wastewater treatment plants	un.	5
	Estimated length of the sewage networks to be rehabilitated	km	29
	Estimated length of the sewage networks to be extended	km	30
	Estimated new house sewer connections	un.	1,700
	Pumping stations to be rehabilitated	un.	5
	Pumping stations to be built	un.	4
Operational Indicators	Estimated drinking water consumption in 2010 in 2010 (domestic, industrial, commercial/collective and tourist users) (1)	m^3/day	31,998
	Estimated infiltration into sewer	m^3/day	44
	Estimated wastewater flow	m^3/day	12,666

(1) Source: SONEDE
(*) – Data not available for 2010

The average specific consumption of drinking water in the governorate is 120 L per capita per day and has been estimated on the basis of data from SONEDE (annual volume consumed and the served population in 2009). For each commune, the specific consumption of drinking water is indicated as follows:

Table 2.1-16: Specific consumption of drinking water (2009)

Commune	Specific consumption of drinking water 2009 (L per capita per day)
Jendouba	110
Tabarka	110 500 *
Boussalem	64
Ghardimaou	65
Fernana	64

* - specific consumption of drinking water for touristic users

The specific consumption in the town of Tabarka is high, due to the high water consumption of the touristic zone during the summer season.

The interventions proposed for each commune of Jendouba governorate are summarized in the following table:

Table 2.1-17: Planned Interventions by commune for the Governorate of Jendouba

Communes	Rehabilitation		Extension	
	Networks (u.)	Pumping stations (u.)	Networks (u.)	Pumping stations (u.)
Boussalem			1	1
Fernana	1		1	1
Ghardimaou	1		2	1
Jendouba	3	4	1	1
Tabarka	1	1	3	2
Total	**6**	**5**	**8**	**6**

2.1.6 Kasserine Governorate

2.1.6.1 Geographical and demographic context

Kasserine Governorate is bordered by the Governorates of El Kef and Siliana in the North, Sidi Bouzid in the East, Gafsa in the South and by Algeria (with 220 kilometers of common border) in the West.

Located at the center of the Thala-Sbeitla-Feriana triangle, the Kasserine region belongs to the Hauts Plateaux (High Plateaus) zone in the center of Tunisia, both with respect to its geographical position as well as its climate and morphology.

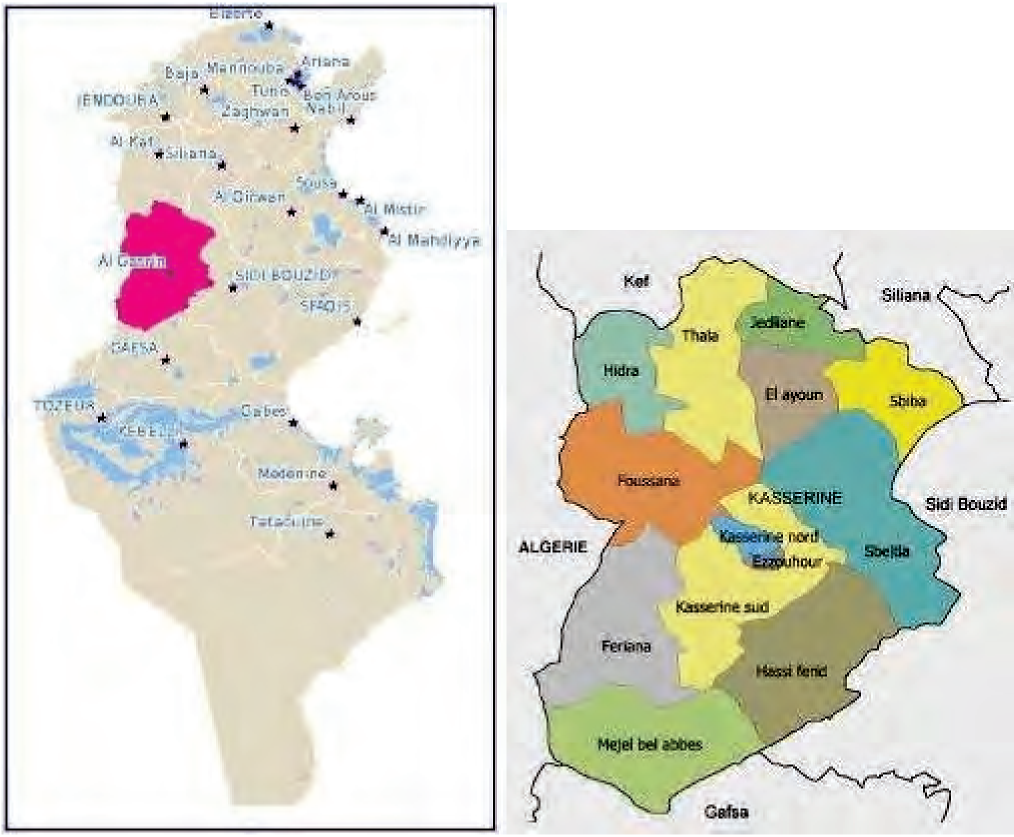


Figure 2.1-16: Maps of location and of delegations of Kasserine governorate

The Kasserine Governorate had a population of 412,278 inhabitants in 2004 which corresponded to 4.16% of the population of Tunisia. The same year, the total number of households was 79,448 and the dwellings were 89,737.

In this governorate, the communes which are part of this study are the following: Kasserine, Sbeitla, Thala, and Feriana.

According to the census of 2004, we can observe the following records by commune and district taken in charge:

Table 2.1-18: Population, Households and Dwellings for the communes and districts in Kasserine Governorate (2004)

Communes Districts	Population	Households	Dwellings
Kasserine	76,243	15,717	17,323
Kasserine	19,982	4,436	5,118
Cité Ennour	35,984	7,247	7,803
Ezzouhour	20,277	4,034	4,402
Sbeitla	20,253	4,168	4,628
Total	**96,496**	**19,885**	**21,951**

2.1.6.2 Physical context

Topography

Kasserine governorate average altitude is relatively high, with the highest point in Tunisia in the Kef Châmbi (1544m). The lowest point in Kasserine is at 565m.

Geology

The geology of Kasserine town and its surroundings is principally composed of:

- Slope eluvia and alluvia with or without surface pebbles (designated Aa on the figure 2.1-17);
- Sandstone, sand and clay with silicified plants (m^3 on the figure 2.1-17).

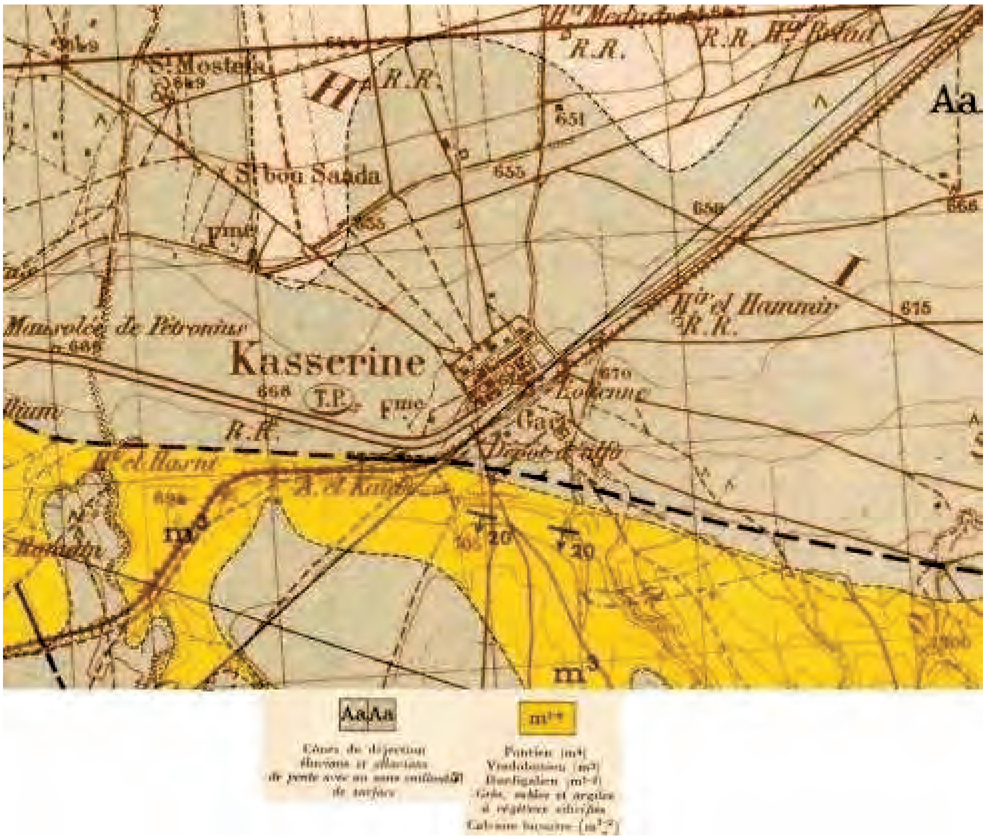


Figure 2.1-17: Geological map of Kasserine

Hydrology and Hydrogeology

The Kasserine region has two very distinct hydraulic systems:

a) The Kasserine Plain

The Kasserine plain (NE zone) is a transversal rift valley filled by a high accumulation of continental quaternary sediments with thickness more than 300 m.

The stratigraphic study of drillings showed that the quaternary sediments in the plain were composed of alternating more or less clayey sand, pebbles and clay, therefore of permeable levels separated by watertight screens. These lenticular formations are connected to each other. Sandy and coarse areas are bigger at the border and pass through more marly zones in the center. This is why the existence of a compartmentalized single ground water table was accepted.

From the hydraulic view point, a heterogeneous surface ground water level was found. The water is close to the surface at all points. The flow is from West to East with a mild slope. In the North West, the El Hattab wadi supplies the ground water table. In the East, it plays the role of a central collector drain. The terrain elevation levels vary from 628 to 671 m NGT. The ground water levels vary respectively from 622.5 to 645.20 m NGT.

b) <u>The Kasserine Cliff</u>

The Kasserine hydraulic sill, marked by the Kasserine cliff and its huge fault, is connected to the quaternary rift valley of the Hattab wadi. The Kasserine cliff region constitutes a clearly specific hydraulic structural unit.

The terrains, known by their outcrops on the sides of folds and at depth through drillings, are from bottom to top:

b-1) Upper Cretaceous limestones:

Cretaceous limestones and Miocene sandstones constitute a unique aquifer. Each horizon differs only by its hydraulic characteristics. Limestones are generally permeable through karstic circulation in the open cracks. Their specific flow rate is high. Permeable sandstones with circulation in the cracks also constitute a favorable aquifer horizon.

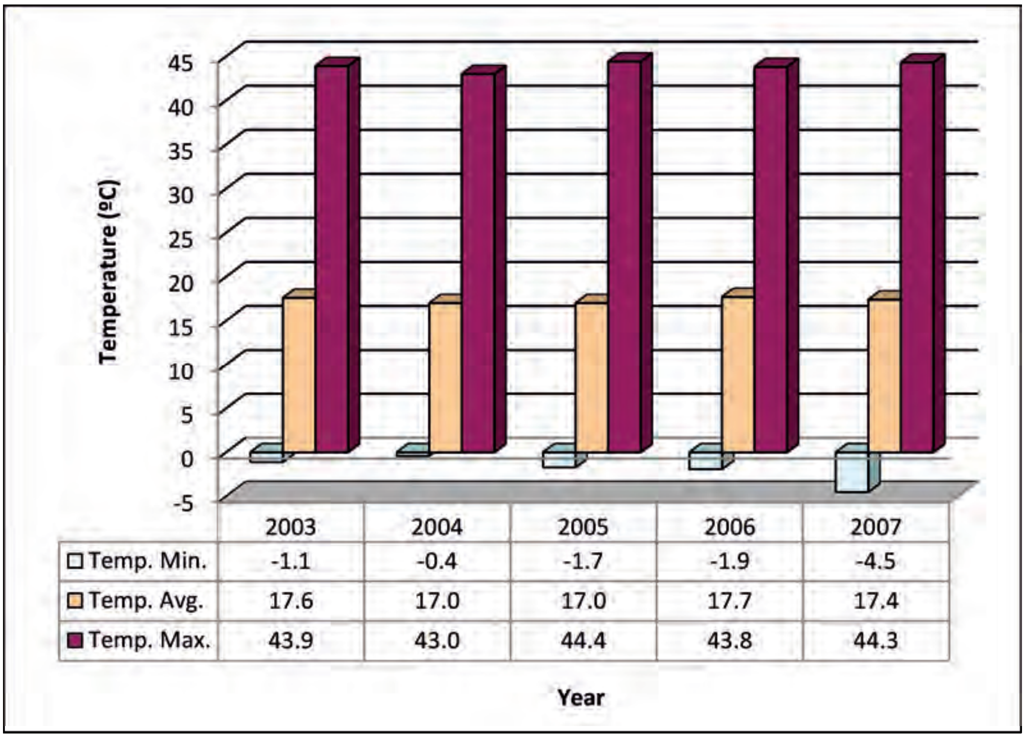
b-2) Miocene sandstones:

As shown in survey works, the Kasserine cliff is a fracture zone in contact with two differentiated lithological compartments: In the South, the Miocene sandstones lying on the limestones and in the North, the sunk quaternary plain of the Hattab wadi. The complex fracture zone creates a natural underground dam.

The free ground water surface is lowered from South to North, from the 750 to 650 m NGT levels, showing a general flow in the direction of the cliff.

2.1.6.3 Climate

The following figure shows the minimum, average and maximum temperatures over recent years in Kasserine.



<u>Figure 2.1-18: Minimum, average and maximum temperatures for Kasserine (Source: INM 2010)</u>

The following figure shows the annual rainfall in recent years in Kasserine, as well as the number of days of rainfall per year. The average annual precipitation recorded in 2003, 2004, 2005, 2006 and 2007 was 546.4 mm per annum.

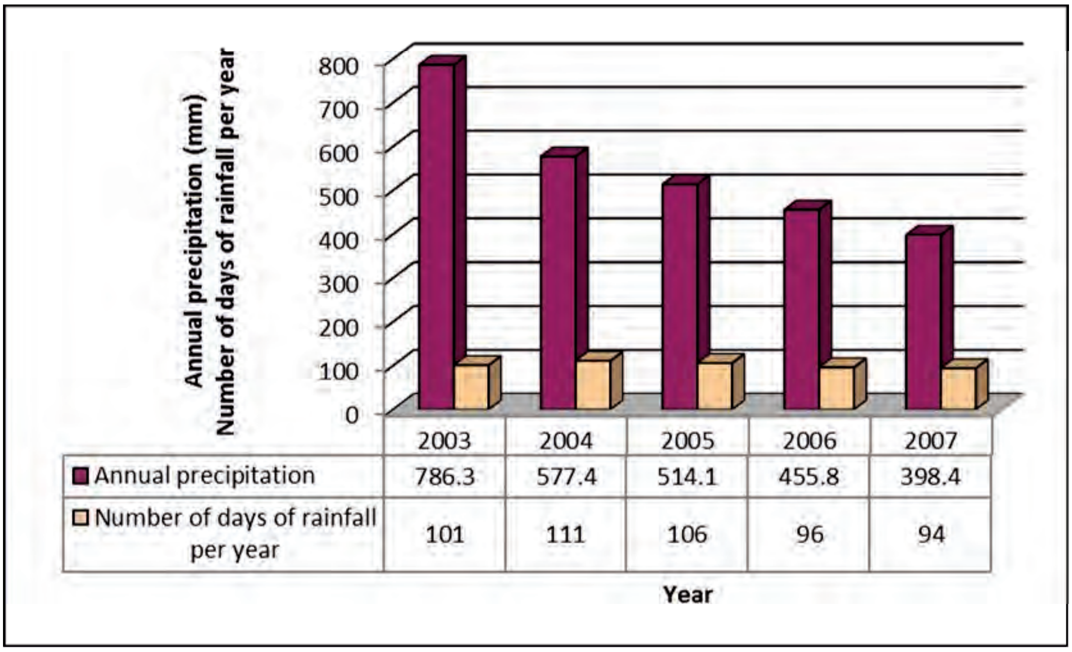


Figure 2.1-19: Annual rainfall in Kasserine (Source: INM 2010)

2.1.6.4 Economic activities

The main economic activity of the Kasserine governorate is agriculture. Nonetheless, there are some industrial estates and hotels located throughout the governorate. Based on ONAS' annual operating reports, the following table presents the number of hotels and industrial units per commune as well as the water consumption of the industrial units connected to ONAS' network.

Table 2.1-19: Tourist Data and Industrial Data per commune

Commune	Tourist Data		Industrial Data	
	Number of hotels	Number of beds	Number of units	Consumption (m^3/j)
Kasserine	3	54	12	463
Sbeitla	4	146	5	183
Thala	-	-	2	27
Feriana	-	-	1	18
Total	7	200	20	-

Source: Tunisian Hotel Business Federation – 2010 and ONAS 2010

2.1.6.5 Sanitation service indicators

The following table summarizes the key indicators that have been estimated for the Kasserine Governorate. The indicators refer to the service of wastewater sanitation and were divided by territorial and demographic indicators; service levels indicators, infrastructure indicators and Operational Indicators. These indicators have been estimated taking into account the latest data provided by the entities consulted for this study.

Table 2.1-20: Indicators of sanitation service for the Kasserine Governorate

Indicator category	Indicators	Unit	Value
Territorial and demographic indicators	Communes taken in charge by ONAS	un.	2
	Population taken in charge by ONAS in 2004	inhabit.	134,662
	Estimated population taken in charge by ONAS in 2010	inhabit.	124,485
	Households in the communes taken in charge by ONAS in 2004	un.	27,552
	Dwelling in the communes taken in charge by ONAS in 2004	un.	30,496
	Inhabitants per dwelling in 2004	inhabit.	5
	Growth rate of the number of dwelling	%	N/A
	Governorate area	km^2	8,066
	Estimated population density of the administrative center commune (Kasserine) in 2004	inhabit./km^2	6,354
Level of Service Indicators	Estimated connected population 2009	inhabit.	83,613
	Number of installations connected to ONAS 2009 (*)	u.	20,900
	Connection rate in 2010	%	N/A
	Connection rate expected in 2029	%	N/A
	House sewer connections in 2010	un.	17,244
Infrastructure indicators	Linear length of the sewage networks	km	220
	Pumping stations	un.	4
	Wastewater treatment plants	un.	2
	Estimated length of the sewage networks to be rehabilitated	km	30
	Estimated length of the sewage networks to be extended	km	49
	Estimated new house sewer connections	un.	3,050
	Pumping stations to be rehabilitated	un.	0
	Pumping stations to be built	un.	4
Operational Indicators	Estimated drinking water consumption in 2010 in 2010 (domestic, industrial, commercial/collective and tourist users) (1)	m^3/day	N/A
	Estimated infiltration into sewer	m^3/day	N/A
	Estimated wastewater flow	m^3/day	N/A

N/A - No Data Available
(*) – Data not available for 2010

The average specific consumption of drinking water in the governorate is 73 L per capita per day and has been estimated on the basis of data from SONEDE (annual volume consumed and served population).

The interventions proposed for each commune of Kasserine governorate are summarized in the following table:

Table 2.1-21: Planned Interventions by commune for the Kasserine Governorate

Communes	Rehabilitation		Extension	
	Networks (u,)	Pumping stations (u,)	Networks (u,)	Pumping stations (u,)
Kasserine	11	0	5	0
Sbeitla	4	0	2	0
Thala	0	0	1	2
Feriana	0	0	1	2
Total	**14**	**0**	**9**	**4**

2.1.7 Kébili governorate

2.1.7.1 Geographical and demographic context

Located several hundred kilometers from the capital Tunis, the Governorate of Kébili is bordered by the Governorate of Gafsa to the North, by the Governorate of Tozeur and by Algeria in the West, by the Governorate of Gabes and the Governorate of Medenine in the East and by the Governorate of Tataouine in the South.

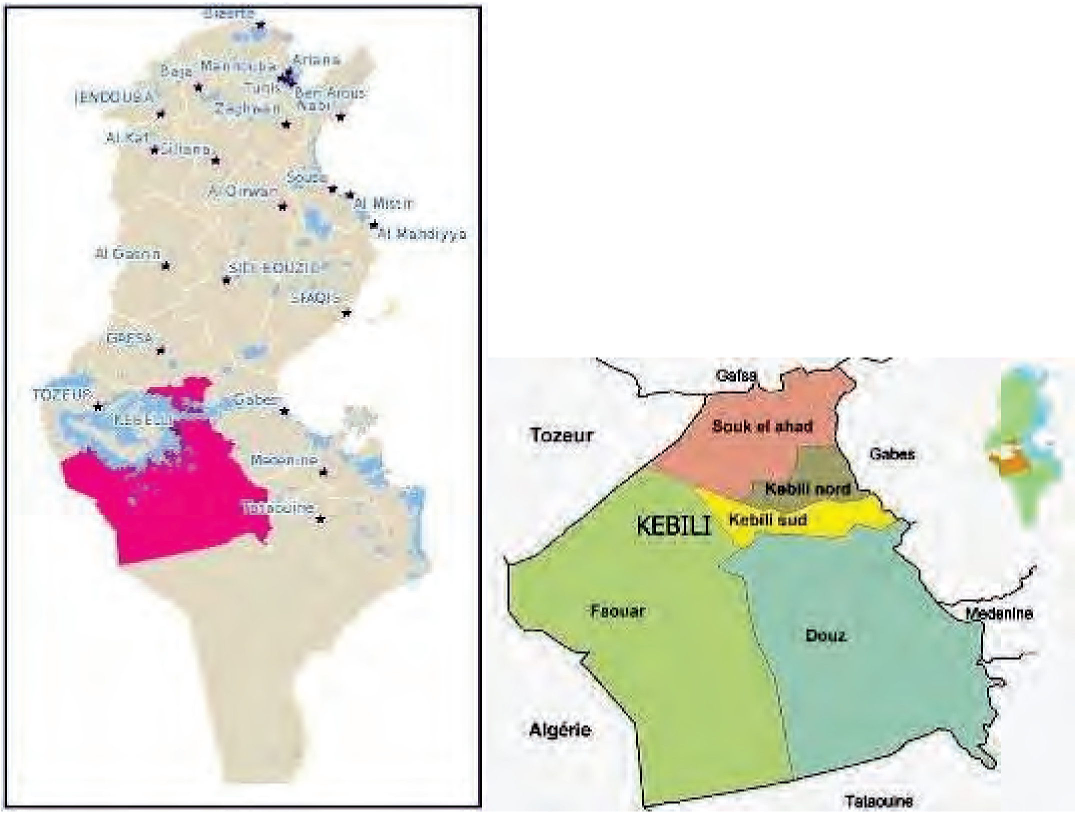


Figure 2.1-20: Maps of location and of delegations of Kébili governorate

The Governorate of Kébili had a population of 143,218 inhabitants in 2004 that corresponded to 1.45% of the population of Tunisia. The same year, the total number of households was of 26,549 and the dwellings were 8,617.

All the communes of Kébili Governorate are included in the present study: Douz, El Golaa, Jemna, Kébili (Kébili North and Kébili South) and Souk Lahad.

The town of Kébili, the administrative center of the Kébili governorate, is located 115 km to the West of the town of Gabes. It is bordered by the Kébili oasis in the South and East, by the El Melah wadi in the North and the Kébili Chott in the West.

The commune of Douz is located in the Nefzaoua region, 29 km to the South of the town of Kébili. It is connected to the RR206 road. It is bordered by a Eucalyptus forest to the North and East, and by oases to the South and West.

The commune of Jemna is located around 20 kilometers to the South of the town of Kébili and 12 km to the North de Douz.

The commune of Golaa is located 15 km to the South of the town of Kébili and 5 km to the North of Douz. It is bordered to the South by the Golaa oasis and to the East by the road connecting Kébili to Douz.

The commune of Souk Lahad is located 15 km to the North of Kébili. It is bordered to the North and South by oases, and as a result the town is stretched along a 9 km band, running alongside the RN16 road.

According to the 2004 census, we can observe the following records by commune taken in charge:

Table 2.1-22: Population, Households and Dwellings for the communes taken in charge in Governorate of Kébili (2004)

Communes	Population	Households	Dwellings
Kébili	18,693	4,189	4,824
Jemna	6,128	1,152	1,332
Douz	27,060	4,675	5,194
El Golaa	7,037	1,219	1,384
Souk Lahad	18,285	3,543	4,049
Total	**77,203**	**14,778**	**16,783**

2.1.7.2 Physical context

Topography

The main topographical characteristics for the communes of this governorate are given hereafter.

The town of Kébili is on a mount, with a sharp slope in the town center and a mild slope in areas bordering the oasis.

The town of Douz is located in a desert plain, about 10 kilometers from the Sahara. The old town center is perched on a high sand dune overlooking the Jemna oasis, while the rest of the town extends across a flat plain.

The general relief of Souk Lahad is characterized by an elevation in the middle of the town, with descending slopes towards the oasis.

Geology

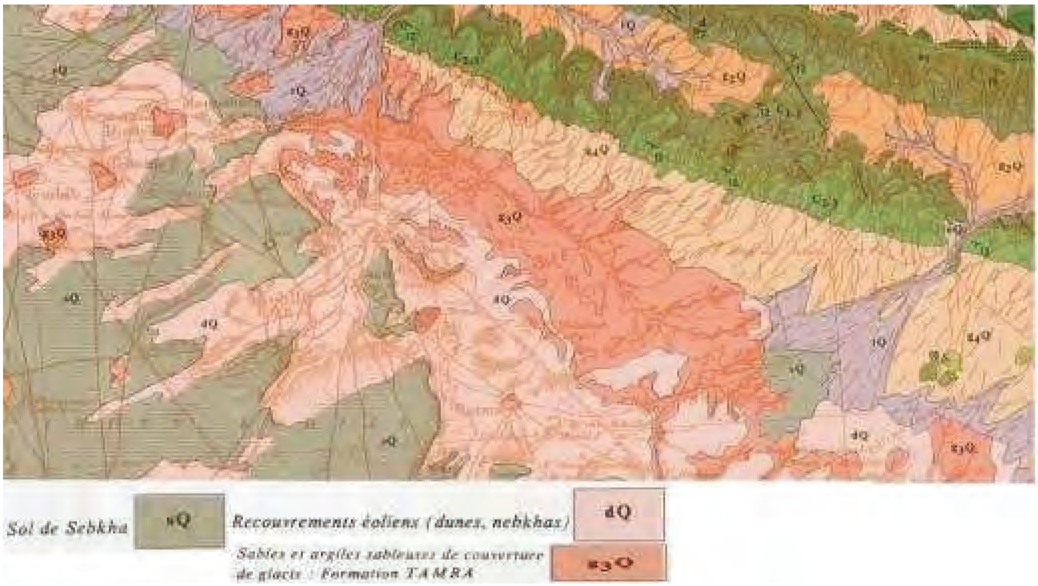
The present and quaternary terrain in Kébili town and its surroundings is principally composed of:

a) Wind-carried sand (dunes) (designated by dQ on the figure 2.1-21):

A big portion of the Chott surface and its surroundings is covered by a more or less thick layer of sand in dune form. It is siliceous sand with variable shades, white, yellowish, beige, grayish, gypseous in general, fine or sometimes coarse.

b) <u>Sebkhas soil (clay, mud, gypseous and silty sand, designated by sQ on the figure 2.1-21):</u>

In general, it consists of silty and gypseous sand, of silt, often gypseous, dark-bluish in color, and of small gravel in certain areas close to the wadi mouths. The sediments are encrusted with a thin layer of white salt during dry periods, with desiccation cracks. In winter, the chotts are covered by a thin layer of water.



<u>Figure 2.1-21: Geological map of Kébili</u>

Hydrology and Hydrogeology

The following ground water tables are found in the Kébili region:

a) <u>Ground water:</u>

They are confined in tuff and clayey-sandy formations of the Plio-Quaternary. The following ground water tables are found from the soil surface:

a-1) <u>Chott ground water:</u>

This ground water only extends to the southwest and northern part of the Kébili region at Kébili Chott and Fedjej Chott.

It is located in upper layers of fine chott alluvia and is fed by the infiltration of surface water from rain or oasis filtering water, as well as from deep water rising to the soil surface.

This ground water has seasonal fluctuations resulting from evaporation (2,400mm/year) and infiltration of water reaching the Chott. These fluctuations are between the soil surface and -1m. It results in the accumulation of crystallized salt during the summer.

This ground water is of very bad chemical quality and has salinity between 60 and 350g/l.

a-2) Oasis ground water:

This ground water is tributary of supply from surface flows, and of sources and drillings capturing deep ground water. With a piezometry highly affected by the drainage water condition in the oases, this ground water presents some piezometric fluctuations which are seasonal and linked to irrigation practices. The chemical quality of this ground water is poor since it dissolves the salts accumulated at the upper layers of the oasis soil. The water salinity varies between the water of sources (2.5g/l) and the water of drillings in the region (10 to 15 g/l).

Ground water tables in the Kébili region are confined in recent geological formations (Plio-Quaternary). The aquifer is generally thin, not exceeding 20 m and has fine lithological features. This ground water therefore constitutes a low hydraulic resource with chemical quality from bad to poor. This is due to the origin of its supply (drainage water) and by the fine lithological nature of the aquifer.

These water tables are only of secondary importance in the economy of the region, but they constitute a serious danger for the deep ground water since its decompression may bring extremely salty water from the upper ground water table.

b) Deep ground water:

There are two principal deep ground water tables at present:

b-1) The terminal complex ground water

Known in the South of the Tébaga chain, this ground water is found in the upper Cretaceous limestones covered, in the Nefzaoua, with the clayey-sandy Moi-Plio-Quaternary.

This ground water is fed in the Western valley flank of Dahar and in the Saharan platform at the Extreme-south of Tunisia. It flows from the Southeast to the Northwest. Its artesian load is from a few meters to 25 m. The water salinity increases as it flows from the ground water table, and increases from 1.8 g/l in Tenkita and Bazma to 2.5g/l in Rabta.

The flow rate from the sources was high up to the beginning of the fifties, and since then has been decreasing due to the multiplication of drillings and increased exploitation.

b-2) The Continental Intercalaire ground water table

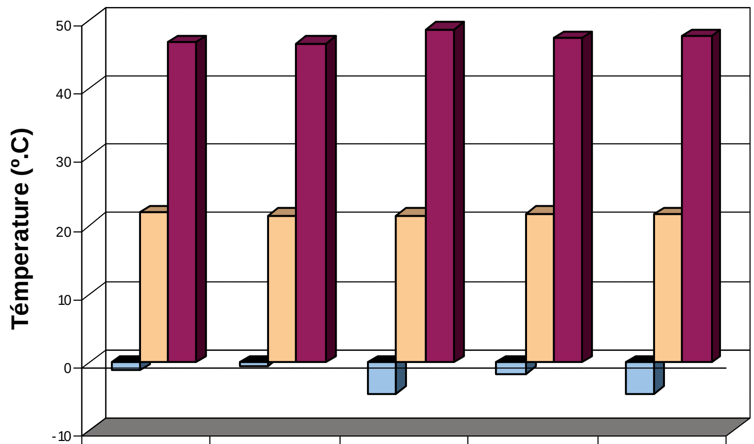
Known in Chott Fedjej (El Bahaier region) and in the Nefzaoua. The aquifer reservoir of this ground water is composed of sandy-sandstone formations of the lower Cretaceous period, of which only a part can be observed as an outcrop.

Due to its high hydrostatic pressure, its hot water and the depth of its capture between 1400m (El Bahaier) and 2500m (Kébili), this ground water can be applied for standard uses in agriculture and potable water supply, only at very high financial costs and by using an efficient capture technology. These make it a secondary water resource whose exploitation is in second place since easy to control resources can be found at shallower depths.

2.1.7.3 Climate

The Kébili governorate has a Saharan climate, with a hot, dry summer. The average temperature is 21.5 °C and precipitation is 90 mm/year, with around 30 days of rainfall.

The following figure shows the minimum, average and maximum temperatures over recent years in Kébili.



	2003	2004	2005	2006	2007
Temp. Min.	-1.1	-0.4	-4.5	-1.6	-4.5
Temp. Moy.	21.9	21.4	21.4	21.8	21.6
Temp. Max.	46.7	46.5	48.5	47.3	47.6

Figure 2.1-22: Minimum, average and maximum temperatures for Kébili (Source: INM 2010)

The following figure shows the annual rainfall as well as the number of days of rainfall per year in Kébili. The average annual precipitation recorded in 2003, 2004, 2005, 2006 and 2007 was 121.14 mm per annum.

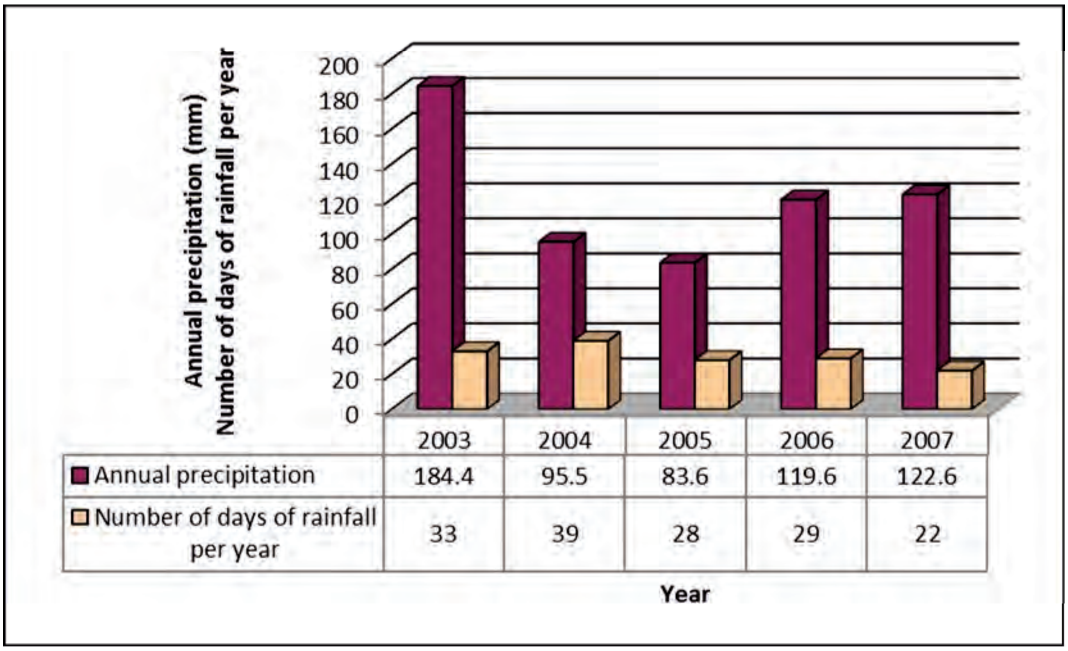


Figure 2.1-23: Annual rainfall in Kasserine (Source: INM 2010)

2.1.7.4 Economic activities

The main economic activities of the governorate are agriculture and tourism. Based on ONAS' annual operating reports, the following table presents the number of hotels and industrial units per commune as well as the water consumption of the industrial units connected to ONAS' network.

Table 2.1-23: Tourist Data and Industrial Data per commune

Commune	Tourist Data		Industrial Data	
	Number of hotels	Number of beds	Number of units	Consumption (m^3/j)
Kébili	8	1,192	3	9
Douz	10	2,159	1	2
Souk Lahad	-	-	-	-
Golaa	-	-	-	-
Jemna	-	-	-	-
Total	**18**	**3,351**	**4**	**-**

Source: Tunisian Hotel Business Federation – 2010 and ONAS 2010

2.1.7.5 Sanitation service indicators

The following table summarizes the key indicators that have been estimated for the Kébili Governorate. The indicators refer to the service of wastewater sanitation and were divided by territorial and demographic indicators, service levels indicators, infrastructure indicators and operational indicators. These indicators have been estimated taking into account the latest data provided by the entities consulted for this study.

Table 2.1-24: Indicators of sanitation service for the governorate of Kébili

Indicator category	Indicators	Unit	Value
Territorial and demographic indicators	Communes taken in charge by ONAS	un.	5
	Population taken in charge by ONAS in 2004	inhabit.	77,203
	Estimated population taken in charge by ONAS in 2010	inhabit.	81,666
	Households in the communes taken in charge by ONAS in 2004	un.	14,778
	Dwelling in the communes taken in charge by ONAS in 2004	un.	16,783
	Inhabitants per dwelling in 2004	inhabit.	4.9
	Growth rate of the number of dwelling	%	32.7
	Governorate area	km^2	22,084
	Estimated population density of the administrative center commune (Kébili) in 2004	inhabit./km^2	5,635
Level of Service Indicators	Estimated connected population 2010	inhabit.	57,166
	Number of installations connected to ONAS 2009 (*)	u.	11,061
	Connection rate in 2010	%	70
	Connection rate expected in 2029	%	90
	House sewer connections in 2010	un.	9,150
Infrastructure indicators	Linear length of the sewage networks	km	194
	Pumping stations	un.	9
	Wastewater treatment plants	un.	2
	Estimated length of the sewage networks to be rehabilitated	km	7.5
	Estimated length of the sewage networks to be extended	km	167
	Estimated new house sewer connections	un.	7,050
	Pumping stations to be rehabilitated	un.	2
	Pumping stations to be built	un.	15
Operational Indicators	Estimated drinking water consumption in 2010 (domestic, industrial, commercial/collective and tourist users) (1)	m^3/day	8,619
	Estimated infiltration into sewer	m^3/day	607
	Estimated wastewater flow	m^3/day	4,540

(1) Main source of drinking water supply data: SONEDE from 21 deep wells
SONEDE Subscribers in 2009: (31,677 domestic, 43 industries, 640 collective, 440 commercial). There are no large-scale water consumers in the Governorate of Kébili.
(*) Data not available for 2010

The average specific consumption of drinking water in the governorate is 65 L per capita per day and has been estimated on the basis of data from SONEDE (annual volume consumed and served population).

For each commune, the specific consumption of drinking water is indicated in the following table:

Table 2.1-25: Specific consumption of drinking water (2009)

Commune	Specific consumption of drinking water 2009 (L per capita per day)
Kébili	65
Douz	72
Souk Lahad	54
Golaa	50
Jemna	49

The interventions proposed for each commune of Kébili governorate are summarized in the following table:

Table 2.1-26: Planned Interventions by commune for the Governorate of Kébili

Communes	Rehabilitation		Extension	
	Networks (u.)	Pumping stations (u.)	Networks (u.)	Pumping stations (u.)
Douz	1		1	1
Douz Sud			1	1
El Golaa			1	
Jemna			1	1
Kébili	1	2	1	1
Kébili Nord			4	4
Kébili Sud			2	2
Souk Lahad			1	5
Total	**2**	**2**	**12**	**15**

2.1.8 El Kef Governorate

2.1.8.1 Geographical and demographic context

El Kef Governorate is located in the Upper Tell area, 175 kilometers from Tunis. It is bordered by the Governorates of Jendouba in the North, Siliana in the East, Kasserine in the South, and by Algeria in the West (with a common border of 145 kilometers).

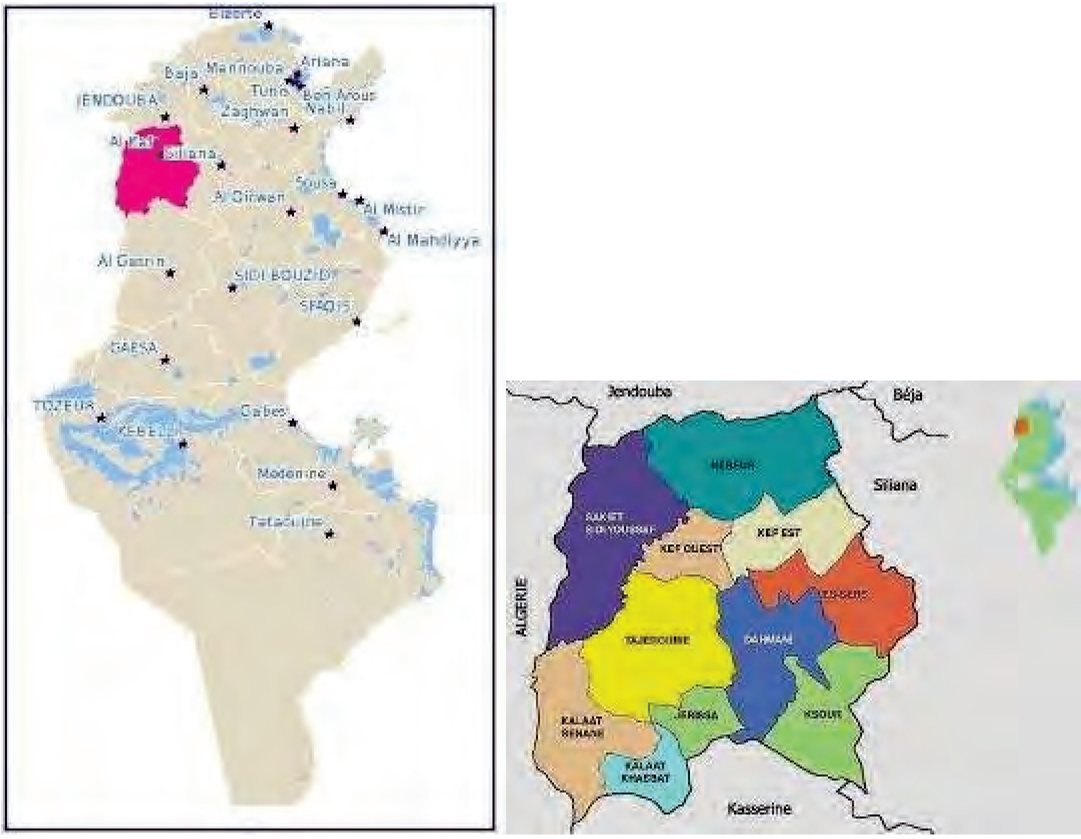


Figure 2.1-24: Maps of location and of delegations of Kef governorate

The El Kef Governorate had a population of 258,790 inhabitants in 2004 which corresponded to 2.61% of the population of Tunisia. The same year, the total number of households was 59.107 and the dwellings were 63,901.

In this Governorate, the communes which are part of this study are Dahmani, El Kef and Tajerouine. These communes correspond to the three communes taken in charge by ONAS.

Administrative center of the governorate, El Kef town is located at around 160km from Tunis. It is located near the Algerian border, between the Ouargha massifs in the North and the Tajerouine plateau in the South.

The town of Tajerouine, a delegation of the El Kef Governorate, is located in the Domes zone of the Northwest of Tunisia, around 40 km to the South of El Kef and 80 km to the North of the town of Kasserine.

The town of Dahmani is located around 25 km to the South of El Kef.

According to the 2004 census, we can observe the following records by commune and district of El Kef:

Table 2.1-27: Population, Households and Dwellings for the communes in El Kef Governorate (2004)

Communes Districts	Population	Households	Dwellings
El Kef	45,191	11,580	12,673
El Kef Medina	26,874	6,927	7,547
El Kef Jedida	18,317	4,653	5,126
Tajerouine	18,185	4,342	4,957
Dahmani	14,061	3,211	3,669
Total	**77,437**	**19,133**	**21,299**

2.1.8.2 Physical context

Topography

The relief of Kef governorate is composed of mountainous chains found at an average altitude of 700 meters. Among the main mountainous massifs (djebels), we can find the Djebel Lobreus (at 809 meters), the Djebel El Houdh (at 955 meters), the Djebel Maïza (at 887 meters), the Table of Jugurtha (at 1,255 meters), the Djebel Slata (at 1,103 meters), and the Djebel Eddyr (at 1,084 meters).

The Kef area is essentially divided into two natural regions: west and north, the most extensive portion, crossed in parts by the Mellègue Wadi, is relatively hilly with extreme levels varying from 900 m NGT, towards the Djebel Ouarrha and Dyr el Kef summits, to only 300 m NGT in the Mellègue valley. This region with quite many rainfall (annual average rainfall = 549 mm) is covered with trees (Alep pine) and undergrowth (cist, alfa, rosemary, holm oak, heather) on high areas, and with prairies and plants on the plateau near the Sakiet road. The other part of the zone, in the Southeast, includes a portion of the plateau which extends from Kef to Tajerouine, with small hills here and there.

The region of Tajerouine is characterized by a highly rugged general topography along the mountains, particularly the Feddam Essema mountains to the East and the Bouhalloufa mountains to the Southeast of the town.

Geology

Connected to the « Tell alignments » bordering the Mellègue wadi and Medjerda valley in the South, El Kef dominate in the South a plain being part of a quaternary gutter terrain which extends from the Southwest to the Northeast (see figure 2.1-25).

This quaternary terrain is composed of recent layers (Aa on the figure). These are either limestones on cretaceous formations SW of Kef, or gypsum downstream of the Triassic massifs, particularly on mild slopes found at both sides of Ben Gasseur.

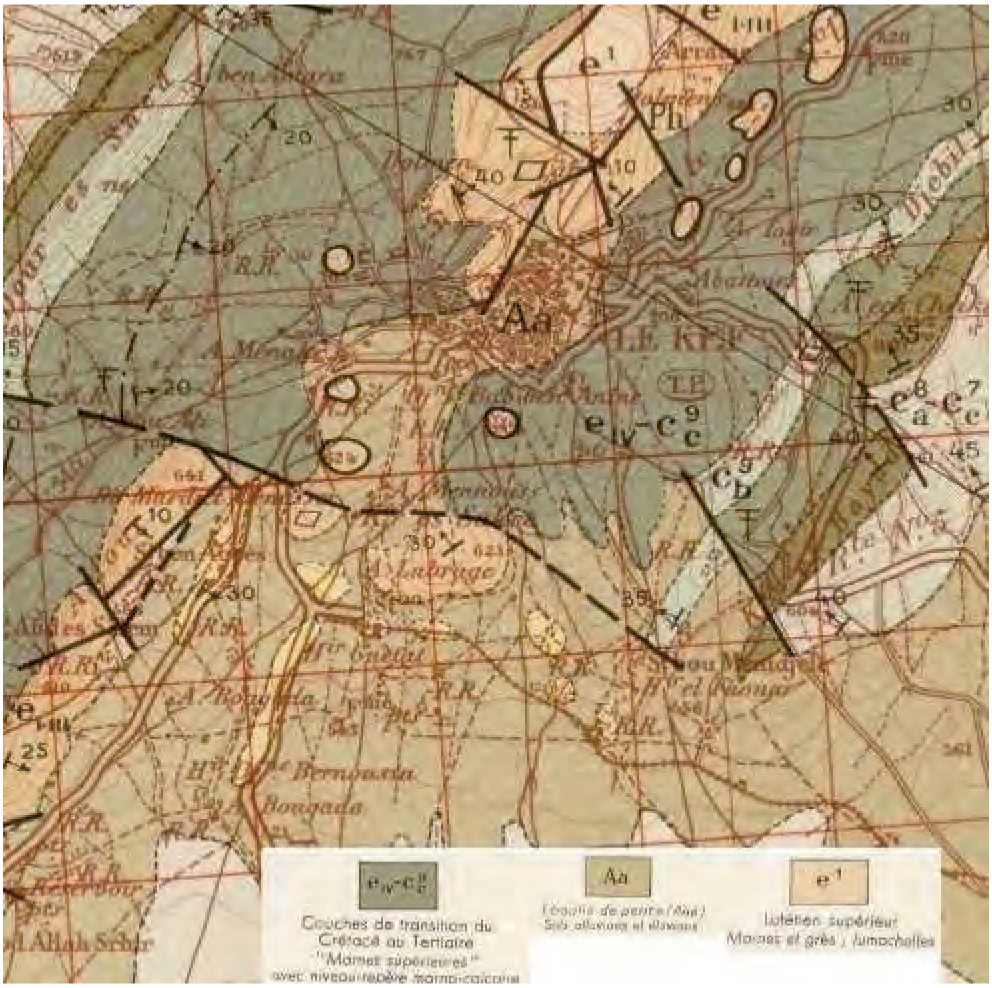


Figure 2.1-25: Geological map of El Kef

Hydrogeology

The perched synclinal of Djebel Dyr el Kef constitutes a remarkable hydraulic unit: the aquifer level is composed of Eocene limestone and marl-limestone, highly fractured, with a thickness of 45m. The mountain, in the form of a boat bottom with a surface area over 5km^2, is inclined by around 4° towards the SW, which leads to the flow of ground water to Kef town, where is the principal emergence (Ain el Kef) already captured by the Romans using filtering galleries. Calcareous scree around the mountain has created a series of small independent sources with mild flow. The water is of excellent quality (0.3 to 0.4g dry residue per liter), but the quantity is insufficient (1500 m^3 per day as an average) to supply the town. Furthermore, the ground water is subject to significant seasonal variations.

The deep resources of the plateau located South of Kef town are unknown. A few small drillings were conducted for around thirty meters on very small ground water tables of old layers.

Hydrology

The town is spread over hills with a high relief whose Eastern side is drained by the Cheriaa Wadi. The other and bigger side has produced the Tine Wadi, right-bank tributary of the Errmell Wadi.

The Kef region is with quite many rainfalls. However, the entire western part has little water: marly formations are widely spread and thin Cretaceous calcareous levels only present few emergences with a very low flow rate.

The river system of Tajerouine is essentially formed by the wadi El Garfa and a multitude of small streams flowing East-West.

Dahmani is located at the foot of the Djebel Ebba mountains, and at the end of the Zouarine plain, crossed by many wadis, the most important of which being the wadi Izid and the wadi Djellef, and by a multitude of small streams.

2.1.8.3 Climate

The El Kef Governorate is characterized by its hard or semi-arid continental climate. The average temperature is 21.5 °C and there is a precipitation of 325 mm/year, though the climate is especially dry in the Western and South-Western part of the governorate. There are also precipitations that can exceed 1,000 millimeters, thus feeding several dams. El Kef also has some snow events in January.

The following figure shows the minimum, average and maximum temperatures over recent years in El Kef.

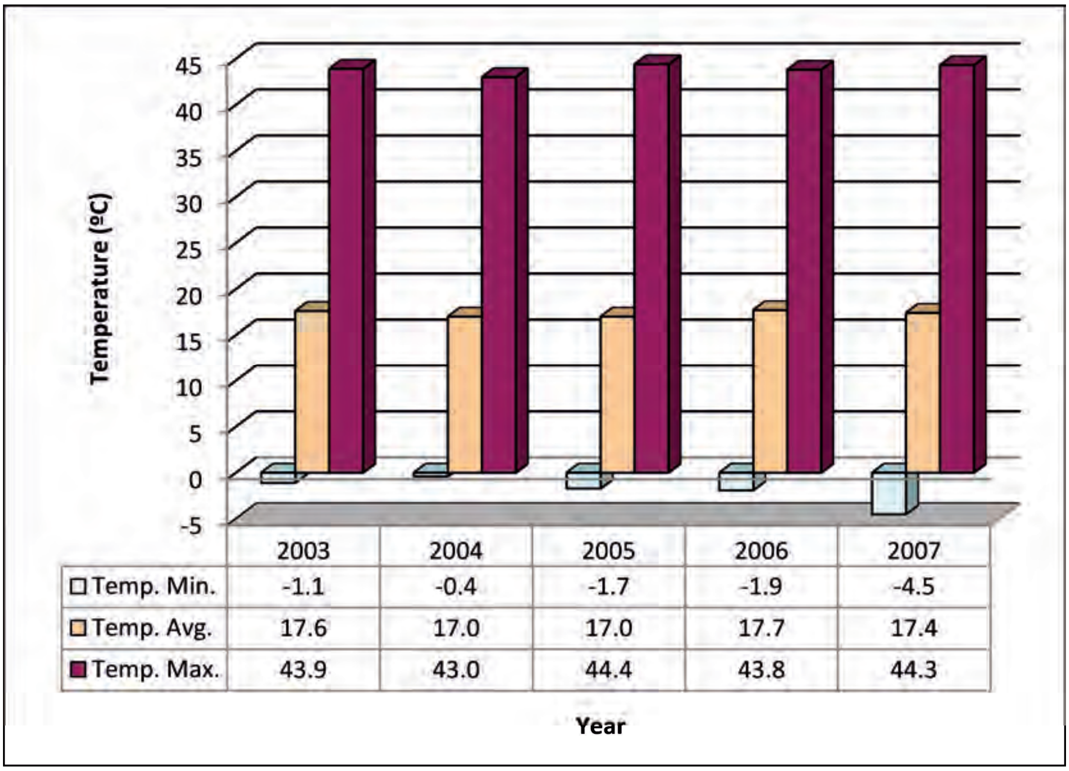


Figure 2.1-26: Minimum, average and maximum temperatures in El Kef (Source: INM 2010)

The figure below shows the annual rainfall as well as the number of days of rainfall per year for El Kef. The average annual precipitation recorded in 2003, 2004, 2005, 2006 and 2007 was 546.4 mm per annum.

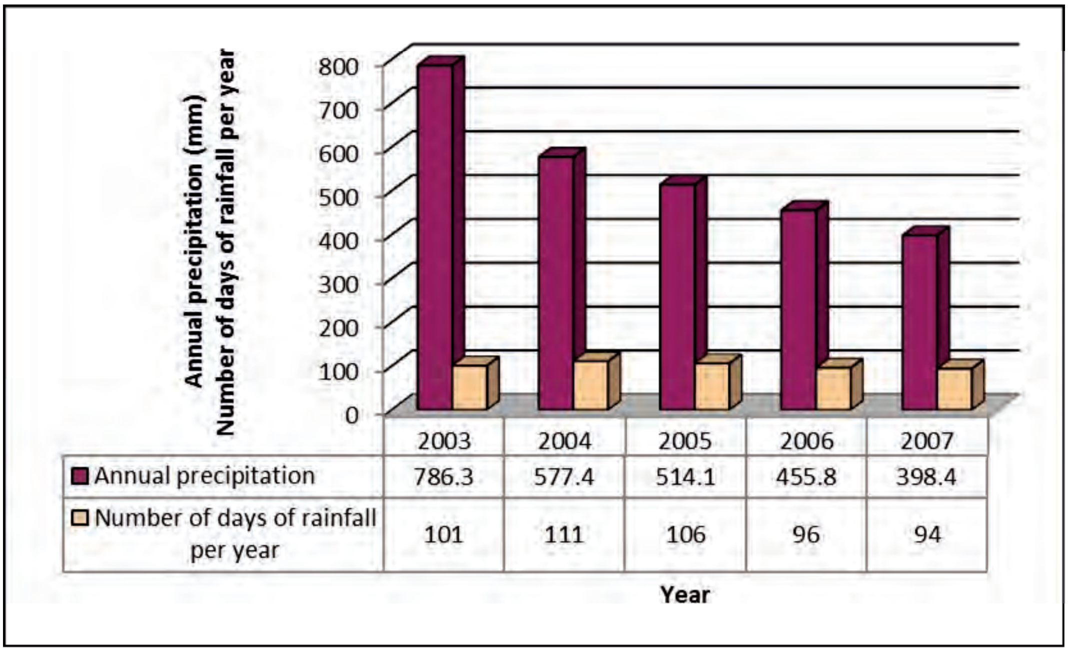


Figure 2.1-27: Annual rainfall in El Kef (Source: INM 2010)

2.1.8.4 Economic activities

The main economic activities are agriculture and building materials. Based on ONAS' annual operating reports, the following table presents the number of hotels and industrial units per commune as well as the water consumption of the industrial units connected to ONAS' network.

Table 2.1-28: Tourist Data and Industrial Data per commune

Commune	Tourist Data		Industrial Data	
	Number of hotels	Number of beds	Number of units	Consumption (m^3/j)
Kef	8	354	9	29
Dahmani	-	-	1	5
Tajerouine	-	-	2	16
Total	**8**	**354**	**12**	**-**

Source: Tunisian Hotel Business Federation – 2010 and ONAS 2010

2.1.8.5 Sanitation service indicators

The following table summarizes the key indicators that have been estimated for the El Kef Governorate. The indicators refer to the service of wastewater sanitation and were divided by territorial and demographic indicators, service levels indicators, infrastructure indicators and operational indicators. These indicators have been estimated taking into account the latest data provided by the entities consulted for this study.

Table 2.1-29: Indicators of sanitation service for the El Kef Governorate

Indicator category	Indicators	Unit	Value
Territorial and demographic indicators	Communes taken in charge by ONAS	un.	3
	Population taken in charge by ONAS in 2004	inhabit.	77,437
	Estimated population taken in charge by ONAS in 2010	inhabit.	78,240
	Households in the communes taken in charge by ONAS in 2004	un.	19,133
	Dwelling in the communes taken in charge by ONAS in 2004	un.	21,299
	Inhabitants per dwelling in 2004	inhabit.	3.7
	Growth rate of the number of dwelling	%	2.94
	Governorate area	km^2	4,965
	Estimated population density of the administrative center commune (El Kef) in 2004	$inhabit./km^2$	3,398
Level of Service Indicators	Estimated connected population 2010	inhabit.	73,546
	Number of installations connected to ONAS 2009 (*)	u.	21,760
	Connection rate in 2010	%	94
	Connection rate expected in 2029	%	98
	House sewer connections in 2010	un.	32,958
Infrastructure indicators	Linear length of the sewage networks	km	380
	Pumping stations	un.	14
	Wastewater treatment plants	un.	1
	Estimated length of the sewage networks to be rehabilitated	km	23.6
	Estimated length of the sewage networks to be extended	km	8
	Estimated new house sewer connections	un.	300
	Pumping stations to be rehabilitated	un.	4
	Pumping stations to be built	un.	1
Operational Indicators	Estimated drinking water consumption in 2010 (domestic, industrial, commercial/collective and tourist users) (1)	m^3/day	121,786
	Estimated infiltration into sewer	m^3/day	32
	Estimated wastewater flow	m^3/day	10,278

(1) Main source of drinking water supply data: SONEDE from 26 points of deep wells, 2 wells, and 4 natural sources
SONEDE Subscribers in 2009 (31,500 domestic, 1,200 industries, 7,500 collectives, 4,800 commercial)
(*) Data not available for 2010

The average specific consumption of drinking water in the governorate is 82 L per capita per day and has been estimated on the basis of data from SONEDE (annual volume consumed and served population).

For each commune, the specific consumption of drinking water is indicated below:

Table 2.1-30: Specific consumption of drinking water (2009)

Commune	Specific consumption of drinking water 2009 (L per capita per day)
Kef	84
Dahmani	78
Tajerouine	78

The interventions proposed for each commune of El Kef governorate are summarized in the following table:

Table 2.1-31: Planned Interventions by commune for the El Kef Governorate

Communes	Rehabilitation		Extension	
	Networks (u.)	Pumping stations (u.)	Networks (u.)	Pumping stations (u.)
Dahmani	1	1	1	
Kef	7	2	1	1
Tajerouine	3	1	3	1
Total	**11**	**4**	**5**	**2**

2.1.9 Sfax Governorate

2.1.9.1 Geographic and demographic context

Sfax governorate is bordered by the Mediterranean Sea in the East, by the Governorate of Gabes in the South, by the Governorate of Mahdia in the North and by the Governorates of Kairouan, Sidi Bouzid and Gafsa in the West. It also includes the archipelago of Kerkennah. The governorate covers a total surface area of 7,545 km², i.e. 5 % of the country's total surface area.

Its privileged geographical position between Center and South of the country, its wide opening to the sea (with a coastline of almost 235 kilometers) and its port (the largest in Tunisia) give it an important role in national and international trade.

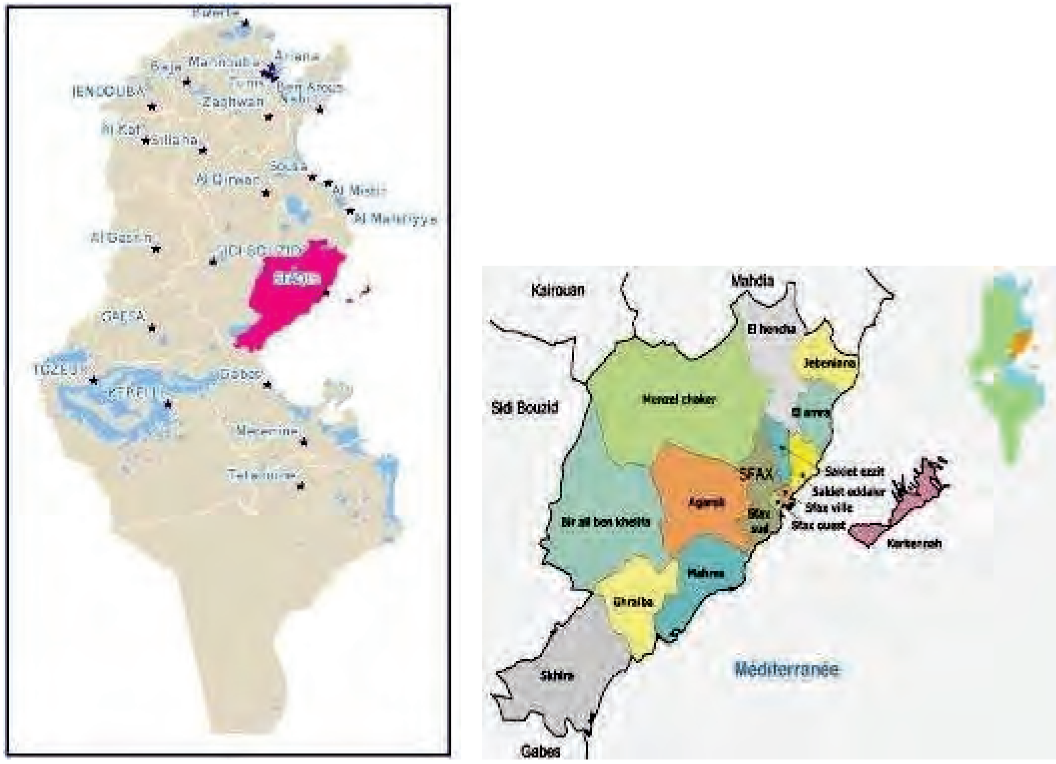


Figure 2.1-28: Maps of location and of delegations of Sfax governorate

The Sfax Governorate had a population of 855,256 inhabitants in 2004 corresponding to 8.63% of the population of Tunisia. The same year, the total number of households was of 198,565 and the dwellings were 233,058.

In this Governorate, the communes which are part of this study are: the administrative center commune of Sfax, Sakiet Ezzit, Chihia, Sakiet Eddaier, Gremda, El Ain, Tyna, Agareb, Jebeniana, El Hencha, and Mahres.

Sfax town is located at around 260 km from Tunis. It is connected with Tunis and Sousse by the Highway No. 1 and RN1 road, with the center and Kasserine through the RN 13 road and with the West till Gafsa by road RN14. In the East, the town is bordered by the Mediterranean Sea.

The town of Mahres is located to the South-West of Sfax, overlooking the Gulf of Gabes. It is a relatively important city within the Sfax governorate. Mahres is a rural town that essentially lives from agriculture.

The town of Agareb, the administrative center of one of the delegations of the Sfax governorate, is located 30 km West of the town of Sfax. Located on the RR119 road, 2 km from the RN14 road connecting Sfax to Gafsa, the commune of Agareb has experienced an industrial expansion, especially due to its location near the Sfax industrial estate.

The town of El Hencha is located around 40 km to the North of the town of Sfax, and is one of the main delegations of the Sfax governorate. The urban area is bordered to the West by the railway line. It has undergone a rapid urban expansion based around two main axes providing important inter-regional links for the town, the RN1 and the RR119 roads.

The town of Jebeniana is located 30 km to the North of the town of Sfax. The commune of Jebeniana has been built up along the road RR82 which links Mahdia to Sfax. It extends along a length of around 2 km with a width of 1 km.

According to the 2004 census, we can observe the following records per commune taken in charge:

Table 2.1-32: Population, Households and Dwellings for the communes taken in charge in Sfax Governorate (2004)

Communes Districts	Population	Households	Dwellings
Sfax	265,131	68,663	80,722
El Medina	21,293	6,453	9,111
Er-Rbadh	41,977	11,178	13,015
Chamalia	26,981	7,002	7,957
Cité El Habib	56,656	14,187	16,279
Merkez Chaker	48,342	12,466	14,216
Sidi Mansour	54,175	13,216	15,355
El Bostane	15,707	4,161	4,789
Sakiet Ezzit	44,886	10,793	12,831
Chihia	23,625	5,857	6,418
Sakiet Eddaier	40,717	9,487	10,827
Gremda	36,405	8,866	10,069
El Ain	38,250	9,256	10,436
Tyna	26,635	6,024	6,858
Agareb	9,610	2,074	2,262
Jebeniana	6,576	1,533	1,801
El Hencha	6,277	1,381	1,665
Mahres	14,499	3,541	4,963
Total	**512,611**	**127,475**	**148,852**

2.1.9.2 Physical context

Topography

From a morphological view point, this region has a quasi-monotonous topography with plateaus and average height mounds ending at 183m in Ksar El Mardgine and 141 m in Hmadet El Houch.

The Sfax governorate is located on a low-lying coastal plain (average 100m), with a gentle slope towards the sea.

Given its relief and climate, Mahres is included within the semi-arid region of Tunisia. The topography is gently sloped. It occupies a large plain, open on the sea, where the monotony of the land is only broken by a few gently rolling hills. The plain has a very gentle slope in a North-South direction, with average elevations between 5 to 50 m above sea level.

The perimeter of Jebeniana city extends along a practically flat terrain. Rain water flows from the North to the South.

Geology

The main geological characteristics for the communes of this governorate are given hereafter.

The geology of Sfax town and its surroundings is composed of red silt and sand of the medium terrace (from the upper Pleistocene, note IQ on the figure 2.1-29).

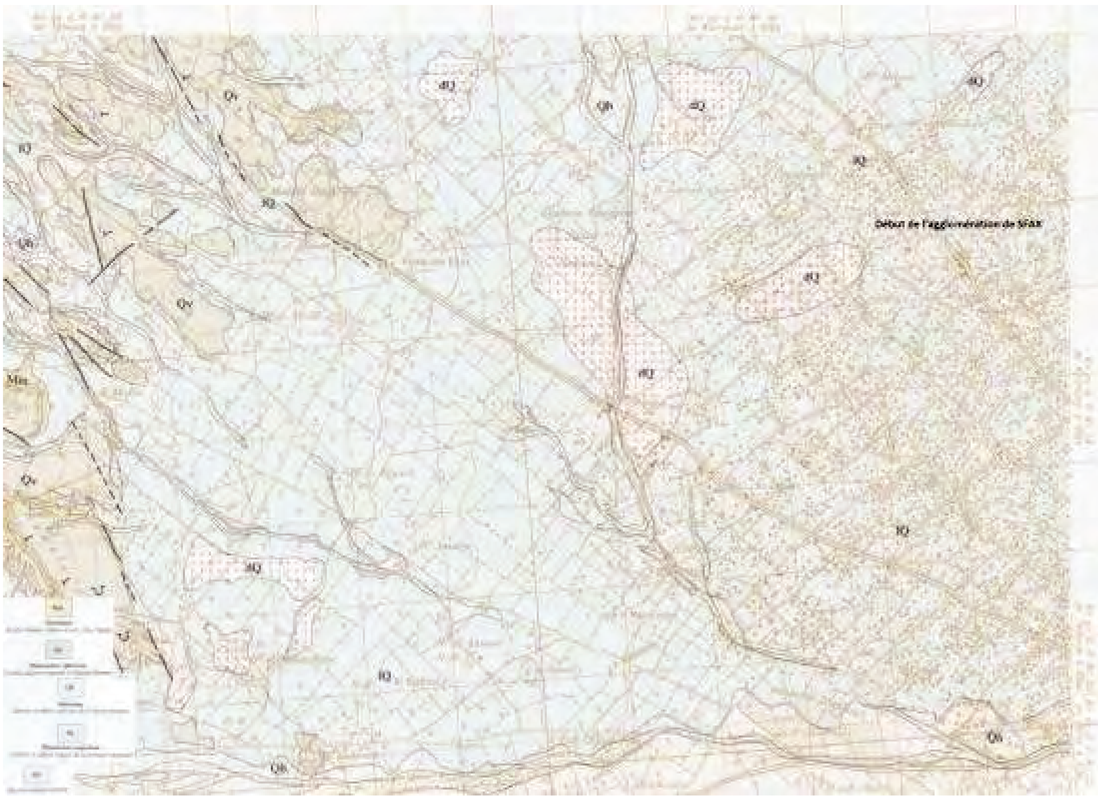


Figure 2.1-29: Geological Map of Sfax

From a geological perspective, three zones that may be considered to constitute the substratum have been identified in the Sfax region:

- The zoned crust, red sandy alluvium
- In case of lack of this zoned crust, we find red sandy alluvium that constitutes the underlying substratum from which the continental or marine soils of the urban zone of Sfax are formed.
- The silty-sandy soils in the zone of the delta of the wadis Agareb and El Maou, where the sandy alluvium and the zoned crust above them are at depths of around 15m, in the wake of a recent tectonic collapse.

Agareb is built on a terrain with small valleys, bordered by the wadi El Kébir and the wadi Zaraa. There is primarily clay soil and the water table is located at a depth of 8 m.

The soils of El Hencha are constituted by marine sediments from the middle quaternary period, predominantly sandy. The sandy valleys provide the best farmland in the region. The shallow alluvial basins are generally covered by salty, salt-affected, and clay and sandy soils of mediocre value. On the hills and foothills, there are clay and gypsum soils or calcareous rock and gypsum soils.

The soils of Jebeniana are sandy with some rock. The water table is fairly deep - 30 m below the natural terrain.

Mahres has various different soils in function of the location: there is muddy terrain bordering the sea, and sand and micaceous chalk in the hillside zones.

Hydrology

The region is highly eroded by big water courses delineating three principal catchment basins: the Agareb wadi basin, the Bouladhiab-Chaffar wadi basin and the El Gouna wadi basin.

The water system of the Mahres city is formed by El Hachana wadi at the east of the town and Ezzir wadi at the west.

In relation to the river system on the southern coastal area of Sfax, two water courses flow into the sea, from the South towards the North. They are:

Wadi Hakmouni: It drains the small water courses that flow to the West of the airport and crosses the road at Km 11. This water course runs alongside a predominantly rural farming area, with some structured urban concentrations. It then crosses part of the terrain reserved to the airport and finally flows into the settlement BEN SAIDA. It then flows downstream of the RN1 road in a natural river which drains the southern part of the old “margine” olive oil by-product deposit and the southern part of the outflow from Tyna to the South from SIAPE. This canal rejoins the drainage canal of discharges from SIAPE between the STEP and the discharge point. The bed of the wadi is not very marked.

Wadi Maou (wadi Khlifa): The wadi is characterized by a sloping basin with a total surface area of 519 Km2 and extension of 36.95 Km. The minor bed has a width of around 35 m. In the city of Sidi Tayari, it receives two tributaries – the wadi Lahmir and the wadi Branech. The wadi Maou joins the wadi Agareb upstream of the bridge of the RN14 road. The wadi Maou has dykes on both banks, following the bridge on the RR81 road (connecting to Kairouan) until the crossing with the RN1 road.

The El Hencha's river system is formed primarily by the wadi Sidi M'hamed - which crosses the town in the West-East direction and by a multitude of small streams from the hillsides bordering the town to the West.

The water table is located at a depth of 6 m.

Hydrogeology

The catchment basin in the region is drained by the Agareb wadi.

The Sfax Sahel basin is a big hydrogeological basin with a surface area of around 8000 km2. It is bordered in the north by the Chorbane dome, the El Jem plateau and the Mahdia plain; in the west with an alignment of reliefs in the North-South axis (Djebel Artsouma, Djebel Goubrar, Djebel Boudinar and Djebel Zebouz); in the South by the Gabes Gulf and in the East by the Mediterranean Sea.

Two principal aquifer formations were identified:

- The ground water aquifer system;
- The upper Miocene ground water known as the Sfax deep ground water table.

The Sfax region has 16 surface ground water, 9 of which are located at the coastal fringe.

The ground water tables are classified into two categories: ground water with huge resources and ground water with small resources. These ground water tables are in the old Plio-Quaternary foundations. The reservoirs are generally composed of two productive horizons. The latter, whose thickness varies from 2 to 5m, is separated by two semi-permeable to permeable levels with marly-clay dominance. These reservoir formations are found at depths of 10 to 35 m and are 1 to 9 m thick. They are alluvial and have a lenticular geometry.

The depth of the water sheet is 5.8 at more than 45 meters. The ground water salinity varies between 1.05g/l and 17.68g/l.

The underground water flow is generally from the Northwest to the Southeast.

2.1.9.3 Climate

The Sfax Governorate is characterized by an arid to semi-arid climate, with an influence of the Mediterranean climate in the coastal zones. In general, the Sfax region is marked by sudden, heavy rain showers with irregular rainfall and fairly frequent gusts of wind. It is subject to the opposing influences of the sea and the mainland. As a result, the Sfax region is characterized by a hot, dry summer and a cold, relatively rainy winter.

The average temperature is 18.8 °C and the precipitation amounts to 215 mm/year. The hotter month is August with an average temperature of 26.7ºC, and the coldest month is January with an average temperature of 11.1º C.

The values for the monthly rainfall data are provided in the following figure for the two weather stations of Sfax and Châal. This data also makes it possible to appraise the pattern of monthly rainfall in the Sfax region. The average annual precipitation recorded in 79 years of observation (1901-1980) in the weather station of Sfax and in 66 years of observation (1914-1980) in the weather station of Châal are 214.5 mm and 187 mm per annum, respectively.

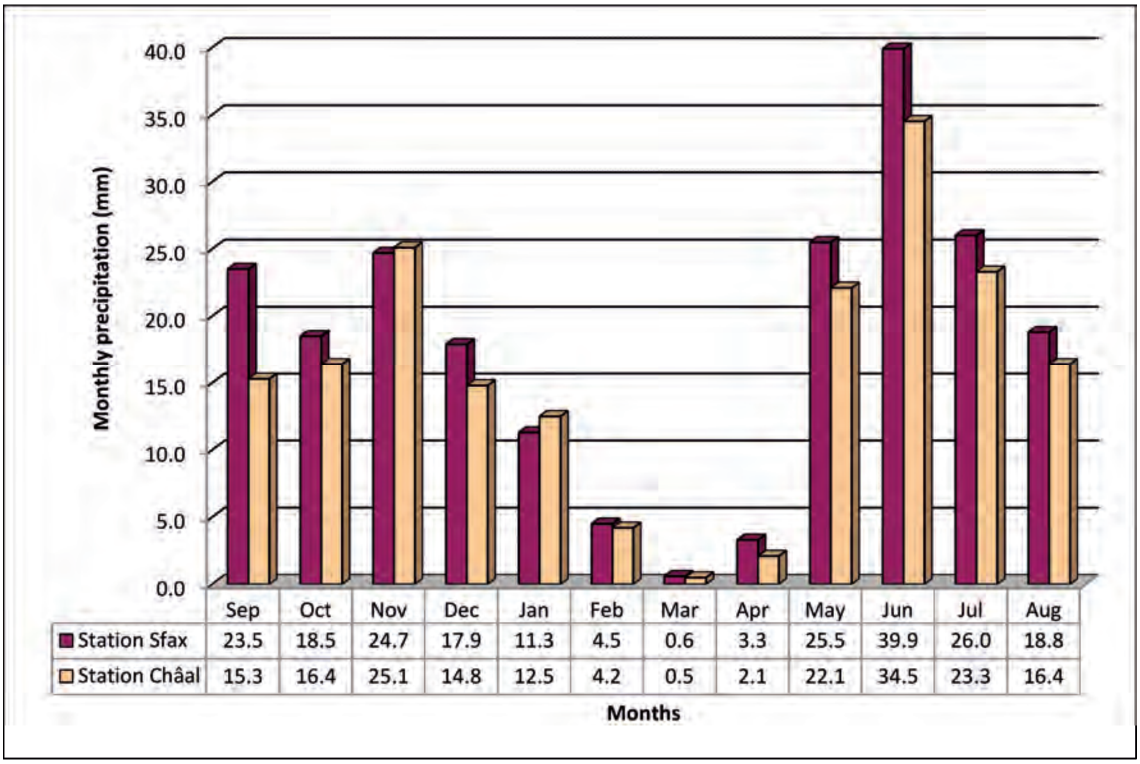


Figure 2.1-30: Annual rainfall in the Sfax and Châal weather stations (Source: INM)

2.1.9.4 Economic activities

The main economic activities in the governorate are agriculture and the tertiary sector. Based on ONAS' annual operating reports, the following table presents the number of hotels and industrial units per commune as well as the water consumption of the industrial units connected to ONAS' network.

Table 2.1-33: Tourist Data and Industrial Data per commune

Commune	Tourist Data		Industrial Data	
	Number of hotels	Number of beds	Number of units	Consumption (m^3/j)
Mahres	2	100	31	113
Jebeniana	-	-	2	3
Tyna	1	54	11	15
El Hencha	-	-	7	26
Agareb	-	-	1	20
Sakiet Ezzit	-	-	7	19
Sakiet Eddaier	-	-	10	25
Chihia	-	-	6	17
El Ain	-	-	2	2
Gremda	-	-	1	4
Sfax Town	11	1,964	939	4,445
Total	**14**	**2,118**	**1,017**	**-**

Source: Tunisian Hotel Business Federation – 2010 and ONAS 2010~

2.1.9.5 Sanitation service indicators

The following table summarizes the key indicators that have been estimated for the Sfax Governorate. The indicators refer to the service of wastewater sanitation and were divided by territorial and demographic indicators, service levels indicators, infrastructure indicators and operational indicators. These indicators have been estimated taking into account the latest data provided by the entities consulted for this study.

Table 2.1-34: Indicators of sanitation service for the Sfax Governorate

Indicator category	Indicators	Unit	Value
Territorial and demographic indicators	Communes taken in charge by ONAS	un.	11
	Population taken in charge by ONAS in 2004	inhabit.	512,611
	Estimated population taken in charge by ONAS in 2010	inhabit.	570,243
	Households in the communes taken in charge by ONAS in 2004	un.	127,475
	Dwelling in the communes taken in charge by ONAS in 2004	un.	148,852
	Inhabitants per dwelling in 2004	inhabit.	5
	Growth rate of the number of dwelling	%	3
	Governorate area	km^2	7,545
	Estimated population density of the administrative center commune (Sfax) in 2004	$inhabit./km^2$	4,734
Level of Service Indicators	Estimated connected population 2010	inhabit.	410,575
	Number of installations connected to ONAS 2009 (*)	u.	120,904
	Connection rate in 2010	%	72
	Connection rate expected in 2029	%	90
	House sewer connections in 2010	un.	70,370
Infrastructure indicators	Linear length of the sewage networks	km	1,210
	Pumping stations	un.	31
	Wastewater treatment plants	un.	7
	Estimated length of the sewage networks to be rehabilitated	km	51.1
	Estimated length of the sewage networks to be extended	km	415
	Estimated new house sewer connections	un.	29,500
	Pumping stations to be rehabilitated	un.	3
	Pumping stations to be built	un.	3
Operational Indicators	Estimated drinking water consumption in 2010 (domestic, industrial, commercial/collective and tourist users) (1)	m^3/day	52,000
	Estimated infiltration into sewer (2)	m^3/day	N/A
	Estimated wastewater flow	m^3/day	47,000

N/A - No Data Available
(1) Main source of drinking water supply data: SONEDE
Large-scale water consumers: 150 units, of which 60 have a quarterly consumption that exceeds 5,000 m3, such as the freezing industrial and agro-alimentary facilities.
(2) Surplus of volumes in the network through infiltration, estimated at approximately 10% of the total volume.
(*) Data not available for 2010.

The average specific consumption of drinking water in the governorate is 101 L per capita per day and has been estimated on the basis of data from SONEDE (annual volume consumed and served population).

For each commune, the specific consumption of drinking water is indicated below:

Table 2.1-35: Specific consumption of drinking water (2009)

Commune	Specific consumption of drinking water 2009 (L per capita per day)
Mahres	88
Jebeniana	88
Tyna	93
El Hencha	87
Agareb	85
Sakiet Ezzit	98
Sakiet Eddaier	98
Chihia	95
El Ain	95
Gremda	93
Sfax Town	104

The interventions proposed for each commune of Sfax governorate are summarized in the following table:

Table 2.1-36: Planned Interventions by commune for the Sfax Governorate

Communes	Rehabilitation		Extension	
	Networks (u.)	Pumping stations (u.)	Networks (u.)	Pumping stations (u.)
Agareb			2	1
Chihia	1		3	
El Ain			4	
Gremda			5	
El Hencha			2	
Jebeniana			2	
Mahres	1	1	2	1
Sakiet Eddaier	1		3	
Sakiet Ezzit	1		3	
Sfax	11	2	10	2
Tyna			2	1
Total	**15**	**3**	**38**	**5**

2.1.10 Sidi Bouzid Governorate

2.1.10.1 Geographic and demographic context

The Sidi Bouzid Governorate connects steppic Tunisia with pre-Saharan Tunisia. It is surrounded by six governorates, namely Siliana in the North, Gabes in the South, Gafsa and Kasserine in the West and Sfax and Kairouan in the North-East.

The Sidi Bouzid Governorate had a population of 395,506 inhabitants in 2004 which corresponded to 3.99% of the population of Tunisia. The same year, the total number of households was 76,771 and the dwellings were 89,304.

In this governorate, there is only one commune which is part of this study, namely the commune of Sidi Bouzid. This commune is also the one taken in charge by ONAS.

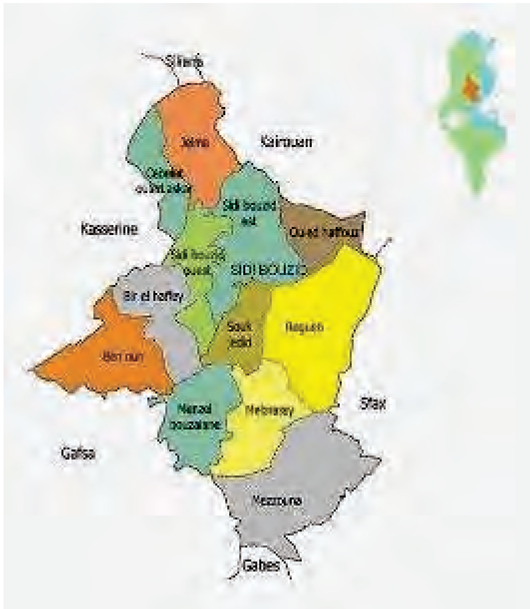


Figure 2.1-31: Maps of location and of delegations of Sidi Bouzid governorate

The town of Sidi Bouzid is located relatively far from the sea (135 kilometers to the west of Sfax) and from the capital (265 kilometers to the South of Tunis). The town has suffered from its natural enclave, which has hampered its development.

Table 2.1-37: Population, Households and Dwellings for the commune taken in charge in the Sidi Bouzid Governorate (2004)

Communes	Population	Households	Dwellings
Sidi Bouzid	39,915	8,729	9,667

2.1.10.2 Physical context

Topography

The town site is a basin surrounded by mountains (including Djebel El Kbar reaching 793 meters in altitude) and threatened by floods from the Gammouda and Falet Galla wadis. Almost the entire region (except for reliefs) is characterized by a mild slope between 0 and 3%.

Geology

The majority of outcrops in the Sidi Bouzid region are composed of quaternary alluvia. The latter are essentially formed by sand, clay and silt. The wadi beds are formed by more permeable deposits (sand, gravel and sandy silt). Relief areas are formed by carbonated deposits (limestone and dolomites) and by clay. Salty depressions (sebkhas and garaâts) are formed by clay, silt and gypsum (figure 2.1-32). The dominance of silty outcrops in the center of the basins and plains has allowed the extension of agriculture (olive growing and truck farming) in this region.

Hydrology - Hydrogeology

Sidi Bouzid is located above the biggest ground water table in the country, which has a surface area of 600km2, with thickness of around fifty meters.

Drilling data and hydro-litho-stratigraphic correlations show that the majority of the ground water in the Sidi Bouzid region is lenticular. These are multilayer aquifer systems whose reservoir levels are lodged in sandy and clayey-sandy, sometimes gravelly, layers. These layers are more or less connected to each other and separated by impermeable to semi-permeable layers (clayey and sandy-clay) whose lateral extension is often discontinuous.

Ground water tables in the Sidi Bouzid region are more or less exploited to supply increasing demands for irrigation. In order to improve the quantity of available water, studies were conducted in collaboration between the Tunisian universities and international universities, particularly in France.

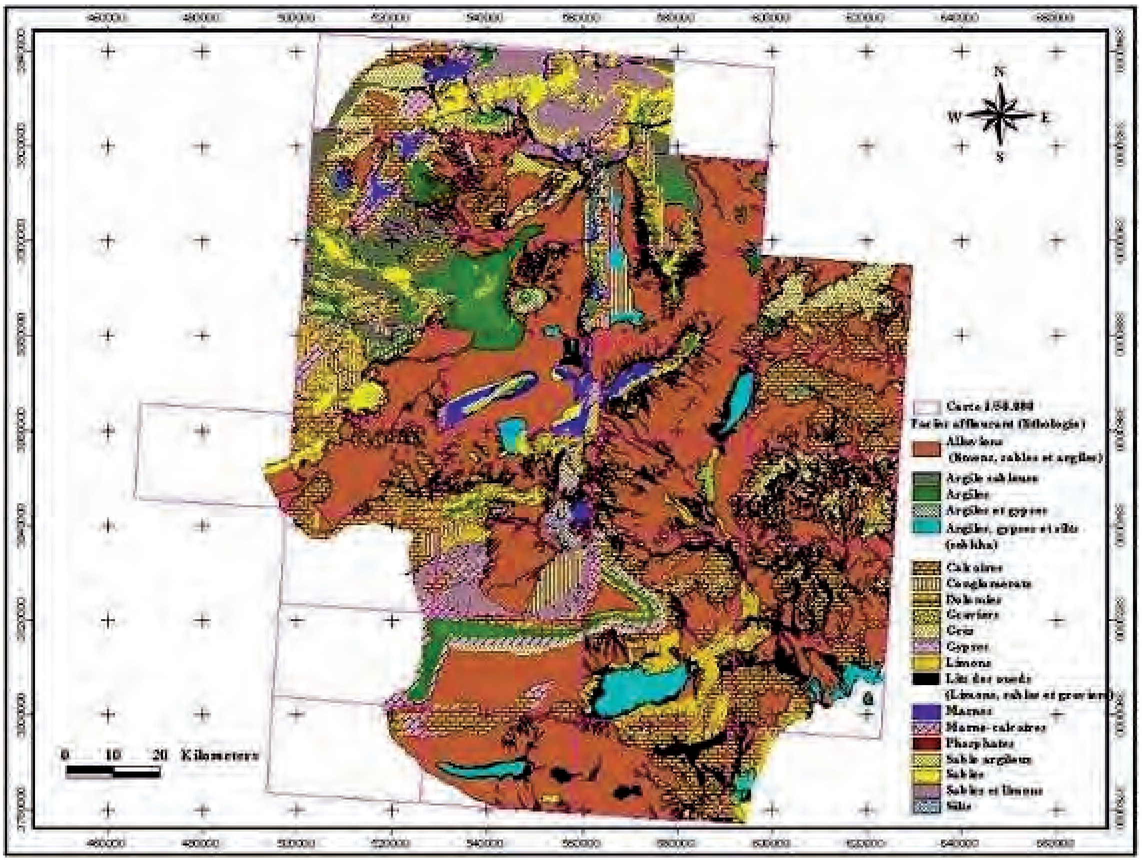


Figure 2.1-32: Map of outcropping lithological facies in the Sidi Bouzid region

2.1.10.3 Climate

The average annual precipitation is 121.14 millimeters and the average temperatures vary from 13.1 °C in winter to 27.5 °C in summer.

The following figure shows the minimum, average and maximum temperatures over recent years in Sidi Bouzid.

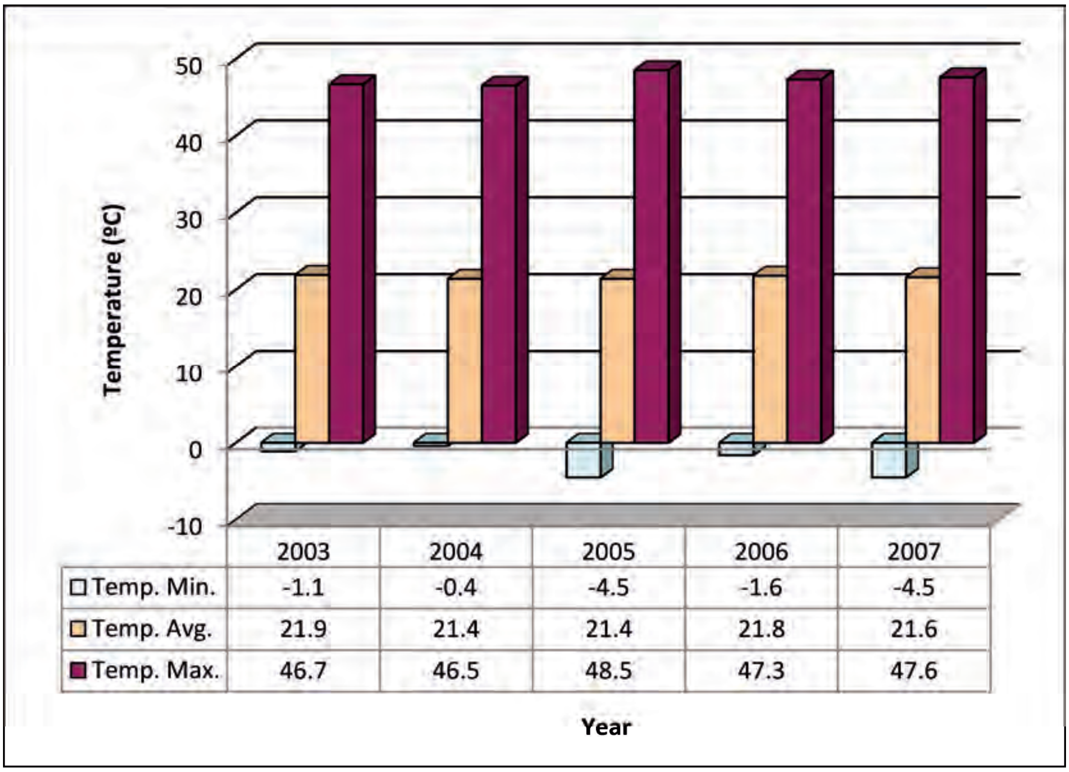


Figure 2.1-33: Minimum, average and maximum temperatures for Sidi Bouzid (Source: INM 2010)

The following figure shows the annual rainfall in recent years as well as the number of days of rainfall per year. The average annual precipitation recorded in 2003, 2004, 2005, 2006 and 2007 was 121.14 mm per annum.

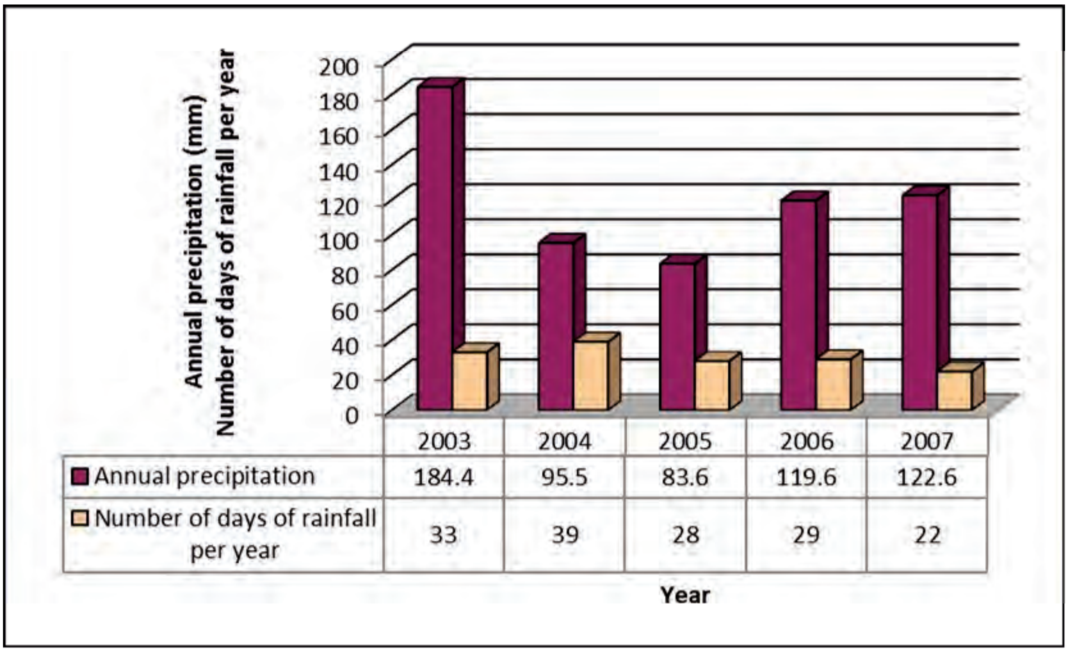


Figure 2.1-34: Annual rainfall in Sidi Bouzid (Source: INM)

2.1.10.4 Economic activities

The main economic activities of the governorate are agriculture textile industry.

Based on ONAS' annual operating reports, the following table presents the number of hotels and industrial units per commune as well as the water consumption of the industrial units connected to ONAS' network.

Table 2.1-38: Tourist Data and Industrial Data per commune

Commune	Tourist Data		Industrial Data	
	Number of hotels	Number of beds	Number of units	Consumption (m^3/j)
Sidi Bouzid	2	50	14	412

Source: Tunisian Hotel Business Federation – 2010 and ONAS 2010

2.1.10.5 Sanitation service indicators

The following table summarizes the key indicators that have been estimated for the Sidi Bouzid Governorate. The indicators refer to the service of wastewater sanitation and were divided by territorial and demographic indicators, service levels indicators, infrastructure indicators and operational indicators. These indicators have been estimated taking into account the latest data provided by the entities consulted for this study.

Table 2.1-39: Indicators of sanitation service for the Sidi Bouzid Governorate

Indicator category	Indicators	Unit	Value
Territorial and demographic indicators	Communes taken in charge by ONAS	un.	1
	Population taken in charge by ONAS in 2004	inhabit.	39,915
	Estimated population taken in charge by ONAS in 2010	inhabit.	44,438
	Households in the communes taken in charge by ONAS in 2004	un.	8,729
	Dwelling in the communes taken in charge by ONAS in 2004	un.	9,667
	Inhabitants per dwelling in 2004	inhabit.	4.6
	Growth rate of the number of dwelling	%	N/A
	Governorate area	km^2	6,994
	Estimated population density of the administrative center commune (Sidi Bouzid) in 2004	inhabit./km^2	3,720
Level of Service Indicators	Estimated connected population 2009 (*)	inhabit.	25,788
	Number of installations connected to ONAS 2009 (*)	u.	9,608
	Connection rate in 2010	%	N/A
	Connection rate expected in 2029	%	N/A
	House sewer connections in 2010	un.	N/A
Infrastructure indicators	Linear length of the sewage networks	km	N/A
	Pumping stations	un.	N/A

Indicator category	Indicators	Unit	Value
	Wastewater treatment plants	un.	N/A
	Estimated length of the sewage networks to be rehabilitated	km	14.76
	Estimated length of the sewage networks to be extended	km	6.9
	Estimated new house sewer connections	un.	530
	Pumping stations to be rehabilitated	un.	0
	Pumping stations to be built	un.	0
Operational Indicators	Estimated drinking water consumption in 2010 (domestic, industrial, commercial/collective and tourist users) (1)	m^3/day	N/A
	Estimated infiltration into sewer	m^3/day	N/A
	Estimated wastewater flow	m^3/day	N/A

(*) Data not available for 2010.
N/A – Not available data.

The average specific consumption of drinking water in the governorate is 77 L per capita per day and has been estimated on the basis of data from SONEDE (annual volume consumed and the served population in 2009).

The planned interventions for the communes of the Sidi Bouzid governorate are summarized in the following table:

Table 2.1-40: Planned Interventions by commune for the Sidi Bouzid Governorate

Communes	Rehabilitation		Extension	
	Networks (u.)	Pumping stations (u.)	Networks (u.)	Pumping stations (u.)
Sidi Bouzid	9	0	6	1

2.1.11 Siliana Governorate

2.1.11.1 Geographic and demographic context

The Siliana Governorate is surrounded by seven other governorates, namely the Béja governorate in the North-East, Jendouba in the North-West, El Kef in the West, Zaghouan and Kairouan in the East, and Kasserine and Sidi Bouzid in the South, which enables it to be used as a passage point between the areas of the North-West, the Center and the South of the country.

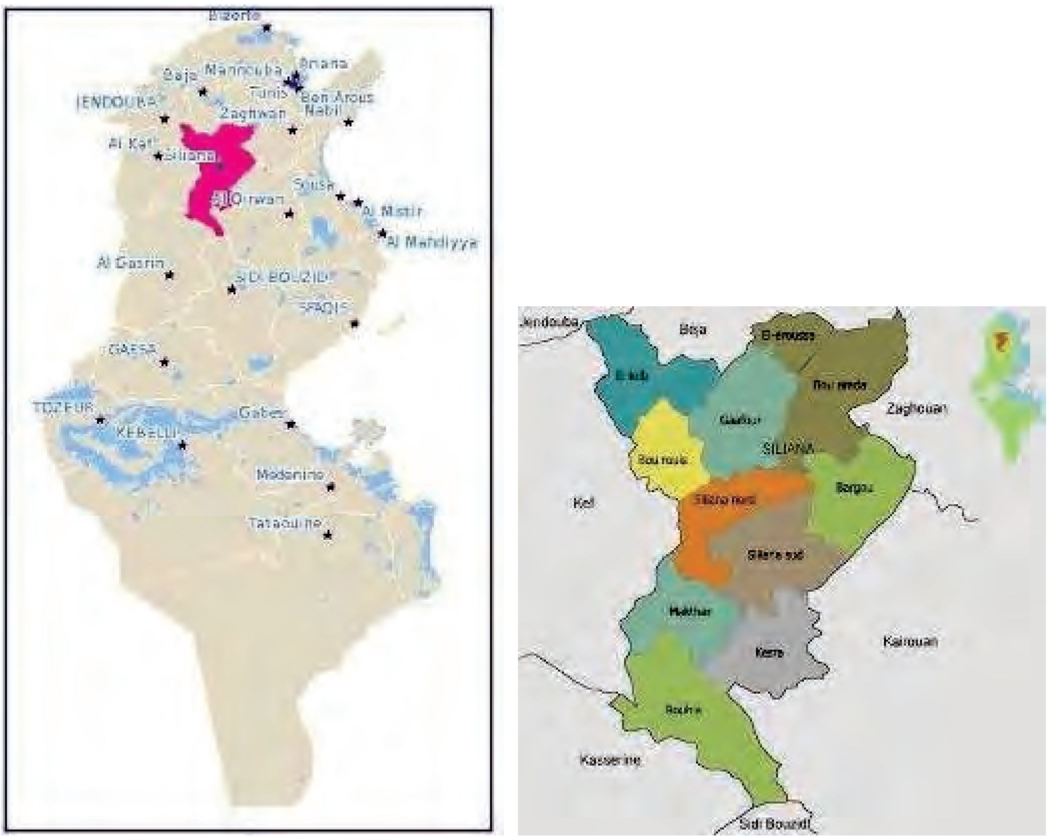


Figure 2.1-35: Maps of location and of delegations of Siliana governorate

The Siliana Governorate had a population of 233,985 inhabitants in 2004 which corresponded to 2.36% of the population of Tunisia. The same year, the total number of households was 48,448 and the dwellings were 51,075.

In this Governorate, the communes which are part of this study are Siliana, Bou Arada and El Krib.

Siliana town, the administrative center of the governorate, is located at around 125 km from Tunis through the RN4 road, along the Siliana wadi 60 km upstream of its confluence with Medjerda wadi.

The town of Bou Arada, administrative center of one of the delegations of the Siliana governorate, is located 90 km from Tunis, along the RN4 and RR47 roads and 28 km from the town of El Fahs. It is served by the railway line that connects Pont du Fahs to El Kef and to Jerissa / Kalâa Khesba.

The town of El Krib, administrative center of one of the delegations of the Siliana governorate, is located around 42 km Northwest of the town of Siliana, and 120 km of Tunis. It is crossed by the RN5 road, connecting Tunis to El Kef.

According to the 2004 census, we can observe the following records per commune taken in charge:

Table 2.1-41: Population, Households and Dwellings for the communes taken in charge in Siliana Governorate (2004)

Communes	Population	Households	Dwellings
Siliana	24,243	5,490	5,812
Bou Arada	12,273	2,757	2,801
El Krib	7,811	1,743	1,820
Total	**44,327**	**9,990**	**10,433**

2.1.11.2 Physical context

Topography

The Siliana Governorate is crossed by two mountainous chains, namely the Tell in the North and the Atlas in the South. The shapes of transition, hills and plateaus, occupy a great area there.

Siliana town is built on the plain of the Siliana wadi and characterized by a relatively flat relief: 420m altitude as an average. The town has a general slope from the Southwest to the Northeast. Siliana is practically shared by two catchment basins with a southwest-northeast separation crest line.

The town of Bou Arada has steep slopes towards the Northeast on one side and to the Northwest on the other. The elevation of the natural terrain varies between 270 m NGT and 234 m NGT.

The region's general topography of El Krib is rugged. The relief is formed by many mountains extending in different directions that form part of the long Atlas mountain range. The town is characterized by fairly regular slopes from the Northwest towards the Southeast and is located at an altitude of 470 m NGT.

Geology

During the basic design of the Siliana STEP, an initial geotechnical drilling survey was carried out. It included mainly 6 drillings and 10 samplings for the identification analysis.

Under the A.P.D. studies (Detailed Design), a second geotechnical survey was carried out which consisted of:

- For the network :
    - 3 auger drillings; depth equal to 5m on the projected network alignment ;
    - 1 static penetrometer and 1 pressiometer.

- For the WwTP :
    - 6 pressiometric drillings ;
    - 4 auger drillings with 5.00m depth.

These geotechnical campaigns highlighted the following courses at the location of the WwTP. Under topsoil cover 30 cm thick, there are two major horizons:

- The first layer consists of slightly gravelly whitish tuff clay with rocky or pebble zones. The thickness of this horizon varies between 3m and 4m in the greater part of the site, except perpendicular to the grit remover where it reaches 6m. The mechanical characteristics are excellent, with high resistance and low compressibility: Ep=220bars; Pl=23bars.

- The second layer is composed of slightly silty clay. Even if its geotechnical characteristics are less than the upper layer, it remains very good - resistance is high and compressibility is low: Ep=122 bars and Pl=16bars with an average of 18.3 bars.

  During the APD geotechnical survey, the ground water table was not encountered.

  The foundations of treatment, backflow and pumping stations are on a general bottom slab supported by the clayey formations mentioned above.

  Earthworks for the network systems should not encounter major difficulties since the soil found below the topsoil is clay with rocky passages or pebbles (aQ in the figure below).

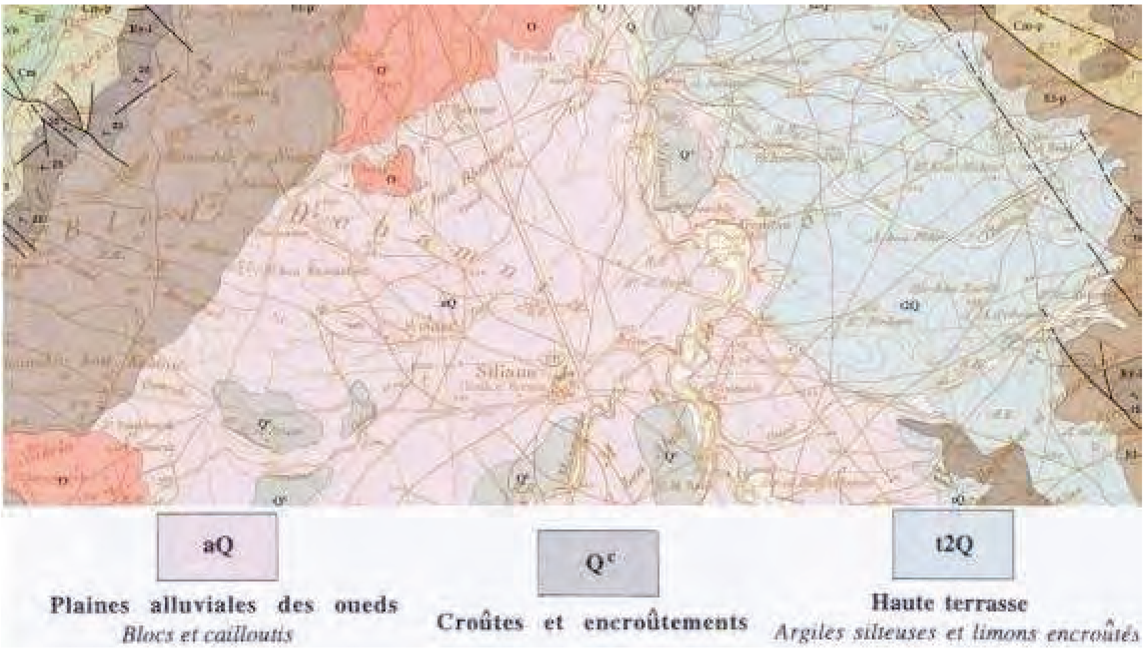


Figure 2.1-36: Geological map of Siliana

The geological formations of El Krib range from marl to calcareous rock, passing through a varied range of marly-calcareous rock and calcareous-marly rock.

Hydrogeology - Hydrology

The town of Siliana is bordered in the east by the Massouge wadi whose catchment basin is relatively vast (120km2) and is crossed in its western part by the Enfidha ravine thalweg (Tamarit wadi) whose catchment basin surface area may be estimated at 350 ha.

These two wadis are of interest within the sanitation context of Siliana since:

- The Massouge wadi does not present risks of flooding in the town;
- The Enfidha ravine crosses the city and is a cause of concern in case of violent storms; (the fifty year flow rate was estimated at 5.4m3/s).

A rainwater collector was built in 1993 – 1994 to protect Siliana town against flooding. The collector is composed of the following sections from upstream to downstream:

- Open air canal (2.00 m x 1.60 m) with length of around 250 m
- Covered box-culvert (2.00 m x 1.60 m) with length of around 1730 m
- Open air canal, 670m long

The Tamarit wadi provides discharge for this rainwater collector.

The water salinity varies from 1.0 to 3g/l.

The town of Bou Arada has been built on the initial slopes of the hills that overlook a rich agricultural plain. It is bordered to the West by the wadi Bou Arada and to the East by the wadi Bou Abdellah. A new tributary of the wadi Bou Arada is formed recently and borders the Northern zone of the town.

The town of El Krib is crossed by the wadi H'ddid to the West and the wadi Bridâa. Both wadis flow into the wadi Abderabou.

2.1.11.3 Climate

The Siliana Governorate is characterized by its semi-arid climate. The average annual precipitations are evaluated in 450 mm/year, including 500 millimeters on the heights and 300 millimeters in the plains. The average temperature is 17.75ºC.

The following figure shows the average annual precipitation recorded in 31 years of observation (1976-2006) in the weather station of Siliana Agricole - 415 mm per annum.

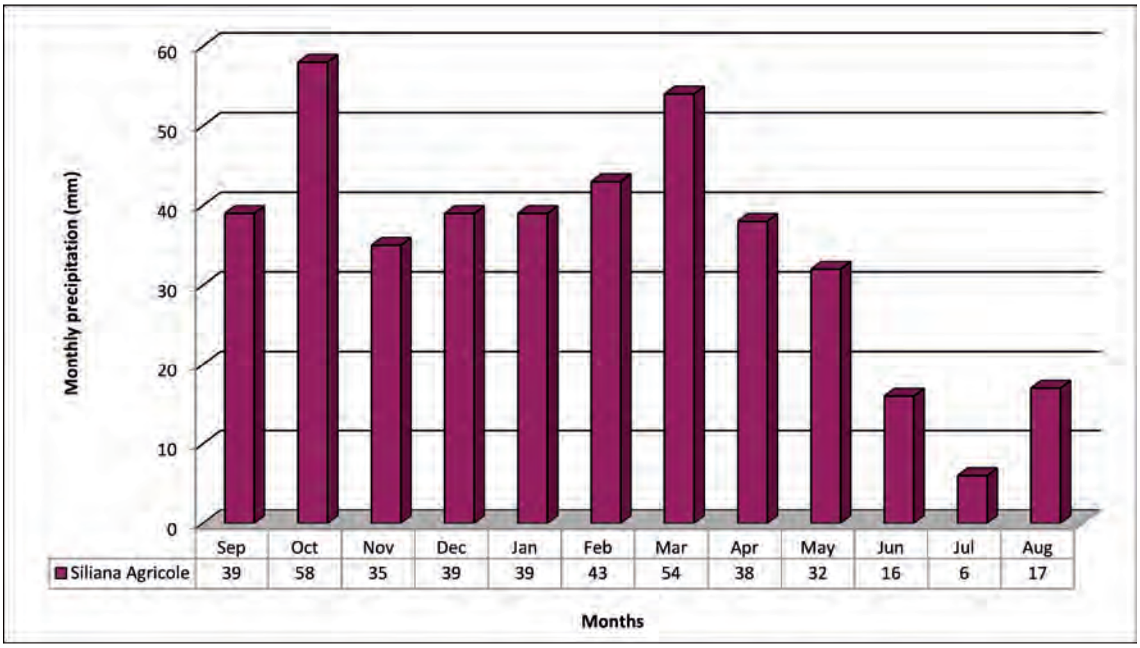


Figure 2.1-37: Annual rainfall in Siliana (Source: INM)

2.1.11.4 Economic activities

The main economic activities of the governorate are agriculture and textile industry.

Based on ONAS's annual operating reports, the following table presents the number of hotels and industrial units per commune as well as the water consumption of the industrial units connected to ONAS' network.

Table 2.1-42: Tourist Data and Industrial Data per commune

Commune	Tourist Data		Industrial Data	
	Number of hotels	Number of beds	Number of units	Consumption (m^3/j)
Siliana	1	32	1	8.3
Bou Arada	-	-	2	10
El Krib	-	-	-	-
Total	**1**	**32**	**3**	**-**

Source: Tunisian Hotel Business Federation – 2010 and ONAS 2010

2.1.11.5 Sanitation service indicators

The following table summarizes the key indicators that have been estimated for the Siliana Governorate. The indicators refer to the service of wastewater sanitation and were divided by territorial and demographic indicators, service levels indicators, infrastructure indicators and operational indicators.

Table 2.1-43: Indicators of sanitation service for the Siliana Governorate

Indicator category	Indicators	Unit	Value
Territorial and demographic indicators	Communes taken in charge by ONAS	un.	4
	Population taken in charge by ONAS in 2004	inhabit.	53,685
	Estimated population taken in charge by ONAS in 2010	inhabit.	56,688
	Households in the communes taken in charge by ONAS in 2004	un.	12,314
	Dwelling in the communes taken in charge by ONAS in 2004	un.	13,031
	Inhabitants per dwelling in 2004	inhabit.	4.4
	Growth rate of the number of dwelling	%	N/A
	Governorate area	km^2	4,642
	Estimated population density of the administrative center commune (Sfax) in 2004	$inhabit./km^2$	4,041
Level of Service Indicators	Estimated connected population 2010	inhabit.	53,740
	Number of installations connected to ONAS 2009 (*)	u.	15,359
	Connection rate in 2010	%	94.8
	Connection rate expected in 2029	%	98
	House sewer connections in 2010	un.	14,300
Infrastructure indicators	Linear length of the sewage networks	km	174
	Pumping stations	un.	10
	Wastewater treatment plants	un.	2
	Estimated length of the sewage networks to be rehabilitated	km	15
	Estimated length of the sewage networks to be extended	km	5
	Estimated new house sewer connections	un.	N/A
	Pumping stations to be rehabilitated	un.	6
	Pumping stations to be built	un.	0
Operational Indicators	Estimated drinking water consumption in 2010 (domestic, industrial, commercial/collective and tourist users) (1)	m^3/day	N/A
	Estimated infiltration into sewer	m^3/day	N/A
	Estimated wastewater flow	m^3/day	5,182

N/A No Data Available
(1) Main source of drinking water supply data: SONEDE from deep wells.
SONEDE Subscribers in 2009 (29,895 domestic, 72 industries, 705 collectives, 713 commercials)
Large-scale water consumers: Siliana industrial park does not have large-scale consumers whose quarterly consumption exceeds 5000 m3.
(*) Data not available for 2010.

The average specific consumption of drinking water in the governorate is 89 L per capita per day and has been estimated on the basis of data from SONEDE (annual volume consumed and the served population in 2009).

For each commune, the specific consumption of drinking water is indicated as follows:

Table 2.1-44: Specific consumption of drinking water (2009)

Commune	Specific consumption of drinking water 2009 (L per capita per day)
Siliana	100
Bou Arada	80
Gaafour	80
El Krib	75

The interventions proposed for each commune of Siliana governorate are summarized in the following table:

Table 2.1-45: Planned Interventions by commune for the Siliana Governorate

Communes	Rehabilitation		Extension	
	Networks (u.)	Pumping stations (u.)	Networks (u.)	Pumping stations (u.)
Bou Arada	4			1
El Krib			1	
Siliana	4			
Total	**8**	**0**	**1**	**1**

2.1.12 Zaghouan Governorate

2.1.12.1 Geographic and demographic context

The Zaghouan Governorate, located at 51 kilometers of the capital, is bordered by the governorates of Ben Arous and La Manouba to the North, Sousse and Kairouan in the South and Siliana and Béja in the West.

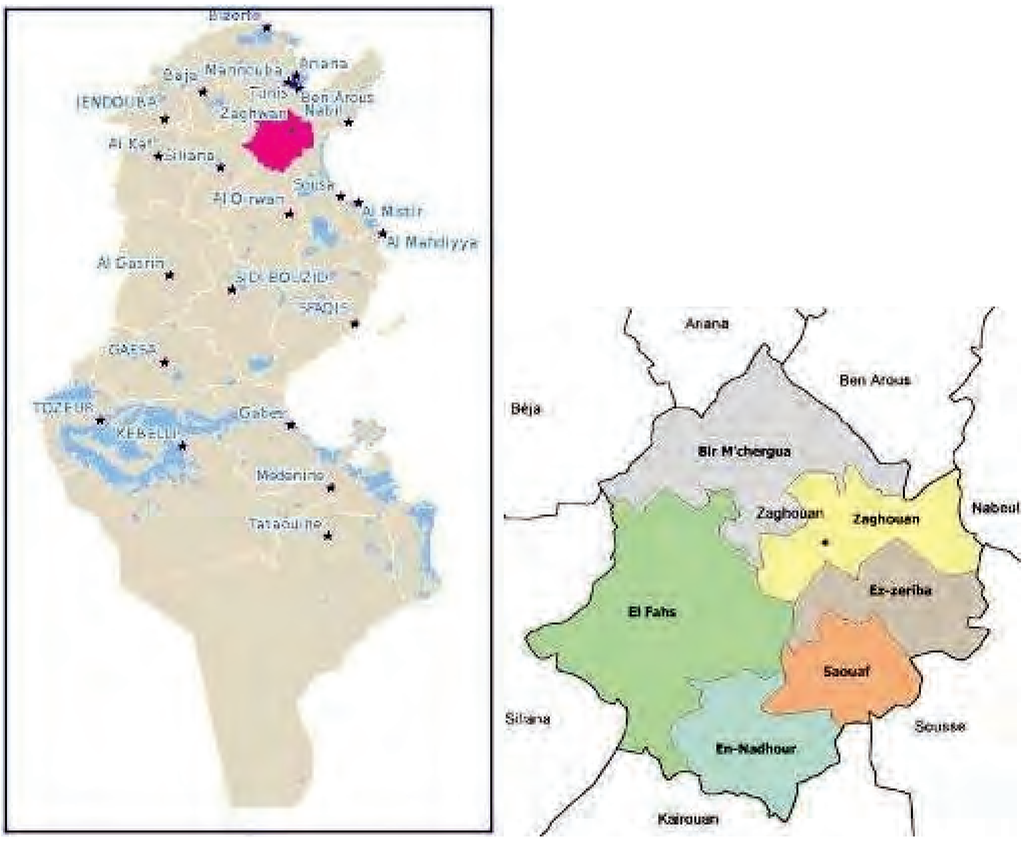


Figure 2.1-38: Maps of location and of delegations of Zaghouan governorate

The Zaghouan Governorate had a population of 160,963 inhabitants in 2004 which corresponded to 1.62% of the population of Tunisia. The same year, the total number of households was of 33,523 and dwellings were 34,959.

In this Governorate, the communes which are part of this study are Zaghouan, Hammam Zriba and El Fahs. These communes correspond to the three ones taken in charge by ONAS.

Zaghouan town, the administrative center of the governorate, is located 60km from Tunis at the foothills of Djebel Zaghouan, and dominates the fertile plain of the North which forms the high R'mel Wadi valley.

The town of Hammam Zriba, a delegation of the Zaghouan Governorate, is located in the upper valley of the wadi R'mel, 12 km from the town of Zaghouan, via the RR133 road.

The town of El Fahs, a delegation of the Zaghouan Governorate, is located around 60 kilometers to the Southwest of Tunis, via the road RN3. It is bordered from the Northeast to the Southwest by the wadi Bou Dhibben, a tributary of the wadi Meliane.

According to the 2004 census, we can observe the following records by commune taken in charge:

Table 2.1-46: Population, Households and Dwellings for the communes taken in charge in Zaghouan Governorate (2004)

Communes	Population	Households	Dwellings
Zaghouan	16,037	4,010	4,496
Hammam Zriba	9,002	2,039	2,164
El Fahs	19,315	4,128	4,355
Total	**44,354**	**10,177**	**11,015**

2.1.12.2 Physical context

Topography

All 3 communes have irregular terrain.

Geology

The main geological characteristics for the communes of this governorate are as follows.

The quaternary series of Zaghouan town are:

- Conglomerates, sandstone and gray clay (P1 on the figure 2.1-39)
- Crusts and calcareous deposits (Q^c on the figure 2.1-39)

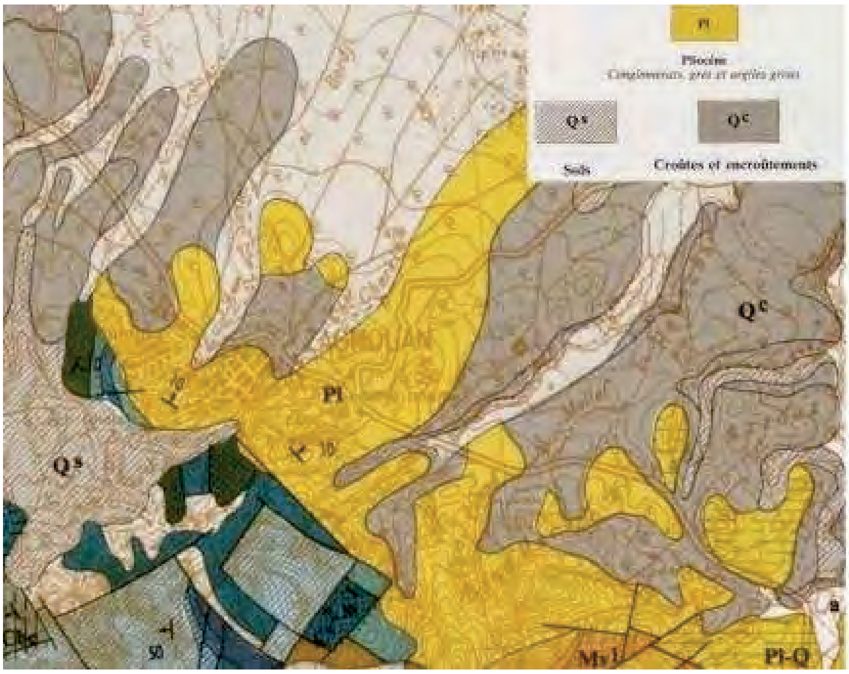


Figure 2.1-39 Geological Map of Zaghouan

In the region of El Fahs, the relief is constituted by chains of foothill mountains, fluvial terraces and alluvial plains. The shallow basins of the main plains are filled with very recent sediments. The soils are formed by marly-calcareous rock.

Hydrogeology - Hydrology

Zaghouan town is drained by the Smar Wadi, which flows into the Hammamet gulf. The old town is perched on a promontory bordered by the ravines of the foothills caused by two wadis flowing from the Southwest to the Northeast: the wadi Ennissa and the wadi Houch Jebara.

The commune of Hammam Zriba, renowned for its thermal springs, is a popular tourism resort. It is crossed by the wadi El Hammam and the town therefore suffers from frequent flooding.

2.1.12.3 Climate

The Zaghouan governorate is characterized by a semi-arid climate. The average temperature is 18°C and the annual rainfall varies between 350 and 550 millimeters according to the delegations, with an average of 504 mm/year.

2.1.12.4 Economic activities

The governorate has a strong agricultural tradition, with some recent industrialization.

Based on ONAS' annual operating reports, the following table presents the number of hotels and industrial units per commune as well as the water consumption of the industrial units connected to ONAS' network.

Table 2.1-47: Tourist Data and Industrial Data per commune

Commune	Tourist Data		Industrial Data	
	Number of hotels	Number of beds	Number of units	Consumption (m^3/j)
Zaghouan	-	-	48	-
Fahs	-	-	21	-
Hammam Zriba	-	-	56	-
Total	**-**	**-**	**125**	**-**

2.1.12.5 Sanitation service indicators

The following table summarizes the key indicators that have been estimated for the Zaghouan Governorate. The indicators refer to the service of wastewater sanitation and were divided by territorial and demographic indicators, service levels indicators, infrastructure indicators and operational indicators. These indicators have been estimated taking into account the latest data provided by the entities consulted for this study.

Table 2.1-48: Indicators of sanitation service for the Zaghouan Governorate

Indicator category	Indicators	Unit	Value
Territorial and demographic indicators	Communes taken in charge by ONAS	un.	3
	Population taken in charge by ONAS in 2004	inhabit.	44,354
	Estimated population taken in charge by ONAS in 2010	inhabit.	46,204
	Households in the communes taken in charge by ONAS in 2004	un.	10,177
	Dwelling in the communes taken in charge by ONAS in 2004	un.	11,015
	Inhabitants per dwelling in 2004	inhabit.	4.2
	Growth rate of the number of dwelling	%	2.8
	Governorate area	km^2	2,768
	Estimated population density of the administrative center commune (Zaghouan) in 2004	inhabit./km^2	3,412
Level of Service Indicators	Estimated connected population 2010	inhabit.	44,772
	Number of installations connected to ONAS 2009 (*)	u.	12.474
	Connection rate in 2010	%	96.9
	Connection rate expected in 2029	%	98.2
	House sewer connections in 2010	un.	9,547
Infrastructure indicators	Linear length of the sewage networks	km	158
	Pumping stations	un.	11
	Wastewater treatment plants	un.	3
	Estimated length of the sewage networks to be rehabilitated	km	52
	Estimated length of the sewage networks to be extended	km	7.5
	Estimated new house sewer connections	un.	150
	Pumping stations to be rehabilitated	un.	0
	Pumping stations to be built	un.	3

Indicator category	Indicators	Unit	Value
Operational Indicators	Estimated drinking water consumption in 2010 (domestic, industrial, commercial/collective and tourist users) (1)	m^3/day	5,165
	Estimated infiltration into sewer	m^3/day	N/A
	Estimated wastewater flow	m^3/day	4,492

N/A No Data Available
(1) Main source of drinking water supply data: SONEDE from the deep wells
SONEDE Subscribers in 2009 (10,572 domestic, 1,813 industries, collectives and commercial)
Large-scale water consumers: Zriba Hammam industrial park
(*) Data not available for 2010.

The average specific consumption of drinking water in the governorate is 97L per capita per day and has been estimated on the basis of data from SONEDE (annual volume consumed and the served population in 2009).

For each commune, the specific consumption of drinking water is indicated as follows:

Table 2.1-49: Specific consumption of drinking water (2009)

Commune	Specific consumption of drinking water 2009 (L per capita per day)
El Fahs	85
Zaghouan	108
Hammam Zriba	107

The interventions proposed for each commune of Zaghouan governorate are summarized in the following table:

Table 2.1-50: Planned Interventions by commune for the Zaghouan Governorate

Communes	Rehabilitation		Extension	
	Networks	Pumping stations	Networks	Pumping stations
El Fahs	8			
Hammam Zriba	10		1	1
Zaghouan	7		4	3
Total	**25**	**0**	**5**	**4**

2.2 METHODOLOGY FOR PRIORITIZATION OF INTERVENTIONS

If an intervention is already to be financed by another project, then it will be removed from this study, or from the interventions that could be selected if the funding occurs during the study.

In order to select and prioritize proposed interventions, three stages will be established according to the type, importance, and cost of each intervention.

The first phase consists in the division of all interventions into four principal categories:

- Type A – Emergency interventions which eliminate serious risks to public health or threats to the environment;
- Type B – Rehabilitation of existing infrastructure in areas already served by sewerage networks;
- Type C – Extension of existing infrastructure to areas that are already inhabited, but without any sewerage network;
- Type D – Extension interventions in uninhabited areas, where urbanization is planned.

The **Type A** is to be used only in exceptional situations and such interventions should be carried out before all others. It may cover rehabilitation or extension of existing infrastructure. It may involve elimination of interference in the urban cycle of water supply, i.e. contamination of drinking water catchment. Other benefits which would justify the classification of an intervention as the Type A can be the elimination of potential for development of water-related diseases or contamination of sensitive areas with high ecological and environmental value. For example, if wastewater currently flows freely on the surface of a street, then the construction of buried sewerage could be Type A.

In order to avoid overuse of the Type A, it was defined that no more than approximately five per cent of the interventions could be classified as the Type A. The classification does not result from economic criteria, since the benefits have major importance. Thus, these interventions will take precedence over all the others, irrespective of the associated costs and type.

After the execution of the interventions of Category A, the interventions of Category B must be realized.

Type B concerns the rehabilitation of existing systems. This classification will be applied to all the interventions for rebuilding, restoration or resizing of sewerage networks or pumping stations in order to improve service. With regard to pumping stations, minimizing energy costs can be the greatest challenge for rehabilitation. The increase in environmental quality and the resolution of problems which affect the quality of services rendered to the customer can be solved through the upgrading of the sanitation infrastructures.

Type C will include the extension of sewerage networks to areas that are already urbanized and inhabited, but, for some reason, are not provided with this infra-structure. Priority will be given to increasing the population served by sewerage and consequently increasing the connections and customers of the sanitation system. The interventions which optimize the profitability of the primary infrastructures through extension, especially wastewater treatment plants, will be also included in this category.

Since an extension of network is associated, in certain cases, with the construction of a pumping station, it is necessary to distinguish, in this phase, the pumping stations which do not require the construction of associated networks. For example, the construction of a new sewerage network in an area where some households have their own sewage system/septic tank could be Type C.

The **Type D** is the interventions consisting of construction of sewerage networks in uninhabited areas where urbanization is planned. In this case, there is no immediate increase in the served population, and also there is no water pollution at present. These interventions thus have low priority. In addition, when urbanization is expected, the infrastructure must be planned or be installed before starting the construction of buildings considering forecast population. In any case, these interventions must be also taken into account.

All interventions having been classified as Type A, B, C and D, the second phase can be undertaken. Through this phase, the interventions of Type B and C shall be classified to subcategories according to their importance. If the intervention has a high degree of importance, it must be classified to subcategory 0 and if not, it is classified to subcategory 1. The criteria that allow classifying an intervention to the subcategory 0 are indicated in the following table.

Table 2.2-1: Relevance criteria for Type B and C interventions, category 0

Interventions of Type B	Interventions of Type C
• Resolution of frequent blockages/leakage of wastewater; • Substitution of damaged critical equipment; • Separation of combined drainage networks without storm drain outlet; • Systems of defective design or construction that have not been brought into service; • Reduction of infiltration.	• Satisfy urgent demand for sewerage; • Connection to a WWTP to be rehabilitated under this study.

The last phase is to estimate the cost of each intervention and to identify the beneficiary population (actual data shall be considered in case of the Type B and C, and provision shall be applied in case of the Type D). With these data, it is possible to estimate the cost per-capita for each intervention. Within each type described above, the interventions will be ordered from lowest to highest according to the cost per-capita. A greater importance will be given to the interventions which would supply a larger population for the same cost.

Note that the beneficiary population is not necessarily equal to the population directly connected to the intervention. It includes all those upstream of an intervention infrastructure, whose wastewater is transported by it.

For a better understanding of the method of prioritization of the interventions, a diagram is presented in the following figure. The selection of the interventions must be made according to the budget available and the classification obtained, since the lower categories do not offer a significant improvement for the population, an increase in the financial resources of the operator, or even for the environment.

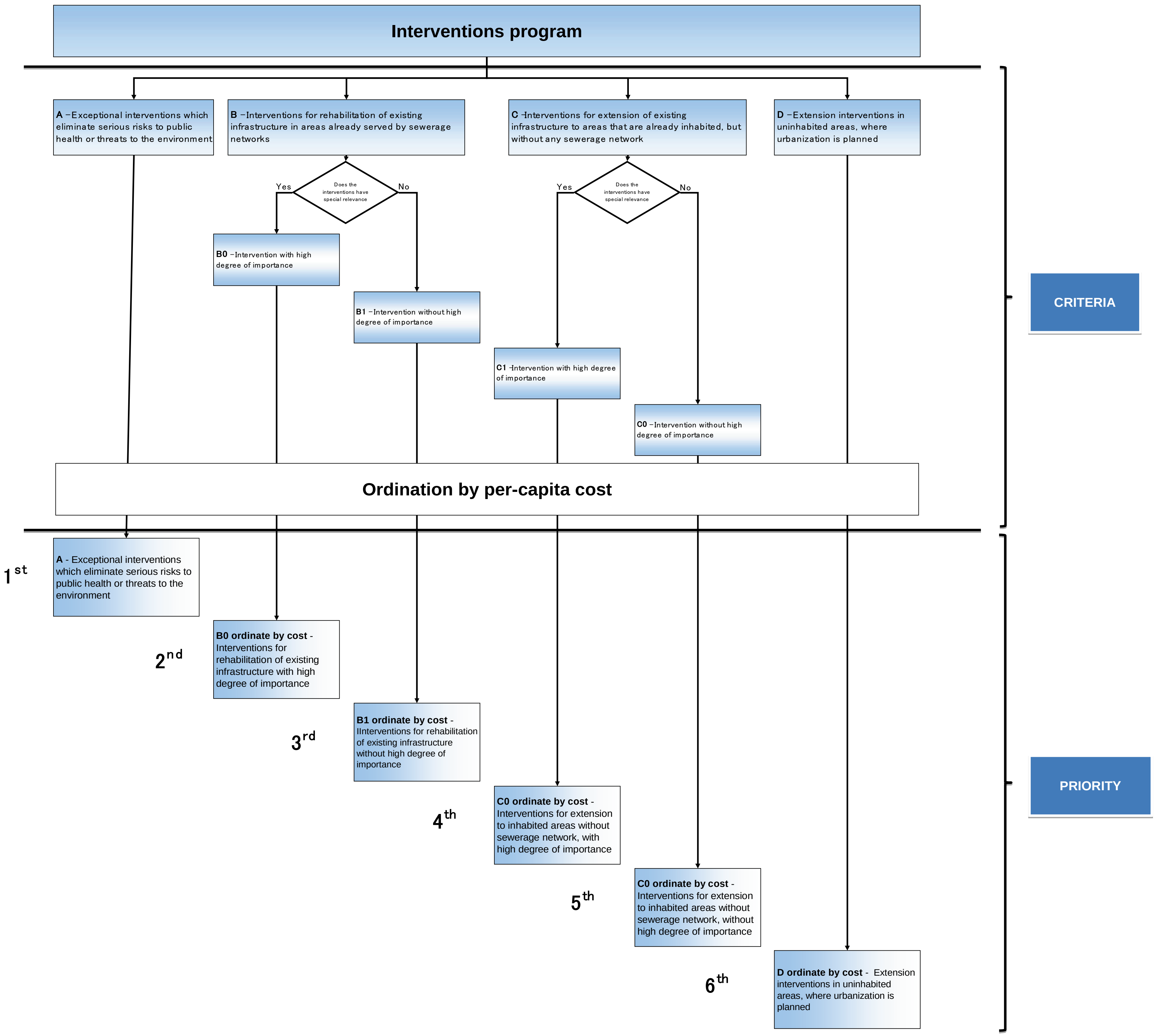


Figure 2.2-1: Method for prioritization of network interventions

2.3 DESIGN CRITERIA

2.3.1 Design period

The design period means the life-span of a project. This time period corresponds to the number of years that the sewerage system or sewerage construction, electrical and electromechanical accessory structures and facilities must operate in good condition.

The choice of design period was based on factors such as:

- Useful life of civil engineering and equipment (electric and mechanical) components ;
- Refunding of the investments ;
- Conditions of first years exploitation (oversizing of the capacity at the beginning).

The networks and pumping stations design will be made for the design period considered in this study, which is 19 years which coincides with Year 2029.

It is necessary to make estimates of domestic, industrial and touristic wastewater flows sources, throughout the design period that must be as accurate as possible.

2.3.2 Contributing areas determination

Contributing areas are defined as those which drain into a given section of a network. In order to determine the contributing areas for each intervention, the available plans, as listed below, will be analyzed:

- Topographic plans of the study area;
- Sewerage plans;
- Rivers and water streams basin plans.

The methodology for determination the contributing area may be differentiated, depending on the size and type of intervention, but anyway, the first step is identical in all cases and consists in determination of the connection point to an existing network, to a WwTP, to a pumping station, etc. The second step is the determination of the area that drains to the connection point determined in the first step. This analysis is based on the plans referred to above, and must take into account the terrain and urban development.

The layouts of the contributing areas must also take into account any pumping stations beyond the catchment area which discharge into it. One can thus determine the total area of influence, which is all the area that drains to a point of connection.

If necessary, the following characteristics can be considered:

- Land occupation and use;
- Contributing area surface;
- Length;
- Maximum slope;
- Minimum slope;

- Average slope;
- Time of concentration ;
- General geological and hydrogeological characteristics.

2.3.3 Population served by each intervention

Each proposed intervention will serve a specific population - that will be benefited by the works. This population does not necessarily correspond to the totality of the population integrated within the catchment water basin in question for each intervention.

The estimate of the population served (in 2009) by each intervention has been obtained on the basis of information provided by ONAS during the field mission. The available elements are as follows:

a) Served population indicated by ONAS;
b) Network layout;
c) Average number of inhabitants per house:
   - 4 to 5 persons per house ;
d) Number of dwellings;
e) Number of connection boxes:
   - indication by ONAS;
   - estimation according to network length:
     - 1 connection box / 10 meters – densest zones;
     - 1 connection box /20 meters – least dense zones.

In some rare cases[1] where the population was not provided by ONAS, the served population was estimated using an average population density indicated by the regional directorate of ONAS, or the following indicators used by ONAS:

Table 2.3-1: Average density of inhabitants, per hectare, by type of inhabitant

Types of inhabitants	Average population density (inhabitants/ha)
Grouped	165
Continuous individual	125
Discontinuous individual	100
Central nucleus	225

[1] The three interventions SIL-Sil-RS-Rh-1, SIL-Sil-RS-Rh-2 and SIL-Sil-RS-Rh-3.

2.3.4 Design flow

2.3.4.1 General considerations

The design flows of wastewater sanitation systems include domestic, industrial and tourism flows, as well as infiltration. The design flows for each sector are related to the forecast flows for the project's design horizon, i.e., the annual average flows by an instantaneous peak factor.

2.3.4.2 Domestic flows

The calculation methods used to estimate the wastewater flows are based on urban data in relation to different modes of soil occupation and statistics concerning specific consumption of drinking water for different uses.

The forecasts of the average consumption of water for the year 2029 will be based upon establishing different flows for each commune, using the specific water requirements of the different types of consumers in each commune.

The average flow of wastewater of domestic origin will be determined on the basis of the average consumption of water, using a discharge coefficient equal to 0.8 (domestic users) or 0.9 (tourism users). This coefficient reflects the percentage of water used and actually discharged into the sewerage network:

$$N = 0.8M$$

Where:

N Specific discharge of wastewater in L/cap./day

M Specific consumption of drinking water in L/cap./day

The specific consumption of drinking water for each commune has been indicated in Chapter 2.1.

Each mode of land use corresponds to a specific flow of wastewater, determined on the basis of the population density and specific discharge of wastewater. The specific flow of domestic wastewater by surface is calculated using the following formula:

$$q = \frac{P}{24}\frac{N}{3600} \quad \text{in liters/second/hectare}$$

Where:

P Population density per hectare

The average flow per second of wastewater of domestic origin may be expressed using the following formula:

$$Q_m^D = q \times S \quad \text{in liters per second}$$

Where:

S Surface area of the water basin considered in hectares

The peak factor will be estimated using the following empirical formula for cities sanitation:

$$Kph = 1.5 + \frac{2.5}{\sqrt{Q_m^D}} \qquad Kph \leq 3$$

Thus the peak domestic flow in L/s may be expressed using the following formula:

$$Q_p^D = Kph \times Q_m^D$$

The quantity of wastewater produced by the population connected to each section of the network will be considered. This value will be added to the flow coming from connections along the network, as it moves downstream in the system.

The design of gravity networks also considers the attenuation of flow, from upstream to downstream, leading to reduction of the peak factor, in function of increases to the accumulated population / average daily flow. As a result, the high peak flows assumed upstream are increasingly smaller downstream.

2.3.4.3 Industrial flows

The design of sanitation networks for communes will consider the main wastewater flows of industrial origin. These flows will only be considered for wastewater originating in industrial zones or large-scale factories. The rest of the industrial flows will be considered as included within the domestic flows.

The average flows of industrial wastewater will be evaluated on the basis of specific flows, and may be evaluated by the surface unit of the industrial zone or by the specific activity of a factory.

Industrial wastewater will be considered to be centralized flows that are not governed by the same seasonal and hourly modulations that govern wastewater of domestic or collective origin. Therefore the industrial peak flow will be determined on the basis of a peak coefficient of 2.0.

$$Q_p^I = 2.0 \times Q_m^I$$

Where:

Q_m^I	Average industrial flow

2.3.4.4 Tourism flows

The methodology used to estimate tourism flows will be identical to that used to estimate industrial flows. The flows considered in this regard are solely flows deriving from large hotels, tourism villages or zones with a high concentration of secondary residences. Other tourism flows will be considered as included within the domestic flows.

The average flows of tourism wastewater will be evaluated on the basis of specific flows, and may be evaluated by number of beds or by type and surface unit of the tourism zone.

The peak tourism flows will be determined using a peak coefficient of 2.0.

$$Q_p^T = 2.0 \times Q_m^T$$

Where:

Q_m^T	Average tourism flow

2.3.4.5 Infiltration

Infiltration flows penetrate the sanitation network via direct connections, connection errors, illegal connections or structural imperfections.

This component of infiltration has a hybrid character and may be observed after periods of rainfall or in the event of a high water table.

The infiltration flow will be determined through consideration that it lays between 40% and 70% of the average flow of wastewater of domestic origin. The choice of the exact percentage for the infiltration flow, C, will be based upon a qualitative assessment of the networks, the characteristics of each commune and the respective type of intervention (rehabilitation/extension). On average, the adopted value is 50%.

$$Q^P = C \times Q_m^D$$

2.3.4.6 Total design flow

The design flow in a separation system will be the sum of the peak flows of the wastewater of the different origins and the infiltration flow. This flow will be used to calculate the piping sections of the sewers, adequate for wastewater transport.

$$Q_p^{Dim} = Q_p^D + Q_p^I + Q_p^T + Q^P$$

Except for infiltration, the flow of rainwater will not be taken into consideration in dimensioning of the infrastructures.

Separate sewerage networks will always be foreseen in the event of an extension intervention, and a proposal will always be made to eliminate rainwater connections and to build a parallel rainwater drainage network in rehabilitation interventions. However, the cost estimates presented here do not include costs of stormwater drainage networks.

2.3.5 Design of drainage networks

The dimensions of gravity sewer networks were calculated according to the Manning-Strickler formula:

$$Q = K_s S R^{\frac{2}{3}} i^{\frac{1}{2}}$$

Where:

Q	Flow (m3/s)
Ks	Roughness coefficient (or Strickler coefficient) (m1/3/s)
S	Wet section (m2)

R Hydraulic radius (m) : R = S/P where P = Wet perimeter (m)

i Slope (m/m)

The sewerage networks will use PVC and PVC/HDPE lined concrete pipes, according to the following table:

DN (nominal diameter)	Material
250	PVC
315	PVC
400	PVC
500	PVC
630	PVC
800	PVC/HDPE lined concrete
1,000	PVC/HDPE lined concrete
1,200	PVC/HDPE lined concrete

It is important to note that the nominal diameter corresponds to the exterior diameter for PVC and to the interior diameter for concrete pipes. The roughness coefficient K_S is 90 $m^{1/3}/s$.

The hydraulic-sanitary design of the networks was carried out according to the following criteria:

Table 2.3-2: Criteria for hydraulic-sanitary design of sewers

Criterion	Unit	Value
Minimum diameter	mm	250
Recommended minimum slope	m/m	0.005
Recommended maximum slope	m/m	0.150
Recommended capacity for sewers with diameter ≤ 500 mm (depth of flow / diameter)	—	h/D ≤ 0.50
Recommended capacity for sewers with diameter > 500 mm (h/D) (depth of flow / diameter)	—	h/D ≤ 0.75
Minimum speed of the flow in order to guarantee self-cleansing	m/s	0.6
Maximum speed of the flow	m/s	3.0
Average distance between man-holes	m	35
Recommended depth for establishment of sewers	m	$D_{(exterior)} + 1.2$

To calculate the cost of construction, we also estimated the number of connection boxes to be constructed, using the following criteria:

- Based on the length of the networks in urban areas:
    - in the more dense areas - 1 connection box / 10 m of sewer;
    - in the less dense areas - 1 connection box / 20 m of sewer;

- According to the number of houses visible on the drawings, considering one box per house.

All the recommendations of ONAS have been taken into consideration for design of the sewerage networks.

2.3.6 Design of the pumping stations

The key design criteria for pumping stations are as follows:

- Minimum design flow 10 L/s (however in some cases an absolute minimum of 5 L/s was accepted)
- Screening (basket or mechanical)
- Submersible pumps
- Water hammer protection (hydro-pneumatic balloon or surge tank)
- Independent access to the wet well, valve chambers, screening room, electricity switchboard room.
- Ventilation of the wet well, access zones to the well and valve chambers
- Odor treatment of wet well and access zones to the well
- Emergency electricity generator

The proposed systems have been designed in order to minimize the pumping of raw wastewater, guaranteeing preventive and corrective measures in order to control the septicity of the wastewater.

Due to the sensitivity of the urban environment and the location planned for most of the pumping stations, it is necessary to adopt solutions that permit a highly reliable operation and which should guarantee a minimum of breakdown situations of the equipment items.

Six types of pumping stations have been taken into consideration for this study, according to the station capacity and equipment items: three capacity thresholds (up to 10 L/s; between 10 L/s and 150 L/s; and above 150 L/s); and two equipment levels (minimal solution and solution with mechanical screening, odor treatment and emergency electricity generator).

For capacities up to 10 L/s, compact pumping stations have been considered (of a prefabricated GRP type with a screening basket). According to the space available in order to implement the pumping station, two different options have been studied:

SP1A - Pumping stations with valves inside the well

SP1B - Pumping stations with valves in a valve chamber next to the well

For capacities between 10 L/s and 150 L/s, concrete pumping stations with two equipment levels have been considered:

SP2A – Vertical screening basket

SP2B - Vertical mechanical screen, odor treatment and emergency electricity generator

For capacities above 150 L/s, concrete pumping stations with two equipment levels have been considered:

SP3A - Screening basket in the channel

SP3B - Mechanical screen in the channel, odor treatment and emergency electricity generator

All the recommendations of ONAS have been taken into consideration for design of the pumping stations.

2.3.7 Design of pumped mains

The diameters of pumped mains were estimated using the following empirical formula:

$$D = 0.9\,Q^{0.45}$$

Where D (m) represents the (interior) diameter chosen and Q the flow (m/s). The diameter obtained is rounded to the nearest commercial diameter available for the materials chosen. In this case, the pumped mains have been planned in HDPE, for the following diameters:

DN (nominal diameter)	Material
125	HDPE
160	HDPE
200	HDPE
250	HDPE
315	HDPE
400	HDPE
1,000	HDPE

HDPE was chosen to optimize technical, economic and public health aspects. Flexibility and security of the pumped mains were also taken into consideration. We should emphasize that the nominal diameters for the HDPE are exterior diameters.

The hydraulic design of the pumped mains respected the following criteria:

- Velocity higher than 0.65 m/s and lower than 1.5 m/s;
- Diameter of the rising main greater than 100 mm;
- Profile of the main preferably rising throughout the layout.

In complement, the pumped mains should be equipped with a set of maintenance and safety devices:

- Air-release valves (at the high points);
- Wash-out points (at the low points);
- Water hammer arrester (normally in the building of the pumping station, at the beginning of the rising main).

All the recommendations of ONAS have been taken into consideration for design of the pumped mains.

2.4 CRITERIA FOR ESTIMATION OF INVESTMENT COSTS

2.4.1 General considerations

The investment costs associated with the sewerage infrastructures (networks, pumped mains and pumping stations) are estimated using the following criteria:

- Economic conditions and unit costs recently used in similar studies;
- Consultations made with Tunisian companies;
- Indicators established using budgets for recent works and budgets for projects developed for similar markets;
- Indicators and information supplied by ONAS.

2.4.2 Sewerage networks

The investment costs for the construction of a new sewerage network were determined in function of the piping material and network layout. The quantities of work for installation of the network were estimated using the following criteria:

- Width of the trench equal to Dext (exterior diameter) + 0.50 m;
- Trench with vertical walls ;
- Replacement of the road structure on a width equal to the width of the trench plus 0.20m either side;
- Average cover over pipes equal to 1.2 m;
- Average distance between manholes = 35 m.

The material considered in the cost estimate is PVC for diameters up to 630 mm and lined with PVC/HDPE reinforced concrete for larger diameters. Construction costs of sewers were estimated using the following unit costs (which include pipes, earthworks, manholes and other associated structures), developed following consultation with ONAS and other local organizations.

The Table 2.4-1 presents the unit costs of purchase (material only, transport and installation excluded) while Table 2.4-2 presents the unit costs of construction (all inclusive) of the linear of sewage network.

Table 2.4-1: Unit purchase costs of sewers pipes and manholes

Pipe	Nominal Diameter DN	Unit	Average purchase price (TND)
Gravity sewer in PVC (SN8)	250	ml	24
	315	ml	38.2
	400	ml	61.2
	500	ml	95.3
	630	ml	206.5
Gravity sewer in lined PVC / HDPE concrete	800	ml	300
	1000	ml	400
HDPE (PN10)	125	ml	10
	160	ml	16
	200	ml	25
	250	ml	40
	315	ml	63
	400	ml	102
	630	ml	259
	800	ml	452
	1000	ml	850
Manhole	Ductile cast iron cover - DN800	u	160
	Manhole in reinforced concrete, including inner and outer coatings - DN800	u	350
	Ductile cast iron cover – DN1000	u	180
	Manhole in reinforced concrete, including inner and outer coatings - DN1000	u	400
Connection box	Connection box in reinforced concrete, including inner and outer coatings	u	400

Table 2.4-2: Unit linear costs (TND/m) of sewers installed in trenches

Soil salinity	Pipe	Nominal Diameter DN	With removal and replacement of the road pavement		On natural terrain without pavement	
			On normal ground	On rocky ground	On normal ground	On rocky ground
Normal	Gravity sewer in PVC (SN8)	250	120	170	85	135
		315	130	180	95	145
		400	160	210	125	175
		500	205	255	165	215
		630	310	360	270	320
	Gravity sewer in lined PVC/HDPE concrete	800	450	500	410	460
		1,000	560	610	515	565
High salinity	HDPE (PN10)	600	445	495	405	455
		800	695	745	655	705
		1,000	975	1025	930	980

For each intervention the percentage of road pavement to be removed and replaced and the percentage of rocky ground were quantified, and the presence or absence of soil salinity was determined. Based on this information, the appropriate unit costs from Table 2.4-2 were then applied to the network lengths in order to obtain the cost of sewers installed in trenches for each intervention.

This study also considered a unit cost of connection boxes and lateral is 400 TND. This unit cost includes the box itself and the pipe which connects it to the sewer, including earthworks, removal and replacement of the road pavement. The quantity of connection box is estimated based on the number of users in each intervention zones, provided by ONAS.

Rehabilitation of sewers:

Pipes in asbestos or concrete that have more than 20 years are usually in bad structural conditions and replacement is imperative since rehabilitation is not possible.

The cost of rehabilitation of sewers was considered to be 120% of the construction cost of a new sewer with the same characteristics, as indicated above, since the work must also include the demolition of existing structures (sewers and existing manholes) and guarantee the operation of the network during the rehabilitation.

2.4.3 Pumping stations

The costs of construction of pumping stations depends on the station capacity and the dynamic pumping heads, and are also influenced by the conception method, the installations program and local constraints. The pumping stations considered in this study will be equipped with submersible pumps and will have a building for installation of various pieces of equipment e.g.: electricity switchboard, screening equipment, odor treatment, electricity generators, etc.

For capacities less than 10 L/s, the pumping station will be solely constituted by a pre-fabricated GRP wet well.

The following formulae, based on information provided by ONAS and other bodies, were used to estimate determine the initial investment costs of pumping stations:

Table 2.4-3: Formulae for Estimating the Investment costs of the Pumping Stations

Type	Description	Station capacity (L/s)	Total Construction Cost (TND)	Civil Engineering Cost (% Total Cost)	Cost of Equipment and Electrical Installations (%Total Cost)
SP1A	Compact with the valves inside the wells	< 10 L/s	80,000	50%	50%
SP1B	Compact with valve chamber	< 10 L/s	100,000	50%	50%
SP2A	Concrete with vertical basket screen	10 à 150 L/s	$16{,}500\ Q^{0.65}$	40%	60%
SP2B	Concrete with vertical mechanical screen	10 à 150 L/s	$23{,}500\ Q^{0.65}$	40%	60%
SP3A	Concrete with a basket screen in channel	> 150 L/s	$16{,}500\ Q^{0.65}$	40%	60%
SP3B	Concrete with mechanical screen in a channel	> 150 L/s	$23{,}500\ Q^{0.65}$	40%	60%

Note: Q = flow capacity of the pumping station (L/s);

Rehabilitation of pumping stations

The cost of rehabilitation of a pumping station was considered as a percentage of the construction cost of a new station, in function of the extent of rehabilitation required.

2.4.4 Pumped mains

The initial investment costs for the construction of pumped mains were estimated in function of the piping material and pipe layout. The quantities of work for installation of the pumped mains were estimated using the following criteria:

- Width of the trench is equal to Dext (exterior diameter) + 0.50 m;
- Trench with vertical sides;
- Replacement of the road structure on a width equal to the width of the trench plus 0.20m either side;
- Average cover of the pipes equal to 1.2 m;

Construction costs of pumped mains were estimated using the following unit costs (which include pipes, earthworks, air release valves, washout points and other associated structures), developed following consultation with ONAS and other local organizations:

Table 2.4-4: Cost (TND) per linear meters of the pumped mains installed in a trench

Pipe	Nominal Diameter DN	With stripping and re-establishment of the road		On natural terrain	
		On normal ground	On rocky ground	On normal ground	On rocky ground
Rising main in HDPE (PN10)	125	110	160	75	125
	160	120	170	85	135
	200	130	180	95	145
	250	150	200	115	165
	315	180	230	145	195
	400	230	280	195	245
	1,000	975	1,025	930	980

Rehabilitation of a pumped main

The cost of rehabilitation of a pumped main was considered to be 120% of the construction cost of a new main with the same characteristics, as indicated above, since the work must also include the demolition of existing structures and guarantee the operation of the main during the rehabilitation.

2.5 CRITERIA FOR ESTIMATION OF OPERATION AND MAINTENANCE COSTS

2.5.1 General considerations

Itemized operating and maintenance costs have been established for each of the proposed sewerage infrastructures, as a percentage of the initial construction costs for the sewerage networks, pumped mains and pumping stations.

For the pumping stations, electricity costs have also been considered.

2.5.2 Gravity sewer networks and pumped mains

The annual operating and maintenance costs were estimated as a percentage of the initial construction costs, according to the following table:

Table 2.5-1: Operation and maintenance costs of sewers and pumped mains

	Annual operation and maintenance cost (% of initial construction cost)
Gravity sewers	3.00%
Pumped mains	3.00%

2.5.3 Pumping stations

The annual operating and maintenance costs of pumping stations were estimated as a percentage of the initial construction costs in two subsets, civil engineering and equipment /electrical installations, according to the following table:

Table 2.5-2: Operation and maintenance costs for pumping stations

	Annual operation and maintenance costs	
	Civil engineering (% of initial construction cost)	Equipment and electrical installations (% of initial construction cost)
Pumping stations	1.50%	5.00%

Electricity consumption costs were also estimated, in function of the average annual flow to each pumping station, the dynamic head of the pumps, the efficiency of the pumps (considered to be 62.5%) and the unit electricity cost.

The unit electricity cost taken into consideration is 0.130 TND/kWh.

In order to determine this cost, we calculated the cost of elevation of 1 m^3 by a height of 1 m, according to the following formula:

$$Cost = (g / 3600\ R)\ C_{kWh} = 5.67\times10^{-4}\ TND/m^3\ m$$

Where:

G	Gravity (ms-2)
R	Efficiency of the pumps (62.5%)
CkWh	Unit electricity cost (0.130 TND/kWh)

2.6 DESCRIPTIONS OF THE INTERVENTIONS

2.6.1 General considerations

The following sections describe the proposed interventions for each governorate, and estimated capital costs and operating costs. The interventions were developed as follows:

- Proposal of interventions by ONAS in the Feasibility Study;
- Field surveys in all governorates by the consultant team to identify and locate the interventions;
- Preparation of drawings of all identified interventions at 1:5000 or 1:10000 scale;
- Meetings with the personnel from ONAS governorate directorates for validation of drawings and data collection (population, flow, condition of infrastructure, etc.).
- Site visits to intervention locations to verify drawings in all governorates except Kasserine, Sidi Bouzid and Kef;
- Elimination of unnecessary interventions, either for technical reasons or those that have already been built or already funded by another project;
- Design and description of retained interventions, preparation of final drawings (presented in Annex II.2) and estimates of costs of initial investment and operation, as total costs and per capita costs (considering the population served).

Table II.1.1 of Annex II.1 presents a complete list of all interventions studied, including those which were eliminated during the study.

All construction and operating costs of the interventions are costs in Tunisia, presented in Tunisian Dinars (TND).

2.6.2 Intervention code system

An identifying code system was developed for the interventions for extension and rehabilitation of sewerage networks and pumping stations, in order to facilitate their classification and analysis. Thus the codes contain information relating to the governorate, town (commune), type of facility, type of intervention and a reference number, as follows:

ZAG	-	Fah	-	RS	-	Rh	-	1
①		②		③		④		⑤

① Name of Governorate:

BIZ: Bizerte, **ZAG**: Zaghouan, **BEJ**: Béja, **SIL**: Siliana, **JEN**: Jendouba, **KEF**: El Kef

SFA: Sfax, **KAS**: Kasserine, **SID**: Sidi Bouzid, **KEB**: Kébili

② Name of Town (commune):

E.g. **Fah**: El Fahs (in the governorate of Zaghouan)

③ Type of facility:

RS: Sewerage network, **SP**: pumping station

④ Type of Intervention:

Rh: Rehabilitation, **Ex**: Extension

⑤ Reference Number:

Unique reference number for same type of intervention in same town (commune).

The following should be noted:

- SP interventions which are extensions include pumping stations and the corresponding pumped mains. In the case of rehabilitations, the intervention may refer to only the pumping station, or only the pumped main, or both. SP interventions may also include short gravity sewers which connect the network to the pumping station.
- RS interventions relate to gravity sewers, but may exceptionally include a pumped main in cases where the corresponding pumping station is not subject to intervention.
- Rh interventions refer to the rehabilitation or substitution of existing infrastructure. The rehabilitation of a sewer may involve its complete substitution by a new sewer of different material and different diameter. Even if the purpose of the infrastructure will change significantly (for example it will serve a much larger area), its substitution is still classed as a rehabilitation.
- Ex interventions refer to the construction of new infrastructure.
- In cases where much of the existing network of a residential area is to be rehabilitated, but some sewers will be laid along routes with no existing sewers, these sewers are considered to be part of the same Rh intervention.

The following table shows the different codes for the governorates and the towns concerned in this project.

Governorate	Governorate code	Commune	Commune code
BÉJA (ONAS North Regional Department)	BEJ	Béja	Bej
		Maagoula	Maa
		Medjez El Bab	Med
		Nefza	Nef
		Teboursouk	Teb
		Testour	Tes
BIZERTE (ONAS North Regional Department)	BIZ	Alia	Ali
		Bizerte	Biz
		Mateur	Mat
		Menzel Abderrahmane	Abd
		Menzel Bourguiba	Men
		Menzel Jamil	Jam
		Raf Raf	Raf
		Tinja	Tin
		Zarzouna	Zar
JENDOUBA (ONAS North Regional Department)	JEN	Boussalem	Bss
		Fernana	Fer
		Ghardimaou	Gha
		Jendouba	Jen
		Tabarka	Tab
KASSERINE (ONAS Central Regional Department)	KAS	Feriana	Fei
		Kasserine	Kas
		Sbeitla	Sbe
		Thala	Tel
KEBILLI (ONAS South Regional Department)	KEB	Douz	Dou
		Douz sud	Dos
		El Golaa	Gol
		Jemna	Jem
		Kébili	Keb
		Kébili nord	Ken
		Kébili sud	Kes
		Souk Lahad	Sou
KEF (ONAS North Regional Department)	KEF	Dahmani	Dah
		Kef	Kef
		Tajerouine	Taj
SFAX (ONAS South Regional Department)	SFA	Agareb	Aga
		Jebeniana	Jeb
		Sfax Sud	Sfs
		Sfax Ville	Sfv
		Mahres	Mah
		Sakiet Eddaier	Sak
		Sakiet Ezzit	Sae
		Chihia	Chi
		El Ain	Ain
		Gremda	Gre
		Tyna	Tyn
		Hencha	Hen
SIDI BOUZID (ONAS Central Regional Department)	SID	Sidi Bouzid	Sid
SILIANA (ONAS North Regional Department)	SIL	Bou Arada	Bou
		Krib	Kri
		Siliana	Sil
ZAGHOUAN (ONAS North Regional Department)	ZAG	El Fahs	Fah
		Hammam Zriba	Ham
		Zaghouan	Zag

2.6.3 Béja Governorate

The planned interventions in the Béja Governorate relate to the rehabilitation and expansion of the wastewater networks and pumping stations in the communes of Béja (Bej), El Maagoula (Maa), Medjez El Bab (Med), Nefza (Nef), Teboursouk (Teb) and Testour (Tes), managed by ONAS. The communes of Béja, El Maagoula and Nefza are the responsibility of the delegation of Béja, while others are managed by the delegation of Medjez El Bab.

Each commune, with the exception of El Maagoula, is served by a WwTP. Wastewater from the commune of El Maagoula are treated in Béja WwTP.

The drainage systems are unitary or pseudo-separate, being connected to roof and courtyard drains. There are some exceptions with separate networks.

Road drainage is mostly superficial and discharges to watercourses. Some main roads have stormwater sewers.

Problems of contamination of groundwater have been identified in the communes of Nefza, Teboursouk and Testour, so some interventions there are classified as exceptional, Type A.

For the areas proposed for extension, particularly at Nefza, the wastewater are currently discharged directly to watercourses without treatment, flowing into the Sidi El Barrak dam reservoir, a major source of water for the region.

Throughout the governorate, specific problems of overflow from sewers were identified, due to the obsolescence of the existing network and its poor condition. At Testour, Medjez El Bab and Béja, overflow problems are the greatest.

For the Design of the infrastructures and estimation of the works, the basic data considered were 1 connection box and 4 persons per dwelling. Consumption per capita data of chapter 2.1 were taken in account.

The terrain is very rugged in Nefza and Teboursouk and almost flat in Medjez El Bab. In general, the alluvial groundwater is deep except at Nefza, where it may be at only 2.5 m depth. The soils are sandy and clayey, except in the towns of Béja and Teboursouk, where the percentages of rock were estimated to be about 40% and 70%, respectively. Nefza is the only municipality that has soil with high salinity.

Tables 2.6-1, 2.6-2 and 2.6-3 present the technical characteristics and estimated costs of investment and operation of the proposed interventions.

The pumping station to be provided at cité Erriadh (intervention BEJ-Maa-SP-Ex-1) could be fully replaced by a gravity network. This hypotheses should be validated in the subsequent phases, namely at the detail design.

Table 2.6-1: Definition of drainage network interventions, Béja Governorate

Intervention code	Location	Existing situation				Diagnosis		Proposed solution								
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Invest-ment cost ('000 TND)	Annual mainte-nance cost ('000 TND)	Other interventions required
BEJ-Bej-RS-Ex-1	Cité Sabbalet el Araneb	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. Discharge to Wadi Bessime.	A	Construction of new sewerage network to improve connection rate and eliminate pollution.	210	0.7	PVC	250	43	10	0	-
BEJ-Bej-RS-Ex-2	Cité Sidi Khalaf	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. Discharge to wadi close to water spring.	A	Construction of new sewerage network to improve connection rate and eliminate pollution.	350	1.2	PVC	250	975	161	5	-
BEJ-Bej-RS-Rh-1	Cité Mzara	3,447	BC	150/200	4,972	Sewers are old and in poor condition. Overflows from manholes during rainfall. Insufficient diameter for some PVC pipes	B1	Replacement of sewers, including manholes and building connections. Increased capacity. It is necessary to construct new stormwater network. Existing road drains to be detached from sewer and connected to new stormwater network*	3,447	11.4	PVC	250	4,972	1,235	31	-
BEJ-Bej-RS-Rh-2	Cité Sidifradj + cité Eddahbia	3,425	BC	200	6,695	Sewers are old and in poor condition. Overflows from manholes during rainfall.	B1	Replacement of sewers, including manholes and building connections. Increased capacity.	3,425	11.3	PVC	400	7,158	1,778	44	-
BEJ-Bej-RS-Rh-3	Cité Nozha	3,227	BC	200/300	1,405	Sewers are old (1974) and in poor condition. Overflows from manholes during rainfall. Blockages.	B0	Replacement of sewers, including manholes and building connections. Increased capacity.	3,227	10.8	PVC	250/315/ 400	1,405	387	10	-
BEJ-Bej-RS-Rh-4	Cité Ain el Goula	920	BC	200	341	Sewers are old (1954 and 1962) and in poor condition. Overflows from manholes during rainfall. Blockages.	B1	Replacement of sewers, including manholes and building connections. Increased capacity.	920	3.2	PVC	250	341	85	2	-
BEJ-Bej-RS-Rh-5	Cité el Medina	1,300	BC	200	1,164	Sewers are old (1945) and in poor condition. Overflows from manholes during rainfall. Blockages.	B1	Replacement of sewers, including manholes and building connections. Increased capacity.	1,300	4.5	PVC	250	2,114	473	12	-
BEJ-Maa-RS-Rh-1	Cité Erriadh	300	PVC	250	22	The sewers are too high to allow connection of adjacent houses. When blockages occur, wastewater backs up.	B1	Construction of new network and pumping station (BEJ-Maa-SP-Ex-1) for unconnected houses.	300	0.8	PVC	250	22	9	0	BEJ-Maa-SP-Ex-1
BEJ-Med-RS-Rh-1	Cité el Bahi	350	BC	250	31	Sewers are old (1970) and in poor condition. Overflows from manholes during rainfall. Blockages.	B1	Replacement of sewers, including manholes and building connections. Existing road drains to be detached from sewer and connected to new stormwater network*	350	1.3	PVC	250	31	44	1	-
BEJ-Med-RS-Rh-2	Cité des professeurs	250	BC	250	354	Sewers are old and in poor condition. Overflows from manholes during rainfall. Buildings are connected directly to sewer, without boxes. Sewer blockages and collapses occur.	B1	Replacement of sewers, including manholes and building connections. Existing road drains to be detached from sewer and connected to new stormwater network*	250	0.9	PVC	250	354	83	2	-

Intervention code	Location	Existing situation				Diagnosis		Proposed solution								
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi -cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Invest-ment cost ('000 TND)	Annual mainte-nance cost ('000 TND)	Other interventions required
BEJ-Med-RS-Rh-3	Cité Erriadh	750	BC	250	196	Sewers are old and in poor condition. Overflows from manholes during rainfall. Buildings are connected directly to sewer, without boxes. Sewer blockages and collapses occur.	B1	Replacement of sewers, including manholes and building connections. Existing road drains to be detached from sewer and connected to new stormwater network*	750	2.8	PVC	250	196	49	1	-
BEJ-Med-RS-Rh-4	Cité el Hana	250	BC	250	552	Sewers are old and in poor condition. Overflows from manholes during rainfall. Buildings are connected directly to sewer, without boxes. Sewer blockages and collapses occur.	B1	Replacement of sewers, including manholes and building connections. Existing road drains to be detached from sewer and connected to new stormwater network*	250	0.9	PVC	250	552	133	3	-
BEJ-Med-RS-Rh-5	Cité Sidi Raies	500	BC	150/200	727	Sewers are old and in poor condition. Overflows from manholes during rainfall. Buildings are connected directly to sewer, without boxes. Sewer blockages and collapses occur.	B1	Replacement of sewers, including manholes and building connections. Existing road drains to be detached from sewer and connected to new stormwater network*	500	1.9	PVC	250	727	175	4	-
BEJ-Med-RS-Rh-6	Cité Nattoucha	200	BC	250	82	Sewers are old and in poor condition. Overflows from manholes during rainfall. Buildings are connected directly to sewer, without boxes. Sewer blockages occur.	B0	Replacement of sewers, including manholes and building connections. Elimination of overflows also requires intervention BEJ-Med-SP-Rh-1. Existing road drains to be detached from sewer and connected to new stormwater network*	200	0.8	PVC	250	262	63	2	BEJ-Med-SP-Rh-1
BEJ-Med-RS-Rh-7	Cité Touaben	350	BC	150/200/ 250	262	Sewers are old and in poor condition. Overflows from manholes during rainfall. Buildings are connected directly to sewer, without boxes. Sewer blockages occur.	B1	Replacement of sewers, including manholes and building connections. Existing road drains to be detached from sewer and connected to new stormwater network*	350	1.3	PVC	250	820	197	5	-
BEJ-Nef-RS-Ex-1	Cité Souassis	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to improve connection rate.	125	0.3	PVC	250	247	37	1	-
BEJ-Nef-RS-Ex-2	Cité Erriadh	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to improve connection rate.	50	0.1	PVC	250	376	44	1	-
BEJ-Nef-RS-Ex-3	Cité Saad	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to improve connection rate.	25	0.1	PVC	250	352	39	1	BEJ-Nef-SP-Ex-2
BEJ-Nef-RS-Ex-4	Cité Farhat Hachad	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. Discharge to wadi.	A	Construction of new sewerage network to improve connection rate and eliminate pollution.	125	0.3	PVC	250	583	93	3	BEJ-Nef-SP-Ex-1
BEJ-Nef-RS-Ex-5	Cité Belle Vue	-	-	-	-	Uninhabited area with urbanization planned.	D	Construction of new sewerage network	450	1.2	PVC	250	1,010	187	6	-
BEJ-Nef-RS-Ex-6	Cité Ouroud 2	-	-	-	-	Uninhabited area with urbanization planned.	D	Construction of new sewerage network	25	0.1	PVC	250	225	35	1	-

		Existing situation				Diagnosis		Proposed solution								
Intervention code	Location	Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Invest-ment cost ('000 TND)	Annual mainte-nance cost ('000 TND)	Other interventions required
BEJ-Nef-RS-Ex-7	Cité Ouroud 3	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to improve connection rate.	90	0.2	PVC	250	375	47	1	-
BEJ-Nef-RS-Ex-8	Cité Elbaraka	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. No contamination problems.	D	Construction of new sewerage network to improve connection rate.	200	0.5	PVC	250	377	73	2	-
BEJ-Nef-RS-Ex-9	Cité Ezzouhour	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to improve connection rate.	15	0.0	PVC	250	265	29	1	-
BEJ-Nef-RS-Ex-10	Av. Republique	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. No contamination problems. Discharge to wadi. Stormwater pipe is connected to wastewater network.	A	Construction of new sewerage network to improve connection rate and eliminate pollution.	135	0.4	PVC	250	265	40	1	-
BEJ-Nef-RS-Rh-1	Rue Erriadh	50	BC	250	84	Sewers are old and in poor condition.	B1	Replacement of sewers, including manholes and building connections.	50	0.1	PVC	250	84	20	1	-
BEJ-Nef-RS-Rh-2	Cité Essaada	75	PVC	80	15	Sewers are old and in poor condition.	B1	Replacement of sewers, including manholes and building connections. Increased capacity.	75	0.2	PVC	250	15	8	0	-
BEJ-Teb-RS-Ex-1	Cité Oued Essaha	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to improve connection rate.	300	0.8	PVC	250	538	97	3	BEJ-Teb-SP-Ex-3
BEJ-Teb-RS-Ex-2	Cité Ain Mrad 1	400	BC	250	2,060	Inhabited area partially served by old sewerage network in poor condition. Other properties are served by septic tanks. Area requires rehabilitation and extension.	B1	Construction of new sewerage network to improve connection rate. Replacement of existing sewers, including manholes and building connections.	783	2.1	PVC	250	2,296	607	15	-
BEJ-Teb-RS-Rh-1	Teboursouk Medina	1,500	BC	200	3,675	Sewers are old (1920) and in poor condition. Overflows from manholes during rainfall.	B1	Existing wastewater sewer shall be converted to a stormwater network. Construction of new wastewater sewerage network, with increased capacity.*	1500	4.0	PVC	250	3,675	952	24	-
BEJ-Teb-RS-Rh-2	Cité El Karma + Cité Avicenne + Cité Ennassim + Cité El Menchia + Cité Ezzayatine1 + Cité Ezzayatine2 (Various Cité)	3,403	BC	200	8,952	Sewers are old (1965-1967) and in poor condition.	B1	Replacement of sewers, including manholes and building connections. Increased capacity.	3405	9.1	PVC	250	8,952	2,409	60	-

Intervention code	Location	Existing situation				Diagnosis		Proposed solution								
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Invest-ment cost ('000 TND)	Annual mainte-nance cost ('000 TND)	Other interventions required
BEJ-Tes-RS-Ex-1	Cité Gharnata (Cité Simpar Grenada)	240	BC	200	114	This intervention is rehabilitation. Existing sewers are old and in poor condition. In some areas sewers pass under housing.	A	Replacement of sewers, including manholes and building connections. Increased capacity.	240	0.6	PVC	250	1,104	228	6	-
BEJ-Tes-RS-Ex-2	Cité Bassatine2 + Cité 20 Mars	295	BC	200	1,178	Inhabited area partially served by old sewerage network in poor condition. Other properties have no sewerage. Area requires rehabilitation and extension.	C1	Construction of new sewerage network to improve connection rate. Replacement of existing sewers, including manholes and building connections.	426	1.1	PVC	250	1,366	300	8	BEJ-Tes-SP-Ex-1
BEJ-Tes-RS-Rh-1	Testour Medina	1,072	BC	200	173	Sewers are old (1940) and in poor condition. Overflows from manholes during rainfall.	B0	Existing wastewater sewer shall be converted to a stormwater network. Construction of new wastewater sewerage network, with increased capacity.*	1,072	2.9	PVC	250	2,812	641	16	-
Total					33,054								44,889	10,766	275	

Notes:

* investment in stormwater network by municipality also required

Table 2.6-2: Diagnosis of pumping stations and pumped mains, Béja Governorate

Intervention code	Location	Existing situation								Diagnosis	
		Population served (hab)	Pumping station				Pumped main			Description	Classifi-cation
			Total capacity (L/s)	No. of pumps (service+ reserve)	Dynamic head (m)	Rated power of each pump (kW)	Pipe material	Nominal diameter (mm)	Length (m)		
BEJ-Maa-SP-Ex-1	SP Erriadh	-	-	-	-	-	-	-	-	Construction of pumping station and pumped main to transport flows from Cité Erriadh to existing network.	B1
BEJ-Med-SP-Rh-1	SP5	5,000	14	1+1	12	4	AC	150	120	Overflows in BEJ-Med-RS-Rh-6 (Cité Nattoucha) and downstream network.	B0
BEJ-Nef-SP-Ex-1	SP Farhat Hachad	-	-	-	-	-	-	-	-	Cité Farhat Hachad has no sewerage network. If a network is to be built, the wastewater will need to be pumped to reach the town network.	A
BEJ-Nef-SP-Ex-2	SP Saada	-	-	-	-	-	-	-	-	Cité Saada has no sewerage network. If a network is to be built, the wastewater will need to be pumped to reach the town network.	C1
BEJ-Teb-SP-Ex-3	SP Oued Essaha	-	-	-	-	-	-	-	-	Cité Oued Essaha has no sewerage network. If a network is to be built, the wastewater will need to be pumped to reach the town network.	C1
BEJ-Tes-SP-Ex-1	SP Bassatine2	-	-	-	-	-	-	-	-	Cité Bassatine 2 has no sewerage network. If a network is to be built, the wastewater will need to be pumped to reach the town network.	C1
Total									120		

Table 2.6-3: Definition of pumping station and pumped main interventions, Béja Governorate

Intervention code	Proposed solution																		
	Population served (hab)	Total design flow (L/s)	Intervention in pumping station					Construction of pumped main			Construction of gravity sewers			Civil construction investment cost ('000 TND)	Equipment investment cost ('000 TND)	Total investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Annual energy cost ('000 TND)	Other interventions required
			Description	Total capacity (L/s)	No. of pumps (service+ reserve)	Estimated power rating (kW)	Type	Pipe material	Nominal diameter (mm)	Length (m)	Pipe materials	Nominal diameters (mm)	Total length network (m)						
BEJ-Maa-SP-Ex-1	300	5	Construction of pumping station and pumped main to lift wastewater from Cité Erriadh.	10	1+1	1.1	SP1B	HDPE	125	8	-	-	-	58	58	116	4	0	BEJ-Maa-RS-Rh-1
BEJ-Med-SP-Rh-1	5 000	16	Construction of pumping station and pumped main to divert from central network directly to SP3.	16	1+1	4.0	SP1B	HDPE	160	120	PVC	400	651	100	29	129	6	1	BEJ-Med-RS-Rh-6
BEJ-Nef-SP-Ex-1	125	5	Construction of pumping station and pumped main to lift wastewater from Cité Farhat Hachad.	10	1+1	2.2	SP1A	HDPE	125	3	-	-	-	46	46	92	3	0	BEJ-Nef-RS-Ex-4
BEJ-Nef-SP-Ex-2	25	5	Construction of pumping station and pumped main to lift wastewater from Cité Saada.	10	1+1	3.0	SP1A	HDPE	125	218	-	-	-	66	46	112	4	0	BEJ-Nef-RS-Ex-3
BEJ-Teb-SP-Ex-3	300	5	Construction of pumping station and pumped main to lift wastewater from Cité Oued Essaha	10	1+1	3.0	SP1A	HDPE	125	571	-	-	-	118	46	164	5	0	BEJ-Teb-RS-Ex-1
BEJ-Tes-SP-Ex-1	38	5	Construction of pumping station and pumped main to lift wastewater from Cité Bassatine 2	10	1+1	1.5	SP1A	HDPE	125	38	-	-	-	49	46	95	3	0	BEJ-Tes-RS-Ex-2
Total										958			651	438	270	709	25	1	

2.6.4 Bizerte Governorate

The planned interventions in the Bizerte Governorate relate to the rehabilitation and expansion of the wastewater networks and pumping stations in the communes of Bizerte (Biz), Zarzouna (Zar), Menzel Jamil (Jam), Menzel Abderrahmane (Abd), Menzel Bourguiba (Men), the central zone of Tinja (Tin), Alia (Ali), the Eastern zone of Raf Raf (Raf) and Southern zone of Mateur (Mat). The networks of all these towns are currently managed by ONAS.

In each commune there is a WwTP towards which all wastewater drains. Specific contamination problems have been identified.

Drainage systems are pseudo-separate, being connected to roof and courtyard drains. The exception is the Medina of Bizerte, which has a unitary network.

Road drainage is mostly superficial and discharges to watercourses. Some main roads have stormwater sewers, but with wastewater from buildings discharged to stormwater sewer, and road drains to the wastewater sewers.

Throughout the governorate, specific problems of overflow from sewers were identified, due to the obsolescence of the existing network and its poor condition. The most severe overflow problems occur in Tinja and Raf Raf.

In general the proposed interventions refer to the replacement of sewers and manholes. Other proposed interventions include the deactivation of existing sewers, due to their poor design / construction, the construction of new sewers and structures, and the separation of wastewater and stormwater sewers, except in the Medina of Bizerte, where the network will continue to be unitary.

Although interventions in stormwater drainage networks are excluded from the present study, we have identified certain stormwater drainage works which are necessary to ensure correct functioning of the wastewater drainage networks, principally the rehabilitation and construction of stormwater canals and road drains.

The most serious contamination problems occur in Tinja (Cité Guingla) and Raf Raf (Raf Raf Plage), classed as Emergency interventions, Class A.

Sewers are cleaned once or twice a year, manually and mechanically.

The quantification of works, considered the following criteria:

- mean water consumption of 80 to 120 L per capita per day;
- 1 connection box per dwelling in rural areas, and 1 box per 5 dwellings in urban areas.

In general the terrain is regular, groundwater levels are high, the soils are sandy and clayey with less than 15% rock.

Tables 2.6-4, 2.6-5 and 2.6-6 present the technical characteristics and estimated costs of investment and operation of the proposed interventions.

Table 2.6-4: Definition of drainage network interventions, Bizerte Governorate

Intervention code	Location	Existing situation				Diagnosis		Proposed solution								
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Invest-ment cost ('000 TND)	Annual mainte-nance cost ('000 TND)	Other interventions required
BIZ-Abd-RS-Rh-1	Av. Habib Bourguiba	3,500	BA	300 / 400	3,410	Network in poor condition with settlement and overflows due to connection of road drains.	B0	Replacement of sewers, including manholes and building connections. Connection of road drains to stormwater channel.	3,500	9.1	PVC	315 / 500	3,410	820	21	-
BIZ-Ali-RS-Rh-1	El Alia	3,500	BA/ PVC	200 / 315	1,950	Network in poor condition with low slopes which cause overflows, contamination of land. Some sections pass below housing.	B0	Replacement of sewers, including manholes and building connections.	3,500	9.6	PVC	250	1,950	451	11	-
BIZ-Biz-RS-Ex-1	Cité Ben Ismail	-	-	-	-	Partially inhabited area, without sewerage, served by septic tanks. Potential contamination.	C1	Construction of new sewerage network to improve connection rate and eliminate pollution.	2,500	9.7	PVC	250	5,200	972	29	BIZ-BIZ-SP-Ex-1
BIZ-Biz-RS-Rh-1	Ancienne Ville Bizerte	15,000	BA	250	9,350	Unitary network in poor condition	B0	Replacement of sewers, including manholes. Network will still be unitary. *	15,000	43.5	PVC	250	9,440	2,635	66	Construction of stormwater channel and stormwater overflow
BIZ-Biz-RS-Rh-2	Cité Fahat Hachad	1,500	BC	500	850	Concrete sewer in poor condition. Building connections over stormwater canal.	B0	Replacement and extension of sewers, including manholes and building connections. Connection of road drains to stormwater channel. *	1,500	5.8	PVC	250 / 315	2,440	509	14	Construction of stormwater channel. Building-sewer connections will have to cross this channel
BIZ-Biz-RS-Rh-3	Cité Othman Allouche	10,000	BA	300	1,650	Concrete and asbestos sewers in poor condition, and with insufficient capacity. Unitary sewers.	B0	Replacement of sewers, including manholes and building connections. Connection of road drains to stormwater channel.	10,000	30.6	PCV	315 / 400 / 500 / 630	1,650	586	15	100m of sewer close to surface need to be protected.
BIZ-Biz-RS-Rh-4	Av. Hassen Nouri	1,000	BC	200	2,300	Concrete sewer in poor condition. Building connections over stormwater canal.	B0	Replacement and extension of sewers, including manholes and building connections. Connection of road drains to stormwater channel. *	1,000	3.9	PVC	315	2,300	548	14	Construction of stormwater channel
BIZ-Biz-RS-Rh-6	Cité Centre Ville	1,000	BC/ AC	250	1,990	Network old and in poor condition, with low slopes, accumulation of sand and overflows. Building connections in poor condition.	B1	Replacement of sewers, including manholes and building connections.	1,000	3.9	PVC	250	1,990	447	11	-
BIZ-Biz-RS-Rh-7	Cité Hachad	6,000	BC / AC	250	5,800	Network old and in poor condition, with low slopes, accumulation of sand and overflows. Building connections in poor condition.	B0	Replacement of sewers, including manholes and building connections.	6,000	19.8	PVC	250	5,800	1,196	30	-
BIZ-Jam-RS-Rh-1	Av. 7 Novembre	3,500	BC / AC	300	2,200	Network in poor condition, with settlement.	B0	Replacement of sewers, including manholes and building connections.	3,500	9.1	PVC	400	2,200	615	15	-
BIZ-Jam-RS-Rh-2	Cité Habib Bourguiba	3,500	BC	400	990	Network in poor condition with settlement and overflows due to connection of road drains.	B0	Replacement of sewers, including manholes and building connections. Connection of road drains to stormwater channel.	3,500	9.1	PVC	400	990	277	7	-
BIZ-Men-RS-Ex-1	Cité Ben Alaya	-	-	-	-	Inhabited area without sewerage, served by septic tanks. Problems of overflows and contamination.	C0	Construction of new sewerage network to improve connection rate and eliminate pollution.	600	1.9	PVC	250	1,200	206	6	BIZ-Men-SP-Ex-1

		Existing situation				Diagnosis		Proposed solution								
Intervention code	Location	Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Invest-ment cost ('000 TND)	Annual mainte-nance cost ('000 TND)	Other interventions required
BIZ-Men-RS-Ex-2	Cité Sidi Yahia	-	-	-	-	Inhabited area without sewerage, served by septic tanks. Problems of overflows and contamination.	C0	Construction of new sewerage network to improve connection rate and eliminate pollution.	400	1.3	PVC	250	900	136	4	-
BIZ-Men-RS-Rh-1	Centre Ville de Menzel Bourguiba	15,500	AC	250	18,800	Sewers are old and in poor condition. Insufficient capacity. Some of network is unitary.	B0	Replacement and extension of sewers, including manholes and building connections. Connection of road drains to stormwater channel.	15,500	38.2	PVC	250 / 315 / 500 / 630	18,800	4,752	119	-
BIZ-Men-RS-Rh-2	Rue Destour	25,000	BA	600	2,750	Sewerage network is completely degraded by H2S from pumping stations upstream. Some of network is unitary.	B0	Replacement and extension of sewers, including manholes and building connections. Connection of road drains to stormwater channel.	25,000	58.3	PVC	500	2,750	939	23	Mechanical ventilation of transition chamber to minimize effects of H2S.
BIZ-Raf-RS-Rh-1	Raf Raf Plage	-	-	-	-	Inhabited area (mostly tourism and holiday homes) without sewerage, served by septic tanks. Problems of overflows onto the beach and contamination. This intervention is an extension.	A	Construction of new sewerage network to improve connection rate and eliminate pollution.	5,000	21.6	PVC	250	6,500	1,361	34	Need for demolition of some houses too close to waterline. BIZ-Raf-Sp-Ex-1
BIZ-Tin-RS-Ex-1	Cité Guingla	-	-	-	-	Inhabited area (including holiday homes) without sewerage, served by septic tanks. Problems of overflows onto the beach and contamination.	A	Construction of new sewerage network to improve connection rate and eliminate pollution.	2,000	5.5	PVC	250	2,150	363	11	BIZ-Tin-SP-Ex-1
BIZ-Tin-RS-Ex-2	Cité Farhatia	-	-	-	-	Inhabited area without sewerage, served by septic tanks. Problems of overflows onto the beach and contamination.	C0	Construction of new sewerage network to improve connection rate and eliminate pollution.	1,500	4.1	PVC	250 / 315	1,900	288	9	BIZ-Tin-SP-Ex-2
BIZ-Tin-RS-Ex-3	Rue Gandi	-	-	-	-	Inhabited area without sewerage, served by septic tanks. Problems of overflows and contamination.	C0	Construction of new sewerage network to improve connection rate and eliminate pollution.	600	1.7	PVC	250	1,300	221	7	-
BIZ-Tin-RS-Rh-1	Cité Ikbale e Cité Fatah	8,000	AC	250	3,400	Sewers are old and in poor condition, with low slopes, accumulation of sand and overflows. Building connections in poor condition. Frequent flooding due to absence of storm drainage network.	B0	Replacement of sewers, including manholes and building connections. *	8,000	18.9	PVC	250	3,400	751	19	Need for construction of stormwater network to reduce flooding.
BIZ-Tin-RS-Rh-2	Route Bizerte-Tinja	10,000	PVC	250	700	Sewerage network is old and in poor condition.	B0	Replacement of sewers, including manholes and building connections.	10,000	22.8	PVC	315	700	164	4	-
BIZ-Zar-RS-Rh-1	Cité Zaghouane	20,000	BC	250	7,230	Sewers are old and in poor condition, with low slopes, accumulation of sand and overflows. Building connections in poor condition.	B0	Replacement of sewers, including manholes and building connections. Connection of road drains to stormwater channel. *	20,000	52.0	PVC	250 / 400	7,230	1,649	41	Construction of stormwater channel
Total					63,370								84,200	19,886	510	

Notes:

* - investment in stormwater network by municipality also required

Table 2.6-5: Diagnosis of pumping stations and pumped mains, Bizerte Governorate

Intervention code	Location	Existing situation								Diagnosis	
		Population served (hab)	Pumping station				Pumped main			Description	Classifi-cation
			Total capacity (L/s)	No. of pumps (service+ reserve)	Dynamic head (m)	Rated power of each pump (kW)	Pipe material	Nominal diameter (mm)	Length (m)		
BIZ-Abd-SP-Rh-1	SPRA 2	18,700	62	1+1	48	48	BPC	400	2,370	Pumps and other equipment are severely corroded and frequently breakdown. Water hammer arrestor is insufficient.	B0
BIZ-Biz-SP-Ex-1	SP Ben Ismail	-	-	-	-	-	-	-	-	Partially inhabited area, without sewerage, served by septic tanks. Potential contamination.	C1
BIZ-Zar-SP-Rh-1	SP RZ1 Oued Romine	15,000	55	2+1	9	5.9	BA	300	160	Equipment in service but in poor condition. Civil works in good condition.	B0
BIZ-Zar-SP-Rh-2	SP RZ2	40,000	100	2+1	7	9	HDPE	2*400	250	Pumps are severely corroded. Grit separator out of service, other equipment and civil works in good condition.	B1
BIZ-Zar-SP-Rh-3	SP RZ3 Marche du Gros	25,000	90	2+1	5	4.8	BA	300	200	Pumps are severely corroded. Wall in poor condition, other equipment and civil works in good condition.	B1
BIZ-Jam-SP-Rh-1	SRJ 1	30,000	80	2+1	52	48	BPC	400	2,700	Pumps and other equipment are severely corroded and frequently breakdown. Water hammer arrestor is broken. Pumped main frequently leaks.	B0
BIZ-Jam-SP-Rh-2	SP Bir Rmal	5,000	22	1+1	5	2.4	AC	160	700	Pumping station equipment and civil works in poor to very poor condition. Several houses are below the level of the pumping station.	B0
BIZ-Mat-SP-Rh-1	SP Hachad	5,000	15	1+1	26	7	HDPE	200	4,000	Pumps' capacity is insufficient. No protection against water hammer. Civil works in good condition.	B0
BIZ-Mat-SP-Rh-2	SP Sadaka	12,000	30	2+1	10	13.5	HDPE	250	350	Equipment, electrical panel and civil works in good condition. Need for light rehabilitation	B1
BIZ-Men-SP-Ex-1	SP Ben Alaya	-	-	-	-	-	-	-	-	Inhabited area without sewerage, served by septic tanks. Problems of overflows and contamination.	C0

Intervention code	Location	Existing situation								Diagnosis	
		Population served (hab)	Pumping station				Pumped main			Description	Classifi-cation
			Total capacity (L/s)	No. of pumps (service+ reserve)	Dynamic head (m)	Rated power of each pump (kW)	Pipe material	Nominal diameter (mm)	Length (m)		
BIZ-Raf-SP-Ex-1 BIZ-Raf-SP-Ex-2	SP Raf Raf Plage 1 et 2	-	-	-	-	-	-	-	-	Inhabited area (mostly tourism and holiday homes) without sewerage, served by septic tanks. Problems of overflows onto the beach and contamination.	A
BIZ-Tin-SP-Ex-1	SP Guingla	-	-	-	-	-	-	-	-	Inhabited area (including holiday homes) without sewerage, served by septic tanks. Problems of overflows onto the beach and contamination.	A
BIZ-Tin-SP-Ex-2	SP Farhatia	-	-	-	-	-	-	-	-	Inhabited area without sewerage, served by septic tanks. Problems of overflows onto the beach and contamination.	C0
BIZ-Tin-SP-Rh-1	SP SPROLS	12,000	15	1+1	14	8	AC	150	890	Pumps' capacity is insufficient. Civil works in good condition.	B0
Total									11,620		

Table 2.6-6: Definition of pumping station and pumped main interventions, Bizerte Governorate

Intervention code	Proposed solution																		
	Population served (hab)	Total design flow (L/s)	Intervention in pumping station					Construction of pumped main			Construction of gravity sewers			Civil construction investment cost ('000 TND)	Equipment investment cost ('000 TND)	Total investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Annual energy cost ('000 TND)	Other interventions required
			Description	Total capacity (L/s)	No. of pumps (service+ reserve)	Estimated power rating (kW)	Type	Pipe material	Nominal diameter (mm)	Length (m)	Pipe materials	Nominal diameters (mm)	Total length network (m)						
BIZ-Abd-SP-Rh-1	18,700	87	Replacement of all equipment including increase in capacity (Bizerte technological area); replacement of initial section of pumped main.	87	1+1	110.0	SP2B	HDPE	315	1,000	-	-	-	350	295	645	21	38	
BIZ-Biz-SP-Ex-1	2,500	10	Construction of new pumping station to allow connection of new network to existing network.	10	1+1	4.0	SP1B	HDPE	125	600	-	-	-	135	58	193	6	1	
BIZ-Zar-SP-Rh-1	18,700	99	Replacement of all equipment including increase in capacity (increase of 15 L/s); light rehabilitation of civil works.	99	2+1	45.0	SP2B	-	-	-	-	-	-	54	322	375	18	16	
BIZ-Zar-SP-Rh-2	70,000	160	Replacement of pumps, electrical panel and grit separator; light rehabilitation of other equipment and civil works.	160	2+1	55.0	SP2B	-	-	-	-	-	-	73	329	402	27	19	
BIZ-Zar-SP-Rh-3	30,000	100	Replacement of pumps, electrical panel and wall; light rehabilitation of other equipment and civil works.	100	2+1	22.0	SP2B	-	-	-	PVC	600	660	339	242	581	28	8	
BIZ-Jam-SP-Rh-1	30,000	79	Replacement of equipment and rehabilitation of civil works. Replacement of pumped main.	79	2+1	90.0	SP2B	HDPE	315	2 700	-	-	-	773	278	1,050	29	30	
BIZ-Jam-SP-Rh-2	5,000	22	Construction of new pumping station on lower land 300m away. Consequently, even this intervention is classified as Rh, it will be considered as Ex in terms of cost estimation and works.	22	1+1	11.0	SP2B	HDPE	200	940	-	-	-	224	122	346	12	4	
BIZ-Mat-SP-Rh-1	15,000	55	Replacement of all equipment and electrical panels, to increase capacity from 15 to 50 /s. Installation of water hammer arrestor. Light rehabilitation of civil works.	55	1+1	45.0	SP2B	HDPE	250	2 200	BA	500	600	634	221	855	25	15	Construction of transition chamber
BIZ-Mat-SP-Rh-2	12,000	36	Light rehabilitation of equipment, electrical panel and civil works.	36	2+1	7.5	SP2B	-	-	-	-	-	-	28	42	70	10	2	
BIZ-Men-SP-Ex-1	600	5	Construction of new pumping station to allow connection of new network to existing network.	10	1+1	7.5	SP2B	HDPE	125	600	-	-	-	108	46	155	5	0	BIZ-Men-RS-Ex-1

Intervention code	Proposed solution																		
	Population served (hab)	Total design flow (L/s)	Intervention in pumping station					Construction of pumped main			Construction of gravity sewers			Civil construction investment cost ('000 TND)	Equipment investment cost ('000 TND)	Total investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Annual energy cost ('000 TND)	Other interventions required
			Description	Total capacity (L/s)	No. of pumps (service+ reserve)	Estimated power rating (kW)	Type	Pipe material	Nominal diameter (mm)	Length (m)	Pipe materials	Nominal diameters (mm)	Total length network (m)						
BIZ-Raf-SP-Ex-1	5,000	22	Construction of a new pumping station to allow connection of new network to existing network.	22	1+1	7.5	SP2B	HDPE	200	100	-	-	-	95	120	215	8	2	BIZ-Raf-RS-Rh-1
BIZ-Raf-SP-Ex-2	4,000	18	Construction of a new pumping station to allow connection of new network to existing network.	18	1+1	5.5	SP2B	HDPE	160	150	-	-	-	92	106	198	7	2	BIZ-Raf-RS-Rh-1
BIZ-Tin-SP-Ex-1	2,000	6	Construction of new pumping station to allow connection of new network to existing network.	10	1+1	3.0	SP2B	HDPE	125	100	-	-	-	46	49	95	3	0	BIZ-Tin-RS-EX-1
BIZ-Tin-SP-Ex-2	8,000	19	Construction of new pumping station to allow connection of new network to existing network.	19	1+1	11.0	SP2B	HDPE	160	300	-	-	-	115	109	225	8	3	BIZ-Tin-RS-EX-2
BIZ-Tin-SP-Rh-1	12,000	34	Replacement of all equipment and electrical panels, to increase capacity from 15 to 25 /s. Installation of water hammer arrestor. Rehabilitation of civil works.	34	1+1	18.5	SP2B	HDPE	200	890	-	-	-	213	159	372	12	4	
Total										9,580			1,260	3,279	2,496	5,775	220	144	

2.6.5 Jendouba Governorate

The wastewater networks of the 5 communes of Jendouba (Jen), Tabarka (Tab), Boussalem (Bou), Ghardimaou (Gha) and Fernana (Fer) in this governorate are managed by ONAS, and were considered by the present study.

The urban wastewaters from each town are transported to a WwTP where they are treated before their discharge in the natural environment.

The areas where network extensions are proposed are generally served by individual septic tanks at present, without problems of contamination of water sources. However, the risk of potential contamination is always present.

The sewerage networks are generally unitary, and connected to roofs and road drains. The networks to be rehabilitated are old and in poor condition, being of asbestos or concrete pipe, and it is necessary to replace them.

In the entire governorate there are occasional problems of overflows due to the age and condition of the networks.

Sewers are cleaned once or twice a year, manually and mechanically.

The quantification of works considered the per capita water consumption data indicated in Section 2.1, also an occupation rate of four people per dwelling. The infiltration flow was considered to be 40% of the mean flow. In the case of Tabarka, the tourist population and associated wastewater production were also considered.

In general, the terrain is not very rugged and groundwater levels are high. The ground conditions (up to 2 m deep) are as follows.

Town	Ground conditions (up to 2m deep)	
	% normal soil	% rock
Jendouba	95	5
Tabarka	60	40
Boussalem	95	5
Ghardimaou	80	20
Fernana	70	30

Tables 2.6-7, 2.6-8 and 2.6-9 present the technical characteristics and estimated costs of investment and operation of the proposed interventions.

The network at the Jendouba town center (near interventions JEN-Jen-RS-Rh-1/3) and the pumped mains from the PS Echorfa was excluded from the ONAS feasibility study and, as a consequence, excluded from the present project. However, due to the network poor condition and strategic importance, the network rehabilitation of those areas is recommended.

Table 2.6-7: Definition of drainage network interventions, Jendouba Governorate

Intervention code	Location	Existing situation				Diagnosis		Proposed solution								
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
JEN-Fer-RS-Rh-1	Fernana	461	AC / BC	200 / 250 / 400	1,276	Very old sewers located under housing. Problems of blockages. Sewers are old and in poor condition. Some streets without sewers.	B0	Replacement and extension of sewers, including manholes and building connections. Connection of houses to existing sewerage network and WwTP.	1,142	2.3	PVC	250	3,159	688	19	-
JEN-Fer-RS-Ex-1	Cité El Fjouj	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. No contamination or public health problems	C0	Construction of new sewerage network to improve connection rate and eliminate pollution. Connection of houses to existing sewerage network and WwTP. This intervention requires construction of pumping station SP El Fjouj.	425	0.9	PVC	250	2,351	329	10	JEN-Fer-SP-Ex-1
JEN-Gha-RS-Rh-1	Ghardimaou	1,466	AC / BC	250 / 300	4,064	Sewers are old (1950) and in poor condition. Buildings are directly connected to sewers without boxes. Blockages occur. Road drains connected to wastewater sewers.	B1	Replacement of sewers. Disconnect storm drains from wastewater sewer and connect to new stormwater network*	1,466	3.0	PVC	250 / 315	4,064	965	24	-
JEN-Gha-RS-Ex-1	Cité Sidi Abbes	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. No contamination or public health problems. It will be necessary to build a pumping station to connect new network to existing network.	C0	Construction of new sewerage network to improve connection rate and eliminate pollution. Connection of houses to existing sewerage network.	458	0.9	PVC	250	2,533	345	10	JEN-Gha-SP-Ex-1
JEN-Gha-RS-Ex-2	Cité Erraja	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. Some buildings discharge directly to stormwater canal. No contamination problems, but there is a risk to public health.	A	Construction of new sewerage network to improve connection rate and eliminate pollution. Connection of houses to existing sewerage network.	548	1.1	PVC	250 / 315	1,518	247	7	-
JEN-Jen-RS-Rh-1	Ville de Jendouba	1,379	AC / BC	250 / 300	3,821	Sewers are old and in poor condition. Some buildings are directly connected to sewers without boxes. Low slopes. Overflows occur during rainfall. No stormwater network.	B1	Replacement of sewers and alteration to direction of drainage. Flow from this area, which currently crosses the center of Jendouba, to be diverted to an outer network, which will transport flow to existing WwTP. Requires rehabilitation of existing pumping station SP Ettataouer (JEN-Jen-SP-Rh-1). Requires construction of stormwater drainage network, and connection of road drains to this, instead of wastewater network.*	1,379	4.8	PVC	250 / 315	3,821	870	22	JEN-Jen-SP-Rh-1

Intervention code	Location	Existing situation				Diagnosis		Proposed solution								
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
JEN-Jen-RS-Rh-2	Cité Militaire	1,912	AC / BC	250 / 300 / 500	5,310	Sewers are old and in poor condition. Some buildings are directly connected to sewers without boxes. Low slopes. Overflows occur during rainfall. No stormwater network.	B1	Replacement of existing sewerage network. Requires rehabilitation of pumping station SP3 (JEN-Jen-SP-Rh-2). Requires construction of stormwater drainage network, and connection of road drains to this, instead of wastewater network.*	1,912	6.6	PVC	250/ 315/ 500	5,310	1,296	32	JEN-Jen-SP-Rh-2
JEN-Jen-RS-Rh-3	Cité Ennour	3,154	AC / BC	250 / 300 / 500	8,752	Sewers are old and in poor condition, with low slopes, and too deep. Problems of overflows during rainfall, blockages, accumulation of sand, occasional collapses. Some buildings are directly connected to sewers without boxes. Road drains connected to wastewater sewers because there is no stormwater network.	B1	Replacement of sewers. Disconnect storm drains from wastewater sewer and connect to new stormwater network*	3,154	10.6	PVC	250/ 315/ 500	8,752	1795	45	-
JEN-Jen-RS-Ex-1	Essaidia III	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. No contamination or public health problems. It will be necessary to build a pumping station to connect new network to existing network.	C0	Construction of new sewerage network to improve connection rate and eliminate pollution. Connection of houses to existing sewerage network and WwTP.	1,077	3.7	PVC	250	2,990	438	13	JEN-Jen-SP-Ex-1
JEN-Tab-RS-Rh-1	Ville de Tabarka	4,110	AC / BC	250 / 300	2,586	Old unitary network with 3 stormwater weirs which discharge to the port. Problems of overflows from sewers, frequent blockages, and occasional collapses.	B0	Replacement and extension of sewers, including manholes and building connections.	4,110	13.1	PVC	250 / 315	2,586	614	15	-
JEN-Tab-RS-Ex-1	Cité Houemdia	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. No contamination or public health problems.	C1	Construction of new sewerage network to improve connection rate and eliminate pollution. Connection of houses to existing sewerage network and WwTP.	800	2.8	PVC	250	4,833	658	20	JEN-Tab-SP-Rh-1
JEN-Tab-RS-Ex-2	Cité Malloula	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. No contamination or public health problems.	C1	Construction of new sewerage network. Connection of houses to existing sewerage network and WwTP. Two pumping stations will also be necessary to difference in level: JEN-Tab-SP-Ex-1 and JEN-Tab-SP-Ex-2.	263	0.9	PVC	250	4,750	607	18	JEN-Tab-SP-Ex-1 / JEN-Tab-SP-Ex-2

Intervention code	Location	Existing situation				Diagnosis		Proposed solution								
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
JEN-Tab-RS-Ex-3	Cité Ain Mazouz	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. No contamination or public health problems.	C1	Construction of new sewerage network to improve connection rate and eliminate pollution. Connection of houses to existing sewerage network and WwTP.	821	2.8	PVC	250	4,555	655	20	-
JEN-Bss-RS-Ex-1	Cité Ennour	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. No contamination or public health problems.	C1	Construction of new sewerage network to improve connection rate and eliminate pollution. This intervention requires construction of the pumping station SP Cité Ennour (JEN-Bss-SP-Ex-1).	724	1.5	PVC	250 / 315	3,003	402	12	JEN-Bss-SP-Ex-1
Total					25,809								54,225	9,910	268	

Notes:

* - investment in stormwater network by municipality also required

Table 2.6-8: Diagnosis of pumping stations and pumped mains, Jendouba Governorate

Intervention code	Location	Existing situation								Diagnosis	
		Population served (hab)	Pumping station				Pumped main			Description	Classifi-cation
			Total capacity (L/s)	No. of pumps (service+ reserve)	Dynamic head (m)	Rated power of each pump (kW)	Pipe material	Nominal diameter (mm)	Length (m)		
JEN-Fer-SP-Ex-1	SP El Fjouj	-	-	-	-	-	-	-	-	Cité El Fjouj has no sewerage network. If a network is to be built, the wastewater will need to be pumped to reach the town network.	C0
JEN-Gha-SP-Ex-1	SP Sidi Abbes	-	-	-	-	-	-	-	-	Cité Sidi Abbes has no sewerage network. If a network is to be built, the wastewater will need to be pumped to reach the town network.	C0
JEN-Jen-SP-Rh-1	SP Ettataouer	20,000	30	2+1	5	4.4	AC	200	380	Need for rehabilitation of equipment and increase in capacity to accommodate rehabilitation of Cité Erriadh network (JEN-Jen-RS-Rh-1). Need for rehabilitation of some civil works and change to route of pumped main, to discharge wastewater to WwTP via existing Echorfa pumping station.	B1
JEN-Jen-SP-Rh-2	SP 3	5,000	28	2+1	10	2.7	AC	150	143	Civil works and equipment are old and in poor condition	B1
JEN-Jen-SP-Rh-3	SP 4	30,000	100	2+1	10	10	AC	no data	10	Civil works and equipment in poor condition. Principal pumping station which transports all wastewater from Jendouba to WwTP.	B0
JEN-Jen-SP-Rh-4	SP Timiria	200	10	1+1	5	2.4	AC	80	100	Civil works and equipment are old (1994) and in poor condition.	B1
JEN-Jen-SP-Ex-1	SP Essaidia III	-	-	-	-	-	-	-	-	Cité Essaidia III has no sewerage network. If a network is to be built, the wastewater will need to be pumped to reach the town network.	C0
JEN-Tab-SP-Rh-1	SP Morjane	1,200	20	2+1	17	3.3	BC	200	743	Need to replace all equipment and pumped main.	B1
JEN-Tab-SP-Ex-1	SP Malloula 1	-	-	-	-	-	-	-	-	Cité Malloula has no sewerage network. If a network is to be built, the wastewater will need to be pumped to reach the town network.	C1
JEN-Tab-SP-Ex-2	SP Malloula2	-	-	-	-	-	-	-	-	Cité Malloula has no sewerage network. If a network is to be built, the wastewater will need to be pumped to reach the town network.	C1
JEN-Bss-SP-Ex-1	SP Cité Ennour	-	-	-	-	-	-	-	-	Cité Ennour has no sewerage network. If a network is to be built, the wastewater will need to be pumped to reach the town network.	C1
Total									1,376		

Table 2.6-9: Definition of pumping station and pumped main interventions, Jendouba Governorate

Intervention code	Proposed solution																		
	Population served (hab)	Total design flow (L/s)	Intervention in pumping station					Construction of pumped main			Construction of gravity sewers			Civil constructio n investment cost ('000 TND)	Equipment investment cost ('000 TND)	Total investment cost ('000 TND)	Annual maintenan ce cost ('000 TND)	Annual energy cost ('000 TND)	Other interventions required
			Description	Total capacity (L/s)	No. of pumps (service+ reserve)	Estimated power rating (kW)	Type	Pipe material	Nominal diameter (mm)	Length (m)	Pipe materials	Nominal diameters (mm)	Total length network (m)						
JEN-Fer-SP-Ex-1	425	5	Construction of pumping station and pumped main to lift wastewater from Cité El Fjouj	10	1+1	3.0	SP1B	HDPE	125	785	-	-	-	140	58	198	6	0	JEN-Fer-RS-Ex-1
JEN-Gha-SP-Ex-1	458	5	Construction of pumping station and pumped main to lift wastewater from Cité Abbes	10	1+1	2.2	SP1B	HDPE	125	580	-	-	-	114	58	172	5	0	JEN-Gha-RS-Ex-1
JEN-Jen-SP-Rh-1	20,000	50	Substitution of all equipment, and change of route of pumped main to divert Jendouba flow to Echorfa pumping station.	50	2+1	5.5	SP2A	HDPE	250	380	PVC	400	1,660	467	145	612	19	2	JEN-Jen-RS-Rh-1
JEN-Jen-SP-Rh-2	5,000	15	Replacement of all equipment, rehabilitation of civil works and pumped main. This intervention will be associated with that of Cité Militaire (JEN-Jen-RS-Rh-2).	15	2+1	4.0	SP2A	HDPE	160	143	PVC	315	317	118	67	185	5	1	JEN-Jen-RS-Rh-2
JEN-Jen-SP-Rh-3	30,000	72	Construction of a new pumping station on the same site.	72	2+1	15.0	SP2B	HDPE	315	10	BA	1000	2,590	2,187	261	2,448	64	5	-
JEN-Jen-SP-Rh-4	200	5	Replacement of all equipment, rehabilitation of some civil works	10	1+1	1.1	SP1B	HDPE	125	100	-	-	-	39	29	68	3	0	-
JEN-Jen-SP-Ex-1	1,077	5	Construction of pumping station and pumped main to lift wastewater from Cité Essaidia III	10	1+1	1.1	SP1B	HDPE	125	466	-	-	-	99	58	157	5	0	Jen-Jen-RS-Ex-1
JEN-Tab-SP-Rh-1	2,000	7	Replacement of all equipment and pumped main.	10	2+1	1.5	SP1B	HDPE	125	744	-	-	-	133	29	162	6	0	JEN-Tab-RS-Ex-1
JEN-Tab-SP-Ex-1	314	5	Construction of pumping station and pumped main to lift wastewater from Cité Malloula	10	1+1	15.0	SP1B	HDPE	125	670	-	-	-	158	58	215	7	0	JEN-Tab-RS-Ex-2
JEN-Tab-SP-Ex-2	314	5	Construction of pumping station and pumped main to lift wastewater from Cité Malloula	10	1+1	15.0	SP1B	HDPE	125	1 123	PVC	250	2,870	687	58	745	23	0	JEN-Tab-RS-Ex-2
JEN-Bss-SP-Ex-1	724	5	Construction of pumping station and pumped main to lift wastewater from Cité Ennour	10	1+1	1.5	SP1B	HDPE	125	1 030	-	-	-	170	58	228	7	0	JEN-Bss-RS-Ex-1
Total										6,031			7,437	4,314	875	5,189	151	9	

2.6.6 Kasserine Governorate

As specified in chapter 2.1, ONAS is responsible for management of the sewerage systems of 4 communes that form part of the present study. The drainage networks of the communes of Thala (Tel) and Feriana (Fei) are currently operated by the municipalities, but it is expected that these will pass to ONAS operation after the works proposed in the present study.

Kasserine (Kas) and Sbeitla (Sbe) area served by WwTP. The construction of WwTP in Feriana and Thala is planned and already has finance outside the present study. At present, in these communes and in locations already served by a public network, domestic wastewater is directly discharged into watercourses without any prior treatment, thus causing problems of water contamination.

Zones where extensions are planned are generally served by soakaways, without any evidence of contamination of water sources.

The drainage networks are pseudo-separate, receiving rainwater from roofs and interior patios. Road drainage is mostly superficial and discharges to watercourses. There is no separate stormwater drainage network.

Throughout the governorate there are occasional problems of overflows because the existing network is very old and in a poor state of conservation.

Sewers are cleansed 1-2 times/year by both manual and mechanical means.

The quantification of works considered the following criteria:

- mean water consumption of 75 L per capita per day ;
- 1 connection box per dwelling.

In general, the terrain is not very rugged, the groundwater table is not very close to the surface and the soil is composed primarily of clay and sand, except for the commune of Thala where the percentage of rock is higher than 70%.

Tables 2.6-10, 2.6-11 and 2.6-12 present the technical characteristics and estimated costs of investment and operation of the proposed interventions.

Table 2.6-10: Definition of drainage network interventions, Kasserine Governorate

		Existing situation				Diagnosis		Proposed solution								
Intervention code	Location	Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
KAS-Fei-RS-Ex-1	Feriana	-	-	-	-	Inhabited area without sewerage network, served by soakaways. No contamination problems but untreated wastewater is discharged to environment.	C0	Construction of new sewerage network to improve regional infrastructure, increase coverage (55%) and eliminate pollution. This intervention requires construction of pumping stations SP1 El Amen and SP2 El Bassatine.	4,950	11.5	PVC	250 / 315	21,179	3079	92	KAS-Fer-SP-Ex-1 KAS-Fer-SP-Ex-2
KAS-Kas-RS-Ex-1	Cité Nouvelle Medina	-	-	-	-	Inhabited area without sewerage network, served by soakaways. No contamination problems.	C1	Construction of new sewerage network to improve regional infrastructure, increase coverage and eliminate pollution	1,000	2.4	PVC	250	2,586	355	11	-
KAS-Kas-RS-Ex-3	Cité Essalem	-	-	-	-	Inhabited area without sewerage network, served by soakaways. No contamination problems.	C1	Construction of new sewerage network to improve regional infrastructure, increase coverage and eliminate pollution	1,000	2.4	PVC	250	3,352	535	16	-
KAS-Kas-RS-Ex-4	Cité el Feth 3	-	-	-	-	Inhabited area without sewerage network, served by soakaways. No contamination problems.	C1	Construction of new sewerage network to improve regional infrastructure, increase coverage and eliminate pollution	1,250	3.0	PVC	250	2,583	294	9	-
KAS-Kas-RS-Ex-5	Cité Loutissement Rahmouni	-	-	-	-	Inhabited area without sewerage network, served by soakaways. No contamination problems.	C1	Construction of new sewerage network to improve regional infrastructure, increase coverage and eliminate pollution	900	2.2	PVC	250	2,723	308	9	-
KAS-Kas-RS-Ex-6	Cité Bnanna	-	-	-	-	Inhabited area without sewerage network, served by soakaways. No contamination problems.	C1	Construction of new sewerage network to improve regional infrastructure, increase coverage and eliminate pollution	750	1.8	PVC	250	2,005	265	8	
KAS-Kas-RS-Rh-1	Conduite vers STEP 1	41,106	BA	600 / 800	3,910	Blockage of sewer due to partial collapse. Difficult to unblock. Sewer in poor condition. Trunk sewer for all Kasserine town.	B0	Replacement of existing sewer by one in PVC with same diameter.	64,660	106.6	PVC/BA	630 / 800	3,910	2148	54	-
KAS-Kas-RS-Rh-2	Conduite vers STEP 2	6,000	AC	250	821	Sewer cleaning is not effective. Frequent blockages. Sewers flow full and overflow to houses.	B0	Replacement of existing sewer by one in PVC with same diameter.	6,000	13.4	PVC	250	1,450	251	6	-
KAS-Kas-RS-Rh-3	Centre Ville de Kasserine	750	AC	250 / 300	2,000	Mechanical sewer cleaning is not effective. Frequent blockages. Sewers flow full and overflow to houses.	B0	Replacement of existing sewers by sewers in PVC with same diameter.	750	1.8	PVC	250 / 300	2,000	423	11	-
KAS-Kas-RS-Rh-4	Collecteur de Ceinture	23,000	AC	250 / 300	2,122	Mechanical sewer cleaning is not effective. Frequent blockages. Sewers in poor condition with insufficient capacity flow full and overflow to houses.	B0	Replacement of existing sewers by sewers in PVC with increased capacity. Replacement of manholes and building connections.	23,000	41.9	PVC	400	2,122	524	13	-
KAS-Kas-RS-Rh-5	Collecteur de AV. Bejaoui	6,000	AC	250 / 300	930	Mechanical sewer cleaning is not effective. Frequent blockages. Sewers in poor condition. Difficult to unblock.	B0	Replacement of existing sewers by sewers in PVC with same diameter. Includes crossing of railway line by pipe-jacking.	6,000	13.4	PVC	250 / 315	930	188	5	-

Intervention code	Location	Existing situation				Diagnosis		Proposed solution								
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
KAS-Kas-RS-Rh-7	Collecteur de Ain el Gaied	30,000	AC	250 / 300	1,137	Mechanical sewer cleaning is not effective. Frequent blockages. Sewers in poor condition. Difficult to unblock. Sewers in poor condition with insufficient capacity flow full and overflow to houses.	B0	Replacement of existing sewers by sewers in PVC with increased capacity. Replacement of manholes and building connections.	30,000	53.1	PVC	400	1,137	290	7	-
KAS-Kas-RS-Rh-8	Cité Saad Eddine	1,000	AC	250	3,600	Mechanical sewer cleaning is not effective. Frequent blockages. Sewers in poor condition. Difficult to unblock. Sewers in poor condition with insufficient capacity flow full and overflow to houses.	B0	Replacement of existing sewers by sewers in PVC with same diameter.	1,000	2.4	PVC	250	3,600	707	18	-
KAS-Kas-RS-Rh-9	Cité el Bassatine 1	2,000	AC	250	4,208	Mechanical sewer cleaning is not effective. Frequent blockages. Sewers flow full and overflow to houses.	B0	Replacement of existing sewer by one in PVC with same diameter.	2,000	4.9	PVC	250	4,208	918	23	-
KAS-Kas-RS-Rh-10	Cité el Bassatine 2	2,500	AC	250	2,164	Mechanical sewer cleaning is not effective. Frequent blockages. Sewers flow full and overflow to houses.	B0	Replacement of existing sewer by one in PVC with same diameter.	2,500	6.1	PVC	250	2,164	634	16	-
KAS-Kas-RS-Rh-11	Cité el Bassatine 3	2,500	AC	250	4,406	Mechanical sewer cleaning is not effective. Frequent blockages. Sewers flow full and overflow to houses.	B0	Replacement of existing sewer by one in PVC with same diameter.	2,500	6.1	PVC	250	4,406	1006	25	-
KAS-Sbe-RS-Ex-1	Cité Zayatine	-	-	-	-	Inhabited area without sewerage network, served by soakaways. No contamination problems but untreated wastewater is discharged to environment.	C1	Construction of new sewerage network to improve regional infrastructure, increase coverage (55%) and eliminate pollution	75	0.2	PVC	250	300	36	1	-
KAS-Sbe-RS-Ex-2	Cité el Khadhra	-	-	-	-	Inhabited area without sewerage network, served by soakaways. No contamination problems but untreated wastewater is discharged to environment.	C0	Construction of new sewerage network to improve regional infrastructure, increase coverage (55%) and eliminate pollution	950	2.3	PVC	250	1,960	279	8	-
KAS-Sbe-RS-Rh-1	Collecteur Oued Sbeitla	1,250	AC	250	750	Existing sewer is inaccessible and blockages are frequent. Mechanical sewer cleaning is not effective. Difficult to unblock. Sewer depths reach 5,8m.	B0	Construction of new sewer on altered route.	1,250	3.0	PVC	250	750	88	2	-
KAS-Sbe-RS-Rh-2	Centre Ville de Sbeitla	750	AC	250	1,015	Sewers in poor condition	B0	Replacement of existing sewers by sewers in PVC with same diameter.	750	1.8	PVC	250	1,015	251	6	-
KAS-Sbe-RS-Rh-3	Cité Loutissement el Feth	1,250	AC	250	2,400	Mechanical sewer cleaning is not effective. Frequent blockages. Sewers in poor condition. Difficult to unblock. Sewers in poor condition with insufficient capacity flow full and overflow to houses.	B0	Replacement of existing sewers by sewers in PVC with same diameter.	1,250	3.0	PVC	250	2,400	535	13	-
KAS-Sbe-RS-Rh-4	Cité Essourour Est / Cité Essourour Ouest	650	BA / PVC	300 / 400	780	Sewer in poor condition. Frequent blockages and overflows due to low slope. 400m to be abandoned.	B0	Abandon 400m of existing sewer in concrete and building connections. Construct new sewer in PVC DN400, and new building connections.	650	1.6	PVC	400	300	138	3	-

Intervention code	Location	Existing situation				Diagnosis		Proposed solution							
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
KAS-Tel-RS-Ex-1	Cité Tela	-	-	-	-	Inhabited area without sewerage network, served by soakaways. No contamination problems.	C0	Construction of new sewerage network to improve regional infrastructure, increase coverage (55%) and eliminate pollution. This intervention requires construction of pumping stations SP1 Cité SNIT and SP2 Ain Ahmed.	5,950	13.3	PVC	250	12,000	2,514	75	KAS-Tel-SP-Ex-1 KAS-Tel-SP-Ex-2
Total													79,080	15,765	432	

Table 2.6-11: Diagnosis of pumping stations and pumped mains, Kasserine Governorate

Intervention code	Location	Existing situation								Diagnosis	
		Population served (hab)	Pumping station				Pumped main			Description	Classifi-cation
			Total capacity (L/s)	No. of pumps (service+ reserve)	Dynamic head (m)	Rated power of each pump (kW)	Pipe material	Nominal diameter (mm)	Length (m)		
KAS-Fei-SP-Ex-1	SP1 - EL Amen	-	-	-	-	-	-	-	-	Cité El Amen has no sewerage network. If a network is to be built, the wastewater will need to be pumped to reach the town network.	C0
KAS-Fei-SP-Ex-2	SP2 - El Bassatine	-	-	-	-	-	-	-	-	Cité El Bassatine has no sewerage network. If a network is to be built, the wastewater will need to be pumped to reach the town network.	C0
KAS-Tel-SP-Ex-1	SP1 - Cité SNIT	-	-	-	-	-	-	-	-	Cité SNIT has no sewerage network. If a network is to be built, the wastewater will need to be pumped to reach the town network.	C0
KAS-Tel-SP-Ex-2	SP 2 - Ain Ahmed	-	-	-	-	-	-	-	-	Cité Ain Ahmed has no sewerage network. If a network is to be built, the wastewater will need to be pumped to reach the town network.	C0
Total											

Table 2.6-12: Definition of pumping station and pumped main interventions, Kasserine Governorate

Intervention code	Proposed solution																	
	Population served (hab)	Total design flow (L/s)	Intervention in pumping station					Construction of pumped main			Construction of gravity sewers			Civil construction investment cost ('000 TND)	Equipment investment cost ('000 TND)	Total investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Annual energy cost ('000 TND)	Other interventions required
			Description	Total capacity (L/s)	No. of pumps (service+ reserve)	Estimated power rating (kW)	Type	Pipe material	Nominal diameter (mm)	Length (m)	Pipe materials	Nominal diameters (mm)	Total length network (m)						
KAS-Fei-SP-Ex-1	800	5	Construction of pumping station and pumped main to transport flows from Cité El Amen. Need to purchase private land for pumping station.	10	1+1	1.1	SP1B	HDPE	125	1,340	-	-	-	181	58	238	7	0	KAS-Fei-RS-Ex-1
KAS-Fei-SP-Ex-2	1,000	5	Construction of pumping station and pumped main to transport flows from Cité El Bassatine. Need to purchase private land for pumping station.	10	1+1	1.1	SP1B	HDPE	125	443	-	-	-	116	58	174	5	0	KAS-Fei-RS-Ex-1
KAS-Tel-SP-Ex-1	375	5	Construction of pumping station and pumped main to transport flows from Cité SNIT. Need to purchase private land for pumping station.	10	1+1	1.1	SP1B	HDPE	125	424	-	-	-	131	58	188	6	0	KAS-Tel-RS-Ex-1
KAS-Tel-SP-Ex-2	375	5	Construction of pumping station and pumped main to transport flows from Cité Ain Ahmed. Need to purchase private land for pumping station.	10	1+1	1.1	SP1B	HDPE	125	241	-	-	-	99	58	157	5	0	KAS-Tel-RS-Ex-1
Total										2,448			0	527	230	757	24	0	

2.6.7 Kébili Governorate

The wastewater networks of 5 communes in this governorate are managed by ONAS, and were considered by the present study.

Wastewaters from Kébili (Keb; Kébili South: Kes; Kébili North: Ken) are treated in Kébili WwTP. Wastewaters from El Golaa (Gol), Jemna (Jem) and Douz (Dou; Douz South: Dos) are treated in Douz WwTP, while those from Souk Lahad (Sou) are discharged to watercourses without treatment. It is intended that a WwTP be constructed in Souk Lahad (currently being studied). At present sanitation in Souk Lahad is by soakaways and latrines, and there are contamination problems.

The areas where network extensions are proposed are generally served by individual soakaways, septic tanks and latrines, without problems of contamination of SONEDE water sources.

Sewers are cleaned once or twice a year, manually and mechanically.

The quantification of works considered the per capita water consumption data indicated in Section 2.1, also that one connection box is required per dwelling and an occupation rate of five people per dwelling.

There is some tourism activity in Kébili, especially Douz. This contribution is included in the calculated flows.

In general the terrain is regular, groundwater levels are deep, and the soils are sandy and clayey. Only the town of Souk Lahad has rocky ground conditions, with about 20% rock. Soils are saline in the entire governorate, except Souk Lahad.

Tables 2.6-13, 2.6-14 and 2.6-15 present the technical characteristics and estimated costs of investment and operation of the proposed interventions.

Table 2.6-13: Definition of drainage network interventions, Kébili Governorate

Intervention code	Location	Existing situation				Diagnosis		Proposed solution							
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
KEB-Keb-RS-Ex-1	Kébili (Nezla) / Kébili (Ville)	-	-	-	-	Inhabited area. Existing sanitation by soakaways. No contamination problems.	C1	Construction of new sewerage network to improve connection rate. Need for pumping station.	1,000	2.1	PVC	250	1,700	286	9	KEB-Keb-SP-Ex-1
KEB-Keb-RS-Rh-1	Kébili (Centre Ville)	4,000	AC	250 / 300	7 115	Sewers are old and in poor condition, sometimes due to H2S.	B1	Replacement of sewers in AC, including manholes and building connections.	4,000	8.4	PVC	250 / 315	7,115	1,682	42	-
KEB-Ken-RS-Ex-1	Cité Rabta	-	-	-	-	Inhabited area. Existing sanitation by soakaways and latrines. Contamination problems.	C0	Construction of new sewerage network to improve connection rate. Need for pumping station.	3,000	6.3	PVC	250	8,900	1,397	42	KEB-Ken-SP-Ex-1
KEB-Ken-RS-Ex-2	Cité Tombar	-	-	-	-	Inhabited area. Existing sanitation by soakaways and latrines. Contamination problems.	C0	Construction of new sewerage network to improve connection rate. Need for pumping station.	5,550	11.2	PVC	250	10,673	1,854	56	KEB-Ken-SP-Ex-2
KEB-Ken-RS-Ex-3	Cité Jdida Mansoura	-	-	-	-	Inhabited area. Existing sanitation by soakaways and latrines. Contamination problems.	C0	Construction of new sewerage network to improve connection rate. Need for pumping station.	3,000	6.3	PVC	250	6,000	1,080	32	KEB-Ken-SP-Ex-3
KEB-Ken-RS-Ex-4	Cité Guetya	-	-	-	-	Inhabited area. Existing sanitation by soakaways and latrines. Contamination problems.	C0	Construction of new sewerage network to improve connection rate. Need for pumping station.	2,530	5.3	PVC	250	5 050	878	26	KEB-Ken-SP-Ex-4
Keb-Kes-RS-Ex-1	Cité Bazma	-	-	-	-	Inhabited area. Existing sanitation by soakaways and latrines. Contamination problems.	C0	Construction of new sewerage network to improve connection rate. Need for pumping station.	3,650	7.7	PVC	250	12,150	1,939	58	KEB-Kes-SP-Ex-1

		Existing situation				Diagnosis		Proposed solution								
Intervention code	Location	Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
Keb-Kes-RS-Ex-2	Cité Rahmat	-	-	-	-	Inhabited area. Existing sanitation by soakaways and latrines. Contamination problems.	C0	Construction of new sewerage network to improve connection rate. Need for 2 pumping stations.	1,350	2.8	PVC	250	5,130	801	24	KEB-Kes-SP-Ex-2 / Keb-Kes-SP-Ex-1
Keb-Sou-RS-Ex-1	Ville de Souk Lahad	-	-	-	-	Inhabited area. Existing sanitation by soakaways and latrines. Contamination problems.	C0	Construction of new sewerage network to improve connection rate. Need for 5 pumping stations.	15,000	21.8	PVC	250 / 315	32,500	6,140	184	KEB-Sou-SP-Ex-1 / KEB-Sou-SP-Ex-2 / KEB-Sou-SP-Ex-3 / KEB-Sou-SP-Ex-4 / KEB-Sou-SP-Ex-5
Keb-Gol-RS-Ex-1	Cité El Golaa	-	-	-	-	Inhabited area. Existing sanitation by soakaways and latrines. Contamination problems.	C0	Construction of new sewerage network to improve connection rate.	750	1.2	PVC	250	3,065	387	12	-
Keb-Jem-RS-Ex-1	Cité Jemna	-	-	-	-	Inhabited area. Existing sanitation by septic tanks. Contamination of wells.	A	Construction of new sewerage network to improve connection rate.	3,500	5.6	PVC	250	11,200	1,777	53	KEB-Jem-RS-Ex-1
Keb-Dou-RS-Ex-1	O M Zarzour / Gharbia	-	-	-	-	Inhabited area. Existing sanitation by septic tanks. No contamination problems.	C1	Construction of new sewerage network to improve connection rate. Need for pumping station.	2,000	4.7	PVC	250	5,648	953	29	KEB-Dou-SP-Ex-1
Keb-Dou-Rs-Rh-1	Douz	40,000	PVC	315 / 400	-	Insufficient capacity. Overflows. Insufficient slope.	B0	Replacement of sewer by one with larger capacity. Replacement of manholes and building connections.	25,000	43.5	PVC	400 / 500	2,451	794	20	-
Keb-Dos-Rs-Ex-1	Cité Zeafrane	-	-	-	-	Inhabited area. Existing sanitation by septic tanks. No contamination problems.	C0	Construction of new sewerage network to improve connection rate. Need for pumping station.	3,000	7.0	PVC	250	12,449	1,693	51	KEB-Dos-SP-Ex-1
Total													124,031	21,661	637	

Table 2.6-14: Diagnosis of pumping stations and pumped mains, Kébili Governorate

Intervention code	Location	Existing situation								Diagnosis	
		Population served (hab)	Pumping station				Pumped main			Description	Classifi-cation
			Total capacity (L/s)	No. of pumps (service+ reserve)	Dynamic head (m)	Rated power of each pump (kW)	Pipe material	Nominal diameter (mm)	Length (m)		
KEB-Keb-SP-Rh-1	SR2	4,000	20	1+1	12	6.7	AC	150	750	Pipework, pumps and pump guide rails severely corroded. Valves need replacing. Well covers damaged. Floor of operation building destroyed by saline corrosion. All civil works in poor condition.	A
KEB-Keb-SP-Rh-2	SR1	2,500	20	1+1	10	6.7	HDPE	200	1,760	Pumping station has sufficient capacity for expansion of network to Kébili Sud (~1000 houses). Need for rehabilitation of civil works and equipment. Pipework, pumps and pump guide rails severely corroded. Windows broken. Valves need replacing. Well covers damaged. Floor of operation building destroyed by saline corrosion. Swelling of concrete in valve chamber. All civil works in poor condition.	A
KEB-Keb-SP-Ex-1	SP Nezla	-	-	-	-	-	-	-	-	Inhabited area without sewerage network	C1
KEB-Ken-SP-Ex-1	SP Rbata	-	-	-	-	-	-	-	-	Inhabited area without sewerage network	C0
KEB-Ken-SP-Ex-2	SP Tombar	-	-	-	-	-	-	-	-	Inhabited area without sewerage network	C0
KEB-Ken-SP-Ex-3	SP Jdida	-	-	-	-	-	-	-	-	Inhabited area without sewerage network	C0
KEB-Ken-SP-Ex-4	SP Guetya	-	-	-	-	-	-	-	-	Inhabited area without sewerage network	C0
KEB-Kes-SP-Ex-1	SP Bazma	-	-	-	-	-	-	-	-	Inhabited area without sewerage network	C0
KEB-Kes-SP-Ex-2	SP Rahmat	-	-	-	-	-	-	-	-	Inhabited area without sewerage network	C0
KEB-Sou-SP-Ex-1	SP1	-	-	-	-	-	-	-	-	Inhabited area without sewerage network	C0

Intervention code	Location	Existing situation								Diagnosis	
		Population served (hab)	Pumping station				Pumped main			Description	Classifi-cation
			Total capacity (L/s)	No. of pumps (service+ reserve)	Dynamic head (m)	Rated power of each pump (kW)	Pipe material	Nominal diameter (mm)	Length (m)		
KEB-Sou-SP-Ex-2	SP2	-	-	-	-	-	-	-	-	Inhabited area without sewerage network	C0
KEB-Sou-SP-Ex-3	SP3	-	-	-	-	-	-	-	-	Inhabited area without sewerage network	C0
KEB-Sou-SP-Ex-4	SP4	-	-	-	-	-	-	-	-	Inhabited area without sewerage network	C0
KEB-Sou-SP-Ex-5	SP5	-	-	-	-	-	-	-	-	Inhabited area without sewerage network	C0
KEB-Jem-SP-Ex-1	SP Jemna 3	-	-	-	-	-	-	-	-	Need for pumping station to eliminate untreated discharges from pumping stations Jemna 1 and Jemna 2, which receive from existing Jemna network, by transporting flow to Douz, from where it will flow to Douz WwTP.	A
KEB-Dou-SP-Ex-1	SP Gharbia	-	-	-	-	-	-	-	-	Inhabited area without sewerage network	C1
KEB-Dos-SP-Ex-1	SP Zeafrane	-	-	-	-	-	-	-	-	Inhabited area without sewerage network	C1
Total									2,510		

Table 2.6-15: Definition of pumping station and pumped main interventions, Kébili Governorate

Intervention code	Proposed solution																		
	Population served (hab)	Total design flow (L/s)	Intervention in pumping station					Construction of pumped main			Construction of gravity sewers			Civil construction investment cost ('000 TND)	Equipment investment cost ('000 TND)	Total investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Annual energy cost ('000 TND)	Other interventions required
			Description	Total capacity (L/s)	No. of pumps (service+ reserve)	Estimated power rating (kW)	Type	Pipe material	Nominal diameter (mm)	Length (m)	Pipe materials	Nominal diameters (mm)	Total length network (m)						
KEB-Keb-SP-Rh-1	4,000	18	Replacement of equipment and pumped main. Rehabilitation of civil works.	18	1+1	7.5	SP2B	HDPE	160	750	-	-	-	189	108	297	8	1	-
KEB-Keb-SP-Rh-2	7,500	14	Replacement of all equipment. Rehabilitation of civil works.	14	1+1	3.0	SP2B	HDPE	160	0	-	-	-	55	92	146	11	1	-
KEB-Keb-SP-Ex-1	850	5	Construction of pumping station and pumped main to connect Cité Nezla network (KEB-Keb-RS-Ex-1) to public network	10	1+1	3.0	SP1B	HDPE	125	810	-	-	-	134	58	191	6	0	-
KEB-Ken-SP-Ex-1	3,000	6	Construction of pumping station and pumped main to connect future Cité Rbata network to public network	10	1+1	3.0	SP1B	HDPE	125	1,260	-	-	-	217	58	274	9	0	KEB-Ken-RS-Ex-1
KEB-Ken-SP-Ex-2	5,550	11	Construction of pumping station and pumped main to connect future Cité Tombar network to public network	11	1+1	3.0	SP2B	HDPE	125	835	PVC	315	1,545	389	78	467	15	1	KEB-Ken-RS-Ex-2
KEB-Ken-SP-Ex-3	600	5	Construction of pumping station and pumped main to connect future Cité Jdida Mansoura network to public network	10	1+1	1.1	SP1B	HDPE	125	390	-	-	-	91	58	149	5	0	KEB-Ken-RS-Ex-3
KEB-Ken-SP-Ex-4	2,530	5	Construction of pumping station and pumped main to connect future Cité Guetya network to Kébili network	10	1+1	11.0	SP1B	HDPE	125	4,290	PVC	250	425	659	58	716	22	1	KEB-Ken-RS-Ex-4
KEB-Kes-SP-Ex-1	5,000	10	Construction of pumping station and pumped main to connect future Cité Rahmat network to Kébili network. This pumping station will transport flow to Bazma pumping station.	10	1+1	4.0	SP2B	HDPE	125	920	PVC	250	285	205	74	279	9	1	KEB-Kes-RS-Ex-1 KEB-Kes-RS-Ex-2
KEB-Kes-SP-Ex-2	1,350	5	Construction of pumping station and pumped main to connect future Cité Guetya network to Kébili network	10	1+1	3.0	SP1B	HDPE	125	760	PVC	250	3,700	557	58	614	19	0	KEB-Kes-RS-Ex-2 KEB-Kes-SP-Ex-1
KEB-Sou-SP-Ex-1	1,915	5	Construction of pumping station and pumped main to connect future Souk Lahad network to WwTP (in study)	10	1+1	5.5	SP1B	HDPE	125	550	-	-	-	131	58	189	6	0	KEB-Sou-RS-Ex-1

Intervention code	Proposed solution																		
	Population served (hab)	Total design flow (L/s)	Intervention in pumping station					Construction of pumped main			Construction of gravity sewers			Civil construction investment cost ('000 TND)	Equipment investment cost ('000 TND)	Total investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Annual energy cost ('000 TND)	Other interventions required
			Description	Total capacity (L/s)	No. of pumps (service+ reserve)	Estimated power rating (kW)	Type	Pipe material	Nominal diameter (mm)	Length (m)	Pipe materials	Nominal diameters (mm)	Total length network (m)						
KEB-Sou-SP-Ex-2	7,500	12	Construction of pumping station and pumped main to connect future Souk Lahad network to WwTP (in study)	12	1+1	2.2	SP2B	HDPE	125	450	-	-	-	116	83	199	7	1	KEB-Sou-RS-Ex-1 KEB-Sou-SP-Ex-3 KEB-Sou-SP-Ex-5
KEB-Sou-SP-Ex-3	6,100	10	Construction of pumping station and pumped main to connect future Souk Lahad network to WwTP (in study)	10	1+1	3.0	SP2B	HDPE	125	495	-	-	-	116	75	191	6	1	KEB-Sou-RS-Ex-1 KEB-Sou-SP-Ex-5
KEB-Sou-SP-Ex-4	620	5	Construction of pumping station and pumped main to connect future Souk Lahad network to WwTP (in study)	10	1+1	1.1	SP1B	HDPE	125	200	-	-	-	84	58	142	5	0	KEB-Sou-RS-Ex-1
KEB-Sou-SP-Ex-5	2,600	5	Construction of pumping station and pumped main to connect future Souk Lahad network to WwTP (in study)	10	1+1	4.0	SP1B	HDPE	125	795	-	-	-	164	58	222	7	0	KEB-Sou-RS-Ex-1
KEB-Jem-SP-Ex-1	4,000	6	Construction of pumping station and pumped main to transport wastewater to Douz.	10	1+1	11.0	SP2B	HDPE	125	11,230	PVC	315	420	1,515	54	1,568	48	2	KEB-Jem-RS-Ex-1
KEB-Dou-SP-Ex-1	500	5	Construction of pumping station and pumped main to transport flow from future Cité Gharbia network.	10	1+1	1.1	SP1B	HDPE	125	175	-	-	-	73	58	130	4	0	Keb-Dou-RS-Ex-1
KEB-Dos-SP-Ex-1	3,000	7	Construction of pumping station and pumped main to connect future Zeafrane network to Douz WwTP	10	1+1	4.0	SP1B	HDPE	125	4,710	PVC	250	160	479	58	537	16	1	Keb-Dos-RS-Ex-1
										28,620			6,535	5,173	1,138	6,311	202	10	

2.6.8 El Kef Governorate

The wastewater networks of 3 communes in this governorate are managed by ONAS, and were considered by the present study.

The urban wastewaters from Kef (Kef) are treated in the town's WwTP, while those from Dahmani (Dah) and Tajerouine (Taj) are discharged to watercourses without treatment. WwTP for these towns are already at the planning stage and are not considered further in this study.

The networks in the town centers are old, with concrete or asbestos pipes which need to be replaced. Most of these networks are unitary or pseudo-separate, and connected to roof drains and courtyards. Road drainage is mostly superficial and discharges to watercourses. There are no stormwater sewerage networks.

In the town of Kef, interventions will be mostly the replacement of old sewers, given that coverage is already high, about 96%.

The areas where network extensions are proposed are generally served by individual septic tanks at present, which may risk contamination of waters, especially wells.

In the entire governorate there are occasional problems of overflows due to the low slopes and insufficient capacity, causing contamination problems.

Sewers are cleaned once or twice a year, manually and mechanically.

The quantification of works considered the per capita water consumption data indicated in Section 2.1, also that one connection box is required per dwelling and occupation rate of five people per dwelling.

In general the terrain in Kef and Tajerouine is irregular, but flat in Dahmani, groundwater levels are deep, the percentage of rock in the soil is small (<40%). Only the soils in Tajerouine are saline.

Tables 2.6-16, 2.6-17 and 2.6-18 present the technical characteristics and estimated costs of investment and operation of the proposed interventions.

Table 2.6-16: Definition of drainage network interventions, El Kef Governorate

Intervention code	Location	Existing situation				Diagnosis		Proposed solution							
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
KEF-Dah-RS-Rh-3	Centre Ville de Dahmani / Cité Ben Amar	3,515	BC / AC / PVC	200 / 250 / 300	5,294	Sewers in BC and AC in poor condition, sometimes due to H2S. Sewer in PVC has insufficient capacity.	B1	Replacement of sewers in BC and AC, including manholes and building connections.	3,515	8.9	PVC	250 / 315	5,294	1,269	32	-
KEF-Dah-RS-Ex-1	Cité Ennasr	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. Possibility of pollution.	C0	Construction of new sewerage network.	125	0.3	PVC	250	230	43	1	-
KEF-Kef-RS-Rh-1	GP 5D	45,191	AC	400	1,960	Main sewer serving the town, old and in poor condition, sometimes due to H2S. Occurrence of overflows to surface. Difficult to clean.	B0	Replacement of sewers, including manholes and building connections.	45,191	95.3	PVC	500	1,960	631	16	-
KEF-Kef-RS-Rh-2	Avenue Hédi Cheker	300	AC	250	470	Sewer is old and in very poor condition, sometimes due to H2S. Possibility of contamination.	B0	Replacement of sewer, including manholes and building connections.	300	0.8	PVC	250	470	117	3	-
KEF-Kef-RS-Rh-3	Cité Chrichi	1,400	AC	250	717	Sewer is old and in very poor condition, and crosses private land.	B1	Replacement of existing sewer on 330m of the same route. Construction of 1060m new sewer along public roads.	2,300	6.8	PVC	250	1,390	238	7	-
KEF-Kef-RS-Rh-4	Cité Liberté	600	AC / BC	200	690	Sewers are old and in very poor condition, sometimes due to H2S.	B1	Replacement of sewers, including manholes and building connections.	600	1.6	PVC	250	690	171	4	-
KEF-Kef-RS-Rh-5	Cité Eddir	1,000	AC	250	430	Sewers are old and in poor condition, sometimes due to H2S.	B1	Replacement of sewers, including manholes and building connections.	1,000	2.9	PVC	250	430	86	2	-
KEF-Kef-RS-Rh-6	Cité Taieb M'hiri	2,400	BC	200	1,570	Sewers are old and in poor condition, sometimes due to H2S. Occurrence of overflows to surface.	B0	Replacement of sewers, including manholes and building connections.	2,400	7.1	PVC	250	1,570	390	10	-
KEF-Kef-RS-Rh-7	Cité El Hana	600	BC	200	810	Sewers are old and in poor condition, sometimes due to H2S.	B1	Replacement of sewers, including manholes and building connections.	600	1.6	PVC	250	810	201	5	
KEF-Kef-RS-Ex-1	Cité Eddir	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. Possibility of pollution.	C0	Construction of new sewerage network and interceptor. This intervention requires construction of pumping station SP KEF-Kef-SP-EX-1.	1,000	2.9	PVC	250	2,290	433	13	KEF-Kef-SP-EX-1
KEF-Taj-RS-Rh-1	Cité Taieb Mhiri	1,500	BC	200	3,200	Sewers are old and in poor condition, sometimes due to H2S.	B1	Replacement of sewers, including manholes and building connections.	1,500	3.8	PVC	250	3,200	729	18	-
KEF-Taj-RS-Rh-2	Cité el Ain	950	BC	200	1,610	Sewers are old and in poor condition, sometimes due to H2S.	B1	Replacement of sewers, including manholes and building connections.	950	2.4	PVC	250	1,610	367	9	-
KEF-Taj-RS-Rh-3	Cité Bourguiba	2,750	BC	250	4,210	Sewers are old and in poor condition, sometimes due to H2S.	B1	Replacement of sewers, including manholes and building connections.	2,750	7.0	PVC	250	4,210	959	24	-
KEF-Taj-RS-Ex-1	Cité Rahba	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. Possibility of pollution.	C0	Construction of new sewerage network.	100	0.3	PVC	250	250	37	1	-
KEF-Taj-RS-Ex-2	Cité Chebbi	-	-	-	-	Inhabited area without sewerage network. Problems of contamination of groundwater and wells.	A	Construction of new sewerage network. This intervention requires construction of pumping station KEF-Taj-SP-Ex-1.	225	0.6	PVC	250	330	49	1	KEF-Taj-SP-Ex-1
KEF-Taj-RS-Ex-3	Cité 2 Mars	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. Possibility of pollution.	C0	Construction of new sewerage network.	300	0.8	PVC	250	820	123	4	-
Total													25,554	5,842	150	

Table 2.6-17: Diagnosis of pumping stations and pumped mains, El Kef Governorate

Intervention code	Location	Existing situation								Diagnosis	
		Population served (hab)	Pumping station				Pumped main			Description	Classifi-cation
			Total capacity (L/s)	No. of pumps (service+ reserve)	Dynamic head (m)	Rated power of each pump (kW)	Pipe material	Nominal diameter (mm)	Length (m)		
KEF-Dah-SP-Rh-1	SP 2	1,000	12	1+1	20	5.5	HDPE	160	150	Need for replacement of manual screen, valves, pipework and electrical panel.	B0
KEF-Kef-SP-Rh-1	SP 9 Avril	3,000	9	1+1	4	3.0	PVC	160	530	Need for replacement of manual screen, pumps, valves, pipework and electrical panel. Emergency generator is broken. Capacity of wet well is insufficient.	B0
KEF-Kef-SP-Rh-2	SP 3 Août	10,000	12	1+1	14	5.5	AC	160	250	Insufficient capacity. Equipment in poor condition.	B0
KEF-Kef-SP-Ex-1	SP Eddir	-	-	-	-	-	-	-	-	Cité Eddir has no sewerage network. If a network is to be built, the wastewater will need to be pumped to reach the town network.	C0
KEF-Taj-SP-Rh-1	SP Essanoubar	400	9	1+1	15	3.0	HDPE	160	700	Equipment in good condition. Need to cement and raise level of surrounding wall.	B1
KEF-Taj-SP-Ex-1	SP Cité Chebbi	-	-	-	-	-	-	-	-	Cité Chebbi has no sewerage network, causing problems of contamination of groundwater and wells. If a network is to be built, the wastewater will need to be pumped to reach the town network.	A
Total									1,630		

Table 2.6-18: Definition of pumping station and pumped main interventions, El Kef Governorate

Intervention code	Proposed solution																		
	Population served (hab)	Total design flow (L/s)	Intervention in pumping station					Construction of pumped main			Construction of gravity sewers			Civil construction investment cost ('000 TND)	Equipment investment cost ('000 TND)	Total investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Annual energy cost ('000 TND)	Other interventions required
			Description	Total capacity (L/s)	No. of pumps (service+ reserve)	Estimated power rating (kW)	Type	Pipe material	Nominal diameter (mm)	Length (m)	Pipe materials	Nominal diameters (mm)	Total length network (m)						
KEF-Dah-SP-Rh-1	1,000	5.0	Replacement of manual screen, valves, pipework and electrical panel.	10.0	1+1	4.0	SP1B	-	-	-	-	-	-	0	14	14	4	0	-
KEF-Kef-SP-Rh-1	3,000	8.9	Replacement of all equipment. Construction of new wet well.	10.0	1+1	1.1	SP1B	HDPE	125	530	-	-	-	138	58	196	6	0	-
KEF-Kef-SP-Rh-2	10,000	24.9	Replacement of all equipment. Construction of new wet well.	24.9	1+1	3.0	SP2A	HDPE	200	250	-	-	-	89	92	181	6	1	-
KEF-Kef-SP-Ex-1	1,000	5.0	Construction of pumping station and pumped main to lift wastewater from Cité Eddir	10.0	1+1	2.2	SP1B	HDPE	125	210	-	-	-	89	58	146	5	0	KEF-Kef-RS-Ex-1
KEF-Taj-SP-Rh-1	400	5.0	Cement and raise level of surrounding wall.	10.0	1+1	3.0	SP1B	-	-	-	-	-	-	6	0	6	6	0	-
KEF-Taj-SP-Ex-1	225	5.0	Construction of pumping station and pumped main to lift wastewater from Cité Chebbi	10.0	1+1	3.0	SP1B	HDPE	125	570	-	-	-	110	58	167	5	0	KEF-Taj-RS-Ex-2
Total										1,560			0	432	279	711	31	2	

2.6.9 Sfax Governorate

Sfax governorate, with over 500 000 inhabitants, includes the city of Sfax, the second most important city and economic center of the country.

The wastewater networks of 11 communes in this governorate are managed by ONAS, and were considered by the present study. These municipalities (communes) are managed by ONAS through offices in 3 *arrondissements*:

- Sfax Ville ONAS office : Sfax commune ;
- Sfax Sud ONAS office : Communes of Mahres (Mah), Tyna (Tyn), Agareb (Aga), El Ain (Ain) and Gremda (Gre) ;
- Sfax Nord ONAS office: Communes of Jebeniana (Jeb), El Hencha (Hen), Sakiet Ezzit (Sae), Sakiet Eddaier (Sak) and Chihia (Chi).

The urban area of Sfax, Greater Sfax, covers these 3 *arrondissements* and surrounding municipalities. The consolidated urban center is spreading out along the principal radial roads to the periurban areas. Thus interventions in Sfax municipality were given codes according to the *arrondissement* in which they are located: Sfax Sud (Sfs) and Sfax Ville (Sfv).

Greater Sfax is crossed by the DHU canal, which diverts surface waters away from the center, in clockwise and anti-clockwise directions, towards the sea. Further from the center, the watercourse wadi Ezzit also crosses the outer areas, towards the sea. Large interceptor sewers have been built parallel to the DHU canal and wadi Ezzit, so as to divert wastewater from the outskirts away from the city center and towards the two large WwTP which serve the city: STEP Nord (North WwTP) and STEP Sud (South WwTP).

The areas where network extensions are proposed are not at present served by sewerage networks, but are generally served by individual septic tanks or soakaways, which may cause groundwater contamination problems. Currently there are no indications of such pollution.

The city has unitary, separate and pseudo-separate drainage networks. In the pseudo-separate drainage networks, roofs and internal courtyards are connected to the wastewater sewers, while road drainage is mostly superficial and discharges to watercourses. There are no stormwater sewerage networks.

The proposed rehabilitation interventions include the replacement of sewers with concrete or asbestos pipes which are in a poor condition, also those which require increased capacity in order to accommodate the expansion of the sewerage network to urban areas not served at present. It is also necessary to replace the pumped main in GRP/PRV, DN 1000, length 5 km, which originates at the SP Saline Pumping Station, due to its poor condition, which limits capacity. This main transports wastewater from the Sfax Ville and Sfax Sud *arrondissements* to the STEP Sud WwTP.

The quantification of works considered the per capita water consumption data indicated in Section 2.1, as well as the following criteria:

- 5 to 10 connection boxes per 100 m of sewer;
- 1 to 12 dwellings per connection box and 5 persons / dwelling.

Generally the terrain is almost flat, groundwater levels are near the surface, and the soils are sandy and clayey. For cost estimation it was considered that soils contain less than 10% rock, with the exception of Jebeniana, where a content of 40% was considered (based on information from ONAS), and that the soils near the coast are saline.

Tables 2.6-19, 2.6-20 and 2.6-21 present the technical characteristics and estimated costs of investment and operation of the proposed interventions.

The intervention SFA-Chi-RS-Ex-1 may need a pumping station. This hypotheses should be validated in the subsequent phases, namely at the detail design.

Table 2.6-19: Definition of drainage network interventions, Sfax Governorate

Intervention code	Location	Existing situation				Diagnosis		Proposed solution							
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
SFA-Chi-RS-Ex-1	Chihia Tr 1	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	2,108	6.5	PVC	250	10,330	1,388	42	-
SFA-Chi-RS-Ex-2	Chihia Tr 2	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	1,045	3.2	PVC	250	4,180	579	17	-
SFA-Chi-RS-Ex-3	Chihia Tr 3	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	810	2.5	PVC	250	4,640	611	18	-
SFA-Chi-RS-Rh-1	Route Teniour	10,491	AC / PVC	250 / 300/ 400	4,003	Sewer along Route Teniour is in poor condition, due to frequent leaks. Overflows onto street are frequent, causing contamination. Recent sections in PVC have insufficient capacity.	B0	Replacement of main sewer along Route Tenoir up to DHU canal, including manholes and building connections. Increased capacity.	10,491	26.1	PVC	315 / 400	4,003	989	25	-
SFA-Sae-RS-Ex-1	Sakiet Ezzit Tr 1	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	658	2.1	PVC	250	2,630	364	11	-
SFA-Sae-RS-Ex-2	Sakiet Ezzit Tr 2	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	950	3.0	PVC	250	3,800	527	16	-
SFA-Sae-RS-Ex-3	Sakiet Ezzit Tr 3	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	4,416	13.0	PVC	250	17,665	2,448	73	-
SFA-Sae-RS-Rh-1	Route de Tunis GP 1	13,819	AC	150 300 / 400	3,300	Sewerage network in very poor condition. Insufficient capacity. Settlements and ruptures on road "Route de Tunis". Pollution of road surface in case of rupture or collapse.	B0	Replacement of main sewer along Route de Tunis up to DHU canal, including manholes and building connections. Includes replacement of pumped main from pumping station SP Sakiet Ezzit and transition chamber.	13,819	33.9	HDPE / PVC	200 400	3,330	847	21	-
SFA-Sak-RS-Ex-1	Sakiet Eddaier Tr 1	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	10,780	27.4	PVC	250	43,210	5,986	180	-
SFA-Sak-RS-Ex-2	Sakiet Eddaier Tr 2	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	13,380	33.0	PVC	250	57,930	8,170	245	-
SFA-Sak-RS-Ex-3	Sakiet Eddaier Tr 3	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	5,405	15.3	PVC	250	21,620	2,996	90	-
SFA-Sak-RS-Rh-1	Route de Mahdia MC 82	53,396	AC / BA	250 / 300 / 500	6,607	Sewerage network in very poor condition. Collapses cause pollution of road surface. Corrosion of concrete by H2S.	B0	Replacement of asbestos sections of sewer on Route Mahdia and trunk sewer to SP5 pumping station. These are principal sewers for the area.	53,396	114.3	PVC	250 / 315 / 500	6,607	2,664	67	-
SFA-Ain-RS-Ex-1	El Ain Tr 1	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	755	2.3	PVC	250	5,210	718	22	-
SFA-Ain-RS-Ex-2	El Ain Tr 2	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	2,290	7.1	PVC	250	9,150	1,343	40	-
SFA-Ain-RS-Ex-3	El Ain Tr 3	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	3,595	10.8	PVC	250	14,380	2,109	63	-

Intervention code	Location	Existing situation				Diagnosis		Proposed solution							
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
SFA-Ain-RS-Ex-4	El Ain Tr 4	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	4,040	11.8	PVC	250	16,150	2,369	71	-
SFA-Gre-RS-Ex-1	Gremda Tr 1	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	2,805	8.5	PVC	250	11,220	1,645	49	-
SFA-Gre-RS-Ex-2	Gremda Tr 2	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	5,040	13.9	PVC	250	20,160	2,956	89	-
SFA-Gre-RS-Ex-3	Gremda Tr 3	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	5,205	14.3	PVC	250	20,810	3,051	92	-
SFA-Gre-RS-Ex-4	Gremda Tr 4	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	4,340	12.3	PVC	250	20,832	2,975	89	-
SFA-Gre-RS-Ex-5	Gremda Tr 5	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	3,315	9.9	PVC	250	13,250	1,943	58	-
SFA-Sfs-RS-Ex-1	Zone Industrielle Sidi Salem	-	-	-	-	Industrial area served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage. It is necessary to also construct a pumping station to lift some domestic wastewater flow to the new network.	2,000	6.7	PVC	250	7,550	1,134	34	SFA-Sfs-SP-Ex-1
SFA-Sfs-RS-Ex-2	Route Soukra Oued Chabounni 1	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	1,030	3.5	PVC	250	4,110	662	20	-
SFA-Sfs-RS-Ex-3	Route Soukra Oued Chabounni 2	750	AC / BC	250	2,990	Inhabited area partially served by sewerage network in concrete and asbestos pipes, which is old and in poor condition. Other housing is served by septic tanks. No contamination problems.	B1	Replacement of existing sewers, including manholes and building connections. Construction of new sewerage network in unserved areas, to provide increase in coverage. Most of intervention is rehabilitation.	810	2.7	PVC	250	3,220	538	14	-
SFA-Sfs-RS-Rh-1	Birjerbi	270	AC	250	540	Inhabited area partially served by sewerage network, which is in poor condition and prone to occasional collapses. Other housing is served by septic tanks. No contamination problems.	B1	Replacement of existing sewers, including manholes and building connections. Construction of new sewerage network in unserved areas, to provide increase in coverage.	2,375	8.0	PVC	250	4,545	855	25	-
SFA-Sfs-RS-Rh-2	Cité M'harza	500	AC	250	990	Inhabited area partially served by sewerage network, which is in poor condition and prone to occasional collapses. Other housing is served by septic tanks. No contamination problems.	B1	Replacement of existing sewers, including manholes and building connections. Construction of new sewerage network in unserved areas, to provide increase in coverage.	3,175	10.5	PVC	250	6,310	1,184	34	-
SFA-Sfs-RS-Rh-3	Cité Barnous	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	1,625	5.5	PVC	250	17,775	3,074	77	-
SFA-Sfs-RS-Rh-4	Cité Essourour	1,025	AC	250	2,045	Sewerage network in poor condition. Low slopes. Accumulation of sand.	B1	Replacement of sewers, including manholes and building connections.	1,025	3.5	PVC	250	2,045	446	11	-
SFA-Sfs-RS-Rh-5	Cité Ellouz / Cité Bouret Avali / Cité Mouroj	1,950	AC	250	3,870	Inhabited area partially served by sewerage network, which is in poor condition and prone to occasional collapses. Other housing is served by septic tanks. No contamination problems.	B1	Replacement of existing sewers, including manholes and building connections. Construction of new sewerage network in unserved areas, to provide increase in coverage.	2,480	8.4	PVC	250	4,930	1,038	27	-
SFA-Sfv-RS-Ex-1	Zone Route Kaied - M'hamed - Gremda	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	1,050	3.5	PVC	250	3,490	570	17	-

		Existing situation				Diagnosis		Proposed solution								
Intervention code	Location	Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
SFA-Sfv-RS-Ex-2	Zone Route Lafrane - El Ain	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	600	2.0	PVC	250	1,970	323	10	-
SFA-Sfv-RS-Ex-3	Zone Route Teniour - Tunis	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	2,250	7.6	PVC	250	7,470	1,221	37	-
SFA-Sfv-RS-Ex-4	Zone Route Gremda - La Frane	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	1,075	3.6	PVC	250	3,570	583	18	-
SFA-Sfv-RS-Ex-5	Cité Habbena / Cité Sidi Mansour	-	-	-	-	Inhabited area without sewerage, served by septic tanks which discharge to the sea. Mostly holiday homes and tourism establishments. Odor problems	B0	Construction of new sewerage network to increase coverage. This extension of Cité Habbena network requires the prior rehabilitation of the sewer on Route Habbena (SFA-Sfv-RS-Rh-6). Part of the extension in Sidi Mansour requires the construction of the Sidi Mansour Plage pumping station (SFA-Sfv-SP-Ex-1).	10,965	29.2	PVC	250	43,840	6,958	209	SFA-Sfv-SP-Ex-1 SFA-Sfv-RS-Rh-6
SFA-Sfv-RS-Ex-6	Cité peripheries Canal DHU	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	1,400	4.7	PVC	250	4,610	754	23	-
SFA-Sfv-RS-Ex-7	Zone Route Teniour - Kaied M'hamed	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	325	1.1	PVC	250	1,060	174	5	-
SFA-Sfv-RS-Rh-1	Cité Saline	240,000	PRV	1,000	5,000	Existing pumped main from the Cité Saline pumping station to Sud WwTP. Receives flow from 2 wastewater sewers and 2 stormwater sewers. However at present only one pup can be used at a time in order to avoid rupture of pumped main. Inner surface of pumped main is degraded. Pumped main is installed in saline soils, and has settlement problems. The equipment and civil works of the pumping station itself are in good condition.	B0	Replacement of the pumped main to Sud WWTP, along new route inland avoiding saline soils.	240,000	500.2	HDPE / BA	1,000	1,565	6,733	30	-
SFA-Sfv-RS-Rh-2	Sfax Centre Ville	5,000	BC / AC	250 / 500	4,135	Sewerage network in poor condition. Connection boxes flow as siphons	B1	Replacement of sewers in concrete and asbestos, including manholes and building connections.	5,000	15.1	PVC	250 / 500	4,135	922	23	-
SFA-Sfv-RS-Rh-3	Arrondissement Medina	4,000	BA / AC	250 / 300	1,330	Sewerage network is old and in poor condition. Requires daily repairs. Low slopes. Negative slopes. Accumulation of sand. Sewers need to be cleaned after every rainfall.	B1	Replacement of sewers in concrete and asbestos, including manholes and building connections.	4,000	12.6	PVC	250 / 300	1,330	330	8	-
SFA-Sfv-RS-Rh-4	Cité Rbat Nord	20,000	BA / AC	250 / 400/500	4,150	Sewers are old and in bad condition.	B1	Replacement of sewers in concrete and asbestos, including manholes and building connections.	20,000	49.5	PVC	250 / 400 / 500	4,132	1,023	26	-
SFA-Sfv-RS-Rh-5	Cité El Boustane	11,150	AC	250	11,235	Sewers are old and in bad condition. Low slopes. Overflows.	B1	Replacement of sewers in asbestos, including manholes and building connections.	11,150	29.7	PVC	250	14,865	3,621	91	-
SFA-Sfv-RS-Rh-6	Route Habbena	2,100	PVC	250	4,713	The existing sewer, built to transport wastewater from the University, is too high to allow connection of lateral sewers from the surrounding area. Need to increase capacity to allow for new connections. All connection boxes flow full.	B0	Replacement of sewers, including manholes and building connections, at a deeper level in order to allow all lateral connections. Increased capacity.	8,100	22.6	PVC	315	4,713	986	25	-

Intervention code	Location	Existing situation				Diagnosis		Proposed solution							
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
SFA-Tyn-RS-Ex-1	Tyna Tr 1	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	390	1.2	PVC	250	1,560	248	7	-
SFA-Tyn-RS-Ex-2	Tyna Tr 2	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage. Requires construction of pumping station to lift wastewater to existing network.	3,830	11.1	PVC	250	17,660	2,749	82	SFA-Tyn-SP-Ex-1
SFA-Aga-RS-Ex-1	Agareb	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	1,500	4.1	PVC	250	5,960	947	28	-
SFA-Aga-RS-Ex-2	Zone Industrielle	-	-	-	-	Industrial area served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage. Requires construction of pumping station to lift domestic wastewater from industrial area.	1,500	4.1	PVC	250	2,085	314	9	SFA-Aga-RS-Ex-1
SFA-Hen-RS-Ex-1	Hencha Tr 1	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	1,750	4.9	PVC	250	7,500	1,209	36	-
SFA-Hen-RS-Ex-2	Hencha Tr 2	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	1,100	3.1	PVC	250	4,500	730	22	-
SFA-Jeb-RS-Ex-1	Jebeniana Tr 1	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	1,000	2.9	PVC	250	4,300	767	23	-
SFA-Jeb-RS-Ex-2	Jebeniana Tr 2	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	1,350	3.9	PVC	250	5,700	1,019	31	-
SFA-Mah-RS-Ex-1	Mahres Tr 1	9,000	AC	250 / 400	1,835	Inhabited area partially served by sewerage. Other housing is served by septic tanks. Frequent overflows. No contamination problems. Need to increase capacity of existing principal sewers which transport wastewater to the principal pumping station (SR2).	B1	Replacement of existing principal sewers, including manholes and building connections, with increased capacity to avoid overflows. Construction of new sewerage network to increase coverage. Need to construct new pumping station to lift part of domestic wastewater from new network in Cité El Hana. Includes rehabilitation.	10,825	25.1	PVC	250/ 315 / 400	9,135	1,684	48	SFA-Mha-SP-Ex-1
SFA-Mah-RS-Ex-2	Mahres Tr 2	-	-	-	-	Inhabited area without sewerage, served by septic tanks. No contamination problems.	C1	Construction of new sewerage network to increase coverage.	2,750	7.8	PVC	250	10,940	1,824	55	-
SFA-Mah-RS-Rh-1	GP 1	750	AC	300	605	Sewer in poor condition. Occasional collapses.	B1	Replacement of existing sewer, increasing capacity.	7,500	18.4	PVC	315	605	126	3	-
Total					57,348				502,573				528,287	91,449	2,485	

Notes:

SFA-Mah-SP-Rh-1 - Population served: pumping of industrial waste water from fish factory

Table 2.6-20: Diagnosis of pumping stations and pumped mains, Sfax Governorate

Intervention code	Location	Existing situation								Diagnosis	
		Population served (hab)	Pumping station				Pumped main			Description	Classifi-cation
			Total capacity (L/s)	No. of pumps (service+ reserve)	Dynamic head (m)	Rated power of each pump (kW)	Pipe material	Nominal diameter (mm)	Length (m)		
SFA-Sfs-SP-Ex-1	SP Zone Industrielle Sidi Salem	-	-	-	-	-	-	-	-	Pumping station required to allow extension in Sidi Salem industrial area, to be connected to the DN400 PVC sewer which drains to SP3 pumping station.	C1
SFA-Sfv-SP-Ex-1	SP Sidi Mansour Plage	-	-	-	-	-	-	-	-	Pumping station required to allow extension in Sidi Salem beach area, to be connected to sewer on Route Sidi Mansour.	B0
SFA-Sfv-SP-Rh-1	SP 2 Habbena	10,000	56	2+0	3.5	2	PVC	80	2	Existing pumping station has sufficient capacity but equipment needs to be replaced and civil works are in poor condition. Pumping station must be located further from housing, since local population complains of odors.	B0
SFA-Sfv-SP-Rh-2	SP Kasset Chabane	10,000	46	2+0	6.1	3.1	Coated steel	150	5	Existing pumping station has sufficient capacity but equipment (from 1990) needs to be replaced. No instrumentation or enclosing wall. Wet well walls and pumped main in poor condition.	B0
SFA-Aga-SP-Ex-1	SP Zone Industrielle	-	-	-	-	-	-	-	-	Pumping station required to lift domestic flow from industrial area and part of Agareb network.	C1
SFA-Mah-SP-Ex-1	SP Mahres Tr 2 (Cité El Hana)	-	-	-	-	-	-	-	-	Pumping station required to lift domestic flow Cité El Hana network.	C1
SFA-Mah-SP-Rh-1	SP Port de Peche	pumping of industrial waste water (from fish factory)	5	1+1	7.7	1.2	HDPE	80	386	Pumps need to be replaced. Pumped main frequently blocked.	B1
SFA-Tyn-SP-Ex-1	SP Tyna	-	-	-	-	-	-	-	-	Pumping station required to lift flow from new network (SFA-Tyn-RS-Ex-2) to existing network, crossing railway.	C1
Total									393		

Notes:

SFA-Mah-SP-Rh-1 - Population served: pumping of industrial waste water from fish factory

Table 2.6-21: Definition of pumping station and pumped main interventions, Sfax Governorate

Intervention code	Proposed solution																		
	Population served (hab)	Total design flow (L/s)	Intervention in pumping station					Construction of pumped main			Construction of gravity sewers			Civil construction investment cost ('000 TND)	Equipment investment cost ('000 TND)	Total investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Annual energy cost ('000 TND)	Other interventions required
			Description	Total capacity (L/s)	No. of pumps (service+ reserve)	Estimated power rating (kW)	Type	Pipe material	Nominal diameter (mm)	Length (m)	Pipe materials	Nominal diameters (mm)	Total length network (m)						
SFA-Sfs-SP-Ex-1	2,000	7	Construction of new pumping station and pumped main to serve Sidi Salem industrial area.	10	1+1	1.1	SP1B	HDPE	125	66	-	-	-	65	58	123	4	0	SFA-Sfs-RS-Ex-1
SFA-Sfv-SP-Ex-1	1,036	5	Construction of new pumping station and pumped main to serve existing Sidi Mansour network.	10	1+1	1.1	SP1A	HDPE	125	430	-	-	-	100	46	146	5	0	SFA-Sfv-RS-Ex-5
SFA-Sfv-SP-Rh-1	10,000	42	Construction of new pumping station and pumped main with same capacity in new location. Site is military land. Need for land purchase.	42	2+1	5.5	SP2B	HDPE	250	2	-	-	-	123	184	306	10	1	-
SFA-Sfv-SP-Rh-2	10,000	42	Replacement of equipment and instrumentation. Rehabilitation of civil works (wet well walls, site wall). Replacement of pumped main.	42	2+1	7.5	SP2A	HDPE	250	200	-	-	-	67	129	196	8	1	-
SFA-Aga-SP-Ex1	3,000	8	Construction of new pumping station and pumped main to lift domestic flow from industrial area, part of existing Agareb network (SFA-Aga-RS-Ex-2) and part of new Agareb Sud network (SFA-Aga-RS-Ex-1).	10	1+1	1.1	SP1B	HDPE	125	50	-	-	-	64	58	121	4	0	SFA-Aga-RS-Ex-1 SFA-Aga-RS-Ex-2
SFA-Mah-SP-Ex-1	410	5	Construction of new pumping station and pumped main to allow increase in flow from industrial area.	10	1+1	3.0	SP1B	HDPE	125	475	-	-	-	116	58	173	5	0	SFA-Mah-RS-Ex-1
SFA-Mah-SP-Rh-1	1	10	Replacement of pumps and pumped main	10	1+1	2.2	SP1B	HDPE	125	386	-	-	-	69	35	104	4	1	-
SFA-Tyn-SP-Ex-1	925	5	Construction of new pumping station and pumped main. Pumped main will cross railway.	10	1+1	1.1	SP1B	HDPE	125	207	-	-	-	85	58	142	5	0	-
SFA-Sfv-RS-Rh-1	-	-	Refer to SFA-Sfv-RS-Rh-1	-	-	-	-	HDPE	1,000	4,123	-	-	-	-	-	-	-	-	-
SFA-Sae-RS-Rh-1	-	-	Refer to SFA-Sae-RS-Rh-1	-	-	-	-	HDPE	200	150	-	-	-	-	-	-	-	-	-
SFA-Sfv-RS-Rh-1	-	-	Refer to SFA-Sfv-RS-Rh-1	-	-	-	-	HDPE	1,000	827	-	-	-	-	-	-	-	-	-
Total										6,916			0	689	623	1,312	44	3	-

Notes:

SFA-Mah-SP-Rh-1 - Population served: pumping of industrial waste water from fish factory

2.6.10 Sidi Bouzid Governorate

The wastewater networks of only one commune, in this governorate, Sidi Bouzid, are managed by ONAS, and were considered by the present study.

The town of Sidi Bouzid (Sid) is currently served by three pumping stations. SP 2 lifts all wastewaters from the town, which then drain to the WwTP.

In general the town's sewers have low slopes, about 0.3%.

The town's principal avenues have stormwater sewers DN 600, DN 800 and DN 1200, as well as stormwater canals. There are problems of overflows from the unitary network, which becomes full in case of rainfall.

Most of the proposed interventions are the rehabilitation (replacement) of sewers with concrete or asbestos pipes, and sewers on some of the main avenues which suffer overflows, breakages and odors, and require frequent repairs by ONAS. There are also extensions to connect outer areas currently without sewerage, and which currently have pollution problems. Due to the town's topography, one of these areas will also require a pumping station.

The areas where network extensions are proposed are generally served by individual soakaways at present, which may be associated with potential contamination of groundwater.

Sewers are cleaned once or twice a year, manually and mechanically.

The quantification of works considered per capita data referred to in Section 2.1, also that one connection box is required per dwelling and occupation rate of five people per dwelling.

The soils are sandy and saline, with groundwater levels deeper than 2 m.

Tables 2.6-22, 2.6-23 and 2.6-24 present the technical characteristics and estimated costs of investment and operation of the proposed interventions.

Table 2.6-22: Definition of drainage network interventions, Sidi Bouzid Governorate

Intervention code	Location	Existing situation				Diagnosis		Proposed solution								
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
SID-Sid-RS-Rh-1	Cité Ennour Ouest	2,000	AC	250	4,046	Sewers are old and in very poor condition. Complaints due to odors. Settlement.	B0	Replacement of sewers, including manholes and building connections.	2,000	5.0	PVC	250	4,046	793	20	-
SID-Sid-RS-Rh-2	Av. Maghreb Arabe	3,900	AC	250 / 300 / ?	1,665	Sewers and pumped main are old and in poor condition. Complaints due to odors. Settlement. Overflows	A	Replacement of sewers, including manholes and building connections, and pumped main.	3,900	9.7	PVC / HDPE	160 / 250 / 315	1,665	372	9	-
SID-Sid-RS-Rh-3	Cité des Professeurs	940	AC	250	495	Sewers are old and in poor condition. Complaints due to odors. Settlement.	B0	Replacement of sewers, including manholes and building connections.	940	2.3	PVC	250	495	109	3	-
SID-Sid-RS-Rh-4	Cité Ali Belhouane	12,000	PVC	400	588	Sewer is old and in poor condition, and with insufficient capacity.	B0	Replacement of sewer, including manholes and building connections.	12,000	24.4	PVC	500	588	199	5	-
SID-Sid-RS-Rh-5	Cité Elworroud 1	2,200	AC	250	4,961	Sewers are old and in poor condition. Complaints. Odors.	B1	Replacement of sewers, including manholes and building connections.	2,200	5.5	PVC	250	4,961	956	24	-
SID-Sid-RS-Rh-7	Cité Hôspital Régional	2,100	AC	160 / 250 / 300	2,136	Sewers and pumped main are old and in poor condition. Insufficient capacity. Overflows.	A	Replacement of sewers, including manholes and building connections, and pumped main.	4,100	10.1	PVC	160 / 250 / 315	2,136	378	9	-
SID-Sid-RS-Rh-8	Cité Derrière Usine de Tomate	500	AC / BA	250 / 300	617	Sewers are old and in poor condition. Settlement occurs	B1	Replacement of sewers, including manholes and building connections.	500	10.8	PVC	250 / 315	617	141	4	-
SID-Sid-RS-Rh-9	Racc. Protection civile	20,000	AC	250 / 300	448	The sewer, one of the main sewers serving the town, is old and in poor condition. Settlement occurs	B0	Replacement of sewers, including manholes and building connections.	20,000	38.0	PVC	250 / 400	448	113	3	-
SID-Sid-RS-Rh-10	Rue Hammam Ibn el Aghlab	100	AC	250	117	Sewers are old and in very poor condition.	B1	Replacement of sewers, including manholes and building connections.	100	0.2	PVC	250	117	26	1	-
SID-Sid-RS-Ex-1	Cité Ouled Belhedi	-	-	-	-	Inhabited area without sewerage network, served by soakaways. Risk of contamination of groundwater.	C0	Construction of new sewerage network.	800	2.0	PVC	250	1,678	205	6	-
SID-Sid-RS-Ex-2	Cité Elfrayjia	-	-	-	-	Inhabited area without sewerage network, served by soakaways. Risk of contamination of groundwater.	A	Construction of new sewerage network.	1,400	3.5	PVC	250	1,989	266	8	-
SID-Sid-RS-Ex-3	Cité Ouled Chelbbi	-	-	-	-	Inhabited area without sewerage network, served by soakaways. Risk of contamination of groundwater.	C0	Construction of new sewerage network.	900	2.2	PVC	250	3,500	388	12	-
SID-Sid-RS-Ex-4	Cité Ennour Ouest	-	-	-	-	Inhabited area without sewerage network, served by soakaways. Risk of contamination of groundwater.	C0	Construction of new sewerage network. This intervention requires construction of pumping station SID-Sid-SP-Ex-1	330	0.8	PVC	250	866	125	4	SID-Sid-SP-Ex-1
SID-Sid-RS-Ex-5	Cité Chrifa	-	-	-	-	Inhabited area without sewerage network, served by soakaways. Risk of contamination of groundwater.	A	Construction of new sewerage network. This intervention requires rehabilitation of the pumped main in SID-Sid-RS-Rh-7	1,100	2.7	PVC	250	499	82	2	SID-Sid-RS-Rh-7
SID-Sid-RS-Ex-6	Cité Jammaa Sayah	-	-	-	-	Inhabited area without sewerage network, served by soakaways. Risk of contamination of groundwater.	C0	Construction of new sewerage network. This intervention requires rehabilitation of the pumped main in SID-Sid-RS-Rh-7	800	2.0	PVC	250	1,299	213	6	SID-Sid-RS-Rh-7 SID-Sid-RS-Ex-5
Total													24,902	4,365	116	

Table 2.6-23: Diagnosis of pumping stations and pumped mains, Sidi Bouzid Governorate

Intervention code	Location	Existing situation								Diagnosis	
		Population served (hab)	Pumping station				Pumped main			Description	Classifi-cation
			Total capacity (L/s)	No. of pumps (service+ reserve)	Dynamic head (m)	Rated power of each pump (kW)	Pipe material	Nominal diameter (mm)	Length (m)		
SID-Sid-SP-Ex-1	SP Cité Ennour Ouest	-	-	-	-	-	-	-	-	Pumping station necessary to allow construction of network SID-Sid-RS-Ex-4.	C0
SID-Sid-RS-Rh-2	Av. Maghreb Arabe	3,900	-	-	-	-	AC	160	192	Sewers and pumped main are old and in poor condition. Complaints due to odors. Settlement. Overflows	A
SID-Sid-RS-Rh-7	Cité Hôspital Régional	1,000	-	-	-	-	AC	160	716	Sewers and pumped main are old and in poor condition. Complaints due to odors. Settlement. Overflows	A
Total									908		

Table 2.6-24: Definition of pumping station and pumped main interventions, Sidi Bouzid Governorate

Intervention code	Proposed solution																	
	Population served (hab)	Total design flow (L/s)	Intervention in pumping station					Construction of pumped main			Construction of gravity sewers			Civil construction investment cost ('000 TND)	Equipment investment cost ('000 TND)	Total investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Annual energy cost ('000 TND)	Other interventions required
			Description	Total capacity (L/s)	No. of pumps (service+ reserve)	Estimated power rating (kW)	Type	Pipe material	Nominal diameter (mm)	Length (m)	Pipe materials	Nominal diameters (mm)	Total length network (m)						
SID-Sid-SP-Ex-1	330	5.0	Construction of pumping station and pumped main to lift wastewater from Cité Ennour Ouest.	10.0	1+1	1.1	SP1B	HDPE	125	433	-	-	-	95	58	152	5	0	SID-Sid-RS-Ex-4
SID-Sid-RS-Rh-2	3,900	-	Replacement of sewers, including manholes and building connections, and pumped main.	-	-	-	-	HDPE	125	192	-	-	-	29	-	29	1	-	-
SID-Sid-RS-Rh-7	1,000	-	Replacement of sewers, including manholes and building connections, and pumped main.	-	-	-	-	HDPE	125	716	-	-	-	109	-	109	2	-	-
Total										1,341				233	58	290	8	0	

2.6.11 Siliana Governorate

The present study considers interventions in three towns: Siliana (Sil), Bou Arada (Bou) and El Krib (Kri). The wastewater networks of the first two are already managed by ONAS, while that of El Krib is managed by the municipality.

Wastewaters collected in Siliana are transported to the towns' WwTP. A WwTP is currently under construction in Bou Arada, and is expected to start operation in 2011. In El Krib, domestic wastewater is directly discharged into watercourses without any prior treatment, thus causing problems of water contamination. However, no problems of contamination of wells have been identified.

The sewerage networks are generally pseudo-separate, and receive rainwater from roofs and inner courtyards

Occasional overflow problems were identified in Siliana, Bou Arada and El Krib, resulting from the age of the networks, their poor condition and in some cases low slopes. Asbestos and concrete pipes need to be replaced.

According to ONAS, the network of Gaafour, commune listed in the request from ONAS, is in good condition, and does not require extension or rehabilitation. This commune was thus cancelled from this study.

The quantification of works considered the per capita water consumption data indicated in Section 2.1, also that one connection box is required per dwelling and occupation rate of four people per dwelling.

It was considered that soils in El Krib contain about 20 % rock.

Tables 2.6-25, 2.6-26 and 2.6-27 present the technical characteristics and estimated costs of investment and operation of the proposed interventions.

Table 2.6-25: Definition of drainage network interventions, Siliana Governorate

Intervention code	Location	Existing situation				Diagnosis		Proposed solution							
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
SIL-Bou-RS-Rh-1	Cité Ibn Kaldoun	1,100	AC	200	853	Sewers are old and in poor condition. Collapses sometimes occur. Blockages are frequent. Connection boxes are arranged in series. The sewers are too high to allow connection of adjacent houses.	B1	Replacement of sewers, including manholes. Connection of existing connection boxes to new sewer. A pumping station (SIL-Bou-SP-Ex-1) will be necessary to connect the sewers to the rest of the network and WwTP.	1,100	3.0	PVC	250	853	136	3	SIL-Bou-SP-Ex-1
SIL-Bou-RS-Rh-2	Cité el Mallassine	308	AC	200	1,048	Sewers are old and in poor condition. The terrain has little slope so blockages and accumulation of sand are frequent. Some houses connected directly to sewer without boxes.	B1	Replacement of sewers, including manholes and building connections.	308	0.8	PVC	250	1,048	212	5	-
SIL-Bou-RS-Rh-3	Cité Bassatines	567	BC	200	1,929	Sewers are old and in poor condition. The terrain has little slope so blockages and accumulation of sand are frequent. Some houses connected directly to sewer without boxes.	B1	Replacement of sewers, including manholes and building connections.	567	1.6	PVC	250	1,929	307	8	-
SIL-Bou-RS-Rh-4	Cité Zayatine Ouest	594	AC	200	2,025	Sewers are old and in poor condition. The terrain has little slope so blockages and accumulation of sand are frequent. Some houses connected directly to sewer without boxes.	B1	Replacement of sewers, including manholes and building connections.	594	1.6	PVC	250	2,025	322	8	-
SIL-Sil-RS-Rh-1	Cité Essabah	317	AC	200	720	Unitary network, old and in poor condition. Collapses sometimes occur. The terrain has little slope so blockages and accumulation of sand are frequent. Road drains connected to sewers and storm overflows discharge high flows to existing storm channel.	B1	Replacement of sewers, including manholes and building connections.	317	1.1	PVC	250	720	159	4	-
SIL-Sil-RS-Rh-2	Cité Taieb Mhiri	1,330	AC	200	3,020	Unitary network, old and in poor condition. Collapses sometimes occur. The terrain has little slope so blockages, accumulation of sand and overflows are frequent. Road drains connected to sewers and storm overflows discharge high flows to existing storm channel.	B1	Replacement of sewers, including manholes and building connections.	1,330	4.6	PVC	250	3,020	667	17	-
SIL-Sil-RS-Rh-3	Centre Ville de Siliana	780	BC	200	635	Unitary network, old and in poor condition. Collapses sometimes occur. The terrain has little slope so blockages, accumulation of sand and overflows are frequent. Road drains connected to sewers and storm overflows discharge high flows to existing storm channel.	B1	Replacement of sewers, including manholes and building connections.	780	2.7	PVC	250	634	140	4	-

Intervention code	Location	Existing situation				Diagnosis		Proposed solution								
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
SIL-Sil-RS-Rh-4	Cité Ennozha	346	AC	200	785	Sewers are old and in poor condition. The terrain has little slope so blockages and accumulation of sand occur. Connection boxes in poor condition.	B1	Replacement of sewers, including manholes and building connections.	346	1.2	PVC	250	785	173	4	-
SIL-Kri-RS-Ex-1	Krib	8,000	AC	200	8,973	Inhabited area mostly without sewerage network, served by soakaways. Some existing unitary sewers, in poor condition. No problems of contamination of wells, but risk to public health due to unsanitary conditions.	A	Construction of new sewerage network. Replacement of sewers, including manholes. Connection of existing connection boxes to new sewer.	8,000	18.1	PVC	250	12,171	2,485	64	-
Total													23,185	4,600	117	

Notes:

* - investment in stormwater network by municipality also required

Table 2.6-26: Diagnosis of pumping stations and pumped mains, Siliana Governorate

Intervention code	Location	Existing situation								Diagnosis	
		Population served (hab)	Pumping station				Pumped main			Description	Classifi-cation
			Total capacity (L/s)	No. of pumps (service+ reserve)	Dynamic head (m)	Rated power of each pump (kW)	Pipe material	Nominal diameter (mm)	Length (m)		
SIL-Bou-SP-Ex-1	SP Ibn Khaldoun	-	-	-	-	-	-	-	-	Pumping station is necessary to lift wastewater from Cité Ibn Kaldoun, whose network will be rehabilitated under the intervention SIL-Bou-RS-Rh-1 to the existing trunk sewer which drains to the WwTP	B1

Table 2.6-27: Definition of pumping station and pumped main interventions, Siliana Governorate

Intervention code	Proposed solution																		
	Population served (hab)	Total design flow (L/s)	Intervention in pumping station					Construction of pumped main			Construction of gravity sewers			Civil construction investment cost ('000 TND)	Equipment investment cost ('000 TND)	Total investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Annual energy cost ('000 TND)	Other interventions required
			Description	Total capacity (L/s)	No. of pumps (service+ reserve)	Estimated power rating (kW)	Type	Pipe material	Nominal diameter (mm)	Length (m)	Pipe materials	Nominal diameters (mm)	Total length network (m)						
SIL-Bou-SP-Ex-1	1,100	5.0	Construction of pumping station and pumped main.	10.0	1+1	1.1	SP1A	HDPE	125	5	-	-	-	46	46	92	3	0	SIL-Bou-RS-Rh-1

2.6.12 Zaghouan Governorate

The wastewater networks of 3 communes in this governorate, Zaghouan (Zag), Hammam Zriba (Ham) and El Fahs (Fah), are managed by ONAS, and were considered by the present study.

Each town is served by a WwTP, but some pollution problems have been identified.

The Medina of Zaghouan is served by a unitary drainage network. Other networks are pseudo-separate, receiving rainwater from roofs and interior patios. Road drainage is mostly superficial and discharges to watercourses. Some main roads have stormwater sewers

In the entire governorate there are occasional problems of overflows due to the age and condition of the networks. Overflows are most problematic in El Fahs.

In general the proposed interventions refer to the replacement of sewers and manholes. Other proposed interventions include the deactivation of existing sewers, due to their poor design / construction, the construction of new sewers and structures, and the separation of wastewater and stormwater sewers, except in the Medina of Zaghouan, where the network will continue to be unitary.

The most serious contamination problems occur in Zaghouan (cité Bouhjar) and Hammam Zriba (spa waters contaminated by used bathing waters), classed as Emergency interventions, Class A.

Sewers are cleaned once or twice a year, manually and mechanically.

The quantification of works considered the following criteria:

- mean water consumption of 85 to 108 L per capita per day;
- 1 connection box per dwelling in rural areas, and 1 box per 5 dwellings in urban areas.

In general the terrain is irregular, groundwater levels are deep, the soils are sandy and clayey at Zaghouan and rocky at El Fahs and Hammam Zriba where a rock content of 50% was considered.

Tables 2.6-28, 2.6-29 and 2.6-30 present the technical characteristics and estimated costs of investment and operation of the proposed interventions.

The costs for the intervention at Hammam Zriba include the pre-treatment needed for the contaminated spa waters before reject in the near river.

Table 2.6-28: Definition of drainage network interventions, Zaghouan Governorate

Intervention code	Location	Existing situation				Diagnosis		Proposed solution							
		Population served (hab)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Description	Classifi-cation	Description	Design population (hab)	Total design flow (L/s)	Pipe materials	Nominal diameters (mm)	Total length of network (m)	Investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Other interventions required
ZAG-Zag-RS-Ex-1	Cité Borj	150	-	-	-	Partially inhabited area without sewerage network, served by septic tanks. Potential for contamination.	B0	Construction of new sewerage network to improve connection rate and eliminate pollution.	150	0.5	PVC	250 / 630	1,525	281	8	ZAG-Zag-SP-Ex-1
ZAG-Zag-RS-Ex-2	Cité Hanaya	200	-	-	-	Partially inhabited area without sewerage network, served by septic tanks. Potential for contamination.	C1	Construction of new sewerage network to improve connection rate and eliminate pollution.	200	0.7	PVC	250	1,550	251	8	ZAG-Zag-SP-Ex-3
ZAG-Zag-RS-Ex-3	Cité Bouhjar	50	-	-	-	Inhabited area without sewerage network, served by septic tanks. Contamination due to discharge of untreated wastewater to the environment.	A	Construction of new sewerage network to improve connection rate and eliminate pollution.	50	0.2	PVC	250	80	16	0	ZAG-Zag-SP-Ex-2
ZAG-Zag-RS-Ex-4	Cité Administrative	75	-	-	-	Inhabited area with sewerage network which passes under houses.	B0	Reconstruction of sewerage network, including manholes and building connections.	75	0.3	PVC	250	310	52	2	-
ZAG-Zag-RS-Rh-1	Cité les Ninfes	1,300	AC/BC	250	2,250	Sewers are old and in poor condition. Low slopes. Accumulation of sand and overflows.	B0	Replacement of sewers, including manholes and building connections.	1,300	4.6	PVC	250	2,250	497	12	-
ZAG-Zag-RS-Rh-2	Cité Lycée	400	AC/PVC	250	2,750	Sewers are old and in poor condition.	B1	Replacement of sewers, including manholes and building connections.	400	1.4	PVC	250	2,750	607	15	-
ZAG-Zag-RS-Rh-3	Cité l'Independance	200	AC	400	1,450	Sewers are old and in poor condition. Low slopes. Accumulation of sand and overflows.	B0	Replacement of sewers, including manholes and building connections. Connection of road drains to storm canal.	200	0.7	PVC	400	1,450	400	10	Rehabilitation of stormwater canal
ZAG-Zag-RS-Rh-4	Cité Nessrine	300	AC	250	1,100	Sewers are old and in poor condition.	B1	Replacement of sewers, including manholes and building connections.	300	1.1	PVC	250	1,100	243	6	-
ZAG-Zag-RS-Rh-5	Medina	800	BC	250	4,900	Sewers of unitary network are old and in poor condition. No connection boxes between buildings and sewers.	B0	Replacement of sewers, including manholes. Construction of connection boxes. Network will still be unitary due to narrowness of streets in the medina.	800	2.8	PVC	250	4,900	1,352	34	Construction of stormwater overflows.
ZAG-Zag-RS-Rh-6	Cité Bassatine	2,000	AC/PVC	250	6,300	Sewers are old and in poor condition.	B1	Replacement of sewers, including manholes and building connections.	2,000	7.0	PVC	250	6,300	1,391	35	-
ZAG-Zag-RS-Rh-7	Route Essouani	8,000	AC	250	2,600	Sewers are old and in poor condition.	B1	Replacement of sewers, including manholes and building connections.	8,000	23.1	PVC	250 / 315	2,600	417	10	-
ZAG-Ham-RS-Ex-1	Hammam Zriba (Distance from SPA water network)	-	-	-	-	Discharge of wastewater flow from public baths / spa direct to watercourse. Flow is too great to allow connection to existing sewerage network and WwTP, which do not have sufficient capacity.	A	Construction of pumping station and sewer to allow discharge further from town. Need for pretreatment before discharge to watercourse.	1	20.0	PVC	315	150	25	1	Construction of pumping station (ZAG-Ham-SP-Ex-1) . Construction of pretreatment plant to allow discharge to watercourse.
ZAG-Ham-RS-Rh-1	Cité Lycée	1,300	AC	250	3,900	Sewers are old but in good condition.	B1	Replacement of sewers, including manholes and building connections.	1,300	4.5	PVC	250	3,900	1,063	27	-
ZAG-Ham-RS-Rh-2	Cité Dispensaire	400	AC	250	900	Sewers are old but in good condition.	B1	Replacement of sewers, including manholes and building connections.	400	1.4	PVC	250	900	245	6	-
ZAG-Ham-RS-Rh-3	Cité 20 Mars	1,500	AC/BC/PVC	250	2,300	Sewers are very old and in poor condition.	B1	Replacement of sewers, including manholes and building connections.	1,500	5.2	PVC	250	2,300	627	16	-

Intervention code	Location	Existing situation				Diagnosis		Proposed solution							
		Population served	Pipe materials	Nominal diameters	Total length of network	Description	Classifi-cation	Description	Design population	Total design flow	Pipe materials	Nominal diameters	Total length of network	Investment cost	Annual maintenance cost	Other interventions required
		(hab)		(mm)	(m)				(hab)	(L/s)		(mm)	(m)	('000 TND)	('000 TND)	
ZAG-Ham-RS-Rh-4	Cité el Hammam	1,000	AC/PVC	250	1,050	Sewers are old but in good condition.	B1	Replacement of sewers, including manholes and building connections.	1,000	3.5	PVC	250	1,050	286	7	-
ZAG-Ham-RS-Rh-5	Cité 18 Janvier	2,000	AC	250	2,100	Sewers are old but in good condition.	B1	Replacement of sewers, including manholes and building connections.	2,000	6.9	PVC	250	2,100	572	14	-
ZAG-Ham-RS-Rh-6	Cité el Houda	1,000	AC/PVC	250	2,200	Sewers are old but in good condition.	B1	Replacement of sewers, including manholes and building connections.	1,000	3.5	PVC	250	2,200	600	15	-
ZAG-Ham-RS-Rh-7	Cité El Ahd / Cité El Jadid 1	1,200	AC/PVC	250	1,750	Sewers are old but in good condition.	B1	Replacement of sewers, including manholes and building connections.	1,200	4.2	PVC	250	1,750	477	12	-
ZAG-Ham-RS-Rh-8	Cité El Ahd / Cité El Jadid 2	500	AC/PVC	250	700	Sewers are old but in good condition.	B1	Replacement of sewers, including manholes and building connections.	500	1.7	PVC	250	700	191	5	-
ZAG-Ham-RS-Rh-9	Cité Essalem	300	AC	250	3,200	Sewers are old but in good condition, partially rehabilitated.	B1	Replacement of older sewers, including manholes and building connections. Maintain recently rehabilitated sewers.	300	1.0	PVC	250	3,200	729	18	-
ZAG-Ham-RS-Rh-10	Cité AFH	1,500	AC	250	4,150	Sewers are old but in good condition. Accumulation of sand.	B1	Replacement of sewers, including manholes and building connections. Need for stormwater network.	1,500	5.2	PVC	250 / 315	4,150	1,110	28	Construction of stormwater canal
ZAG-Fah-RS-Rh-1	Cité Erriadh	600	AC/PVC	250	1,600	Sewers are in poor condition. Settlements and overflows due to connection of road drains. Accumulation of sand in stormwater network.	B0	Replacement of sewers, including manholes and building connections. Connection of road drains to storm canal.	600	1.7	PVC	250	1,600	408	10	Rehabilitation of stormwater canal
ZAG-Fah-RS-Rh-2	Cité Essaada 1	5,000	AC/PVC	300	4,100	Sewers are in poor condition. Settlements and overflows due to connection of road drains. No connection boxes between buildings and sewers. Accumulation of sand in stormwater network.	B0	Replacement of sewers, including manholes. Construction of connection boxes. Connection of road drains to storm canal.	5,000	12.8	PVC	315	4,100	1,103	28	Rehabilitation of stormwater canal
ZAG-Fah-RS-Rh-3	Cité Essaada 2	2,000	AC/PVC	301	4,350	Sewers are very old and in poor condition.	B1	Replacement of sewers, including manholes and building connections.	2,000	5.5	PVC	315	4,350	1,171	29	-
ZAG-Fah-RS-Rh-4	Cité el Amel	2,000	AC	250	2,750	Sewers are very old and in poor condition.	B1	Replacement of sewers, including manholes and building connections.	2,000	5.5	PVC	250	2,750	702	18	-
ZAG-Fah-RS-Rh-5	Cité el Ennour	2,000	AC	300	1,900	Sewers are very old and in poor condition. Some unitary sections.	B1	Replacement of sewers, including manholes and connection boxes. Connection of road drains to storm canal.	2,000	5.5	PVC	315	1,900	511	13	Construction of stormwater canal
ZAG-Fah-RS-Rh-6	Cité el Essalem	2,000	AC	300	2,150	Sewers are very old and in poor condition.	B1	Replacement of sewers, including manholes and building connections.	2,000	5.5	PVC	315	2,150	579	14	-
ZAG-Fah-RS-Rh-7	Av. Liberte	4,000	PVC	315	950	Although existing sewer network was built in 2005, it was poorly designed and built: insufficient capacity, frequent overflows during rainfall.	B0	Replacement of sewers, including manholes and building connections. Elimination of stormwater overflows.	4,000	13.0	PVC	315	950	210	6	-
ZAG-Fah-RS-Rh-8	Route Kairouan	700	AC/BC	250	650	Existing sewer network was poorly designed and built: insufficient capacity, frequent overflows during rainfall.	B0	Replacement of sewers, including manholes and building connections. Construction of new sewer to reduce load on existing network.	700	2.5	PVC	250 / 400	650	158	4	-
Total													65,665	16,274	410	

Note:

ZAG-Ham-RS-Ex-1 - Design population = discharge of wastewater flow from public baths / spa

Table 2.6-29: Diagnosis of pumping stations and pumped mains, Zaghouan Governorate

Intervention code	Location	Existing situation								Diagnosis	
		Population served (hab)	Pumping station				Pumped main			Description	Classifi-cation
			Total capacity (L/s)	No. of pumps (service+ reserve)	Dynamic head (m)	Rated power of each pump (kW)	Pipe material	Nominal diameter (mm)	Length (m)		
ZAG-Zag-SP-Ex-1	SP Essouani	-	-	-	-	-	-	-	-	Partially inhabited area without sewerage network, served by septic tanks. Potential for contamination.	B0
ZAG-Zag-SP-Ex-2	SP Bouhjar	-	-	-	-	-	-	-	-	Inhabited area without sewerage network, served by septic tanks. Contamination problems.	A
ZAG-Zag-SP-Ex-3	SP Hanaya	-	-	-	-	-	-	-	-	Partially inhabited area without sewerage network, served by septic tanks. Potential for contamination.	C1
ZAG-Ham-SP-Ex-1	SP Hammam	-	-	-	-	-	-	-	-	Discharge of wastewater flow from public baths / spa direct to watercourse. Flow is too great to allow connection to existing sewerage network and WwTP, which do not have sufficient capacity.	A
Total											

Note:
ZAG-Ham-RS-Ex-1 - Design population = discharge of wastewater flow from public baths / spa

Table 2.6-30: Definition of pumping station and pumped main interventions, Zaghouan Governorate

Intervention code	Proposed solution																		
	Population served (hab)	Total design flow (L/s)	Intervention in pumping station					Construction of pumped main			Construction of gravity sewers			Civil construction investment cost ('000 TND)	Equipment investment cost ('000 TND)	Total investment cost ('000 TND)	Annual maintenance cost ('000 TND)	Annual energy cost ('000 TND)	Other interventions required
			Description	Total capacity (L/s)	No. of pumps (service+ reserve)	Estimated power rating (kW)	Type	Pipe material	Nominal diameter (mm)	Length (m)	Pipe materials	Nominal diameters (mm)	Total length network (m)						
ZAG-Zag-SP-Ex-1	600	5	Construction of new pumping station to allow connection of part of existing network and future network of Cité Borj to existing town network.	10	1+1	3.0	SP2B	HDPE	125	400	-	-	-	81	46	128	4	0	ZAG-Zag-RS-EX-1
ZAG-Zag-SP-Ex-2	50	5	Construction of new pumping station to allow connection of future network of Cité Bouhjar to existing town network.	10	1+1	2.2	SP1A	HDPE	125	80	-	-	-	56	46	102	3	0	ZAG-Zag-RS-EX-3
ZAG-Zag-SP-Ex-3	200	5	Construction of new pumping station to allow connection of future network of Cité Hanaya to existing town network.	10	1+1	3.0	SP1B	HDPE	125	80	-	-	-	68	58	125	4	0	ZAG-Zag-RS-EX-2
ZAG-Ham-SP-Ex-1	1	30	Construction of new pumping station to allow correct discharge of wastewater from spa / public baths.	30	1+1	15.0	SP2A	HDPE	200	2,100	-	-	-	452	448	900	34	5	ZAG-Ham-RS-EX-1
Total										2,660			0	658	598	1,255	46	6	

Note:

ZAG-Ham-RS-Ex-1 - Design population = discharge of wastewater flow from public baths / spa

2.6.13 Summaries

Table 2.6-31 presents a summary of the technical characteristics of the proposed interventions, while Table 2.6-32 presents a summary of the associated estimated investments.

Detail calculation and cost estimation are included in Annex II, as follows:

- Tables II.1.1 to II.1.3 – General information, per-capita water consumption and geology ;
- Tables II.1.4 to II.1.7 – Flow calculation, sizing and cost estimation for each intervention ;
- Table II.1.8 – Summary of cost for each intervention ;
- Table II.1.9 – As Table II.1.8 but with bond interventions ;
- Tables II.1.10 to II.1.13 – Summary of characteristics and cost by Town and Governorate.

For each intervention, it has been taken in account not only the cost of works on pipe itself, but also the total number and costs of associated connection boxes. Thus, the total cost of each intervention represents the sum of the costs of works on sewer pipes and the costs of connection box, and that’s why, depending on the number of connection box, we find important gaps in costs when reported by meter.

Table 2.6-31: Summary of technical characteristics of proposed network interventions

Governorate	No. of towns	Gravity networks				Pumped mains			Pumping Stations		
		Laterals	Rehabilitation	Extension	Total	Rehabilitation	Extension	Total	Rehabilitation	Extension	Total
		(un.)	(km)	(km)	(km)	(km)	(km)	(km)	(no.)	(no.)	(no.)
Béja	6	4,217	38.3	7.2	45.5	0.1	0.8	1.0	1	5	6
Bizerte	9	8,540	70.7	14.7	85.5	6.8	2.8	9.6	8	7	15
Jendouba	5	4,040	28.7	32.9	61.7	1.4	4.7	6.0	5	6	11
Kasserine	4	5,885	30.4	48.7	79.1	0.0	2.4	2.4	0	4	4
Kébili	8	10,013	9.6	121.0	130.6	0.8	27.9	28.6	2	15	17
Kef	3	2,140	20.6	5.0	25.6	0.8	0.8	1.6	4	2	6
Sfax	12	27,886	73.8	454.5	528.3	1.6	5.4	6.9	3	5	9
Sidi Bouzid	1	1,472	15.1	9.8	24.9	0.9	0.4	1.3	0	1	1
Siliana	3	1,834	20.0	3.2	23.2	0.0	0.0	0.0	0	1	1
Zaghouan	3	6,285	61.5	4.2	65.7	0.0	2.7	2.7	0	4	4
Total	**54**	**72,312**	**368.6**	**701.3**	**1,069.9**	**12.3**	**47.8**	**60.1**	**23**	**50**	**73**

Table 2.6-32: Summary of interventions' investment costs

Governorate	Rehabilitation					Extension					Total Rehabilitation + Extension
	Gravity networks	Pumped mains	Pumping stations		Total	Gravity networks	Pumped mains	Pumping stations		Total	
	Civil works	Civil works	Civil works	Equipment and electrical installations		Civil works	Civil works	Civil works	Equipment and electrical installations		
	(TND)	(TND)	(TND)	(TND)	(TND)	(TND)	(TND)	(TND)	(TND)	(TND)	(TND)
Béja	9,693,332	15,732	5,750	28,750	9,743,564	1,151,426	96,796	241,500	241,500	1,731,222	11,474,785
Bizerte	17,712,542	1,554,501	489,093	1,886,866	21,643,002	2,592,043	390,770	425,423	609,385	4,017,621	25,660,622
Jendouba	7,916,923	250,832	315,751	530,369	9,013,875	4,833,657	561,636	345,000	345,000	6,085,293	15,099,168
Kasserine	8,100,338	0	0	0	8,100,338	7,664,173	296,579	230,000	230,000	8,420,753	16,521,090
Kébili	2,475,852	124,200	119,584	199,307	2,918,944	20,008,785	3,287,413	817,573	938,859	25,052,629	27,971,573
Kef	4,986,161	168,360	65,194	163,957	5,383,672	855,698	83,835	115,000	115,000	1,169,533	6,553,205
Sfax	17,179,046	1,223,612	171,191	347,028	18,920,877	68,509,439	4,779,021	276,000	276,000	73,840,460	92,761,337
Sidi Bouzid	3,086,107	137,834	0	0	3,223,941	1,278,693	37,346	57,500	57,500	1,431,039	4,654,980
Siliana	4,133,692	0	0	0	4,133,692	466,157	431	46,000	46,000	558,588	4,692,280
Zaghouan	15,548,633	0	0	0	15,548,633	725,679	424,638	232,897	597,596	1,980,809	17,529,441
Total	**90,832,624**	**3,475,072**	**1,166,563**	**3,156,279**	**98,630,537**	**108,085,749**	**9,958,465**	**2,786,893**	**3,456,839**	**124,287,946**	**222,918,483**

2.7 PRIORITIZATION OF INTERVENTIONS

The proposed interventions have been prioritized according to the methodology described in Chapter II.2: by the classification (A/B0/B1/C0/C1/D) and the estimated investment cost per capita. Where several interventions are interdependent (e.g. a network intervention and the pumping station which will lift its wastewater), they were prioritized together. Table 2.6.33 presents this prioritization.

Table 2.6-33: Prioritization of interventions

Priority	Intervention code	Classification	*Population 2029*	*Intervention investment cost*	*Per capita cost*
			(hab)	(TND)	(TND/hab)
1	KEB-Keb-SP-Rh-2	A	7,500	146,480	20
2	BEJ-Bej-RS-Ex-1	A	210	9,792	47
3	KEB-Keb-SP-Rh-1	A	4,000	296,611	74
4	SID-Sid-RS-Rh-2	A	3,900	400,711	103
5	SID-Sid-RS-Ex-2	A	1,400	266,185	190
6	SID-Sid-RS-Rh-7 SID-Sid-RS-Ex-5 SID-Sid-RS-Ex-6	A	4,100	781,796	191
7	BIZ-Tin-RS-Ex-1 BIZ-Tin-SP-Ex-1	A	2,000	458,274	229
8	BEJ-Nef-RS-Ex-10	A	135	39,848	295
9	SIL-Kri-RS-Ex-1	A	8,000	2,484,544	311
10	BIZ-Raf-RS-Rh-1 BIZ-Raf-SP-Ex-1 BIZ-Raf-SP-Ex-2	A	5,000	1,774,199	355
11	JEN-Gha-RS-Ex-2	A	548	246,977	451
12	BEJ-Bej-RS-Ex-2	A	350	160,511	459
13	KEB-Jem-RS-Ex-1 KEB-Jem-SP-Ex-1	A	4,000	3,345,872	836
14	BEJ-Tes-RS-Ex-1	A	240	227,861	949
15	KEF-Taj-RS-Ex-2 KEF-Taj-SP-Ex-1	A	225	216,775	963
16	BEJ-Nef-RS-Ex-4 BEJ-Nef-SP-Ex-1	A	125	185,282	1,482
17	ZAG-Zag-RS-Ex-3 ZAG-Zag-SP-Ex-2	A	50	117,760	2,355
18	ZAG-Ham-RS-Ex-1 ZAG-Ham-SP-Ex-1	A	1	925,631	925,631
19	SID-Sid-RS-Rh-9	B0	20,000	112,596	6
20	KAS-Kas-RS-Rh-7	B0	30,000	289,690	10
21	KEF-Kef-RS-Rh-1	B0	45,191	630,660	14
22	KEF-Dah-SP-Rh-1	B0	1,000	14,375	14
23	BIZ-Tin-RS-Rh-2	B0	10,000	164,220	16
24	SID-Sid-RS-Rh-4	B0	12,000	198,772	17
25	KEF-Kef-SP-Rh-2	B0	10,000	181,427	18
26	SFA-Sfv-SP-Rh-2	B0	10,000	196,102	20
27	BIZ-Zar-SP-Rh-1	B0	18,700	375,238	20
28	KAS-Kas-RS-Rh-4	B0	23,000	523,738	23
29	SFA-Sfv-RS-Rh-1	B0	240,000	6,732,638	28

Priority	Intervention code	Classification	*Population 2029*	*Intervention investment cost*	*Per capita cost*
			(hab)	(TND)	(TND/hab)
30	SFA-Sfv-SP-Rh-1	B0	10,000	306,349	31
31	BIZ-Tin-SP-Rh-1	B0	12,000	372,091	31
32	KAS-Kas-RS-Rh-5	B0	6,000	188,122	31
33	KEB-Dou-RS-Rh-1	B0	25,000	793,908	32
34	KAS-Kas-RS-Rh-1	B0	64,660	2,147,970	33
35	BIZ-Abd-SP-Rh-1	B0	18,700	644,782	34
36	BIZ-Jam-SP-Rh-1	B0	30,000	1,050,112	35
37	BIZ-Men-RS-Rh-2	B0	25,000	939,263	38
38	BEJ-Med-RS-Rh-6 BEJ-Med-SP-Rh-1	B0	5,000	191,912	38
39	KAS-Kas-RS-Rh-2	B0	6,000	251,160	42
40	SFA-Sak-RS-Rh-1	B0	53,396	2,664,276	50
41	ZAG-Fah-RS-Rh-7	B0	4,000	210,105	53
42	BIZ-Mat-SP-Rh-1	B0	15,000	854,570	57
43	BIZ-Biz-RS-Rh-3	B0	10,000	585,914	59
44	SFA-Sae-RS-Rh-1	B0	13,819	874,506	63
45	KEF-Kef-SP-Rh-1	B0	3,000	195,960	65
46	BIZ-Jam-SP-Rh-2	B0	5,000	346,063	69
47	KAS-Sbe-RS-Rh-1	B0	1,250	87,975	70
48	BIZ-Jam-RS-Rh-2	B0	3,500	277,208	79
49	JEN-Jen-SP-Rh-3	B0	30,000	2,448,057	82
50	BIZ-Zar-RS-Rh-1	B0	20,000	1,648,928	82
51	BIZ-Tin-RS-Rh-1	B0	8,000	750,720	94
52	SFA-Chi-RS-Rh-1	B0	10,491	988,625	94
53	SID-Sid-RS-Rh-3	B0	940	108,944	116
54	BEJ-Bej-RS-Rh-3	B0	3,227	386,966	120
55	BIZ-Ali-RS-Rh-1	B0	3,500	450,743	129
56	JEN-Tab-RS-Rh-1	B0	4,110	614,100	149
57	KEF-Kef-RS-Rh-6	B0	2,400	389,988	162
58	BIZ-Biz-RS-Rh-1	B0	15,000	2,634,736	176
59	BIZ-Jam-RS-Rh-1	B0	3,500	614,790	176
60	BIZ-Biz-RS-Rh-7	B0	6,000	1,195,770	199
61	KAS-Sbe-RS-Rh-4	B0	650	138,000	212
62	ZAG-Fah-RS-Rh-2	B0	5,000	1,103,310	221
63	ZAG-Fah-RS-Rh-8	B0	700	158,125	226
64	BIZ-Abd-RS-Rh-1	B0	3,500	820,169	234
65	KAS-Kas-RS-Rh-10	B0	2,500	634,358	254
66	BIZ-Men-RS-Rh-1	B0	15,500	4,752,030	307
67	KAS-Sbe-RS-Rh-2	B0	750	250,884	335
68	BIZ-Biz-RS-Rh-2	B0	1,500	509,019	339
69	ZAG-Zag-RS-Rh-1	B0	1,300	496,800	382
70	KEF-Kef-RS-Rh-2	B0	300	116,748	389
71	SID-Sid-RS-Rh-1	B0	2,000	792,510	396
72	KAS-Kas-RS-Rh-11	B0	2,500	1,005,634	402
73	KAS-Sbe-RS-Rh-3	B0	1,250	535,440	428
74	KAS-Kas-RS-Rh-9	B0	2,000	917,645	459
75	BIZ-Biz-RS-Rh-4	B0	1,000	547,515	548
76	KAS-Kas-RS-Rh-3	B0	750	423,163	564
77	BEJ-Tes-RS-Rh-1	B0	1,072	640,734	598
78	JEN-Fer-RS-Rh-1	B0	1,142	687,651	602

Priority	Intervention code	Classification	*Population 2029*	*Intervention investment cost*	*Per capita cost*
			(hab)	(TND)	(TND/hab)
79	ZAG-Zag-RS-Ex-1 ZAG-Zag-SP-Ex-1	B0	600	408,418	681
80	ZAG-Fah-RS-Rh-1	B0	600	408,480	681
81	ZAG-Zag-RS-Ex-4	B0	75	51,980	693
82	KAS-Kas-RS-Rh-8	B0	1,000	706,560	707
83	SFA-Sfv-RS-Ex-5 SFA-Sfv-RS-Rh-6 SFA-Sfv-SP-Ex-1	B0	10,965	8,089,803	738
84	ZAG-Zag-RS-Rh-5	B0	800	1,352,400	1,691
85	ZAG-Zag-RS-Rh-3	B0	200	400,200	2,001
86	BIZ-Zar-SP-Rh-2	B1	70,000	401,838	6
87	BIZ-Mat-SP-Rh-2	B1	12,000	69,819	6
88	KEF-Taj-SP-Rh-1	B1	400	5,750	14
89	SFA-Mah-RS-Rh-1	B1	7,500	126,349	17
90	BIZ-Zar-SP-Rh-3	B1	30,000	580,954	19
91	SFA-Sfv-RS-Rh-4	B1	20,000	1,023,052	51
92	ZAG-Zag-RS-Rh-7	B1	8,000	416,760	52
93	BEJ-Med-RS-Rh-3	B1	750	48,686	65
94	JEN-Jen-RS-Rh-1 JEN-Jen-SP-Rh-1	B1	20,000	1,482,047	74
95	SFA-Sfv-RS-Rh-3	B1	4,000	330,434	83
96	KEF-Kef-RS-Rh-5	B1	1,000	85,836	86
97	BEJ-Bej-RS-Rh-4	B1	920	84,704	92
98	KEF-Kef-RS-Rh-3	B1	2,300	237,728	103
99	BEJ-Nef-RS-Rh-2	B1	75	8,108	108
100	BEJ-Med-RS-Rh-1	B1	350	44,201	126
101	SFA-Mah-RS-Ex-1 SFA-Mah-SP-Ex-1	B1	10,825	1,856,582	172
102	SIL-Sil-RS-Rh-3	B1	780	140,093	180
103	SFA-Sfv-RS-Rh-2	B1	5,000	921,726	184
104	SIL-Bou-RS-Rh-1 SIL-Bou-SP-Ex-1	B1	1,100	227,999	207
105	ZAG-Fah-RS-Rh-5	B1	2,000	511,290	256
106	SID-Sid-RS-Rh-10	B1	100	25,968	260
107	SID-Sid-RS-Rh-8	B1	500	141,154	282
108	KEF-Kef-RS-Rh-4	B1	600	171,396	286
109	ZAG-Ham-RS-Rh-4	B1	1,000	286,178	286
110	ZAG-Ham-RS-Rh-5	B1	2,000	572,355	286
111	ZAG-Fah-RS-Rh-6	B1	2,000	578,565	289
112	JEN-Jen-RS-Rh-2 JEN-Jen-SP-Rh-2	B1	5,000	1,480,841	296
113	SFA-Sfv-RS-Rh-5	B1	11,150	3,620,806	325
114	BEJ-Med-RS-Rh-2	B1	250	83,048	332
115	KEF-Kef-RS-Rh-7	B1	600	201,204	335
116	JEN-Jen-SP-Rh-4	B1	200	68,195	341
117	KEF-Taj-RS-Rh-3	B1	2,750	958,617	349
118	BEJ-Med-RS-Rh-5	B1	500	175,013	350
119	ZAG-Fah-RS-Rh-4	B1	2,000	702,075	351
120	BEJ-Bej-RS-Rh-1	B1	3,447	1,235,045	358
121	SFA-Sfs-RS-Rh-1	B1	2,375	854,880	360

Priority	Intervention code	Classification	*Population 2029*	*Intervention investment cost*	*Per capita cost*
			(hab)	(TND)	(TND/hab)
122	KEF-Dah-RS-Rh-3	B1	3,515	1,269,407	361
123	BEJ-Bej-RS-Rh-5	B1	1,300	472,678	364
124	SFA-Sfs-RS-Rh-2	B1	3,175	1,184,436	373
125	ZAG-Ham-RS-Rh-8	B1	500	190,785	382
126	KEF-Taj-RS-Rh-2	B1	950	366,597	386
127	ZAG-Ham-RS-Rh-7	B1	1,200	476,963	397
128	BEJ-Nef-RS-Rh-1	B1	50	20,010	400
129	JEN-Tab-RS-Ex-1 JEN-Tab-SP-Rh-1	B1	2,000	820,328	410
130	BEJ-Maa-RS-Rh-1 BEJ-Maa-SP-Ex-1	B1	300	125,051	417
131	ZAG-Ham-RS-Rh-3	B1	1,500	626,865	418
132	SFA-Sfs-RS-Rh-5	B1	2,480	1,038,073	419
133	KEB-Keb-RS-Rh-1	B1	4,000	1,681,944	420
134	SID-Sid-RS-Rh-5	B1	2,200	956,230	435
135	SFA-Sfs-RS-Rh-4	B1	1,025	446,168	435
136	BIZ-Biz-RS-Rh-6	B1	1,000	446,810	447
137	KEF-Taj-RS-Rh-1	B1	1,500	728,640	486
138	SIL-Sil-RS-Rh-4	B1	346	173,328	501
139	SIL-Sil-RS-Rh-2	B1	1,330	666,816	501
140	SIL-Sil-RS-Rh-1	B1	317	158,976	502
141	BEJ-Bej-RS-Rh-2	B1	3,425	1,778,047	519
142	BEJ-Med-RS-Rh-4	B1	250	132,885	532
143	SIL-Bou-RS-Rh-3	B1	567	306,576	541
144	SIL-Bou-RS-Rh-4	B1	594	321,833	542
145	BEJ-Med-RS-Rh-7	B1	350	197,401	564
146	JEN-Jen-RS-Rh-3	B1	3,154	1,795,049	569
147	ZAG-Fah-RS-Rh-3	B1	2,000	1,170,585	585
148	ZAG-Ham-RS-Rh-6	B1	1,000	599,610	600
149	ZAG-Ham-RS-Rh-2	B1	400	245,295	613
150	BEJ-Teb-RS-Rh-1	B1	1,500	951,683	634
151	JEN-Gha-RS-Rh-1	B1	1,466	965,200	658
152	SFA-Sfs-RS-Ex-3	B1	810	538,367	665
153	SIL-Bou-RS-Rh-2	B1	308	212,115	689
154	ZAG-Zag-RS-Rh-6	B1	2,000	1,391,040	696
155	BEJ-Teb-RS-Rh-2	B1	3,405	2,409,425	708
156	ZAG-Ham-RS-Rh-10	B1	1,500	1,110,383	740
157	BEJ-Teb-RS-Ex-2	B1	783	607,453	776
158	ZAG-Zag-RS-Rh-4	B1	300	242,880	810
159	ZAG-Ham-RS-Rh-1	B1	1,300	1,062,945	818
160	ZAG-Zag-RS-Rh-2	B1	400	607,200	1,518
161	ZAG-Ham-RS-Rh-9	B1	300	728,640	2,429
162	SFA-Mah-SP-Rh-1	B1	1	103,843	103,843
163	BIZ-Tin-RS-Ex-2 BIZ-Tin-SP-Ex-2	C0	8,000	512,995	64
164	SID-Sid-RS-Ex-1	C0	800	204,993	256
165	KAS-Sbe-RS-Ex-2	C0	950	278,990	294
166	BIZ-Men-RS-Ex-2	C0	400	136,275	341
167	KEF-Dah-RS-Ex-1	C0	125	43,108	345
168	BIZ-Tin-RS-Ex-3	C0	600	220,800	368

Priority	Intervention code	Classification	Population 2029	Intervention investment cost	Per capita cost
			(hab)	(TND)	(TND/hab)
169	KEF-Taj-RS-Ex-1	C0	100	37,375	374
170	KEF-Taj-RS-Ex-3	C0	300	122,590	409
171	KEB-Ken-RS-Ex-3 KEB-Ken-SP-Ex-3	C0	3,000	1,228,488	409
172	KEB-Ken-RS-Ex-2 KEB-Ken-SP-Ex-2	C0	5,550	2,320,601	418
173	SID-Sid-RS-Ex-3	C0	900	388,115	431
174	KEB-Sou-RS-Ex-1 KEB-Sou-SP-Ex-1 KEB-Sou-SP-Ex-2 KEB-Sou-SP-Ex-3 KEB-Sou-SP-Ex-4 KEB-Sou-SP-Ex-5	C0	15,000	7,081,368	472
175	KAS-Tel-RS-Ex-1 KAS-Tel-SP-Ex-1 KAS-Tel-SP-Ex-2	C0	5,950	2,858,613	480
176	KEB-Gol-RS-Ex-1	C0	750	387,109	516
177	JEN-Jen-RS-Ex-1 JEN-Jen-SP-Ex-1	C0	1,077	594,941	552
178	KEB-Ken-RS-Ex-1 KEB-Ken-SP-Ex-1	C0	3,000	1,671,123	557
179	KEF-Kef-RS-Ex-1 KEF-Kef-SP-Ex-1	C0	1,000	579,025	579
180	BIZ-Men-RS-Ex-1 BIZ-Men-SP-Ex-1	C0	600	360,405	601
181	KEB-Ken-RS-Ex-4 KEB-Ken-SP-Ex-4	C0	2,530	1,594,719	630
182	KAS-Fei-RS-Ex-1 KAS-Fei-SP-Ex-1 KAS-Fei-SP-Ex-2	C0	4,950	3,490,627	705
183	KEB-Kes-RS-Ex-1 KEB-Kes-RS-Ex-2 KEB-Kes-SP-Ex-1 KEB-Kes-SP-Ex-2	C0	5,000	3,633,540	727
184	KEB-Dos-RS-Ex-1 KEB-Dos-SP-Ex-1	C0	3,000	2,230,196	743
185	SID-Sid-RS-Ex-4 SID-Sid-SP-Ex-1	C0	330	277,007	839
186	JEN-Gha-RS-Ex-1 JEN-Gha-SP-Ex-1	C0	458	517,041	1,129
187	JEN-Fer-RS-Ex-1 JEN-Fer-SP-Ex-1	C0	425	527,204	1,240
188	KEB-Keb-SP-Ex-1	C1	850	191,383	225
189	KAS-Kas-RS-Ex-4	C1	1,250	293,888	235
190	KEB-Keb-RS-Ex-1	C1	1,000	285,545	286
191	BEJ-Nef-RS-Ex-1	C1	125	37,065	297
192	KAS-Kas-RS-Ex-5	C1	900	307,573	342
193	KAS-Kas-RS-Ex-6	C1	750	264,989	353
194	KAS-Kas-RS-Ex-1	C1	1,000	355,190	355
195	SFA-Aga-RS-Ex-1 SFA-Aga-RS-Ex-2	C1	3,000	1,381,400	460

Priority	Intervention code	Classification	*Population 2029*	*Intervention investment cost*	*Per capita cost*
			(hab)	(TND)	(TND/hab)
	SFA-Aga-SP-Ex-1				
196	BIZ-Biz-RS-Ex-1 BIZ-Biz-SP-Ex-1	C1	2,500	1,164,375	466
197	KAS-Sbe-RS-Ex-1	C1	75	36,225	483
198	BEJ-Nef-RS-Ex-7	C1	90	47,093	523
199	SFA-Sfv-RS-Ex-7	C1	325	173,742	535
200	KAS-Kas-RS-Ex-3	C1	1,000	534,658	535
201	SFA-Sfv-RS-Ex-2	C1	600	322,529	538
202	SFA-Sfv-RS-Ex-6	C1	1,400	754,377	539
203	KEB-Dou-RS-Ex-1 KEB-Dou-SP-Ex-1	C1	2,000	1,082,685	541
204	SFA-Sfv-RS-Ex-3	C1	2,250	1,220,679	543
205	SFA-Sfv-RS-Ex-4	C1	1,075	583,349	543
206	SFA-Sfv-RS-Ex-1	C1	1,050	570,193	543
207	SFA-Chi-RS-Ex-2	C1	1,045	579,244	554
208	SFA-Sae-RS-Ex-1	C1	658	364,452	554
209	SFA-Sae-RS-Ex-2	C1	950	526,585	554
210	SFA-Sae-RS-Ex-3	C1	4,416	2,447,927	554
211	SFA-Sak-RS-Ex-3	C1	5,405	2,995,992	554
212	SFA-Sak-RS-Ex-1	C1	10,780	5,985,756	555
213	SFA-Gre-RS-Ex-5	C1	3,315	1,943,011	586
214	SFA-Gre-RS-Ex-3	C1	5,205	3,051,496	586
215	SFA-Ain-RS-Ex-2	C1	2,290	1,342,769	586
216	SFA-Ain-RS-Ex-4	C1	4,040	2,369,144	586
217	SFA-Gre-RS-Ex-1	C1	2,805	1,645,133	587
218	SFA-Gre-RS-Ex-2	C1	5,040	2,955,960	587
219	SFA-Ain-RS-Ex-3	C1	3,595	2,108,928	587
220	SFA-Sak-RS-Ex-2	C1	13,380	8,170,365	611
221	SFA-Sfs-RS-Ex-1 SFA-Sfs-SP-Ex-1	C1	2,000	1,256,718	628
222	SFA-Tyn-RS-Ex-1	C1	390	247,572	635
223	SFA-Sfs-RS-Ex-2	C1	1,030	661,940	643
224	SFA-Chi-RS-Ex-1	C1	2,108	1,387,780	658
225	SFA-Mah-RS-Ex-2	C1	2,750	1,824,245	663
226	SFA-Hen-RS-Ex-2	C1	1,100	729,963	664
227	SFA-Gre-RS-Ex-4	C1	4,340	2,974,636	685
228	SFA-Hen-RS-Ex-1	C1	1,750	1,208,938	691
229	SFA-Chi-RS-Ex-3	C1	810	610,788	754
230	SFA-Jeb-RS-Ex-2	C1	1,350	1,018,958	755
231	SFA-Tyn-RS-Ex-2 SFA-Tyn-SP-Ex-1	C1	3,830	2,891,198	755
232	SFA-Jeb-RS-Ex-1	C1	1,000	766,993	767
233	JEN-Tab-RS-Ex-3	C1	821	654,896	798
234	BEJ-Tes-RS-Ex-2 BEJ-Tes-SP-Ex-1	C1	462	395,871	857
235	JEN-Bss-RS-Ex-1 JEN-Bss-SP-Ex-1	C1	724	629,375	869
236	BEJ-Nef-RS-Ex-2	C1	50	43,516	870
237	BEJ-Teb-RS-Ex-1 BEJ-Teb-SP-Ex-3	C1	300	261,476	872

Priority	Intervention code	Classification	*Population 2029*	*Intervention investment cost*	*Per capita cost*
			(hab)	(TND)	(TND/hab)
238	SFA-Ain-RS-Ex-1	C1	755	717,686	951
239	ZAG-Zag-RS-Ex-2 ZAG-Zag-SP-Ex-3	C1	200	375,820	1,879
240	SFA-Sfs-RS-Rh-3	C1	1,625	3,073,881	1,892
241	BEJ-Nef-RS-Ex-9	C1	15	28,808	1,921
242	JEN-Tab-RS-Ex-2 JEN-Tab-SP-Ex-1 JEN-Tab-SP-Ex-2	C1	314	1,567,266	4,991
243	BEJ-Nef-RS-Ex-3 BEJ-Nef-SP-Ex-2	C1	25	150,788	6,032
244	BEJ-Nef-RS-Ex-8	D	200	72,594	363
245	BEJ-Nef-RS-Ex-5	D	450	186,588	415
246	BEJ-Nef-RS-Ex-6	D	25	34,644	1,386

Notes:
* Design Population = 1: discharge of wastewater flow from public baths / spa (ZAG-Ham-RS-Ex-1)
** Population served = 1: pumping of industrial waste water from fish factory (SFA-Mah-SP-Rh-1)

CHAPTER III

PROPOSED SOLUTIONS FOR WASTEWATER TREATMENT PLANTS

CHAPTER III: PROPOSED SOLUTIONS FOR WASTEWATER TREATMENT PLANTS

3.1 INTRODUCTION

During the preparation of this study, it was found that some of the information provided, whether transmitted orally during the technical visits to the WwTP, or subsequently provided in paper or digital format, is inconsistent in some points, specifically regarding the dimensions of the existing facilities in each WwTP, which made difficult to properly characterize the current situation.

To synthesize all the basic information, as well as the general description of solutions proposed for each WwTP, two summary tables are presented in Annex III (Annex III.1, Table III.1.1 and Table III.1.2). The content of these tables is presented in more detail in the following chapters.

3.2 DESIGN DATA

3.2.1 Forecast of the connected population in each town

3.2.1.1 Domestic users

The connected population in each municipality has been established taking into consideration the results of the population censuses of 1994 and 2004 and the geometric growth rate between these two census years, assuming a connection rate to the sewerage network of 95 %. The results of this estimation are presented in the following table:

Table 3.2-1: Estimated connected population, by year

Municipalities	Census		Growth rate	Connected population (hab.)				
	1994	2004		2009	2011	2020	2025	2029
Béja and Maagoula	60,361	64,367	1.00% [1]	67,650	65,560	71,701	75,359	78,419
Medjez El-Bab	18,141	20,308	1.13%	20,700	20,113	22,264	23,556	24,644
Jendouba	39,731	43,997	1.03%	55,785	54,088	59,288	62,389	64,988
Tabarka	12,599	15,634	2.18%	21,412	21,239	25,793	28,731	31,322
Siliana	21,341	24,243	1.28%	25,984	25,322	28,401	30,270	31,855

[1] Based on information from ONAS, supplied during the meeting of 25 May 2011.

3.2.1.2 Tourist users

In the towns of Béja, El Maagoula, Medjez El-Bab, Jendouba and Siliana, the contribution of tourist users was not taken into account for the purposes of the estimate of sewage production, due to the weak capacity of the existing hotels and the low level of tourism in these towns - according to forecasts provided by the Tourism Real Estate Agency (AFT).

By contrast, it is necessary to consider significant tourism activity in the town of Tabarka. The following table provides projections of the number of beds for the town of Tabarka.

Table 3.2-2: Estimated connected population for different time horizons

Municipalities	Number of beds	
	2009	2029
Tabarka	5,304 [1]	9,400 [2]

[1] Tabarka WwTP's annual operating report (2009);
[2] The Tourism Real Estate Agency (AFT).

3.2.1.3 Industrial users

For the estimation of industrial effluents, this study considers the industrial users currently connected to the WwTP and also evaluates the capacity of the sewage treatment structures to accept connections from the new industrial zones planned in each town.

The surface of industrial zones that can be accepted in each WwTP is presented in the following table.

Table 3.2-3: Surface of industrial zones for each WwTP

Municipalities	Surface (ha)
	2029
Béja	85
Medjez El-Bab	46
Jendouba	100
Tabarka	14.2
Siliana	16.3

The amounts listed above have been established taking in account the document entitled «The Future Strategy of ONAS» within which is considered the separation of industrial wastewater from domestic wastewater in excess of 20%, which was confirmed during meetings with ONAS.

3.2.2 Specific consumption of drinking water

3.2.2.1 Domestic users

The specific consumption of domestic users, adopted for each town, has been evaluated on the basis of data from the Société Nationale d'Exploitation et de Distribution des Eaux (SONEDE – the national water distribution company). The following table presents the specific water consumption levels for 2009.

Table 3.2-4: Specific consumption of drinking water in 2009

Municipalities	Specific consumption per year 2009 (L/capita/d)
Béja	110
Medjez El-Bab	120
Jendouba	110
Tabarka	110
Siliana	100

Source: SONEDE, Volume distributed, volume consumed (2008-2009)

For the projections of the levels of specific consumption of drinking water in the towns in question, a constant growth rate of 1.5% was considered for the period 2009-2029. The consumption levels thereby obtained are presented in the following table.

Table 3.2-5: Estimated specific consumption of drinking water for different time horizons

Municipalities	Specific consumption of drinking water (L/capita/d)					
	2009	2011	2015	2020	2025	2029
Béja et El Maagoula	110	113	120	130	140	148
Medjez El-Bab	120	124	131	141	152	162
Jendouba	110	113	120	130	140	148
Tabarka	110	113	120	130	140	148
Siliana	100	103	109	118	127	135

3.2.2.2 Tourist users

The consumption of drinking water considered for tourist users is 500 L/bed/day, according to information provided by ONAS during the meeting of 25 May, 2011.

The consumption of drinking water for tourist users was considered to be constant during the course of the project’s time horizon (i.e. 0% growth rate).

3.2.2.3 Industrial users

The consumption of drinking water by industrial users will not be taken into account, as a result of the production of wastewater.

The water flow considered for the industrial zones will be 40 m^3/ha/day, according to information provided by ONAS, during the meeting of 25 May, 2011.

3.2.3 Discharge rate

The discharge rate assumed for domestic-use water will be 80%. The discharge rate assumed for tourist-use water will be 90%.

3.2.4 Daily peak coefficients

The peak coefficient for domestic effluent is obtained using the following formula:

$$K_{ph} = 1.5 + \frac{2.5}{\sqrt{Q_m}}$$

where

Q_m = average flow per day.

The peak coefficient considered for tourist and industrial effluents is 2.0.

3.2.5 Infiltration flow

Infiltration flow is considered to be within a range of 40% to 70% of the average domestic flow, which is corroborated by the operating data supplied by ONAS.

3.2.6 Average daily flow

The average daily flow (m^3/day) is defined by the following formula:

$$Q_{m/day} = Q_{domestic} + Q_{tourist} + Q_{industrial}$$

where

$Q_{domestic}$ = Population x Consumption of drinking water x Discharge rate

Q_{touris} = Beds x Consumption of drinking water x Discharge rate

3.2.7 Peak flow

The peak flow is defined as follows:

$$Q_p = K_{ph} \times Q_{domestic} + 2 \times (Q_{tourist} + Q_{industrial})$$

3.2.8 Maximum flow

The maximum flow is defined as follows:

$$Q_{max} = Q_p + Q_{infiltration}$$

3.2.9 Specific production of polluting flows

3.2.9.1 Domestic and tourist users

The following table provides an estimate of the specific production of polluting flows for domestic and tourist users, in the towns analyzed in the study. These amounts are considered to be constant during the course of the project's time horizon.

Table 3.2-6: Specific production of polluting flows

Municipalities	BOD_5 (g/capita/d)	N_T (g/capita/d)	P_T (g/capita/d)
Béja et El Maagoula	60 [2]		
Medjez El-Bab	60 [1]		
Jendouba	40 [2]	8.0	1.5
Tabarka	60 [2]		
Siliana	45 [1]		

1 Based on information from ONAS, supplied during the meeting of 25 May 2011.

2 Based on the operating reports (2008-2010) and the results of the chemical analyses implemented by a consulting team.

3.2.9.2 Industrial users

As agreed with ONAS, this project will be developed assuming that all the new industrial zones to be connected to the WwTP will have pre-treatment and that their discharges will respect the norm on the discharge rate to the public sewerage networks (NT 106.02, 1989), presented in Table 1.3-4 of Chapter I.

3.3 WWTP OF BEJA

3.3.1 Current situation of the WwTP

3.3.1.1 General information

3.3.1.1.1 General localization and accessibility

The wastewater treatment plant of Béja is located in the commune and governorate of Béja, close to the town of Béja and to ONAS regional laboratory for this governorate (see Figure 3.3-1). The following figure shows an aerial view of the WwTP and the receiving water for the treated effluent.

The access to the WwTP was found to be in good condition.

Figure 3.3-1: Aerial view of the WwTP of Béja
(Source: Google Earth 2010)

3.3.1.1.2 Environmental restrictions – local and surroundings

The WwTP of Béja is located 2 km from the town of Béja and 400 m from the nearest dwelling.

According to the information available from ONAS, the field location of the WwTP has an area of 5 ha. The treatment facility is limited to the east by the receiving environment.

3.3.1.1.3 Description of the existing infrastructures

The WwTP of Béja was brought into operation in 1994 to treat wastewater from the communes of Béja and El Maagoula and the industrial wastewater from yeast manufacturing plants. The installation was dimensioned to treat the wastewater produced by 144,000 p.e. (population equivalent) corresponding to a flow of 14,000 m^3/day and to an organic load (BOD) of 7,800 kg/day.

Currently, the wastewater arrives gravitationally at the WwTP. There are 6 industrial wastewater storage silos, with a total volume of 300 m^3, which are out of service.

The WwTP of Béja was designed according to the extended aeration activated sludge process. The treatment line incorporates the following facilities:

- Pretreatment
    - Screening consisting of 2 mechanical bar screens in parallel, with bars spacing of 12 mm, a conveyor belt and a trailer;
    - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge;
    - Flow measurement in a Venturi channel using an ultrasonic level meter;
- Biological or secondary treatment
    - Oxidation of the organic matter in 4 treatment lines, each one with 5 aeration tanks equipped with surface aerators submersible agitators;
    - Settling of sludge in 4 secondary clarifiers of rectangular plan, equipped with a suction scraper bridge;
    - Pumping of a fraction of the treated effluent upstream of the plant inlet for dilution of the industrial effluent;
    - Sludge recycling at the beginning of the aeration tanks and flow measurement in a Venturi channel using an ultrasonic level meter;
    - Excess activated sludge extraction and feeding into the thickener;
- Tertiary treatment
    - Chemical precipitation of phosphorus with aluminum sulfate dosage inside the aeration tanks;
- Treatment of sludge
    - Excess activated sludge thickening in 2 thickeners of square plan, equipped with a scraper bridge;
    - Dewatering of the thickened sludge in 54 drying beds;
    - Pumping of the thickener supernatant and the drying beds filtrate, by means of a pumping station, towards the sludge recycle channel.

The treated effluent is discharged into the receiving water by means of gravity drainage pipe. Part of the effluent is reused for the irrigation of 350 ha.

The following figures present the general layout and the treatment scheme of the WwTP of Béja. Some photographs of the plant are shown thereafter.

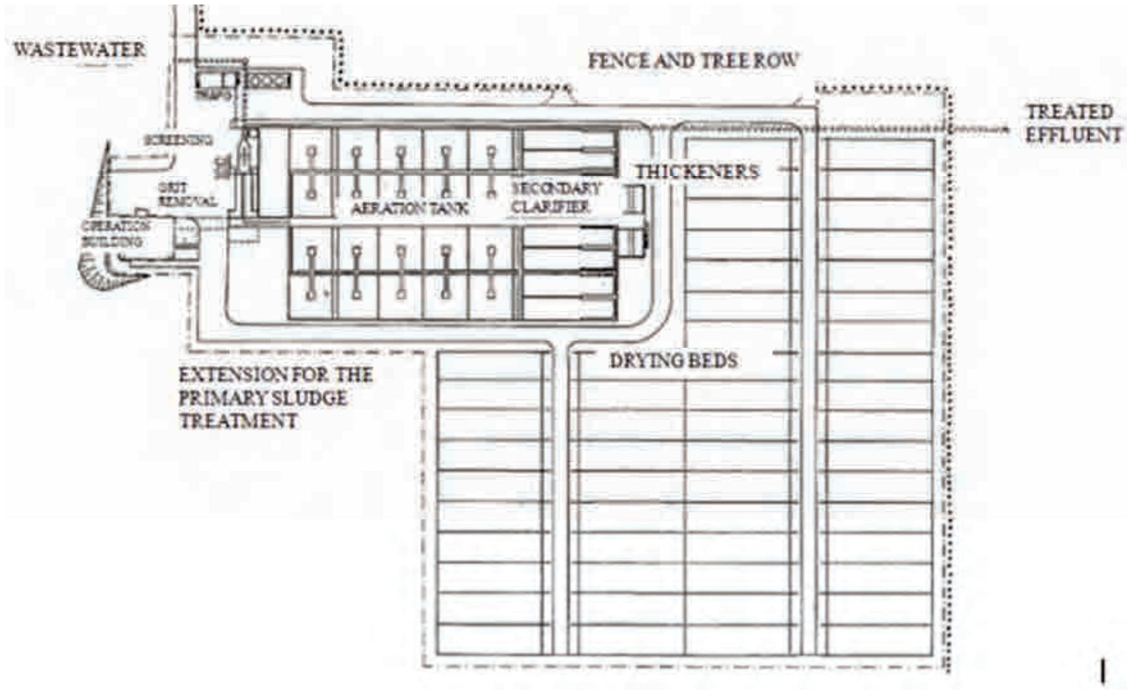


Figure 3.3-2: General layout of the WwTP of Béja

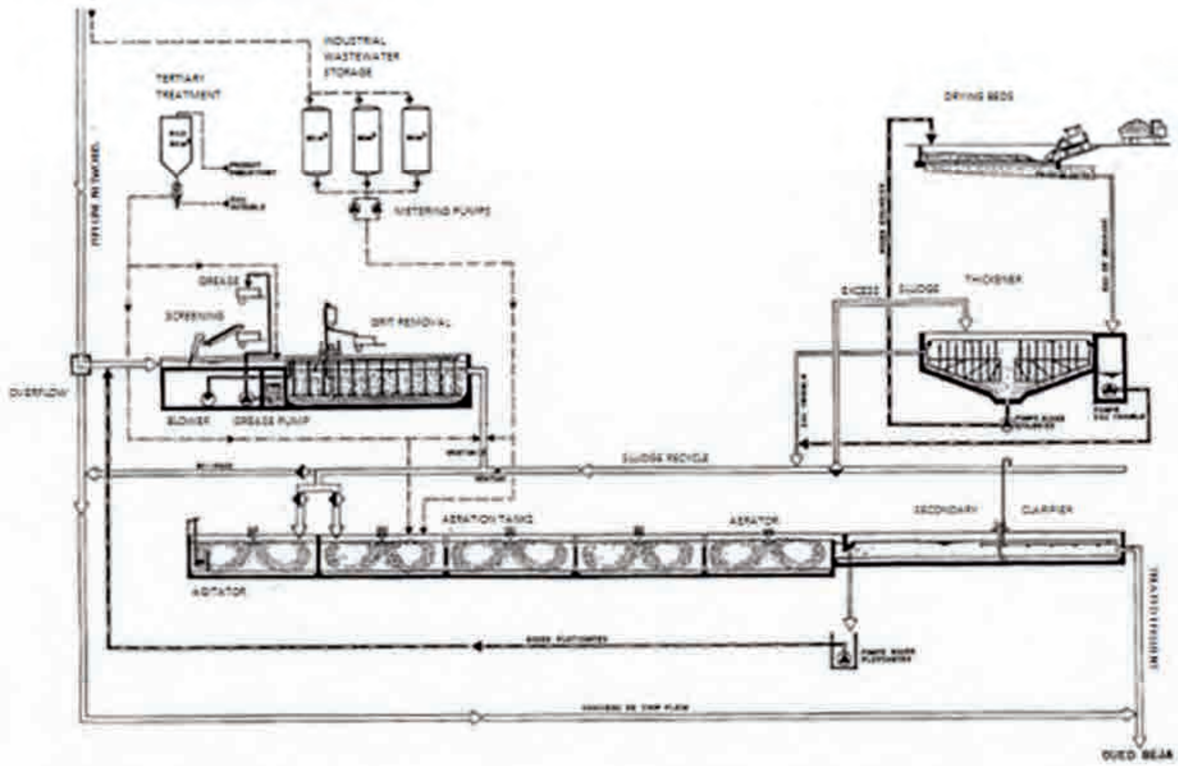


Figure 3.3-3: Treatment scheme of the WwTP of Béja

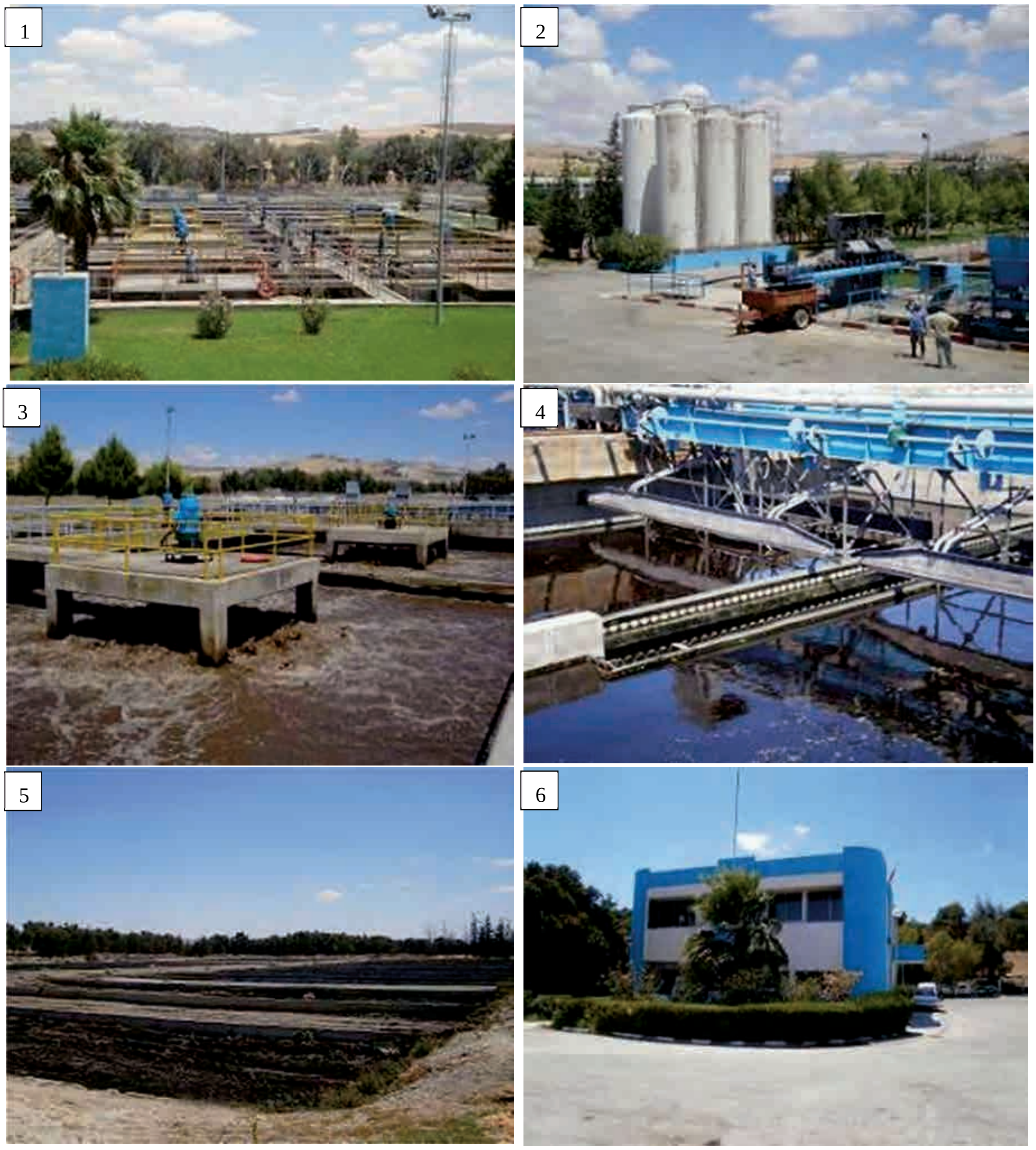


Figure 3.3-4: Photographs of the WwTP of Béja

1 – Overall picture; 2 – Pretreatment and industrial effluent storage silos; 3 – Aeration tanks; 4 – Secondary clarifiers; 5 – Drying beds; 6 – Operating building.

The main dimensions of the existing facilities are presented in Annex III (Annex III.2).

It should be noted that the WwTP has a main building with two stages, which includes the WC/showers, locker rooms, small laboratory, office, meeting room and control room with a synoptic board. There is a second building for the main low voltage (LV) distribution.

3.3.1.2 Quantitative and qualitative characteristics of the wastewater and treated wastewater

3.3.1.2.1 ONAS' operating reports

The following tables summarize the quantitative and qualitative characterization of the wastewater influent to the WwTP of Béja, as well as the treated effluent, taking into account the annual operation reports of 2008, 2009 and 2010 provided by ONAS.

Table 3.3-2: Quantitative characterization of tributary wastewater in 2008 to 2010

Year	Value	Daily flow (m^3/day)	Monthly flow (m^3/month)	Annual flow (m^3/year)
2008	Minimum	3,021	91,945	2,648,984
	Average	7,244	220,749	
	Maximum	11,200,	273,300	
2009	Minimum	3,518	109,053	2,373,848
	Average	6,531	197,821	
	Maximum	12,279	271,668	
2010	Minimum	3,734	112,006	2,135,389
	Average	5,866	177,949	
	Maximum	13,239	213,281	

Table 3.3-3: Qualitative characterization of tributary wastewater in 2008 to 2010

Year	Value	BOD (kg/day O_2)	COD (kg/day O_2)	TSS (kg/day)
2008	Minimum	3,839	8,009	2,090
	Average	8,420	21,618	4,741
	Maximum	16,406	44,521	13,155
2009	Minimum	1,558	6,174	1,277
	Average	4,972	14,739	4,615
	Maximum	8,798	31,435	17,024
2010	Minimum	2,605	6,508	2,348
	Average	3,997	8,954	3,018
	Maximum	6,679	12,478	4,665

Table 3.3-4: Qualitative characterization of the treated effluent in 2008 to 2010

Year	Value	BOD (mg/L O_2)	COD (mg/L O_2)	TSS (mg/L)
2008	Minimum	9	41	7.5
	Average	31	137.8	31.3
	Maximum	81	282	115
2009	Minimum	11	57	6.5
	Average	19	87.5	12.3
	Maximum	28	164.5	23.5
2010	Minimum	16	67	12
	Average	20	78	16
	Maximum	27	93	20

3.3.1.2.2 Sampling program implemented and discussion of the main results

In the framework of this project, a sampling program of the raw and treated wastewater has been carried out, aimed at consolidating the conclusions drawn from analysis of the wastewater treatment plant's operating reports.

The samples have been taken by the Société PPE/Tunisie Environnement, in conformity with the Norms NF-EN-ISO 5667/1, in relation to the general guidelines for establishment of the sampling program and the Norms NF-EN-ISO 5667/2 in relation to the general guideline on sampling techniques.

In order to guarantee that the results are as homogenous and representative as possible, two sampling campaigns have been programmed and implemented as follows:

- A campaign for sunny days, that simulate the dry season;
- A campaign for rainy days, that simulate the wet season.

All this is achieved while maintaining the importance previously agreed in relation to the different days of the week, in particular week-ends. In addition, ONAS has suggested that the sampling should also contemplate the potential effect of market days in each week.

Each campaign includes a survey of samples at the entry and exit points of the treatment plant. The analyses have been carried out using average samples, mixing the instantaneous samples collected each hour over a 24 hour period (from 8 a.m. on the first day to 8 a.m. on the following day).

Sampling of the Béja wastewater treatment plant was carried out on the following dates:

- Tuesday 19/10/2010 – Wednesday 20/10/2010: day of the weekly market; it rained on Monday evening;
- Friday 22/10/2010 – Saturday 23/10/2010: week-end day;
- Tuesday 02/11/2010 – Wednesday 03/10/2010: weekly souk; on Wednesday, at 5 h00 a.m. it started to rain;

- Thursday 04/11/2010 – Friday 05/11/2010; rainy day.

The following table presents the main results of the sampling program carried out.

Table 3.3-4: Results of the sampling program

Parameters	19 to 20/10/2010		22 to 23/10/2010		02 to 03/11/2010		04 to 05/11/2010	
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow
Daily flow (m^3/d)	4,482	-	4,347	-	6,051	-	6,414	-
pH	5.8	6.97	6.1	7.42	7.65	7.43	6.87	7.54
TSS (mg/L)	255	161	473	17	447	7	635	11
VSS (mg/L)	1.8	0.4	1.27	0.32	1.64	0.12	0.55	0.11
COD (mg/L O_2)	3,522	152	2,060	82	2 667	77	881	61
BOD_5 (mg/L O_2)	1 689	45	919	30	1 290	28	379	23
Carbonates (mg/L)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bicarbonates (mg/L)	276	244	573	333	519	201	323	282
Hydroxides (mg/L)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitrogen Kjeldahl (mg/L N)	68.4	5.2	50	2.3	70.7	2.5	39.2	2.1
Nitrates (mg/L N)	<0.04	3.66	<0.04	1.4	<0.04	0.27	<0.04	1.5
Phosphorus total (mg/L P)	4.3	2	5.6	1.9	9.17	0.7	3.4	1.2
Oils & grease (mg/L)	79	20	183	5	75.6	<0.1	36	<0.1
Hydrocarbons (mg/L)	265	121	131	<3.3	161	<3.3	113.6	<3.3
Total coliforms	9.5×10^7	9.5×10^4	2.5×10^8	2.5×10^8	9.5×10^6	9.5×10^3	7.5×10^6	2.5×10^5
Fecal coliforms	1.5×10^6	2.5×10^3	4.5×10^5	2.5×10^5	2.5×10^6	2.5×10^3	2.5×10^6	2.5×10^5

Following analysis of the above results, it is necessary to emphasize the major influence of rainfall on the daily flow to the wastewater treatment plant. In effect, the daily flow recorded during the period from 03/11/2010 to 05/11/2010 is almost 150% higher than on a day without rain.

The BOD_5/COD ratios obtained vary between 0.43 to 0.48, which lies within the typical range for biodegradable effluents.

Furthermore, the effectiveness of the degradation of the organic load was very high, around 93 - 97%. The effectiveness of elimination of the nitrogen was also very high, between 87% and 96.1% (for this calculation, we considered that the total value of nitrogen corresponds to the Kjeldahl nitrogen and to the nitrates, since nitrites in raw effluent are generally negligible).

In addition, analysis of the BOD_5:N:P ratio indicates a lack of phosphorus in the raw wastewater, but higher than the reference of 100:5:1, in the four days of the sampling. However this did not undermine the effectiveness of the degradation of the organic load.

Comparing the mean results from the sampling program (undertaken during October and November 2010) with the mean analytical results from the 2010 Operation Report, it is concluded that:

- The mean of the mean daily flows recorded in the sampling program is about 9% inferior to the mean of the values recorded in the 2010 Operation Report;
- The results from the sampling program for concentrations of COD and BOD_5 in raw wastewater are, on average, 50% to 60% above the mean values from the Operation Report, while the mean TSS concentration is about 5% lower;
- The concentrations of COD and BOD_5 in treated effluent obtained from the sampling program are, on average, 20% to 55% above the mean values recorded in 2010, though the mean TSS value is almost 3 times the mean value in the Operation Report;

Comparing the mean results from the sampling program with the mean analytical results for only October and November from the 2010 Operation Report, it is concluded that:

- The mean daily flow data recorded in the sampling program are of the same order as the results indicated in the 2010 Operation Report;
- The results from the sampling program for concentrations of TSS, COD and BOD_5 in raw wastewater are very variable: from values 40% below to almost 2 times higher than the values recorded in the Operation Report;
- The concentrations of TSS, COD and BOD_5 in treated effluent obtained from the sampling program are very variable: from values 50% below to almost 2 times higher than the values recorded in the Operation Report; one result for TSS was 10 times the value recorded in the Operation Report.

3.3.1.3 Evaluation of the existing plant operation

The annual operation reports provided by ONAS indicate that, in 2008, 2009 and 2010, the wastewater flow tributary to the WwTP was always lower than the plant design flow (14,000 m^3/day), corresponding, in average, to approximately 50% of the installed capacity.

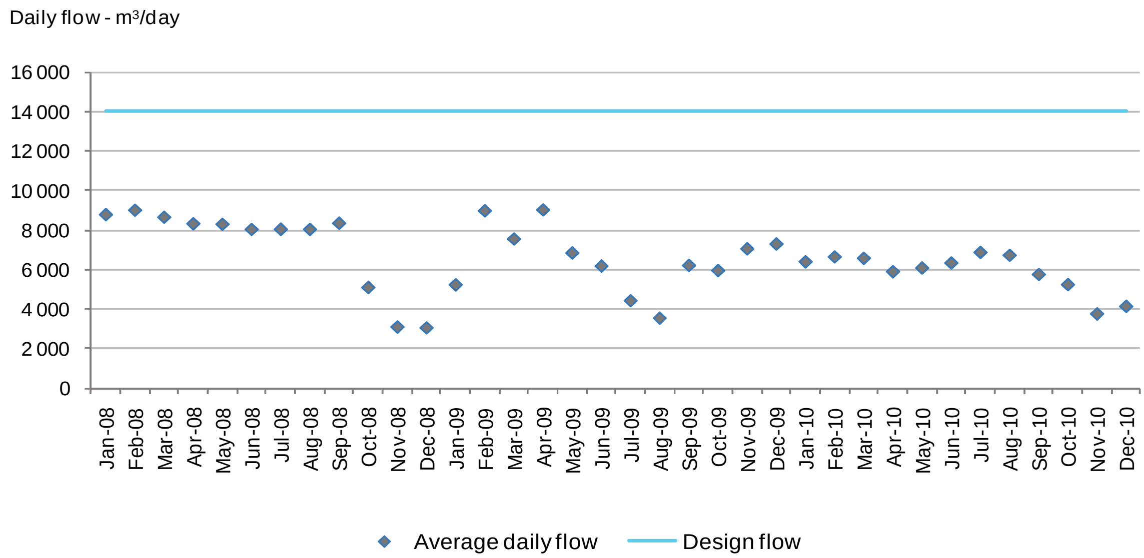


Figure 3.3-5: Variation of the average daily flow of the affluent between 2008 and 2010 and the design flow

In 2008, the treatment capacity for the organic load of the WwTP of Béja has been quickly exceeded, recording some situations of twice the design organic load (BOD of 16,406 kg/day and 7,800 kg/day, respectively). This problem may be due to the fact that the WwTP of Béja also treats the wastewater from yeast manufacturing food industry, which is extremely loaded and colored.

The annual operation reports analyzed indicate that the average organic load in 2008 was much higher than the one recorded in 2009 and in 2010. The average load recorded in 2009 (4,972 kg/day) corresponds to approximately 63.7% of the installed capacity and the average load recorded in 2010 (4 113 kg/d) corresponds to approximately 52.7% of the installed capacity.

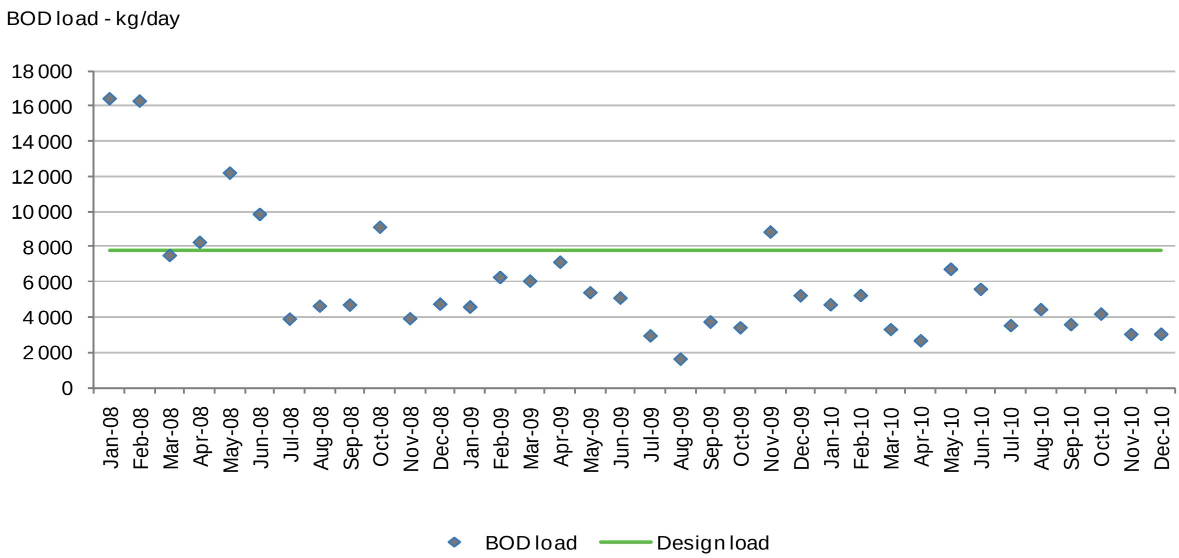


Figure 3.3-6: Variation of the affluent BOD load between 2008 and 2010 and the design load

The analytical results of the treated effluent reveal a very high efficiency in decomposing the biodegradable organic matter, higher than 95%, which guarantees the value of 30 mg/L O_2 imposed to BOD by the legislation in force. Nevertheless, during the period of analysis, some cases of non-compliance with the limit value are recorded, possibly justified by the fact that the organic load which reached the WwTP in these days is significantly greater than that permitted by the plant design. It is also possible to state that the limit imposed by the legislation referring to COD (90 mg/L O_2) is often exceeded.

The relation obtained between the organic matter and nutrients (BOD:N:P), being lower than the relation of reference of 100:5:1, shows good equilibrium conditions for the development of bacterial biomass. Also, a relation of BOD/N higher than 3.5 is compatible with the biological removal of nitrogen.

The wastewater to be treated presents urban and industrial characteristics, therefore the BOD/COD relation values are within the lower limit of the interval of 0.3 – 0.8. Therefore, we can infer that such an effluent has a biodegradation compatible with the generality of biological treatments.

The visit to the WwTP of Béja made it possible to identify the following irregularities in the plant functioning, which should be solved in the short term:

- The flow meter, due to its location, measures also the volume of the treated effluent used to dilute the industrial effluent;

- The existing infrastructure does not allow a good management of the sludge recycling and the purge of excess activated sludge, which negatively affects the biological treatment efficiency;
- On the secondary clarifier surface, it was possible to observe floating sludge, which indicates the occurrence of denitrification in this infrastructure, with loss for the settling of sludge and for the treated effluent quality;
- During winter, the drying beds capacity is not sufficient for the sludge dewatering. In order to solve this problem, the sludge height on the drying beds is increased to more than 30 cm and the biological system is exploited without activated sludge extraction, which can negatively affect the biological treatment performance.

With regard to the plant energy consumption, the annual operation reports indicate an average specific consumption of 0.89 kWh/m^3 of treated effluent in 2008, 0.93 kWh/m^3 in 2009 and 1.18 kWh/m^3 in 2010. The following table summarizes the values of energy consumption in the WwTP of Béja.

Table 3.3-5: Energy consumption

Year	Value	Energy consumption (kWh/month)	Energy consumption indicator (kWh/m^3)
2008	Minimum	144,839	0.89
	Average	196,711	
	Maximum	228,860	
2009	Minimum	150,650	0.93
	Average	183,186	
	Maximum	248,912	
2010	Minimum	170,652	1.18
	Average	210,047	
	Maximum	240,482	

The following figure shows the variation in energy consumption during the period analyzed, being evident the increase in energy consumption during the summer months.

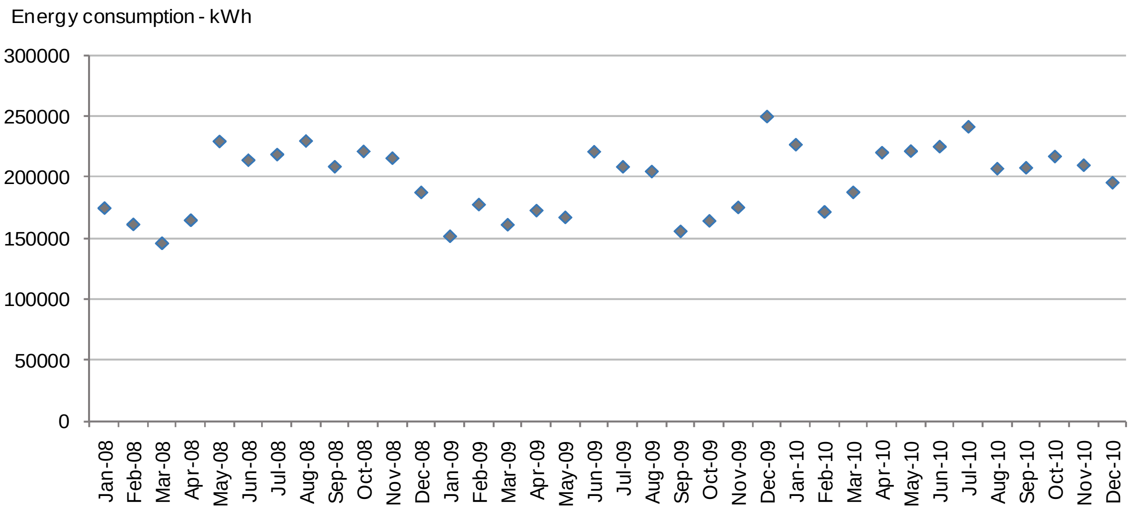


Figure 3.3-7: Variation of the energy consumption between 2008 and 2010

3.3.1.4 Greatest limitations found and the necessary actions

The greatest limitations found in the WwTP of Béja relates to the accumulation of grit in the treatment tanks, to the management of the industrial wastewater treatment, the tanks aeration, the biological removal of nitrogen, the effluent disinfection, the management of the sludge recycle system and the excess sludge purging and the sludge dewatering during winter.

Accumulation of grit

The wastewater presents a high quantity of grit that is not eliminated in the existing aerated grit and grease chamber, found in the sediments of the aeration tanks. In order to resolve this problem, a proposal has been made to build a grit retention chamber upstream from the headworks, which will act as a complement to the aerated grit and grease chamber.

Management of the industrial wastewater treatment

The industrial wastewater, from the yeast manufacturing plants, presents a very high organic load and is too colored.

Currently, urban and industrial wastewater effluents arrive gravitationally at the WwTP where they are mixed with a fraction of the treated effluent in order to dilute the organic load flow. The effluent is distributed equitably among the four treatment lines.

In order to increase the removal of the color and the organic matters chemically degradable, complementary treatment solutions to the biological treatment will be proposed.

Aeration of the tanks

The height of water in the aeration tanks (4.6 m) is higher than the recommended height for the good efficiency of the surface aerators. Generally, the surface aerators have lower efficiencies than those obtained by the submersible aeration systems, such as diffused air (with fine bubbles), which is beneficial to nitrification. In addition, this surface aeration produces aerosols during operation, which affects the operating staff health. For all these reasons, we propose the replacement of the surface aerators by the air blowing system with fine bubbles. This system includes blowers with variable speed, air ducts and diffusers (tubular or disc). The blowers must be provided with a protection against noise and they must be installed in a building equipped with an overhead travelling crane and forced ventilation.

Biological nitrogen removal

The Tunisian standard NT 106.02 imposes limits for nitrate, nitrite, organic nitrogen and ammonia, which can be achieved by means of a biological treatment.

The nitrogen biological removal process is characterized by a set of biochemical reactions which are responsible for the transformation of nitrogen compounds. Nitrification consists in the bacterial conversion of ammonia nitrogen (NH_4^+) to nitrite (NO_2^-) and nitrate (NO_3^-), and denitrification consists in the reduction of nitrate to nitrogen gas (N_2), with the use of nitrate as final electron receptor for a large fraction of the heterotrophic bacterial population in the absence of dissolved oxygen and in the presence of a carbon source.

The organic nitrogen is hydrolyzed to ammonia nitrogen under the mediation of a wide range of heterotrophic bacteria, which seldom limit the rate of nitrification.

Nitrification is the process by which the reduced forms of nitrogen in wastewater are partially converted to nitrite and nitrate. It is an autotrophic process, that is to say, the energy required for bacterial growth is obtained by oxidation of nitrogen compounds, ammonia nitrogen in particular, by using inorganic carbon (CO_2) for synthesis of new cells.

The nitrifying bacteria, generally of the kind Nitrosomonas and Nitrobacter, are strictly aerobic, and there is a consumption of 4.6 g of oxygen and 7.14 g of alkalinity ($CaCO_3$) per gram of N^-NH_4 oxidized.

In order to improve carbon removal and nitrification in the same reactor, it is necessary to ensure that the aerobic sludge age in the reactor is sufficiently old to allow development of the autotrophic population responsible for the nitrification, which has growth rates definitely more limited than the heterotrophic population. As a reference, a 10-day old sludge for urban wastewater without inhibiting factors is deemed sufficient, assuming an effluent temperature of 15ºC.

The process of biological nitrogen removal can reach more than 80%, depending on the concentration of nitrogen in the influent and on the nitrate recycling from the aerobic reactor to the anoxic reactor, which can range from one to three times the average daily flow. Another aspect is the composition of the influent, especially the amount of carbon and nitrogen present initially, because the elimination of large amounts of nitrates in the anoxic zone necessarily implies the removal of large quantities of carbon. For some effluents, it may be necessary to dose a carbon exogenous source (for example methanol) to ensure the presence of sufficient carbon for denitrification.

It is also necessary to ensure that the dissolved oxygen concentrations are higher than 2 mg/L, in order to prevent the process of nitrification to be limited by this factor.

The biological denitrification is the process through which oxidized forms of nitrogen are reduced to molecular nitrogen, where the nitrite and nitrate molecules replace the molecular oxygen as receiver. These reactions normally occur in anoxic conditions, where the release of 2.9 g of oxygen, the replacement of 3.57 g of alkalinity and the consumption of approximately 3.5 to 4.0 g of BOD per g NO_3^-N reduced to N_2 takes place.

In summary, the success of biological nitrogen removal depends on a number of factors, namely: the availability of carbon and nitrate in the anoxic reactor and of oxygen in the aerobic reactor, the availability of the alkalinity for nitrification, the recycling of nitrate and the inhibitory toxic factors.

Thus, the existing reactors need to be modified to adapt them to the nitrogen biological removal, i.e., it is necessary to size the anoxia volume and to install nitrate recycling pumps (with frequency variation) for the nitrate recycling from the last basin to the first, including the installation of an electromagnetic flow meter on the recycle pipe.

Disinfection

According to the Standard NT 106.02 (1989) in force, the microbiological quality prescribed for the maritime and hydraulic public domain (achievement of 2,000/100 mL fecal coliforms and 1,000/100 mL of fecal streptococci) implies the integration of a final stage for the effluent disinfection, independently of the uses associated with the receiving water.

This stage consists of a disinfection system via ultraviolet radiation, being served upstream by an operation of filtration in order to guarantee the necessary water transmittance so that an efficient radiation distribution is ensured.

Sludge recycle and excess activated sludge purge

The secondary clarifier sludge extraction system includes the biological sludge recycling circuit to the upstream of the biological reactor and the excess sludge purging circuit conveyed gravitationally to the thickener. Currently, the flow partition is made by a partition valve. The flow regulation is operated manually, without precision, which negatively affects the sludge recycle management and the treatment process.

Therefore, the construction of biological sludge pumping stations equipped with submersible pumps for the excess sludge extraction to the thickener and the sludge recycling to the aeration tanks upstream is planned.

Sludge dewatering

During winter, the existing drying beds do not have sufficient capacity for dewatering the thickened sludge. The drainage system of the drying beds clogs easily, affecting their functioning. According to ONAS technicians, they do not have sufficient personnel to remove the sludge from the drying beds. In order to solve this problem, the sludge dewatering should be carried out by mechanical equipment, such as a filter band or a decanter centrifuge, with the addition of polyelectrolyte.

Condition and operation of electromechanical equipment

In general, the electromechanical equipment is reasonably well maintained, judging by its working condition. ONAS said to have a preventive maintenance plan, which incorporates the lubrication frequency and the planning of spare parts replacement.

As for the maintenance working procedure, it was mentioned that a small stock of spare parts is kept, and that there are no major difficulties for parts acquisition in the market. Some equipment has to be ordered and the delivery time is approximately one month. However, it was stated that this never puts at risk the plant functioning.

Automation could be increased by installing additional measurement probes (for instance, oxygen measurement in the biological reactor) and focusing on its integration between instrumentation and operation of mechanical equipment.

To complement this information, a table with the main comments on the WwTP electromechanical equipment is presented in Annex III (Annex III.2).

3.3.2 Design data

3.3.2.1 Planning year of the project

The project planning year is defined by the period of time after which an infrastructure reaches its useful lifetime. The study was undertaken for the following years:

i) 2011 – reference year;

ii) 2016 – investment year;

iii) 2019 – first year of operation;

iv) 2029 – project planning year (civil engineering and equipment).

3.3.2.2 Quantitative and qualitative characteristics of the forecast effluents

There is a very high level of industrial activity in Béja: this factor must therefore be taken into account. According to information from ONAS, the concentrations of BOD_5 and COD in the industrial wastewater are 8.5 g/L and 15 g/L respectively. Taking into consideration the average daily flow arriving into the Béja wastewater treatment plant (estimated on the basis of the operating reports) and admitting specific production of BOD_5 of 60 g/cap/d, one obtains an equivalent industrial population of 42 500 equivalent-inhabitants.

The summary of the quantitative and qualitative classification of the wastewater to be treated is presented in the following table and in Annex III (Annex III.2, Table III.2.2.1).

Table 3.3-6: Estimate of the characteristics of the raw wastewater

Parameter	Unit	2011	2029
Population			
Domestic	inhabitants	65,560	78,419
Industrial	Equivalent inhabitants	42,500	65,167
Tourism	beds	-	-
Total	Equivalent inhabitants	108,060	143,586
Flows			
Average daily flow	m^3/d	6,244	12,994
	L/s	72.3	150.4
Infiltration flow	m^3/d	2,377	3,718
	L/s	27.5	43.0
Average daily flow + infiltration	m^3/d	8,621	16,712
	L/s	99.8	193.4
Peak flow	m^3/h	504	1,054
	L/s	140	293
Pollutant loads			
TSS	kg/d	7,370	9,888
BOD_5	kg/d	6,484	8,615
COD	kg/d	12,367	17,310
TN	kg/d	561	1,082
TP	kg/d	101	155
Fecal coliforms (FC)	NMP/d	6.56×10^{15}	7.84×10^{15}
Concentrations (without infiltration flow)			
TSS	mg/L	1,180	761
BOD_5	mg/L	1,038	663
COD	mg/L	1,981	1,332
TN	mg/L	90	83
TP	mg/L	16	12
Fecal coliforms (FC)	NMP/100mL	1.05×10^{8}	6.03×10^{7}

3.3.2.3 Legislative framework relating to the quality of the receiving water and required quality for the treated effluent

The wastewater treated in the WwTP of Béja is rejected to the Wadi Béja, tributary river to Wadi Medjerda immediately upstream of the dam of Sidi Salem. This reservoir plays a strategic role in the area, because it constitutes one of the most important water dams for the production of drinking water and irrigation. Therefore, the receiving water of the Béja treatment plant could be considered a sensitive receiving water in the future in light of the new decree (still in draft), which sets the values of the effluent discharges into the receiving water. This means that water pollution caused by substances contributing to eutrophication, especially nitrates, phosphorus and nitrogen, substances exerting an adverse influence on oxygen balance and measurable by parameters such as BOD, COD, suspended solids and microbiological substances become a particularly sensitive issue.

The volume of reused effluent corresponds to only 1.6% of the annual volume of treated water, and therefore it is necessary to strengthen the disinfection of this fraction of treated water.

In conclusion, the water treated in the WwTP of Béja must follow the quality framework defined in the legislation applicable and in force, especially the standard NT 106.02 mentioned in Table 3.3-1, Chapter I, until the new decree comes into force.

3.3.2.4 Legislative framework concerning the final destination of sludge

According to the strategy defined by ONAS, the final destination of the dewatered sludge should observe the following priorities:

1. Green sector – agricultural use;
2. Red sector – incineration;
3. Black sector – controlled landfill.

The industrial wastewater treated in Baja's WwTP is originated in a factory of the food sector; therefore it is expected that the wastewater does not contain heavy metals or other harmful elements for the application of sludge in agriculture. Although the qualitative characteristics of wastewater generated in the new industrial zone to connect to the WwTP are not known, it is assumed that treated sludge complies with all the provisions of existing legislation (see Chapter I, 1.3.3.3.3) and can be recovered for agriculture.

3.3.3 Eligible solutions of rehabilitation and extension

3.3.3.1 General considerations

For the rehabilitation of Béja treatment plant, three alternative solutions are identified. They are considered to be the most suitable, since they can be appropriately implemented in the available site and allow the integration of the majority of the existing facilities.

We assumed that the biological treatment would be undertaken through a suspended growth method, in the regimes of extended aeration or conventional aeration. The three solutions being studied are as follows:

- Solution 1 – biological treatment of the totality of the wastewater (domestic and industrial) using activated sludge in extended aeration mode;
- Solution 2 – biological treatment of the totality of the wastewater (domestic and industrial) using activated sludge in conventional aeration mode with mesophilic anaerobic digestion of the sludge and energy use of the biogas;
- Solution 3 – pre-treatment of the industrial wastewater through anaerobic digestion (UASB); biological treatment of the domestic wastewater and industrial wastewater,

pre-treated using activated sludge in extended aeration mode.

For all these three solutions, the replacement of the surface aerators by the diffused air system fed by blowers, the installation of an internal nitrate recycling system from the last to the first aeration tank, the construction of pumping stations for the sludge recycle and excess sludge extraction, the installation of a final disinfection system via ultraviolet radiation and the construction of a new stage for thickened sludge mechanical dewatering, as a complement or as an alternative to the existing drying beds, will be provided.

For the three solutions, a dosage of aluminium sulfate is foreseen in the aeration tanks, which will make it possible to increase the transmittance of the effluent, thereby benefiting the disinfection stage, and also foregoing the need for coloring of the treated water.

A fourth solution including a pre-treatment of the industrial wastewater through anaerobic digestion (UASB) with energy use of the biogas, and biological treatment of the domestic wastewater and the pre-treated industrial wastewater using activated sludge in conventional aeration mode with mesophilic anaerobic digestion of the sludge and energy use of the biogas, was discarded the main reasons being:

- For the coming years the organic load reduction related to the pre-treatment of the yeast industrial effluent represents no more than 22% of the total affluent load to the activated sludge process;
- Flow reduction is marginal;
- The energy balance, namely the amount of electricity recovered, is about the same as the solution 2
- Investment costs associated with this alternative are higher than the solution 2;
- The pre-treated effluent coming from the UASB will include organic matter not readily biodegradable and it will be probably more difficult to attain the water discharge standard using an activated sludge process in conventional aeration mode.

For the sludge treatment, the following solutions have been evaluated and compared: belt press, decanter centrifuge machine, filter press and solar drying. The dewatering by belt press is based on the shearing and pressing of sludge. This equipment is frequently used only in small and average size facilities, due to the high continuous water consumption for belt washing. The capture efficiencies and levels of dryness achieved with belt filters are lower than the dewatering with decanter centrifuges. A new generation of belt filters takes into consideration the problems of pollution (release of malodorous sulfur compounds and aerosols) and health and safety for the operators, allowing the installation of an integral cover.

The decanter centrifuge uses the centrifugal force to accelerate the sedimentation of the sludge solid particles to be separated from water. The operation of a decanter centrifuge is continuous and can be automatic. The quantity of washing water that must be used is limited to one cleaning operation at the end of the dewatering period. The decanter centrifuge is provided with an integral cover, therefore there are no problems of harmful effects, except for noise. The most important disadvantages of this equipment are the special maintenance requirements and the high power consumption.

In the case of filter press or plateau filters, the conditioned sludge is dewatered by compression between two plateaus, equipped with filtering screens. The operation is completed by a cleaning phase that is carried out every 15 to 30 pressed operations, through injection of acidified water at very high pressure (around 90 bars). This technique makes it possible to obtain dryness of around 30-40%, which is higher than the centrifugal technique or the band filter. However, the investment costs are relatively high in comparison with the other procedures.

The mechanical dewatering requires in most cases the polymer contribution in order to improve the solids capture and dryness. If the final destination of the dewatered sludge is the landfill, it will be necessary to had lime in order to obtain a minimum dryness of 30%.

Solar drying applies to the sludge that is already dewatered; therefore this does not represent a valid solution for the dewatering of sludge, but for the increase of dryness of the dewatered sludge.

At the request of ONAS, there will also be odor treatment of the structures and of the buildings associated with emission of the odors.

In relation to safety conditions for the workers of the wastewater treatment plant, we recommend installation of a hand rail around all the structures that have a liquid depth of more than 1 m, in particular: the aerated grit and grease chamber, biological reactors (in addition to the existing rails), clarifiers, thickeners, *etc*.

The description of the treatment lines, the advantages and disadvantages for each of these biological treatment systems are presented in the following chapters. The main design criteria related to operation design and the operations which could integrate the treatment schemes, as well as operational conditions, are presented in Annex III (Annex III.2).

The treatment schemes of each studied solution are presented in Annex III (Annex III.7).

3.3.3.2 Solution 1

3.3.3.2.1 Detailed description of the treatment sequence – design and criteria

For Solution 1, the rehabilitation of the WwTP according to the same existing treatment process, i.e., activated sludge in extended aeration regime, will be studied.

This treatment solution offers a greater flexibility concerning the variations of flow and affluent polluting load and, because of the old age of sludge, it allows the nitrification of ammonia. The biological sludge in excess is mineralized, without the need of a posterior stabilization (anaerobic or chemical). With this solution, primary settling and construction of facilities dedicated to sludge stabilization (anaerobic digesters) are not necessary. However, extended aeration requires greater power consumption in comparison with the conventional aeration system.

The design that has been carried out revealed that the available activated sludge volume is not sufficient for the extended aeration treatment of wastewater in the project planning year. So it will be proposed the construction of a fifth biological treatment line.

The estimated maximum inflow is lower than the design flow of the existing facilities; therefore the capacity of the grit and grease removal operation and the secondary clarifiers is sufficient. Nevertheless, it will be proposed the construction of a fifth clarifier, because each activated sludge line is connected just to one clarifier, being difficult to change this situation.

As mentioned previously, the construction of three pumping stations for biological sludge (one for each two existing biological treatment lines and one third for the fifth line to build) is planned, provided with submersible pumps for pumping up sludge in excess into the thickener and sludge recycling into the aeration tanks upstream. The sludge recycling pumps must allow the pumping of a flow between 50% and 150% of the average daily flow affluent to the WwTP. In order to facilitate the sludge management control, the pumps will be provided with variable speed and electromagnetic flow meters will be installed in the circuit rising mains.

Downstream of the secondary clarifier, a tertiary treatment stage is planned, aiming at the reduction of the bacteriological load in order to fulfill the requirements of the standard NT 106.02, by means of a filtration followed by UV disinfection.

As for the thickening stage, the solids loading rate and the hydraulic loading rate are exceeded for the existing infrastructures; therefore it is necessary to build a third thickener.

The design calculations indicate that the 54 existing drying beds do not have the capacity to dewater the thickened sludge. This problem can be solved using the sludge mechanical dewatering by means of the decanter centrifuge machine. Storing sludge is recommended prior to dewatering with capacity for two days of production, in order to cope with an eventual equipment failure. The addition on line of a polyelectrolyte solution to the sludge to be dewatered is planned. On the other hand, the dewatered sludge will be stored in containers that will be a driving regularization for sending it to their final destination.

The treatment line of Solution 1 for the rehabilitation of the WwTP of Béja presents the following stages:

- Preliminary treatment
  - Grit retention in tank (new);
  - Screening consisting of 2 mechanical bar screens in parallel, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);
  - Flow measurement in a Venturi channel using an ultrasonic level meter (existing);
- Biological treatment
  - Oxidation of the organic matter in 5 treatment lines (4 existing and 1 new), each one with 5 aeration tanks (existing) aerated by a new air diffused system supplied by blowers equipped with variable speed (new);
  - Settling of sludge in 5 secondary rectangular plant clarifiers (4 existing and 1 new), equipped with a suction scraper bridge (existing);
  - Sludge elevation by three pumping stations (new);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
  - Excess sludge elevation towards thickeners and flow measurement using an electromagnetic flow meter (new);
- Tertiary treatment
  - Biological removal of nitrogen through the nitrate internal recycling system

which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);

- Dosage of aluminium sulfate for the chemical precipitation de phosphorus and in order to increase the transmittance of the effluent, thus benefiting the disinfection stage;
- Disinfection by ultraviolet radiation served upstream by a filtration (new);

- Sludge treatment
  - Excess activated sludge thickening in 3 thickeners of square plant (2 existents and 1 new), equipped with a scraper bridge (existing);
  - Temporary storage of the thickened sludge in a tank upstream of the dewatering (new);
  - Dewatering of the thickened sludge in the decanter centrifuge machine with addition of polymer (new); in the event of recourse, dewatering of the thickened sludge in drying beds (existing);
  - Storage of dewatered sludge in containers (new);
  - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are returned through a pumping station to the biological treatment facility;
- Treatment of odors
  - treatment of the contaminated air, extracted from the grit retention chambers, from the preliminary treatment building, thickeners, thickened sludge storage tank and from the dewatering building, using a biofilter (new).

3.3.3.2.2 Energy report

The average electricity consumptions (solution 1, planning year) are presented in Annex (see Annex III, Annex III.2.10.1).

3.3.3.2.3 Consumption of chemical reagents

The chemical reagents consumed in the wastewater treatment process are aluminium sulfate and polyelectrolyte. The quantities of chemical reagents consumed between year zero and planning year are presented in Annex III.2 (page 56 and following).

3.3.3.2.4 Management of by-products

The quantities of by-products resulting from of the wastewater treatment process, in particular solid waste, grit, grease and sludge, are presented in Annex III.2 (at the end).

3.3.3.2.5 Equipment

In general, the electromechanical equipment items present a high level of maintenance, if one takes into consideration their working conditions and maintenance level.

The following table summarizes the solutions proposed in terms of replacement of the existing equipment items in the Béja WwTP, in the framework of solution 1. For a fuller understanding of the following comments, it is necessary to view the treatment scheme of the solution attached to the report.

Table 3.3-7: Electro-mechanical equipment, instruments and electrical installations

Designation	Diagnosis	Proposed solution	Characteristics
Preliminary treatment			
Grit extraction system by “air-lift”	The wastewater includes a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber.	We propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber. Grit extraction will be achieved via an “air-lift” system.	Estimated extraction flow rate = 18 m^3/h
Mechanical multi-rake bar screen	The mechanical screens present widespread corrosion in stainless steel.	The demonstrated state of degradation justifies their replacement.	Maximum flow via the mechanical screen = 525 m^3/h Spacing between bars = 6 mm
Measurement of the difference in water level (screening)	The demonstrated state of degradation justifies replacement. Diagnosis of state of conservation of equipment is detailed in Annex III (Table III.2.1.1.1).	Automation should be improved, in particular in terms of integration between measurement of the level and operation of the mechanical screen.	
Belt conveyor	The paintwork is a bit degraded and altered in certain places; nonetheless the equipment does appear to be painted in order to avoid further corrosion.	Replacement is not judged to be necessary	Estimated volumetric flow rate of screenings = 1.2 m^3/d
Scraper bridge (grit and grease extraction in a double aerated channel)	The scraper bridge has a deviation in its longitudinal movement. The wheels of the scraper bridge present a high level of degradation. In general, the scraper bridge presents a high level of corrosion and ageing.	The demonstrated state of degradation justifies its replacement.	To be installed in the existing work

Designation	Diagnosis	Proposed solution	Characteristics
Grit pumps (grit and grease extraction in a double aerated channel)	The occurrence of frequent breakdowns was reported to the consulting team	We recommend ensuring that the equipment items are maintained at a satisfactory level. There are two pumps per scraper bridge.	Estimated flow per pump = 18 m^3/h.
Grit classifier (grit and grease extraction in a double aerated channel)	The grit classifier on the scraper bridge does not operate correctly and presents a certain amount of degraded paintwork.	The grit classification operation must be improved with installation of specialized equipment for this function. The equipment will be installed on the scraper bridge.	Estimated total capacity = 24 m^3/h.
Compressors (grit and grease extraction in a double aerated channel)	The compressors present a certain level of degradation; they are dirty and covered in dust.	We recommend ensuring that the equipment items are maintained at a satisfactory level. There are three compressors for the double channel: 2+1.	Estimated volumetric flow rate of air by compressor = 292 m^3/h
Grease removal via a screw conveyor (grit and grease extraction in a double aerated channel)	The grease pumping circuit is out of service. The consulting team was informed that the circuit was immediately blocked after the start-up of the installation and was then abandoned.	Grease removal will be implemented via a screw conveyor installed in the grease tank.	Estimated volumetric flow rate of grease = 106 m^3/d
Measurement of effluent flow	Measurement is made by an ultrasonic level meter.	Replacement is not judged to be necessary	

Designation	Diagnosis	Proposed solution	Characteristics
Secondary or biological treatment			
Aeration	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor. Also, in order to maximize the volume of the existing reaction, it is necessary to implement a more effective aeration method. The tanks are too deep in order to obtain maximum performance of the existing surface aerators.	The replacement of the surface aerators by a fine bubble aeration system is recommended. This system includes compressors endowed with speed variation, air ducts and diffusers installed in the tanks. There are six compressors: 5+1; one compressor for each line.	Estimated volumetric flow rate of air for each compressor = 3,933 m^3/h
Oxygen measurement (aeration tank)	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor.	We recommend installation of a programmable automation controller that permits integration of oxygen measurements with the aeration operation.	
Mixing	The submersible mixers are not in a good state of conservation. In the framework of this solution, it is necessary to add submersible mixers to the new line.	Replacement is judged to be necessary, and it is necessary to add submersible mixers to the new line.	Submersible mixers identical to the existing one to be installed in the new tanks.
Scraper bridges (secondary clarifiers)	The scraper bridges are not in a good state of conservation. In the framework of this solution, it is necessary to add a scraper bridge to the new line.	Their complete replacement is judged to be necessary.	

Designation	Diagnosis	Proposed solution	Characteristics
Biological sludge lift pumps (secondary clarifiers)	The pumps present a reasonable state of conservation given their working conditions. In the framework of this solution, it is necessary to add biological sludge lift pumps to the new scraper bridge.	Replacement is not judged to be necessary, but it is necessary to install pumps identical to the existing ones in the new scraper bridge. There are two pumps per scraper bridge.	Volumetric flow rate of sludge estimated for each pump = 144 m^3/h.
Sludge recirculation pump	The distribution of the flow to the biological sludge recirculation circuits and purging of the excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process. In the framework of this solution, it is necessary to add sludge recirculation pumps to the new line.	We recommend the construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks. The construction of a pumping station dedicated to the new line is recommended. There is one pumping station for two secondary clarifiers.	Estimated flow for each pump = 353 m^3/h. estimated flow for each new pump = 177 m^3/h.
Measurement of the flow of sludge recirculation	No measurement of the sludge recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm

Designation	Diagnosis	Proposed solution	Characteristics
Excess sludge extraction pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process. In the framework of this solution, it is necessary to add extraction pumps for the excess sludge to the new line.	We recommend the construction of a biological sludge pumping station equipped with submersible pumps in order to lift the excess sludge towards the thickener. The construction of a pumping station dedicated to the new line is recommended.	Estimated flow for each pump = 23 m^3/h.
Measurement of the flow of excess sludge	No measurement of the excess sludge exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 80 mm
Tertiary treatment			
Nitrate recirculation pump	The Tunisian norm NT106.02 sets maximum limits for nitrate, nitrite, organic and ammoniacal nitrogen. Hence, it is necessary to modify the existing reactors to adapt them for biological elimination of nitrogen. In the framework of this solution, it is necessary to add a Nitrate recirculation pump to the new line.	It is necessary to install submersible pumps (with frequency variation) for nitrate recirculation, in the existing aeration tanks - from the last aeration tank to the first.	Estimated flow for each pump = 353 m^3/h.
Measurement of the flow of nitrate recirculation	No measurement of the nitrate recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm

Designation	Diagnosis	Proposed solution	Characteristics
Dosing pump of aluminium sulfate and dosing circuit	Chemical precipitation of phosphorus with dosing of aluminium sulfate	We recommend a dosing circuit with dosing tank, retention chamber, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Estimated flow for each pump = 186 L/h.
Disinfection	The Tunisian norm NT 106.02 obliges observance of 2000/100 mL of faecal coliforms and 1000/100 mL of faecal streptococci in order to guarantee the microbiological quality of the public water supply.	Disinfection by ultraviolet radiation implemented upstream by the filtration operation via multicellular vertical feeding pumps linked to the filters, self-cleaning pressure filters and an ultraviolet radiation system in the open channel.	Maximum flow = 1,054 m^3/h
Treatment of the sludge			
Scraper bridge (thickener)	The paintwork of the existing scraper bridge is a bit degraded and altered in certain places. In the framework of this solution for renovation of the WwTP, we propose construction of another thickener.	Complete replacement of the existing thickeners is not judged to be necessary but it is necessary to consider application of a new layer of paint.	The new thickener will be square-shaped like the existing one.
Thickened sludge pumps	The sludge pumps (which lift the sludge towards the thickened sludge storage tank or towards the sludge drying beds) present a high level of deterioration.	In the framework of renovation of the WwTP, it will be necessary to replace these pumps and to add another because of this new thickener. An excentric screw pump is recommended. There is one pump for each thickener.	Estimated flow per pump = 18 m^3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Submersible mixer (thickened sludge storage tank)	In the framework of renovation of the WwTP, we propose temporary storage of thickened sludge in a tank upstream of the dewatering stage.	It is necessary to install a submersible mixer in order to avoid sedimentation of the sludge.	-
Lift pump to raise the thickened sludge to the centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer	An excentric screw pump is recommended.	Estimated flow per pump = 40 m^3/h.
Centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer.	installation of two equipment items is recommended.	Capacity 40 m^3/h
Polymer preparation equipment	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer	We recommend installation of fully automatic continuous polymer solution preparation equipment. Dosing tank, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Capacity 4,000 L/h.
Polymer dosing pump	-	Membrane dosing pumps are recommended.	Estimated flow per pump = 2.5 m^3/h.
Lifting the dewatered sludge		The dewatered sludge will be lifted via a screw conveyor.	Estimated volumetric flow rate of the dewatered sludge = 60 m^3/d

Designation	Diagnosis	Proposed solution	Characteristics
Treatment of odors			
Contaminated air treatment system	We propose to extract the contaminated air from the grit retention tank, preliminary treatment building, thickener, thickened sludge storage tank and dewatering building	The contaminated air will be deodorized via a bio filter, a piping circuit and fan	
Electrical installations			
MV-LV transformation station	In the framework of the intervention proposed for the wastewater treatment plant, this equipment item should be renovated.	We recommend the replacement of this equipment item	
Low voltage cupboard	In the framework of the intervention proposed for the wastewater treatment plant, this equipment item should be renovated.	We recommend the replacement of this equipment item	
Command station with master control panel	In the framework of the intervention proposed for the wastewater treatment plant, these equipment items should be renovated.	We recommend installation of a programmable automation controller that permits integration between the measurement instruments and operation of the mechanical equipment.	

3.3.3.3 Solution 2

3.3.3.3.1 Detailed description of the treatment sequence – design and criteria

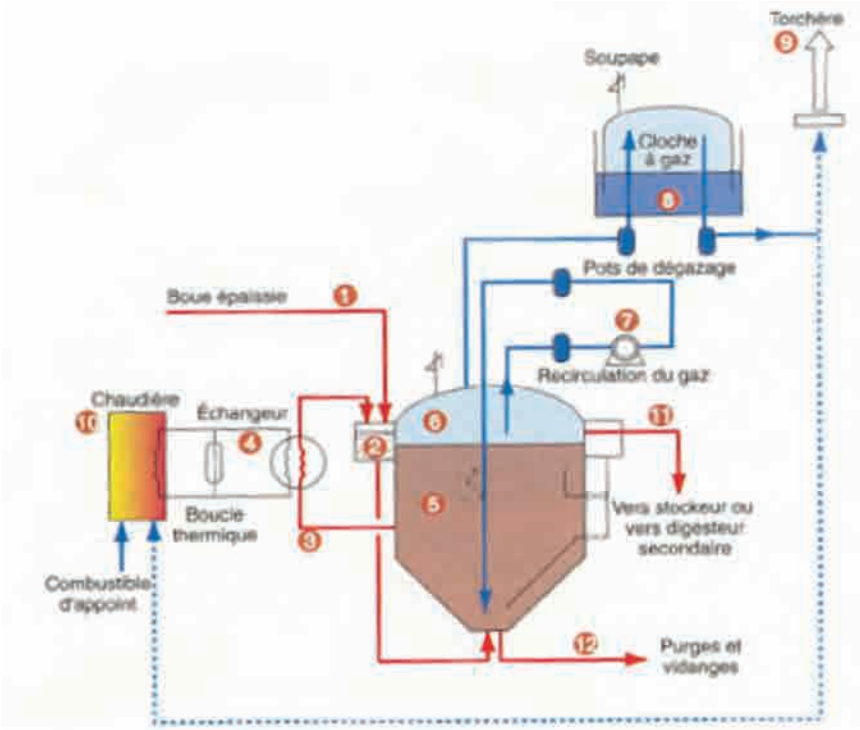
Solution 2 integrates the biological treatment by activated sludge in conventional aeration, with sludge anaerobic digestion and biogas energy recovery. The treatment line integrates new facilities, the primary treatment equipment and the sludge mesophilic anaerobic stabilization, namely anaerobic digester, gasholder, flare, equipment for biogas treatment, motor generators, boiler and heat exchanger. This solution integrates a high number of operations; therefore the complexity of operation and maintenance is remarkable. In order to overcome this difficulty, the operators must be specially trained for operating the new equipment. On the other hand, this is an advantageous solution concerning energy consumption, considering the lower power consumption relating to the extended aeration systems and the possibility to recover energy from the produced biogas.

The design that has been carried out revealed that the biological volume of only two treatment lines is sufficient for the biological treatment, in the conventional aeration mode, of the wastewater affluent in the planning year. Because of the greatest production of sludge, it is necessary to build other two thickeners with the characteristics of the existing thickeners.

As mentioned for Solution 1, the maximum inflow estimated is lower than the design flow of the existing facilities, and therefore the capacity of the grit and grease removal operation and the secondary settling is sufficient. According to the Detailed Preliminary Design of the Béja wastewater treatment plant, extending the size of the plant may be achieved through modification of the extended aeration to conventional aeration process, through construction of the primary decantation structures and aerobic or anaerobic stabilization of the sludge. As a result, we consider that the hydraulic profile of the wastewater treatment plant has been conceived from the outset in order to safeguard the possibility of inclusion of a primary decantation stage. This conclusion has been corroborated by the topographical survey of the plant.

Biogas is generally composed of two thirds of methane (CH_4) and a third of carbon dioxide (CO_2), with a lower heating value (LHV) of about 6.63 kWh/ Nm^3. Biogas can be burned in an electricity generator, which can provide the partial consumption of electric power of the plant, and allows to recover the thermal energy to heat the digester (see Figure 2.1-8).

The thickened sludge (1) will be placed in a mixture chamber (2) where it is heated by the digested sludge (3), itself heated through a heat exchanger (4). Then, the mixture is sent into the digester (5) which is agitated by a mechanical device or through injection of compressed biogas or recycling sludge (7). Biogas surplus is stored in a gasholder (8). It is thus possible to ensure the supply pressure of the flare (9) or the boiler (10), providing the necessary power for the reheating of sludge.



Torchère	Flare
Soupape	Valve
Cloche à gaz	Gasholder
Recirculation du gaz	Gas recirculation
Vers stockeur ou vers digesteur secondaire	Towards the storage or the secondary digester
Purges et vidanges	Purging and draining
Pots de dégazage	Degassing chambers
Boue épaissie	Thickened sludge
Echangeur	Heat exchanger
Boucle thermique	Thermal loop
Chaudière	Boiler
Combustible d'appoint	Auxiliary fuel

Figure 3.3-8: Principle of operation of a mesophilic anaerobic digester
Source: OTV, Traiter et valoriser les boues, Collection OTV, 1997

The treatment line of Solution 2 for the rehabilitation of the WwTP of Béja includes the following stages:

- Preliminary treatment
  - Grit retention in tank (new);
  - Screening consisting of 2 mechanical bar screens in parallel, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);

- Flow measurement in a Venturi channel using an ultrasonic level meter (existing);

- Primary treatment
  - Primary settling in 4 rectangular plant clarifiers, with bottom and surface scrapers bridge (new);
  - Feeding of floats into the thickeners (new);
  - Extraction of primary sludge for the thickeners (new);

- Biological treatment
  - Oxidation of the organic matter in 2 treatment lines, each one with 5 aeration tanks (existing) aerated by a new air diffused system supplied by blowers equipped with variable speed (new);
  - Settling of sludge in 4 secondary rectangular plant clarifiers, equipped with a suction scraper bridge (existing);
  - Sludge directing for two pumping stations (new);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
  - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (new);

- Tertiary treatment
  - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
  - Dosage of aluminium sulfate for the Chemical precipitation of phosphorus and in order to increase the transmittance of the effluent, thus benefiting the disinfection stage (existing);
  - Disinfection by ultraviolet radiation served upstream by a filtration (new);

- Sludge treatment
  - Thickening of the primary sludge, in excess and physicochemical, in 4 thickeners of square plant, with scraper bridge (2 existing and 2 new);
  - Mesophilic anaerobic stabilization of thickened sludge (new);
  - Storage of biogas in a gasholder (new);
  - Biogas energy recovery by a motor generator with production of thermal and electrical energy (new);
  - Heating of sludge in digestion with heat produced by cogeneration (new);
  - Burning the biogas in excess and the bad quality biogas in the flare (new);

  - Dewatering of the digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
  - Storage of dewatered sludge in containers (new);
  - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are returned through a pumping station to the biological treatment facility;

- Treatment of odors
  - treatment of the contaminated air, extracted from the grit retention chambers, the preliminary treatment building, thickeners and dewatering building using a biofilter (new).

3.3.3.3.2 Energy report

The average electricity consumption (solution 2, planning year) is presented in the Annex (see Annex III, Annex III.2). The energy report for solution 2 includes electricity produced by cogeneration.

3.3.3.3.3 Consumption of chemical reagents

The chemical reagents consumed in the wastewater treatment process are aluminium sulfate, hydrated lime and polyelectrolyte. The quantities of chemical reagents consumed from year zero to the planning year are presented in Annex III.2 (at the end).

3.3.3.3.4 Management of the by-products

The quantities of by-products resulting from the wastewater treatment process, in particular solid waste, grit, grease and sludge, are presented in Annex III.2 (at the end).

3.3.3.3.5 Equipment

The following table summarizes the solutions proposed in terms of replacement of the existing equipment items in the Béja wastewater treatment plant, in the framework of solution 2. For a fuller understanding of the following comments, it is necessary to view the treatment scheme of the solution attached to the report.

Table 3.3-8: Electro-mechanical equipment, instruments and electrical installations

Designation	Diagnosis	Proposed solution	Characteristics
Preliminary treatment			
Grit extraction system by “air-lift”	The wastewater includes a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber.	We propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber. Grit extraction will be achieved via an “air-lift” system.	Estimated extraction flow rate = 18 m^3/h
Mechanical multi-rake bar screen	The mechanical screens present widespread corrosion in stainless steel.	The demonstrated state of degradation justifies their replacement.	Maximum flow via the mechanical screen = 525 m^3/h Spacing between bars = 6 mm
Measurement of the difference in water level (screening)	The demonstrated state of degradation justifies replacement. Diagnosis of state of conservation of equipment is detailed in Annex III (Table III.2.1.1.1).	Automation should be improved, in particular in terms of integration between measurement of the level and operation of the mechanical screen.	
Belt conveyor	The paintwork is a bit degraded and altered in certain places; nonetheless we can affirm that the equipment seems to be sufficiently painted in order to avoid further corrosion.	Replacement is not judged to be necessary	Estimated volumetric flow rate of screenings = 1.2 m^3/d

Designation	Diagnosis	Proposed solution	Characteristics
scraper bridge (grit and grease extraction in a double aerated channel)	The scraper bridge has a deviation in its longitudinal movement. The wheels of the scraper bridge present a high level of degradation. In general, the scraper bridge presents a high level of corrosion and ageing.	The demonstrated state of degradation justifies its replacement.	To be installed in the existing work
Grit pumps (grit and grease extraction in a double aerated channel)	The occurrence of frequent breakdowns was reported to the consulting team	We recommend ensuring that the equipment items are maintained at a satisfactory level. There are two pumps per scraper bridge.	Estimated flow for each pump = 18 m^3/h.
Grit classifier (grit and grease extraction in a double aerated channel)	The grit classifier on the scraper bridge does not operate correctly and presents a certain amount of degraded paintwork.	The grit classification operation must be improved with installation of specialized equipment for this function. The equipment will be installed on the scraper bridge.	Estimated total capacity = 24 m^3/h.
Compressors (grit and grease extraction in a double aerated channel)	The compressors present a certain level of degradation; they are dirty and covered in dust.	We recommend ensuring that the equipment items are maintained at a satisfactory level. There are three compressors for the double channel: 2+1.	Estimated volumetric flow rate of air for each compressor = 292 m^3/h
Grease removal via a screw conveyor (grit and grease extraction in a double aerated channel)	The grease pumping circuit is out of service. The consulting team was informed that the circuit was immediately blocked after the start-up of the installation and was then abandoned.	Grease removal will be implemented via a screw conveyor installed in the grease tank.	Estimated volumetric flow rate of grease = 106 m^3/d
Measurement of effluent flow	Measurement is made by an ultrasonic level meter.	Replacement is not judged to be necessary	

Designation	Diagnosis	Proposed solution	Characteristics
Primary treatment			
Scraper bridges (primary sedimentation tanks)	In the framework of this solution for renovation of the WwTP, the existence of a primary treatment is proposed.	The scraper bridge is constituted by a mobile transversal beam that serves as a walkway, two lateral guides, an articulated system for collecting the sludge and discharging the scum, a motor reduction unit for activating the two lateral guides, a control unit of the articulated system of bottom scraper/scum blade and a command and control panel.	
Primary sludge lift pumps (primary sedimentation tanks)		It is necessary to install submersible pumps. There is one pump per scraper bridge.	Estimated flow for each pump = 18 m^3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Secondary or biological treatment			
Aeration	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor. Also, in order to maximize the volume of the existing reaction it is necessary to implement a more effective aeration method. The tanks are too deep in order to obtain maximum performance of the existing surface aerators.	We recommend replacement of the surface aerators by a fine bubble aeration system. This system includes compressors endowed with speed variation, air ducts and diffusers installed in the tanks. There are three compressors: 2+1; one compressor for each line.	Estimated volumetric flow rate of air for each compressor = 6,045 m^3/h.
Oxygen measurement (aeration tank)	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor.	We recommend installation of a programmable automation controller that permits integration of oxygen measurements with the aeration operation.	
Mixing	The submersible mixers are not in a good state of conservation. In the framework of this solution, it is necessary to add submersible mixers to the new line.	Replacement is judged to be necessary, and it is necessary to add submersible mixers to the new line.	
Scraper bridges (secondary clarifiers)	The scraper bridges are not in a good state of conservation. In the framework of this solution, it is necessary to add a scraper bridge to the new line.	Their complete replacement is judged to be necessary.	
Biological sludge lift pumps (secondary clarifiers)	The pumps are in a reasonable state of conservation, given their working conditions.	Replacement is not judged to be necessary. There are two pumps per scraper bridge.	Volumetric flow rate of sludge estimated for each pump = 144 m^3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Sludge recirculation pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process.	We recommend the construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks.	Estimated flow for each pump = 433 m^3/h.
Measurement of the flow of sludge recirculation	No measurement of the sludge recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Excess sludge extraction pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process.	We recommend construction of a biological sludge pumping station equipped with submersible pumps in order to lift the excess sludge towards the thickener.	Estimated flow for each pump = 20 m^3/h.
Measurement of the flow of excess sludge	No measurement of the excess sludge exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 80 mm
Tertiary treatment			
Nitrate recirculation pump	The Tunisian norm NT106.02 sets maximum limits for nitrate, nitrite, organic and ammoniacal nitrogen. Hence, it is necessary to modify the existing reactors to adapt them for biological elimination of nitrogen.	It is necessary to install submersible pumps (with frequency variation) for nitrate recirculation, in the existing aeration tanks - from the last aeration tank to the first	Estimated flow for each pump = 866 m^3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Measurement of the flow of nitrate recirculation	No measurement of the nitrate recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Dosing pump of aluminium sulfate and dosing circuit	Chemical precipitation of phosphorus with dosing of aluminium sulfate	We recommend a dosing circuit with dosing tank, retention chamber, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Estimated flow for each pump = 196 L/h.
Disinfection	The Tunisian norm NT 106.02 obliges observance of 2000/100 mL of fecal coliforms and 1000/100 mL of fecal streptococci in order to guarantee the microbiological quality of the public water supply.	Disinfection by ultraviolet radiation implemented upstream by the filtration operation via multicellular vertical feeding pumps linked to the filters, self-cleaning pressure filters and an ultraviolet radiation system in the open channel.	Maximum flow = 1,054 m^3/h
Treatment of the sludge			
Scraper bridge (existing thickener)	The paintwork of the existing scraper bridge is a bit degraded and altered in certain places. In the framework of this solution for renovation of the WwTP, we propose the construction of two supplementary thickeners.	We estimate that complete replacement of the existing thickeners is not necessary. However, it is necessary to consider application of a new layer of paint.	The new thickeners will be square-shaped like the existing one.

Designation	Diagnosis	Proposed solution	Characteristics
Thickened sludge pumps	The sludge pumps (which lift the sludge towards the thickened sludge storage tank or towards the sludge drying beds) present a high level of deterioration.	In the framework of renovation of the WwTP it will be necessary to replace these pumps and to add others due to the new thickeners. We recommend an excentric screw pump. There is one pump for each thickener.	Estimated flow per pump = 18 m^3/h.
Anaerobic digestion of the sludge	In the framework of this solution for renovation of the WwTP we propose mesophilic anaerobic stabilization of the thickened sludge.	The anaerobic digestion of the sludge will be implemented using the digesters, agitation of the digesters via the Sludge recirculation pumps, pumps for the sludge heating circuit during digestion, gasholder and torch.	
Sludge heating system during digestion	For mesophilic anaerobic stabilization of the thickened sludge, it is necessary to foresee a sludge heating system during digestion.	We always recommend the use of a boiler and a hot water tank with recirculation pumps for these circuits.	The boiler must operate with natural gas and biogas
Cogeneration	The cogeneration system enables energy use of the biogas produced and also heating of the sludge during digestion with the heat produced by the motor-generator.	In addition to the sludge heating system during digestion using the boiler, we propose a cogeneration system constituted by elements such as the biogas-driven motor-generator.	

Designation	Diagnosis	Proposed solution	Characteristics
Lift pump of the digested sludge to the centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer.	We recommend an excentric screw pump.	Estimated flow per pump = 40 m^3/h.
Centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of two equipment items.	Capacity 40 m^3/h
Polymer preparation equipment	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of fully automatic continuous polymer solution preparation equipment. Dosing tank, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Capacity 4,000 L/h.
Polymer dosing pump	-	We recommend membrane dosing pumps.	Estimated flow per pump = 2.5 m^3/h.
Lifting the dewatered sludge		The dewatered sludge will be lifted via a screw conveyor.	Estimated volumetric flow rate of the dewatered sludge = 60 m^3/d

Designation	Diagnosis	Proposed solution	Characteristics
Treatment of odors			
Treatment of the contaminated air	We propose to extract the contaminated air from the grit retention tank, preliminary treatment building, thickener and dewatering building	The contaminated air will be deodorized implemented via a bio filter and a piping circuit and fan	
Electrical installations			
MV-LV transformation station	In the framework of the intervention proposed for the wastewater treatment WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Low voltage cupboard	In the framework of the intervention proposed for the wastewater treatment WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Command station with master control panel	In the framework of the intervention proposed for the wastewater treatment WwTP, these equipment items should be renovated.	We recommend installation of a programmable automation controller that permits integration between the measurement instruments and operation of the mechanical equipment.	-

3.3.3.4 Solution 3

3.3.3.4.1 Detailed description of the treatment sequence – design and criteria

Solution 3 includes anaerobic pre-treatment of industrial wastewater from yeast producers, achieved in an anaerobic reactor with a UASB – (*upflow anaerobic sludge blanket*). The yeast wastewater will be equalized in a tank equipped with an electro-mechanical mixer and will be raised for the UASB. Within the reactor there is a sludge blanket constituted by granulated anaerobic micro-organisms. The flow rises from the bottom to the top of the reactor. At the time of the anaerobic degradation, biogas is formed which will be incinerated in the torch. The upper section of the UASB reactor includes a separation system, which makes it impossible to separate the biogas from the pre-treated water. In addition, the granulated elements (biomass) are retained in the reactor.

The domestic wastewater, the pre-treated yeast wastewater and other industrial wastewater will be treated together, in a biological system using activated sludge in extended aeration mode, implemented in the 4 existing sectors of biological treatment. The separation between solids and liquids will be carried out in the 4 existing secondary clarifiers.

The treatment sector of solution 3 of rehabilitation of the Béja wastewater treatment plant encompasses the following stages:

- Pre-treatment of the yeast wastewater
    - equalization of the wastewater in a tank (new) ;
    - anaerobic treatment of the wastewater in a UASB-type reactor (new) ;
    - introduction of the pre-treated effluent in the headwork (new) ;
    - combustion in the torch of the biogas produced (new) ;
- Preliminary treatment
    - grit retention in tank (new);
    - screening constituted by 2 mechanical screens in parallel with spacing between the bars of 6 mm, a conveyor belt and a towline (existing) ;
    - extraction of grit and oil in a double aerated channel, equipped with a scraper bridge (existing) ;
    - measurement of the flow of the wastewater in a Venturi channel with the aid of an ultrasonic level meter (existing) ;
- Biological treatment
    - oxidation of the organic materials in 4 lines (existing) each with 5 tanks, aerated by a new system of diffused air supplied by the compressors equipped with a speed control (existing) ;
    - sedimentation of the sludge in 4 rectangular-shaped secondary clarifiers supplied with a suction scraper bridge (existing) ;
    - conveying of the sludge via two pumping stations (new) ;
    - recirculation of the sludge towards the beginning of the aeration tanks and

measurement of the flow using an electro-magnetic flow meter (new) ;

- o extraction of the excess sludge towards the thickeners and measurement of the flow using an electro-magnetic flow meter (new) ;

- Tertiary treatment
  - o Biological elimination of the materialized nitrogen through recirculation of compressed nitrate after exiting from the nitrifying tank (final compartments) towards the beginning of the anoxic tank (first compartments) ; measurement of the recirculated flow using an electro-magnetic flow meter (new) ;
  - o dosage of aluminium sulfate for the Chemical precipitation of phosphorus and in order to increase the transmittance of the effluent, in order to benefit the disinfection stage (existing);
  - o Disinfection by ultraviolet radiation preceded upstream by a filtering operation (new) ;
- Treatment of the sludge
  - o thickening of the excess and physical-chemical primary sludge, in 3 square-shaped thickeners, equipped with a scraper bridge (2 existing and 1 new) ;
  - o dewatering of the thickened sludge in a centrifugal decanter with addition of polymers (new) ; in case of emergency, dewatering of the thickened sludge on drying beds (existing) ;
  - o storage of the dewatered sludge in containers (new) ;
  - o the supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are returned through a pumping station to the biological treatment facility;
- Treatment of odors
  - o treatment of the contaminated air, extracted from the grit retention chambers, from the preliminary treatment building, thickeners, thickened sludge storage tank and from the dewatering building using a biofilter (new).

3.3.3.4.2 Energy report

The average electricity consumption (solution 3, planning year) is presented in Annex (see Annex III, Annex III.2).

3.3.3.4.3 Consumption of chemical reagents

The chemical reagents consumed in the wastewater treatment process are aluminium sulfate and polyelectrolyte. The quantities of chemical reagents consumed between year zero and the planning year are presented in Annex III.2 (at the end).

3.3.3.4.4 Management of by-products

The quantities of by-products resulting from of the wastewater treatment process, in particular solid waste, grit, grease and sludge, are presented in Annex III.2 (at the end).

3.3.3.4.5 Equipment

In general, the electromechanical equipment items present a high level of maintenance, if one takes into consideration their working conditions and maintenance level.

The following table summarizes the solutions proposed in terms of replacement of the existing equipment items in the Béja wastewater treatment plant, in the framework of solution 3. For a fuller understanding of the following comments, it is necessary to view the treatment scheme of the solution attached to the report.

Table 3.3-9: Electro-mechanical equipment, instruments and electrical installations

Designation	Diagnosis	Proposed solution	Characteristics
Pre-treatment of the yeast wastewater			
Initial lifting and equalization of the yeast wastewater	In the framework of this solution, we propose anaerobic pretreatment of the industrial wastewater sourced from the yeast factories, achieved via an Up-flow Anaerobic Sludge Bed (UASB) reactor	The yeast wastewater will be equalized in a tank equipped with an electro-mechanical mixer and will be lifted to the Up-flow Anaerobic Sludge Bed (UASB) by 1+1 submersible pumps.	maximum design flow = 25 m^3/h
Measurement of the flow of the yeast wastewater	Installation of the flow-meter in the yeast wastewater rising main	Measurement using an electro-magnetic flow-meter.	Estimated diameter = 150 mm
Preliminary treatment			
Grit extraction system by “air-lift”	The wastewater includes a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber.	We propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber. Grit extraction will be achieved via an “air-lift” system.	Estimated extraction flow rate = 18 m^3/h
Mechanical multi-rake bar screen	The mechanical screens present widespread corrosion in stainless steel.	The demonstrated state of degradation justifies their replacement.	Maximum flow via the mechanical screen = 525 m^3/h Spacing between bars = 6 mm
Measurement of the difference in water level (screening)	The demonstrated state of degradation justifies replacement. Diagnosis of state of conservation of equipment is detailed in Annex III (Table III.2.1.1.1).	Automation should be improved, in particular in terms of integration between measurement of the level and operation of the mechanical screen.	

Designation	Diagnosis	Proposed solution	Characteristics
Belt conveyor	The paintwork is a bit degraded and altered in certain places. Nonetheless, the equipment does appear to be painted in order to avoid further corrosion.	Replacement is not judged to be necessary	Estimated volumetric flow rate of screenings = 1.2 m^3/d
Scraper bridge (grit and grease extraction in a double aerated channel)	The scraper bridge has a deviation in its longitudinal movement. The wheels of the scraper bridge present a high level of degradation. In general, the scraper bridge presents a high level of corrosion and ageing.	The demonstrated state of degradation justifies their replacement.	Installed in the existing work
Grit pumps (grit and grease extraction in a double aerated channel)	The occurrence of frequent breakdowns was reported to the consulting team	We recommend the replacement of the equipment items. There are two pumps per scraper bridge.	Estimated flow for each pump = 18 m^3/h.
Grit classifier (grit and grease extraction in a double aerated channel)	The grit classifier on the scraper bridge does not operate correctly and presents a certain amount of degraded paintwork.	The grit classification operation must be improved with installation of specialized equipment for this function. The equipment will be installed on the scraper bridge.	Estimated total capacity = 24 m^3/h.
Compressors (grit and grease extraction in a double aerated channel)	The compressors present a certain level of degradation; they are dirty and covered in dust.	We recommend the replacement of the equipment items. There are three compressors for the double channel: 2+1.	Estimated volumetric flow rate of air for each compressor = 292 m^3/h
Grease removal via a screw conveyor (grit and grease extraction in a double aerated channel)	The grease pumping circuit is out of service. The consulting team was informed that the circuit was immediately blocked after the start-up of the installation and was then abandoned.	Grease removal will be implemented via a screw conveyor installed in the grease tank.	Estimated volumetric flow rate of grease = 106 m^3/d
Measurement of effluent flow	Measurement is made by an ultrasonic level meter.	Replacement is not judged to be necessary	

Designation	Diagnosis	Proposed solution	Characteristics
Secondary or biological treatment			
Aeration	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor. Also, in order to maximize the volume of the existing reaction it is necessary to implement a more effective aeration method. The tanks are too deep in order to obtain maximum performance of the existing surface aerators.	We recommend replacement of the surface aerators by a fine bubble aeration system. This system includes compressors endowed with speed variation, air ducts and diffusers installed in the tanks. There are five compressors: 4+1; one compressor for each line.	Estimated volumetric flow rate of air for each compressor = 3,602 m^3/h.
Oxygen measurement (aeration tank)	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor.	We recommend installation of a programmable automation controller that permits integration of oxygen measurements with the aeration operation.	
Mixing	The submersible mixers are not in a good state of conservation. In the framework of this solution, it is necessary to add submersible mixers to the new line.	Replacement is judged to be necessary, and it is necessary to add submersible mixers to the new line.	
Scraper bridges (secondary clarifiers)	The scraper bridges are not in a good state of conservation. In the framework of this solution, it is necessary to add a scraper bridge to the new line.	Their complete replacement is judged to be necessary.	
Biological sludge lift pumps (secondary clarifiers)	The pumps are in a reasonable state of conservation given their working conditions.	Replacement is not judged to be necessary. There are two pumps per scraper bridge.	Volumetric flow rate of sludge estimated for each pump = 144 m^3/h.
Sludge recirculation pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process.	We recommend the construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks. There is one pumping station for two secondary clarifiers.	Estimated flow for each pump = 434 m^3/h.
Measurement of the flow of sludge recirculation	No measurement of the sludge recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm

Designation	Diagnosis	Proposed solution	Characteristics
Excess sludge extraction pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process.	We recommend the construction of a biological sludge pumping station equipped with submersible pumps in order to lift the excess sludge towards the thickener.	Estimated flow for each pump = 23 m^3/h.
Measurement of the flow of excess sludge	No measurement of the excess sludge exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 80 mm
Tertiary treatment			
Nitrate recirculation pump	The Tunisian norm NT106.02 sets maximum limits for nitrate, nitrite, organic and ammoniacal nitrogen. Hence, it is necessary to modify the existing reactors to adapt them for biological elimination of nitrogen.	It is necessary to install submersible pumps (with frequency variation) for nitrate recirculation, in the existing aeration tanks - from the last aeration tank to the first.	Estimated flow for each pump = 434 m^3/h.
Measurement of the flow of nitrate recirculation	No measurement of the nitrate recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Dosing pump of aluminium sulfate and dosing circuit	Chemical precipitation of phosphorus with dosing of aluminium sulfate	We recommend a dosing circuit with dosing tank, retention chamber, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Estimated flow for each pump = 186 L/h.
Disinfection	The Tunisian norm NT 106.02 obliges observance of 2000/100 ml of fecal coliforms and 1000/100 ml of fecal streptococci in order to guarantee the microbiological quality of the public water supply.	Disinfection by ultraviolet radiation implemented upstream by the filtration operation via multicellular vertical feeding pumps linked to the filters, self-cleaning pressure filters and an ultraviolet radiation system in the open channel.	maximum flow = 1,054 m^3/h
Treatment of the sludge			
Scraper bridge (thickener)	The paintwork of the existing scraper bridge is a bit degraded and altered in certain places In the framework of this solution for renovation of the WwTP, we propose construction of another thickener.	Complete replacement of the existing thickeners is not judged to be necessary but it is necessary to consider application of a new layer of paint.	The new thickener will be square-shaped like the existing one.

Designation	Diagnosis	Proposed solution	Characteristics
Thickened sludge pumps	The sludge pumps (that lift sludge to the thickened sludge storage tank or to the sludge drying beds) present a high level of deterioration.	In the framework of renovation of the WwTP it will be necessary to replace these pumps and to add another because of the new thickener. We recommend an excentric screw pump. There is one pump for each thickener.	Estimated flow per pump = 18 m^3/h.
Submersible mixer (thickened sludge storage tank)	In the framework of renovation of the WwTP, we propose temporary storage of the thickened sludge in a tank upstream of the dewatering stage.	It is necessary to install a submersible mixer in order to avoid sedimentation of the sludge.	-
Lift pump to raise the thickened sludge to the centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	An excentric screw pump is recommended.	Estimated flow per pump = 40 m^3/h.
Centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge centrifugal clarifier with the addition of polymer.	We recommend installation of two equipment items.	Capacity 40 m^3/h
Polymer preparation equipment	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of fully automatic continuous polymer solution preparation equipment. Dosing tank, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	capacity 4,000 L/h.
Polymer dosing pump	-	We recommend membrane dosing pumps.	Estimated flow per pump = 2.5 m^3/h.
Lifting the dewatered sludge		The dewatered sludge will be lifted via a screw conveyor.	Estimated volumetric flow rate of the dewatered sludge = 61 m^3/d
Treatment of odors			
Contaminated air treatment system	We propose to extract the contaminated air from the grit retention tank, preliminary treatment building, thickener, thickened sludge storage tank and dewatering building	The contaminated air will be deodorized via a bio filter and a piping circuit and fan	

Designation	Diagnosis	Proposed solution	Characteristics
Electrical installations			
MV-LV transformation station	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	
Low voltage cupboard	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	
Command station with master control panel	In the framework of the intervention proposed for the WwTP, these equipment items should be renovated.	We recommend installation of a programmable automation controller that permits integration between the measurement instruments and operation of the mechanical equipment.	

3.3.4 Economic assessment

3.3.4.1 Investment costs

The estimate of the fixed capital investment costs associated with the civil engineering and equipment items is based on market consultations and information supplied by ONAS.

The following table presents a summary of the fixed capital investment costs associated with each treatment solution studied. Annex III.8 presents systematization of the partial values used for the values presented in the following table. The breaking down of prices for the proposed solution is given in Annex III.9.

Cost estimation takes 2011 as reference year for prices.

Table 3.3-10: Estimate of the initial investment costs

Treatment Solutions	Civil engineering (TND)	Equipment and IE (TND)	Total (TND)
1	2,326,879	5,904,972	8,231,851
2	3,422,392	9,811,845	13,234,237
3	2,307,241	5,540,939	7,848,180

In conformity with the project implementation timetable described in chapter V, it is admitted that the initial investment will be made in 2016, which corresponds to the start of the construction works.

3.3.4.2 Operating costs and maintenance

For the estimation of the operating costs and maintenance, the unit costs supplied by ONAS have been used for the following aspects:

- maintenance;
- consumption of chemical reagents;
- consumption of electricity;
- transport and final deposit of the by-products and sludge.

The operating costs associated with analytic control of operation of the wastewater treatment plant has not been counted since it depends upon the planning deadline by ONAS and are common for all the treatment solutions studied.

The maintenance costs resulting from addition of the two parts, corresponds to the civil engineering and maintenance of the electromechanical equipment items. They have been estimated based upon application of a rate of 2.5% and 1.0% on the budgetary forecasts of the investment for the electromechanical equipment items and civil engineering, respectively.

In relation to the chemical reagents, the following unit prices admitted:

- aluminium sulfate – 400 TND;
- cationic polyelectrolyte – 6500 TND;

- lime – 150 TND.

The electricity consumption has been estimated on the basis of the energy reports presented in Annex III.2, and a unit electricity cost of 0.13 TND/kWh has been admitted.

In order to estimate of the costs of transport and final deposit of the by-products and of the sludge, a unit cost of 40 TND/t has been taken into consideration.

In conformity with the project implementation timetable, the start date of operation of the WwTP after renovation will be 2019.

3.3.4.3 Updated total costs

Annex III.8 presents the updated total costs for the year 2016, through application of an updating rate of 3%. A summary of the results obtained is presented in the following table.

Table 3.3-11: Estimate of the fixed capital investment costs (FCIC), operating costs (OC) and updated total costs (UTC) for each solution studied

Treatment solutions	FCIC (TND)	OC (TND)	UTC (TND)
1	8,210,351	26,089,409	28,757,655
2	13,234,237	23,744,096	31,954,393
3	7,848,180	24,674,864	27,284,368

For each solution studied the ratio TND/m^3 is respectively, 0.64, 0.72 and 0.62.

3.3.5 Technical and economic comparison of the solutions

From the previous table, it is noted that although Solution 2 has lower operating costs, its total discounted costs are the highest due to the high initial capital investment costs. From a strictly economic perspective, the solution 3 is the most advantageous one, with the investment costs and total discounted costs the lowest.

During the missions in Tunisia, the consultant team tried to find examples of WwTP using the process of conventional aeration activated sludge, with mesophilic anaerobic digestion of sludge and energy recovery from biogas. Although it may not be a representative sample of such plants, the team visited Choutrana WwTP near Tunis. At the time of the visit the anaerobic digestion of sludge with energy recovery of biogas was out of service. The team notes that based on the training plans provided by ONAS, a major effort would be needed to implement Solution 2, for the integration of training of the operation team.

In contrast, Solutions 1 and 3 uses an existing treatment process, which is much simpler and well controlled by the operation team.

The consultant team recommends that the rehabilitation of the Béja WwTP be carried out according to Solution 3.

3.3.6 Conclusion and recommendations

As the conclusion through discussion with ONAS during the present Survey, Solution 3 is selected as the best solution for the Béja WwTP to be proceeded for detailed design.

3.3.6.1 Summary of key interventions for the selected solution

With regard to the solution adopted key interventions recommended include:

- Pre-treatment of the yeast wastewater
  - construction of a new equalization tank for receiving the wastewater;
  - construction of the anaerobic treatment of the wastewater in a UASB-type reactor ;
  - installation of a torch for the combustion of the biogas produced ;
- Preliminary treatment
  - construction of a new grit retention tank including the grit extraction system by "air-lift";
  - replacement of the mechanical multi-rake bar screen;
  - replacement of the belt conveyor;
  - replacement of the scraper bridge;
  - replacement of the grit pumps (grit and grease extraction);
  - installation of a grit classifier;
  - replacement of the compressors;
  - installation of a screw conveyor for grit removal;
  - replacement of the measurement flow equipment;
- Secondary or biological treatment
  - replacement of the surface aerators by a fine bubble aeration system including compressors endowed with speed variation, air ducts and diffusers installed in the tanks;
  - replacement of submersible mixers;
  - replacement of the scraper bridges (secondary clarifiers);
  - construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks, and excess sludge extraction;
- Tertiary treatment
  - installation of nitrate recirculation pumps;

  - construction of an ultraviolet radiation disinfection system in the open channel implemented upstream by the filtration operation via multicellular vertical feeding pumps linked to the filters, self-cleaning pressure filters;

- Sludge treatment
  - construction of another thickener ;
  - construction and installation of all the civil works and equipment relative to the sludge mechanical dewatering;

- Odor treatment
  - construction and installation of all the civil works and equipment associated with the contaminated air treatment system including the extraction Of the contaminated air from the grit retention tank, preliminary treatment building, thickener, thickened sludge storage tank and dewatering building.

3.3.6.2 Recommendation regarding continuation of normal activity during works

As it is necessary to maintain the operation of the WWTP it becomes essential to perform all work in a progressive manner. In this sense, it is recommended:

- interventions should be made as much as possible during the dry season, so that the affluent flow is smaller;
- construction of the sand retention tank sand should be a priority and be completed before interventions in the pre-treatment;
- interventions provided at the pre-treatment should be carried out alternately on each channel;
- interventions in the aeration tanks and secondary clarifiers must be done line by line to allow the rest to maintain in operation;
- interventions concerning the pre-treatment of wastewater from the yeast production, disinfection, sludge treatment and odor treatment, are not directly involved in the operation of STEP, so can be done sequentially.

3.3.6.3 Remarks on further studies

The results for the STEP of Béja helped to find a solution for setting the budget of the operation of rehabilitation and extension.

However, the further studies, especially the Detailed Design, will have to validate in detail the technical choices proposed or to propose some technical amendments in the budget of the operation.

3.4 WWTP OF MEDJEZ EL-BAB

3.4.1 Current situation of the WwTP

3.4.1.1 General information

3.4.1.1.1 General localization and accessibility

The WwTP of Medjez El-Bab is located in the Commune of Medjez El-Bab, governorate of Béja, near the town of Medjez El-Bab (see Figure 3.4-1), and it is situated in a rural zone. The following figure displays an aerial view of the WwTP.

The access to the WwTP was found to be in good condition.

Figure 3.4-1: Aerial view of the WwTP of Medjez El-Bab
(Source: Google Earth 2010)

3.4.1.1.2 Environmental restrictions of the area and the surroundings

The WwTP of Medjez El-Bab is located 360 m from the town of Medjez El-Bab. The area of the WwTP is approximately 3 ha and it offers the space necessary for its extension.

3.4.1.1.3 Description of the existing facilities

The WwTP of Medjez El-Bab was brought into service in 1994 to treat wastewater from the commune of Medjez El-Bab. The installation was dimensioned to treat the wastewater produced by 40,000 p.e. (population equivalent), corresponding to a flow of 4,500 m^3/day and to an organic load (BOD) of 2,000 kg/day.

Currently, the wastewater arrives gravitationally at the WwTP and is pumped to the inlet infrastructure by two Archimedean screws.

The WwTP of Medjez El-Bab was designed according to the extended aeration activated sludge process. The treatment line incorporates the following facilities:

- Pretreatment
    - Effluent pumping by 2 Archimedean screws;
    - Screening consisting of 1 mechanical bar screen, with bars spacing of 12 mm, a conveyor belt and a trailer;
    - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge;
    - Flow measurement in a Venturi channel using an ultrasonic level meter;
- Biological or secondary treatment
    - Oxidation of the organic matter in 2 treatment lines, each one with 3 aeration tanks equipped with surface aerators and submersible agitators
    - Settling of sludge in 2 secondary clarifiers of rectangular plan, equipped with a suction scraper bridge;
    - Pumping of scum to a trailer;
    - Sludge recycling at the beginning of the aeration tanks and flow measurement in a Venturi channel using an ultrasonic level meter;
    - Excess activated sludge extraction and feeding into the thickener;
- Tertiary treatment
    - Chemical precipitation of phosphorus with aluminum sulfate dosage into the aeration tanks;
- Treatment of sludge
    - Excess activated sludge thickening in 1 thickener of square plan, equipped with a scraper bridge;
    - Dewatering of the thickened sludge in 14 drying beds (surface of 4,900 m^2);
    - Pumping of the thickener supernatant and the drying beds filtrate by means of a pumping station into the sludge recycle channel.

The treated effluent is discharged into the receiving water by means of a gravity drainage pipe. During periods of heavy rain, the water level goes up in the receiving water, reaching a height which allows the water to enter into the WwTP. In order to avoid this situation, ONAS has installed a pumping station which allows pumping the treated effluent to the receiving water during these periods.

Part of the effluent is reused for the irrigation of 120 ha.

The following figures present the general layout, and some photographs of the plant are shown thereafter.

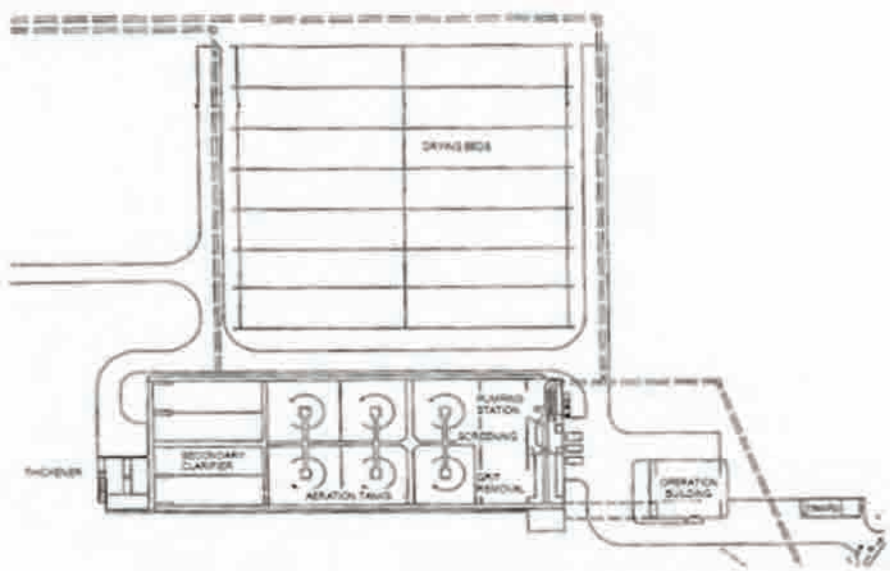


Figure 3.4-2: General layout of the WwTP of Medjez El-Bab

Figure 3.4-3: Photographs of the WwTP of Medjez El-Bab

1 – Overall picture; 2 – Pretreatment – Degreasing and de-oiling; 3 – Aeration tanks; 4 – Secondary clarifiers; 5 – Drying beds; 6 – Operating building.

The main dimensions of the existing facilities are presented in Annex III (Annex III.3).

It should be noted that the WwTP has a main building with two stages, which includes the WC/showers, locker rooms, a small laboratory and a control room with a synoptic board. There is a second building for the main low voltage (LV) distribution.

3.4.1.2 Current quantitative and qualitative characteristics of the wastewater and treated wastewater

3.4.1.2.1 ONAS' operating reports

The following tables summarize the quantitative and qualitative characterization of the wastewater influent to the WwTP of Medjez El-Bab, as well as the treated effluent, taking into account the annual operation reports of the years 2008, 2009 and 2010 provided by ONAS.

Table 3.4-1: Quantitative characterization of tributary wastewater in 2008 to 2010

Year	Value	Daily flow (m^3/day)	Monthly flow (m^3/month)	Annual flow (m^3/year)
2008	Minimum	2,417	75,003	1,111,987
	Average	3,037	92,666	
	Maximum	11,960	118,457	
2009	Minimum	1,689	52,376	978,855
	Average	2,686	81,571	
	Maximum	18,427	107,557	
2010	Minimum	1,442	44,715	
	Average	1,873	56,958	695,741
	Maximum	4,723	82,511	

Table 3.4-2: Qualitative characterization of tributary wastewater in 2008 to 2010

Year	Value	BOD (kg/day O_2)	COD (kg/day O_2)	TSS (kg/day)
2008	Minimum	1,295	2,500	1,482
	Average	2,272	7,024	2,442
	Maximum	3,237	18,457	6,029
2009	Minimum	912	2,252	953
	Average	1,847	4,461	1,801
	Maximum	3,503	8,670	3,142
2010	Minimum	609	1 988	924
	Average	1 243	3 148	1 410
	Maximum	1 992	4 376	2 107

Table 3.4-3: Qualitative characterization of the treated effluent in 2008 to 2010

Year	Value	BOD (mg/L O_2)	COD (mg/L O_2)	TSS (mg/L)
2008	Minimum	11.5	43.5	16
	Average	25	73.0	51.3
	Maximum	45	101	254
2009	Minimum	10	40	9
	Average	25	70.1	23.2
	Maximum	43.5	117	60
2010	Minimum	20	59	12
	Average	25	73	19
	Maximum	40	90	33

3.4.1.2.2 Sampling program implemented within the framework of the project

In the framework of this project, a sampling program of the raw and treated wastewater has been implemented, aimed at consolidating the conclusions of analysis of the operating reports of the wastewater treatment plant.

The sampling has been implemented in conformity with the premises described in paragraph 3.3.1.2.2.

Sampling of the Medjez el-Bab wastewater treatment plant was implemented on the following dates:

- Monday 11/10/2010 – Tuesday 12/10/2010: weekly market ; without rain;
- Sunday 17/10/2010 – Monday 18/10/2010: week-end ; 10 h de rain;
- Tuesday 26/10/2010 – Wednesday 27/10/2010: weekday; without rain;
- Wednesday 10/11/2010 – Thursday 11/11/2010: weekday; without rain.

The following table presents the main results of the sampling program carried out.

Table 3.4-4: Results of the sampling program

Parameters	From 11 to 12/10/2010		From 17 to 18/10/2010		From 26 to 27/11/2010		From 10 to 11/11/2010	
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow
Daily flow (m^3/d)	1,345		3,033		1,544		1,608	
pH	7.42	7.5	8.14	7.48	7.40	7.46	7.25	7.35
TSS (mg/L)	407	14	287	9	446	8	280	18
VSS (mg/L)	1.01	0.28	0.73	0.27	0.85	0.26	0.58	0.17
COD (mg/L O_2)	1,195	41	818	22	818	46	728	39
BOD_5 (mg/L O_2)	528	16	340	12	363	16	345	12
Carbonates (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bicarbonates (mg/L)	750	480	607	415	430	366	769	329
Hydroxides (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitrogen Kjeldahl (mg/L N)	62	15.6	29.3	5.1	40.6	10.3	52	12.8
Nitrates (mg/L N)	<0.04	0.66	<0.04	1	<0.04	1.41	<0.04	1.8
Phosphorus total (mg/L P)	7.15	2.17	4.86	0.53	6.7	2.6	8.3	3.4
Oils & grease (mg/L)	55	<0.1	24	<0.1	104	<0.1	157	<0.1
Hydrocarbons (mg/L)	19.6	<3.3	25.3	<3.3	61.4	<3.3	61	<3.3
Total coliforms	1.5×10^8	3×10^5	4.5×10^7	2.5×10^6	4.5×10^7	9.5×10^5	9.5×10^7	2.5×10^5
Fecal coliforms	2.0×10^6	1.5×10^5	9.5×10^6	2.5×10^6	1.5×10^7	4.5×10^5	2.5×10^7	1.5×10^5

Following analysis of the above results, it is necessary to emphasize the strong influence of rainfall on the daily flow to the wastewater treatment plant. In effect, the daily flow recorded during the period from 11/10/2010 to 12/10/2010 is almost 200% higher than a day without rain.

The BOD_5/COD ratios obtained vary between 0.41 to 0.47 that lies within the typical range of biodegradable effluents.

Furthermore, the effectiveness of the degradation of the organic load was very high, around 95 - 97%. The effectiveness of elimination of the nitrogen was also very high, between 71.1% and 79.2% (for this calculation, we considered that the total value of nitrogen corresponds to the Kjeldahl nitrogen and to the nitrates, since nitrites in raw effluent are generally negligible).

In addition, analysis of the BOD_5:N:P ratio indicates a lack of phosphorus in the raw wastewater, lower than the reference de 100:5:1, in the four days of the sampling, which demonstrates good equilibrium conditions for the development of bacterial biomass.

Comparing the mean results from the sampling program (undertaken during October and November 2010) with the mean analytical results from the 2010 Operation Report, it is concluded that:

- The mean of the mean daily flows recorded in the sampling program is about 1.5% inferior to the mean of the values recorded in the 2010 Operation Report;
- The results from the sampling program for concentrations of TSS, COD and BOD_5 in raw wastewater are, on average, 30% to 40% below the mean values from the Operation

Report;

- The concentrations of TSS, COD and BOD_5 in treated effluent obtained from the sampling program are, on average, 35% to 50% below the mean values recorded in 2010.

Comparing the mean results from the sampling program with the mean analytical results for only October and November from the 2010 Operation Report, it is concluded that:

- The mean daily flows recorded in the sampling program are, generally, of the same order as those recorded in the Operation Report, except one value which is twice as large;
- The results from the sampling program for concentrations of TSS, COD and BOD_5 in raw wastewater are of the same order as those recorded in the Operation Report;
- The concentrations of TSS in treated effluent obtained from the sampling program are, generally, of the same order as those in the Operation Report, but those of COD and BOD_5 are about 40% to 50% lower.

3.4.1.3 Evaluation of the existing plant operation

The annual operation reports provided by ONAS indicate that in 2008, 2009 and 2010 the wastewater flow tributary to the WwTP was always lower than the plant design flow (4,500 m^3/day), corresponding, in average, to approximately 56.5% of the installed capacity.

However, the daily flow tributary to the WwTP has already exceeded in some situations the design flow, having recorded between 11,960 m^3/day, 18,427 m^3/day and 4 723 m^3/day respectively, for the years 2008, 2009 and 2010.

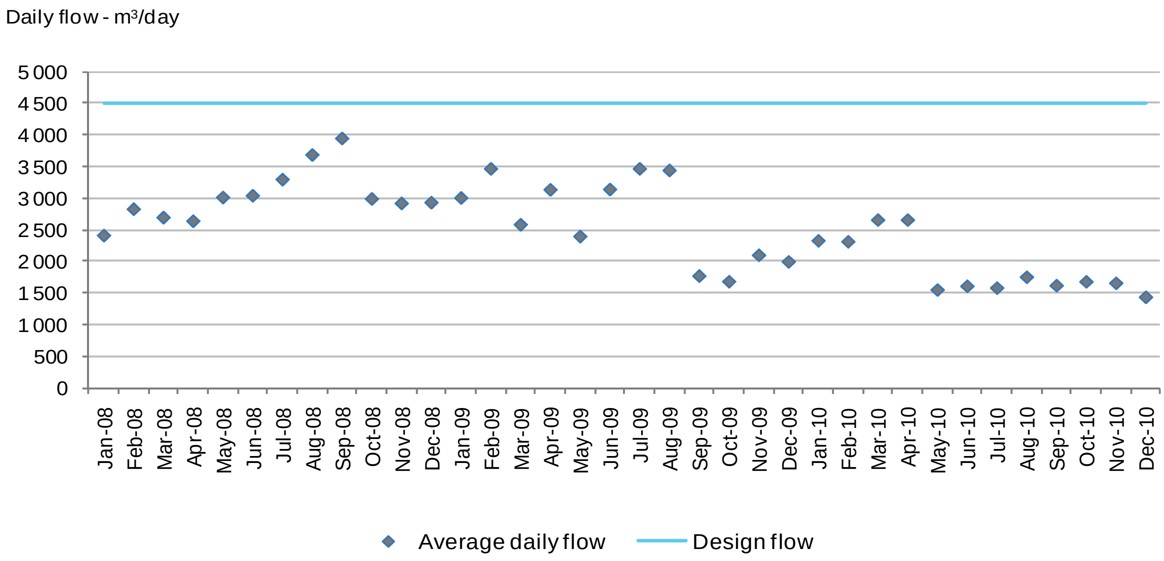


Figure 3.4-4: Variation of the average daily flow of the affluent between 2008 and 2010 and the design flow

These last years, the treatment capacity for the organic load of the WwTP of Medjez El-Bab was frequently exceeded, recording some situations of approximately twice the designed organic load (BOD of 3,503 kg/day and 1,990 kg/day, respectively). Assuming that the values of the tributary organic load remain unchanged, the second treatment line must be placed in operation.

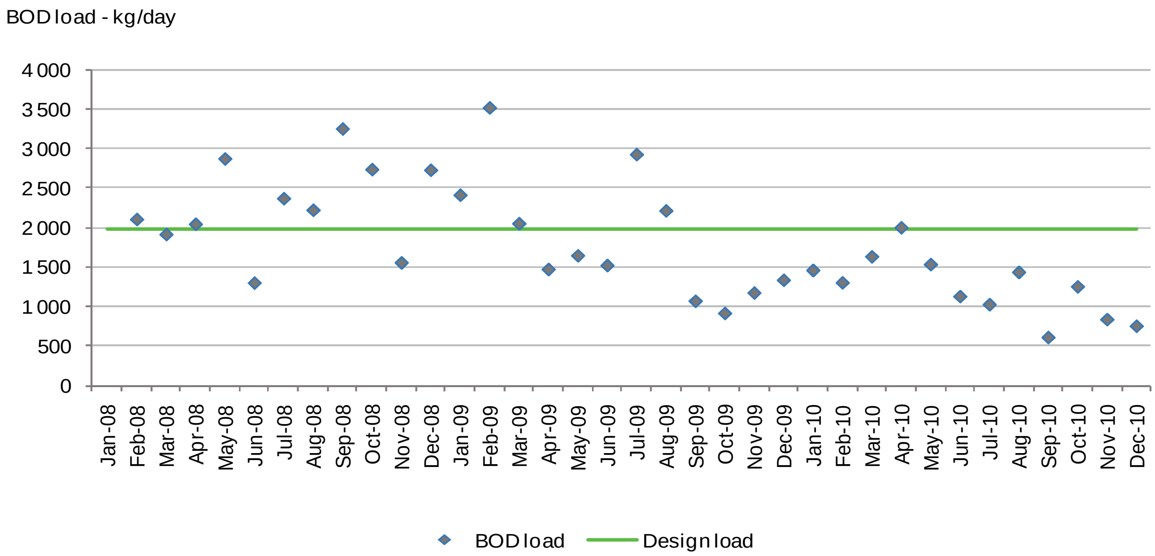


Figure 3.4-5: Variation of the affluent BOD load between 2008 and 2010 and the design load

The analytical results of the treated effluent reveal a very high efficiency in decomposing the biodegradable organic matter, higher than 95%, which guarantees the value of 30 mg/L O_2 imposed to BOD by the legislation in force. Nevertheless, during the period of analysis, some cases of non-compliance with the limit value are recorded, possibly justified by the fact that the organic load which reached the WwTP in these days is significantly greater than that permitted by the plant design. It is also possible to state that the limit imposed by the legislation referring to COD (90 mg/L O_2) is often exceeded.

The relation obtained between the organic matter and nutrients (BOD:N:P), being lower than the relation of reference of 100:5:1, shows good equilibrium conditions for the development of bacterial biomass. Also, a relation of BOD/N higher than 3.5 is compatible with the biological removal of nitrogen.

The wastewater to be treated presents urban and industrial characteristics, therefore the BOD/COD relation values are within the interval of 0.3 – 0.8. Therefore, we can infer that such an effluent has a biodegradation compatible with the generality of biological treatments.

The visit to the WwTP of Medjez El-Bab made it possible to identify the following irregularities in the plant functioning, which should be solved in the short term:

- Several electromechanical equipment items, in particular the mechanical screen, are in a poor state of operation and repair;
- The existing infrastructure does not allow a good management of the sludge recycling and the purge of excess activated sludge, which negatively affects the biological treatment efficiency;
- On the secondary clarifier surface, it was possible to observe floating sludge, which indicates the occurrence of denitrification in this infrastructure, with loss for the settling of sludge and for the treated effluent quality;
- During winter, the drying beds capacity is not sufficient for the sludge dewatering. In order to solve this problem, the system is exploited without activated sludge extraction, which can negatively affect the biological treatment performance

With regard to the plant energy consumption, the annual operation reports indicate an average specific consumption of 0.30 kWh/m^3 of treated effluent in 2008, 0.43 kWh/m^3 in 2009 and 0.51 kWh/m^3 of treated effluent in 2010. The following table summarizes the values of energy consumption in the WwTP of Medjez El-Bab.

Table3.4-5: Energy consumption

Year	Value	Energy consumption (kWh/month)	Energy consumption indicator (kWh/m^3)
2008	Minimum	25,333	0.30
	Medium	27,622	
	Maximum	29,555	
2009	Minimum	27,776	0.43
	Medium	35,018	
	Maximum	45,178	
2010	Minimum	25,778	0.51
	Average	29,288	
	Maximum	32,570	

The following figure shows the variation in energy consumption during the period analyzed, being evident the increase in energy consumption during the summer months of 2009.

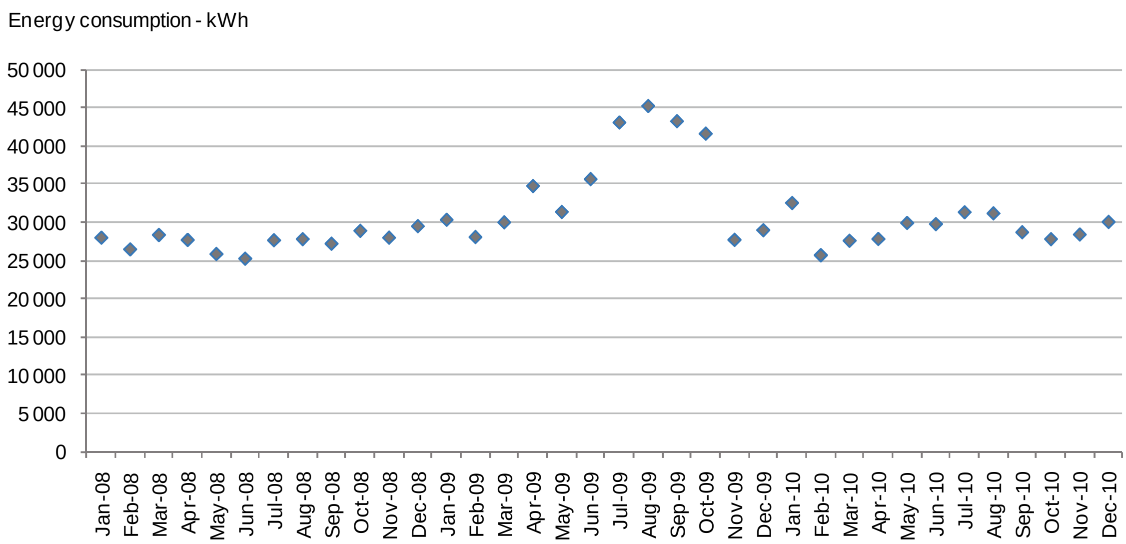


Figure 3.4-6: Variation of the energy consumption between 2008 and 2010

3.4.1.4 Greatest limitations found and the necessary actions

As for the WwTP of Béja, the greatest limitations found in the WwTP of Medjez El-Bab concern basically issues such as the accumulation of grit in the treatment tanks, the aeration of the tanks, the biological removal of nitrogen, the management of the sludge recycling system, the excess sludge purging and the sludge dewatering during winter. The organic influent to the WwTP, which is often higher than the WwTP design load, is also a concern.

Accumulation of grit

The wastewater presents a high quantity of grit which is not eliminated in the existing aerated grit and grease chamber, found in the sediments of the aeration tanks. In order to resolve this problem, a proposal has been made to build a grit retention chamber upstream from the headwork that will act as a complement to the aerated grit and grease chamber.

Affluent organic load

As mentioned previously, the organic load affluent to the WwTP already exceeded in some cases the plant design admissible load. Therefore, it is admitted that both existing treatment lines should be brought into service. On the other hand, the need for expanding the plant treatment capacity will be assessed.

Aeration of the tanks

The height of the water in the aeration tanks (5.07 m) is higher than the recommended height for the good efficiency of the surface aerators. For all the reasons mentioned in Chapter 2.1-4 (namely the production of aerosols by the surface aerators and their lower efficiency compared with the submersible systems), the replacement of the surface aerators by the air blowing system with fine bubbles is recommended. This system includes blowers with variable speed, air ducts and diffusers (tubular or disc). The blowers must be provided with a protection against noise and they must be installed in a building equipped with an overhead travelling crane and forced ventilation.

Biological nitrogen removal

The Tunisian standard NT 106.02 imposes limits for nitrate, nitrite, organic nitrogen and ammonia, which can be achieved by means of a biological treatment.

Thus, the existing reactors need to be modified to adapt them to the nitrogen biological removal, i.e., it is necessary to size the anoxia volume and to install nitrate recycling pumps (with frequency variation) for the nitrate recycling from the last basin to the first, including the installation of an electromagnetic flow meter on the recycle pipe.

Disinfection

As mentioned, the Tunisian standard NT 106.02 prescribes the achievement of 2,000/100 mL of fecal coliforms and 1,000/100 mL of fecal streptococci for the maritime and hydraulic public domain and, as such, implies the integration of a final stage for the effluent disinfection, independently of the uses associated with the receiving water.

It is thus necessary to implement a new stage of disinfection which will consist of a disinfection system via ultraviolet radiation, being served upstream by an operation of filtration in order to guarantee the necessary water transmittance so that an efficient radiation distribution is ensured.

Sludge recycle and excess activated sludge purge

As for the WwTP of Béja, the flow partition for the biological sludge recycle and the excess activated sludge purge is carried out manually with a partition valve, without precision, which negatively affects the biological treatment.

In order to solve this problem, the construction of one biological sludge pumping stations equipped with submersible pumps for the excess sludge extraction to the thickener and the sludge recycling to the aeration tanks upstream is planned.

Sludge dewatering

During winter, the existing drying beds do not have sufficient capacity for dewatering the thickened sludge. In order to solve this problem, the sludge dewatering should be carried out by mechanical equipment, such as a filter band or a decanter centrifuge, with the addition of polyelectrolyte.

Condition and operation of electromechanical equipment

A big flood (in 2003) submerged a lot of mechanical and electrical equipment. This forced the replacement of equipment, namely the major electrical cupboards, which were moved to the control room in the first floor of the main building.

The installation of equipment underground presents advantages to prevent high temperatures when working; however it has to be completed with a solution against floods or rain water intrusion as well as with good water drainage of these underground facilities.

In general, the electromechanical equipment is reasonably well maintained, judging by its working condition. ONAS said to have a preventive maintenance plan, which incorporates the lubrication frequency and the planning of spare parts replacement.

As for the maintenance working procedure, it was mentioned that a small stock of spare parts is kept, and that there are no major difficulties for parts acquisition in the market. Some equipment has to be ordered and the delivery time is approximately one month. However, it was stated that this never puts at risk the plant functioning.

Additionally, some cases of degradation and malfunctioning were referred. For instance, the screening device at the inlet needed some repair in order to prevent screens from falling out of the device and the scrapper of the grit and grease removal operation suffers from some deviation on the longitudinal movement.

Automation could be increased by installing additional measurement probes (for instance, oxygen measurement in the biological reactor) and focusing on its integration between instrumentation and operation of mechanical equipment.

To complement this information, a table with the main comments on the WwTP electromechanical equipment is presented in Annex III (Annex III.3).

3.4.2 Design data

3.4.2.1 Planning year of the project

The planning year of this study is 2029, assuming 2016 as the investment year and 2019 as the first year of operation.

3.4.2.2 Quantitative and qualitative characteristics of the foreseen effluent

According to the annual operation report of 2009 provided by ONAS, the industrial population connected to the WwTP of Medjez el-Bab was 2,681 inhabitants equivalent. ONAS stated that there is a plan to build a new industrial park in the district, with a total surface of 110 ha, that will be connected to the WwTP.

The calculations indicate that the maximal flow into the installation will be 445 m^3/h during periods of rainfall. Nonetheless, the maximal flow into the wastewater treatment plant will be imposed by the capacity of the existing Archimedes' Screw, P1 (180 m^3/h) and P2 (360 m^3/h), i.e. a total of 540 m^3/h.

The summary of the quantitative and qualitative classification of the wastewater to be treated is presented in Annex III (Annex III.3, Table III.3.2.1).

Table 3.4-6: Estimate of the characteristics of the raw wastewater

Parameter	Unit	2011	2029
Population			
Domestic	inhabitants	20,113	24,644
Industrial	EH	2,681	14,948
Tourism	beds	-	-
Total	EH	22,794	39,592
Average daily flow	m^3/d	2,391	5,429
	L/s	27.7	62.8
Infiltration flow	m^3/d	796	1,274
	L/s	9.2	14.8
Average daily flow + infiltration	m^3/d	3,187	6,703
	L/s	36.9	77.6
Peak flow	m^3/h	196	445
	L/s	54.3	123.7
Maximum design flow	m^3/h	540	540
	L/s	150	150
Pollutant loads			
TSS	kg/d	1,971	3,115
BOD_5	kg/d	1,368	2,376
COD	kg/d	2,816	5,199
TN	kg/d	211	474
TP	kg/d	34	59
Fecal coliforms (FC)	NMP/d	2.0×10^{15}	2.5×10^{15}
Concentrations (without infiltration flow)			
TSS	mg/L	824	574
BOD_5	mg/L	572	438
COD	mg/L	1,177	958
TN	mg/L	88	87
TP	mg/L	14	11
Fecal coliforms (FC)	NMP/100mL	8.4×10^{7}	4.5×10^{7}

3.4.2.3 Legislative framework relating to the quality of the receiving water and required quality for the treated effluent

The water treated in the WwTP of Medjez El-Bab is rejected to the Wadi Medjerda, downstream of the dam of Sidi Salem.

No other uses are known for the receiving water which would require a treatment level more advanced than the one specified in the legislation applicable and in force, especially NT 106.02 presented in Table 1.3-4 of Chapter I, for discharge into receiving water.

According to the information provided by ONAS, only one small fraction of treated water is reused for cleaning the facility and the complementary watering of 120 ha of agricultural farming, therefore it is necessary to strengthen the disinfection of this fraction of treated water.

3.4.2.4 Legislative framework concerning the final destination of sludge

The wastewater, which is treated in the WwTP of Medjez el-Bab, presents characteristics that are definitely domestic; therefore it is expected that the wastewater does not contain heavy metals or other harmful elements for the application of sludge in agriculture. In this case, it is assumed that treated sludge complies with all the provisions of existing legislation (see Chapter I, 1.3.3.3.3) and can be recovered for agriculture.

3.4.3 Eligible solutions of rehabilitation and extension

3.4.3.1 General considerations

For rehabilitation of the Medjez el-Bab treatment plant, three alternative solutions have been identified; they are considered to be the most appropriate, since they adapt well to the available site and make it possible to integrate the majority of the existing structures.

We also admit the possibility that the biological treatment will be carried out using a free culture process in extended aeration or conventional aeration variants.

The three solutions to be studied will be as follows:

- Solution 1 – activated sludge in extended aeration mode;
- Solution 2 – activated sludge in conventional aeration with mesophilic anaerobic digestion of the sludge and energy recovery of the biogas;
- Solution 3 – activated sludge in conventional aeration with mesophilic anaerobic digestion of the sludge and incineration of the excess biogas.

For all the three solutions, the replacement of the surface aerators by the diffused air system, the installation of the internal nitrate recycling system, the construction of pumping stations for the sludge recycle and excess sludge extraction, the installation of a system of pathogenic microorganisms removal (final disinfection) via ultraviolet radiation and the construction of a new stage for thickened sludge mechanical dewatering, as a complement or as an alternative to the existing drying beds, will also take place.

As requested by ONAS, there will also be odor treatment of the structures and of the buildings associated with emission of the odors.

In relation to safety conditions for the workers of the wastewater treatment plant, we recommend installation of a hand rail around all the structures that have a liquid depth of more than 1 m, in particular: the aerated grit and grease chamber, biological reactors (in addition to the existing rails), clarifiers, thickeners, *etc*.

The description of the treatment lines, the advantages and disadvantages for each of these biological treatment systems are presented in the following chapters. The main design criteria, the operations that could integrate the treatment lines, as well as the operational conditions are presented in Annex III (Annex III.3).

The treatment schemes of each studied solution are presented in Annex III (Annex III.7).

Note about floods:

Although some electrical appliances such as control panels have been refurbished in the upper floors after the flood of 2003, some equipment is still below the water level if a ten-year flood occurs as in 2003.

This problem should not be considered directly related to the existing STEP but as a matter of flood control at the regional level. Thus, the proposed solution must correspond to the regional policy of flood management.

A detailed review of the provision of electrical appliances, such as cables, connection boxes, etc., should be taken to the stage of the DD, by taking into account the maximum level of the historical flood (currently being identified). The result will be included in the technical specifications for construction.

3.4.3.2 Solution 1

3.4.3.2.1 Detailed description of the treatment sequence – design and criteria

For Solution 1, the rehabilitation of the WwTP according to the same existing treatment process, i.e., activated sludge in extended aeration regime, will be studied.

It has been ascertained that the available biological volume is sufficient for the biological treatment of affluent wastewater in extended aeration regime in the project planning year, but the operation mass loading rate (0.107 kg BOD/kg MLSS/day) is close to the higher limit of the acceptable F/M range for the extended aeration (0.04 – 0.12 kg BOD/kg MLSS/day).

The WwTP maximum inflow has not changed, because it is imposed by the capacity of the two existing Archimedean screws; therefore the hydraulic capacity of the WwTP remains the same. Consequently, it is not necessary to increase the grit and grease removal infrastructure or the secondary settling tanks.

The construction of a biological sludge pumping station (common to both treatment lines) is planned, provided with submersible pumps for the pumping up sludge in excess into the thickener and sludge recycling into the aeration tanks upstream. The sludge recycling pumps must allow the pumping of a flow between 50% and 150% of the average daily flow affluent to the WwTP. In order to facilitate the sludge management control, the pumps will be provided with variable speed and electromagnetic flow meters will be installed in the circuit rising mains.

Downstream of the secondary clarifier, a tertiary treatment stage is planned, aiming at the reduction of the bacteriological load in order to fulfill the requirements of the standard NT 106.02, by means of a filtration followed by UV disinfection.

As for the thickening stage, the solids loading rate and the hydraulic loading rates are not exceeded; therefore it is not necessary to enlarge the existing thickeners.

The pre-design calculations indicate that the 14 existing drying beds do not have the capacity to dewater the thickened sludge. This problem can be solved using the sludge mechanical dewatering by means of the decanter centrifuge machine. Storing sludge is recommended prior to dewatering with capacity for three days of production, in order to cope with an eventual equipment failure. The addition on line of a polyelectrolyte solution to the sludge to be dewatered is planned. On the other hand, the dewatered sludge will be stored in containers that will be a driving regularization for sending it to their final destination.

The treatment line of Solution 1 for the rehabilitation of the WwTP of Medjez el-Bab presents the following stages:

- Preliminary treatment
    - Grit retention in tank (new);
    - Water rising by 2 Archimedean screws (existing);
    - Screening consisting of 1 mechanical bar screen in parallel, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
    - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);
    - Flow measurement in a Venturi channel using an ultrasonic level meter (existing);
- Biological treatment
    - Oxidation of the organic matter in 2 treatment lines, each one with 3 aeration tanks (existing) aerated by a new air diffused system supplied by blowers equipped with variable speed (new);
    - Settling of sludge in 2 secondary rectangular plant clarifiers, equipped with a suction scraper bridge (existing);
    - Sludge directing for a pumping station (new);
    - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
    - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (new);
- Tertiary treatment
    - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
    - Chemical precipitation of phosphorus with aluminum sulfate dosing;
    - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
    - Excess activated sludge thickening in 1 thickener of square plant, equipped with

a scraper bridge (existing);

  - Temporary storage of the thickened sludge in a tank upstream of the dewatering (new);
  - Dewatering of the thickened sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
  - Storage of dewatered sludge in containers (new);
  - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are returned through a pumping station to the biological treatment facility;

- Treatment of odors
  - Treatment of the contaminated air, extracted from the grit retention chambers, from the preliminary treatment building, thickeners, thickened sludge storage tank and from the dewatering building using a biofilter (new).

3.4.3.2.2 Energy report

The average electricity consumptions (solution 1, planning year) are presented in Annex (see Annex III, Annex III.3).

3.4.3.2.3 Consumption of chemical reagents

The chemical reagents consumed in the wastewater treatment process are aluminium sulfate and polyelectrolyte. The quantities of chemical reagents consumed between year zero and the planning year are presented in Annex III.3 (at the end).

3.4.3.2.4 Management of by-products

The quantities of by-products resulting from of the wastewater treatment process, in particular solid waste, grit, grease and sludge, are presented in Annex III.3. (at the end)

3.4.3.2.5 Equipment

In general, the electromechanical equipment items present a high level of maintenance, if one takes into consideration their working conditions and maintenance level. Furthermore, certain cases of degradation and malfunctioning of equipment items have been noted.

The following table summarizes the solutions proposed in terms of replacement of the existing equipment items in the Medjez El Bab wastewater treatment plant, in the framework of solution 1. For a fuller understanding of the following comments, it is necessary to view the treatment scheme of the solution attached to the report.

Table 3.4-7: Electro-mechanical equipment, instruments and electrical installations

Designation	Diagnosis	Proposed solution	Characteristics
Preliminary treatment			
Grit extraction system by "air-lift"	The wastewater includes a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber.	We propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber. Grit extraction will be achieved via an "air-lift" system.	Estimated extraction flow rate = 18 m3/h
Archimedes screw n°1	The Archimedes screws are operational. They present a high level of corrosion in their thread. The motor and the speed reducer are in a poor state of conservation.	The demonstrated state of degradation justifies their replacement.	Flow = 180 m3/h Height ≈ 3.5 mce(meters of water columns)
Archimedes screw n°2	The Archimedes screws are operational. They present a high level of corrosion in their thread.	Replacement is not judged to be necessary.	Flow = 360 m3/h Height ≈ 3.5 mce(meters of water columns)
Mechanical multi-rake bar screen	The mechanical screen presents widespread corrosion in stainless steel. The occurrence of frequent breakdowns was reported to the consulting team	The demonstrated state of degradation justifies their replacement.	Maximum flow = 540 m3/h Spacing between bars = 6 mm
Measurement of the difference in water level (screening)	The electrical material and measurement instruments were upgraded in 2007. Automation should be improved, in particular in terms of integration between measurement of the level and operation of the mechanical screen.	Replacement is not judged to be necessary Measurement by an ultrasonic level meter.	
Belt conveyor	The paintwork is a bit degraded and altered in certain places; nonetheless we can affirm that the equipment seems to be sufficiently painted in order to avoid further corrosion.	Replacement is not judged to be necessary	Estimated volumetric flow rate of screenings = 0.2 m3/d

Designation	Diagnosis	Proposed solution	Characteristics
Scraper bridge (grit and grease extraction in a double aerated channel)	The scraper bridge has a deviation in its longitudinal movement. The wheels of the scraper bridge present a high level of degradation. The paintwork is a bit degraded and altered in certain places.	The demonstrated state of degradation justifies their replacement.	Installed in the existing work
Grit pumps (grit and grease extraction in a double aerated channel)	The occurrence of frequent breakdowns was reported to the consulting team	We recommend the replacement of the equipment items. There are two pumps per scraper bridge.	Estimated flow for each pump = 18 m3/h.
Grit classifier (grit and grease extraction in a double aerated channel)	The grit classifier on the scraper bridge does not operate correctly. Furthermore, the occurrence of frequent breakdowns of the scraper bridge was indicated to the consulting team.	The grit classification operation must be improved with installation of specialized equipment for this function. The equipment will be installed on the scraper bridge.	Estimated total capacity = 20 m3/h.
Compressors (grit and grease extraction in a double aerated channel)	The compressors present a certain level of degradation; they are dirty and covered in dust.	We recommend ensuring that the equipment items are maintained at a satisfactory level. There are three compressors for the double channel: 2+1.	Estimated volumetric flow rate of air for each compressor = 162 m3/h
Grease removal via a screw conveyor (grit and grease extraction in a double aerated channel)	The grease pumping circuit is out of service. The consulting team was informed that the circuit was immediately blocked after the start-up of the installation and was then abandoned.	Grease removal will be implemented via a screw conveyor installed in the grease tank.	Estimated volumetric flow rate of grease = 29 m3/d
Measurement of effluent flow	The electrical material and measurement instruments were upgraded in 2007. Measurement is made by an ultrasonic level meter.	Replacement is not judged to be necessary.	

Designation	Diagnosis	Proposed solution	Characteristics
Secondary or biological treatment			
Aeration	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor. Also, in order to maximize the volume of the existing reaction it is necessary to implement a more effective aeration method. The tanks are too deep in order to obtain maximum performance of the existing surface aerators.	We recommend replacement of the surface aerators by a fine bubble aeration system. This system includes compressors endowed with speed variation, air ducts and diffusers installed in the tanks. There are three compressors: 2+1; one compressor for each line.	Estimated volumetric flow rate of air for each compressor = 3,202 m3/h.
Oxygen measurement (aeration tank)	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor.	We recommend installation of a programmable automation controller that permits integration of oxygen measurements with the aeration operation.	
Mixing	The submersible mixers are not in a good state of conservation.	Replacement is judged to be necessary.	Installed in the existing tanks and in an identical number to the existing items.
Scraper bridges (secondary clarifiers)	The scraper bridges are not in a good state of conservation. In the framework of this solution, it is necessary to add a scraper bridge to the new line.	Their complete replacement is judged to be necessary.	
Biological sludge lift pumps (secondary clarifiers)	The pumps are in a reasonable state of conservation given their working conditions.	Replacement is not judged to be necessary. There are two pumps per scraper bridge.	Estimated flow for each pump = 182 m3/h.
Sludge recirculation pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process.	We recommend the construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks.	Estimated flow for each pump = 359 m3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Measurement of the flow of sludge recirculation	No measurement of the sludge recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Excess sludge extraction pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process.	We recommend the construction of a biological sludge pumping station equipped with submersible pumps for elevation for elevation of the excess sludge towards the thickener.	Estimated flow for each pump = 18 m3/h.
Measurement of the flow of excess sludge	No measurement of the excess sludge exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 80 mm
Tertiary treatment			
Nitrate recirculation pump	The Tunisian norm NT106.02 sets maximum limits for nitrate, nitrite, organic and ammoniacal nitrogen. Hence, it is necessary to modify the existing reactors to adapt them for biological elimination of nitrogen.	It is necessary to install submersible pumps (with frequency variation) for nitrate recirculation, in the existing aeration tanks - from the last aeration tank to the first	Estimated flow for each pump = 359 m3/h.
Measurement of the flow of nitrate recirculation	No measurement of the nitrate recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Dosing pump of aluminium sulfate and dosing circuit	Chemical precipitation of phosphorus with dosing of aluminium sulfate	We recommend a dosing circuit with dosing tank, retention chamber, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Estimated flow for each pump = 92 L/h.
Disinfection	The Tunisian norm NT 106.02 obliges observance of 2000/100 ml of fecal coliforms and 1000/100 ml of fecal streptococci in order to guarantee the microbiological quality of the public water supply.	Disinfection by ultraviolet radiation implemented upstream by the filtration operation via multicellular vertical feeding pumps linked to the filters, self-cleaning pressure filters and an ultraviolet radiation system in the open channel.	Maximum flow = 540 m3/h

Designation	Diagnosis	Proposed solution	Characteristics
Treatment of the sludge			
Scraper bridge (thickener)	The paintwork of the existing scraper bridge is a bit degraded and altered in certain places.	Complete replacement is not necessary. It is necessary to consider application of a new layer of paint. There is a scraper bridge in service.	
Thickened sludge pumps	The sludge pump (which lifts the sludge to the thickened sludge storage tank or to the sludge drying beds) presents a high level of deterioration. The sludge pump and the motor seem to be beyond repair.	In the framework of renovation of the WwTP it will be necessary to replace this pump. We recommend an excentric screw pump.	Estimated flow per pump = 21 m3/h.
Submersible mixer (thickened sludge storage tank)	In the framework of renovation of the WwTP, we propose temporary storage of the thickened sludge in a tank upstream of the dewatering stage.	It is necessary to install a submersible mixer in order to avoid sedimentation of the sludge.	-
Lift pump to raise the thickened sludge to the centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend an excentric screw pump.	Estimated flow per pump = 21 m3/h.
Centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of an equipment item.	Capacity estimated = 21 m3/h.
Polymer preparation equipment	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of fully automatic continuous polymer solution preparation equipment. Dosing tank, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Capacity 1,000 L/h.
Polymer dosing pump	-	Membrane dosing pumps	Estimated flow per pump = 0.8 m3/h.
Lifting the dewatered sludge		The dewatered sludge will be lifted via a screw conveyor.	Estimated volumetric flow rate of the dewatered sludge = 18 m3/d

Designation	Diagnosis	Proposed solution	Characteristics
Treatment of odors			
Contaminated air treatment system	We propose to extract the contaminated air from the grit retention tank, preliminary treatment building, thickener, thickened sludge storage tank and dewatering building	The contaminated air will be deodorized via a bio filter and a piping circuit and fan	
Electrical installations			
MV-LV transformation station	In the framework of the intervention proposed for the wastewater treatment plant, this equipment item should be renovated.	We recommend the replacement of this equipment item.	
Low voltage cupboard	In the framework of the intervention proposed for the wastewater treatment plant, this equipment item should be renovated.	We recommend the replacement of this equipment item.	
Command station with master control panel	In the framework of the intervention proposed for the wastewater treatment plant, these equipment items should be renovated.	We recommend installation of a programmable automation controller that permits integration between the measurement instruments and operation of the mechanical equipment.	

3.4.3.3 Solution 2

3.4.3.3.1 Detailed description of the treatment sequence – design and criteria

Solution 2 integrates the biological treatment by activated sludge in conventional aeration, with sludge anaerobic digestion and biogas energy recovery. The treatment line integrates new facilities, the primary treatment equipment and the sludge mesophilic anaerobic stabilization, namely anaerobic digester, gasholder, flare, equipment for biogas treatment, motor generators, boiler and heat exchanger. This solution integrates a high number of operations; therefore the complexity of operation and maintenance is remarkable. In order to overcome this difficulty, the operators must be specially trained for operating the new equipment. On the other hand, this is an advantageous solution concerning energy consumption, considering the lower power consumption relating to the extended aeration systems and the possibility to recover energy from the produced biogas.

The design that has been carried out revealed that the biological volume of only one treatment line is sufficient for the biological treatment, in the conventional aeration mode, of the wastewater affluent in the project planning year. Because of the greatest production of sludge, it is necessary to build a second thickener with the characteristics of the existing thickeners.

As mentioned for Solution 1, the maximum inflow estimated is lower than the design flow of the existing facilities, and therefore the capacity of the grit and grease removal operation and the secondary settling is sufficient. The topographical survey indicates that the hydraulic profile of the wastewater treatment plant permits inclusion of a primary settling operation between the aerated grit and grease chamber and the aeration tanks.

The treatment line of Solution 2 for the rehabilitation of the WwTP of Medjez el-Bab includes the following stages:

- Preliminary treatment
    - Grit retention in tank (new);
    - Water rising by 2 Archimedean screws (existing);
    - Screening consisting of 1 mechanical bar screen in parallel, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
    - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);
    - Flow measurement in a Venturi channel using an ultrasonic level meter (existing);
- Primary treatment
    - Primary settling in 2 rectangular plant clarifiers, with bottom and surface scrapers bridge (new);
    - Extraction of floating residue towards the thickeners (new);
    - Extraction of primary sludge for the thickeners (new);
- Biological treatment
    - Oxidation of the organic matter in 2 treatment lines, each one with 3 aeration

tanks (existing), aerated by a new air diffused system supplied by blowers equipped with variable speed (new);

- Settling of sludge in 2 secondary rectangular plant clarifiers, equipped with a suction scraper bridge (existing);
- Sludge directing for the pumping station (new);
- Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
- Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (new);

- Tertiary treatment
  - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
  - Chemical precipitation of phosphorus with aluminum sulfate dosing;
  - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
  - Thickening of the primary sludge, excess sludge and physicochemical sludge, in 2 thickeners of square plant, with scraper bridge (1 existing and 1 new);
  - Mesophilic anaerobic stabilization of thickened sludge (new);
  - Storage of biogas in a gasholder (new);
  - Biogas energy recovery by a motor generator with production of thermal and electrical energy (new);
  - Heating of sludge in digestion with heat produced by cogeneration (new);
  - Burning the biogas in excess and the bad quality biogas in the flare (new);
  - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
  - Storage of dewatered sludge in containers (new);
  - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility (new).
- Treatment of odors
  - Treatment of the contaminated air, extracted from the grit retention chambers, from the preliminary treatment building, thickeners and from the dewatering building using a biofilter (new).

3.4.3.3.2 Energy report

The average electricity consumptions (solution 2, planning year) are presented in Annex (see Annex III, Annex III.3) (at the end).

3.4.3.3.3 Consumption of chemical reagents

The chemical reagents consumed in the wastewater treatment process are aluminium sulfate and polyelectrolyte. The quantities of chemical reagents consumed between year zero and the planning year are presented in Annex III.3 (at the end).

3.4.3.3.4 Management of by-products

The quantities of by-products resulting from of the wastewater treatment process, in particular solid waste, grit, grease and sludge, are presented in Annex III.3.

3.4.3.3.5 Equipment

The following table summarizes the solutions proposed in terms of replacement of the existing equipment items in the Medjez El Bab wastewater treatment plant, in the framework of solution 2. For a fuller understanding of the comments, it is necessary to view the treatment scheme of the solution attached to the report.

Table 3.4-8: Electro-mechanical equipment, instruments and electrical installations

Designation	Diagnosis	Proposed solution	Characteristics
Preliminary treatment			
Grit extraction system by “air-lift”	The wastewater includes a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber.	We propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber. Grit extraction will be achieved via an “air-lift” system.	Estimated extraction flow rate = 18 m3/h
Archimedes screw n°1	The Archimedes screw is operational. It presents a high level of corrosion in the thread. The motor and the speed reducer are in a poor state of conservation.	The demonstrated state of degradation justifies their replacement.	Flow = 180 m3/h Height ≈ 3.5 mce(meters of water columns)
Archimedes screw n°2	The Archimedes screw is operational. It presents a high level of corrosion in the thread.	Replacement is not judged to be necessary.	Flow = 360 m3/h Height ≈ 3.5 mce(meters of water columns)
Mechanical multi-rake bar screen	The mechanical screen presents a widespread corrosion in stainless steel. Moreover, The occurrence of frequent breakdowns was reported to the consulting team	The demonstrated state of degradation justifies their replacement.	Maximum flow = 540 m3/h Spacing between bars = 6 mm
Measurement of the difference in water level (screening)	The electrical material and measurement instruments were upgraded in 2007. Automation should be improved, in particular in terms of integration between measurement of the level and operation of the mechanical screen.	Replacement is not judged to be necessary. Measurement by an ultrasonic level meter.	
Belt conveyor	The paintwork is a bit degraded and altered in certain places; nonetheless we can affirm that the equipment seems to be sufficiently painted in order to avoid further corrosion.	Replacement is not judged to be necessary.	Estimated volumetric flow rate of screenings = 0.2 m3/d

Designation	Diagnosis	Proposed solution	Characteristics
Scraper bridge (grit and grease extraction in a double aerated channel)	The scraper bridge has a deviation in its longitudinal movement. The wheels of the scraper bridge present a high level of degradation. The paintwork is a bit degraded and altered in certain places.	The demonstrated state of degradation justifies their replacement.	Installed in the existing work
Grit pumps (grit and grease extraction in a double aerated channel)	Moreover, The occurrence of frequent breakdowns was reported to the consulting team	We recommend the replacement of the equipment items. There are two pumps per scraper bridge.	Estimated flow for each pump = 18 m3/h.
Grit classifier (grit and grease extraction in a double aerated channel)	The grit classifier on the scraper bridge does not operate correctly. Moreover, the occurrence of frequent breakdowns of the scraper bridge was indicated to the consulting team.	The grit classification operation must be improved with installation of specialized equipment for this function. The equipment will be installed on the scraper bridge.	Estimated total capacity = 20 m3/h.
Compressors (grit and grease extraction in a double aerated channel)	The compressors present a certain level of degradation; they are dirty and covered in dust.	We recommend the replacement of the equipment items. There are three compressors for the double channel: 2+1.	Estimated volumetric flow rate of air for each compressor = 162 m3/h
Grease removal via a screw conveyor (grit and grease extraction in a double aerated channel)	The grease pumping circuit is out of service. The consulting team was informed that the circuit was immediately blocked after the start-up of the installation and was then abandoned.	Grease removal will be implemented via a screw conveyor installed in the grease tank.	Estimated volumetric flow rate of grease = 29 m3/d
Measurement of effluent flow	The electrical material and measurement instruments were upgraded in 2007. Measurement is made by an ultrasonic level meter.	Replacement is not judged to be necessary.	

Designation	Diagnosis	Proposed solution	Characteristics
Primary treatment			
Scraper bridges (primary sedimentation tanks)	In the framework of this solution for renovation of the WwTP, we propose the existence of a primary treatment.	The scraper bridge is constituted by a mobile transversal beam that serves as a walkway, two lateral guides, an articulated system for collecting the sludge and discharging the scum, a motor reduction unit for activating the two lateral guides, a control unit of the articulated system of bottom scraper/scum blade and a command and control panel.	
Primary sludge lift pumps (primary sedimentation tanks)		It is necessary to install submersible pumps. There is one pump per scraper bridge.	Estimated flow for each pump = 18 m3/h.
Secondary or biological treatment			
Aeration	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor. Also, in order to maximize the volume of the existing reaction it is necessary to implement a more effective aeration method. The tanks are too deep in order to obtain maximum performance of the existing surface aerators.	We recommend replacement of the surface aerators by a fine bubble aeration system. This system includes compressors endowed with speed variation, air ducts and diffusers installed in the tanks. There are two compressors: 1+1; one compressor for each line.	Estimated volumetric flow rate of air for each compressor = 4,389 m3/h.
Oxygen measurement (aeration tank)	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor.	We recommend installation of a programmable automation controller that permits integration of oxygen measurements with the aeration operation.	
Mixing	The submersible mixers are not in a good state of conservation.	Replacement is judged to be necessary.	

Designation	Diagnosis	Proposed solution	Characteristics
Scraper bridges (secondary clarifiers)	The scraper bridges are not in a good state of conservation. In the framework of this solution, it is necessary to add a scraper bridge to the new line.	Their complete replacement is judged to be necessary.	Installed in the existing work. (There are two scraper bridges with two sedimentation tanks)
Biological sludge lift pumps (secondary clarifiers)	The pumps present are in a reasonable state of conservation, given their working conditions.	Replacement is not judged to be necessary There are two pumps per scraper bridge.	Estimated flow for each pump = 182 m3/h.
Sludge recirculation pump	The distribution of the flow to the biological sludge recirculation circuits and purging of the excess sludge is achieved manually using a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process	We recommend the construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks.	Estimated flow for each pump = 354 m3/h.
Measurement of the flow of sludge recirculation	No measurement of the sludge recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Excess sludge extraction pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process.	We recommend the construction of a biological sludge pumping station equipped with submersible pumps in order to lift the excess sludge towards the thickener.	Estimated flow for each pump = 18 m3/h.
Measurement of the flow of excess sludge	No measurement of the excess sludge exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 80 mm

Designation	Diagnosis	Proposed solution	Characteristics
Tertiary treatment			
Nitrate recirculation pump	The Tunisian norm NT106.02 sets maximum limits for nitrate, nitrite, organic and ammoniacal nitrogen. Hence, it is necessary to modify the existing reactors to adapt them for biological elimination of nitrogen.	It is necessary to install submersible pumps (with frequency variation) for nitrate recirculation, in the existing aeration tanks - from the last aeration tank to the first	Estimated flow for each pump = 709 m3/h.
Measurement of the flow of nitrate recirculation	No measurement of the nitrate recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Dosing pump of aluminium sulfate and dosing circuit	Chemical precipitation of phosphorus with dosing of aluminium sulfate	We recommend a dosing circuit with dosing tank, retention chamber, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Estimated flow for each pump = 91 L/h.
Disinfection	The Tunisian norm NT 106.02 obliges observance of 2000/100 ml of fecal coliforms and 1000/100 ml of fecal streptococci in order to guarantee the microbiological quality of the public water supply.	Disinfection by ultraviolet radiation implemented upstream by the filtration operation via multicellular vertical feeding pumps linked to the filters, self-cleaning pressure filters and an ultraviolet radiation system in the open channel.	Maximum flow = 540 m3/h
Treatment of the sludge			
Scraper bridge (existing thickener)	The paintwork of the scraper bridge is a bit degraded and altered in certain places. In the framework of this solution for renovation of the WwTP, we propose the construction of another thickener.	Their complete replacement is not judged to be necessary. It is necessary to consider application of a new layer of paint.	The new thickener will be square-shaped like the existing one.
Thickened sludge pumps	In the framework of this solution, the pump that lifts sludge towards the digesters or to the sludge drying beds will be replaced.	In the framework of renovation of the WwTP it will be necessary to replace these pumps and to add another because of the new thickener. We recommend an excentric screw pump. There is one pump for each thickener.	Estimated flow per pump = 18 m3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Anaerobic digestion of the sludge	In the framework of this solution for renovation of the WwTP, we propose mesophilic anaerobic stabilization of the thickened sludge.	The anaerobic digestion of the sludge will be implemented using the digesters, agitation of the digesters via the Sludge recirculation pumps, pumps for the sludge heating circuit during digestion, gasholder and torch.	
Sludge heating system during digestion	For mesophilic anaerobic stabilization of the thickened sludge, it is necessary to foresee a sludge heating system during digestion.	We always recommend the use of a boiler and a hot water tank with recirculation pumps for these circuits.	The boiler must work with natural gas and biogas
Cogeneration	The cogeneration system enables energy use of the biogas produced and also heating of the sludge during digestion with the heat produced by the motor-generator.	In addition to the sludge heating system during digestion using the boiler, we propose a cogeneration system constituted by elements such as the biogas-driven motor-generator.	
Lift pump of the digested sludge to the centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer.	We recommend an excentric screw pump.	Estimated flow per pump = 23 m3/h.
Centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer	-	Capacity 23 m3/h.
Polymer preparation equipment	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer	We recommend installation of fully automatic continuous polymer solution preparation equipment. Dosing tank, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Capacity 1,000 L/h.
Polymer dosing pump	-	Membrane dosing pumps	Estimated flow per pump = 0.8 m3/h.
Lifting the dewatered sludge		The dewatered sludge will be lifted via a screw conveyor.	Estimated volumetric flow rate of the dewatered sludge = 18 m3/d

Designation	Diagnosis	Proposed solution	Characteristics
Treatment of odors			
Treatment of the contaminated air	We propose to extract the contaminated air from the grit retention tank, preliminary treatment building, thickener and dewatering building	The contaminated air will be deodorized via a bio filter and a piping circuit and fan	-
Electrical installations			
MV-LV transformation station	In the framework of the intervention proposed for the wastewater treatment plant, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Low voltage cupboard	In the framework of the intervention proposed for the wastewater treatment plant, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Command station with master control panel	In the framework of the intervention proposed for the wastewater treatment plant, these equipment items should be renovated.	We recommend installation of a programmable automation controller that permits integration between the measurement instruments and operation of the mechanical equipment.	-

3.4.3.4 Solution 3

3.4.3.4.1 Detailed description of the treatment sequence – design and criteria

Solution 3 integrates the biological treatment by activated sludge in conventional aeration, with mesophilic anaerobic digestion of sludge. Biogas is frequently used as combustible for the boiler which provides the necessary power for the reheating of sludge. Biogas in excess will be incinerated in the flare.

The treatment line integrates the new facilities, the primary treatment equipment and the sludge mesophilic anaerobic stabilization, namely anaerobic digester, gasholder, flare, equipment for biogas treatment, motor generators, boiler and heat exchanger.

The treatment line of Solution 3 for the rehabilitation of the WwTP of Medjez el-Bab includes the following stages:

- Preliminary treatment
    - Grit retention in tank (new);
    - Water rising by 2 Archimedean screws (existing);
    - Screening consisting of 1 mechanical bar screen in parallel, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
    - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);
    - Flow measurement in a Venturi channel using an ultrasonic level meter (existing);
- Primary treatment
    - Primary settling in 2 rectangular plant clarifiers, with bottom and surface scrapers bridge (new);
    - Feeding of floats into the thickeners (new);
    - Extraction of primary sludge for the thickeners (new);
- Biological treatment
    - Oxidation of the organic matter in 1 treatment line, with 3 aeration tanks (existing) aerated by a new air diffused system supplied by blowers equipped with variable speed (new);
    - Settling of sludge in 2 secondary rectangular plant clarifiers, equipped with a suction scraper bridge (existing);
    - Sludge directing for the pumping station (new);
    - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
    - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (new);

- Tertiary treatment
    - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
    - Chemical precipitation of phosphorus with aluminum sulfate dosing;
    - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
    - Thickening of the primary sludge, excess sludge and physicochemical sludge, in 2 thickeners of square plant, with scraper bridge (1 existing and 1 new);
    - Mesophilic anaerobic stabilization of thickened sludge (new);
    - Storage of biogas in a gasholder (new);
    - Heating of sludge in digestion with heat produced by the boiler (new);
    - Burning the biogas in excess and the bad quality biogas in the flare (new);
    - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
    - Storage of dewatered sludge in containers (new);
    - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility;
- Odor treatment
    - Treatment of the contaminated air, extracted from the grit retention chambers, from the preliminary treatment building, thickeners and from the dewatering building using a biofilter (new).

3.4.3.4.2 Energy report

The average electricity consumptions (solution 3, planning year) are presented in Annex (see Annex III, Annex III.3).

3.4.3.4.3 Consumption of chemical reagents

The chemical reagents consumed in the wastewater treatment process are aluminium sulfate and polyelectrolyte. The quantities of chemical reagents consumed between year zero and the planning year are presented in Annex III.3 (at the end).

3.4.3.4.4 Management of by-products

The quantities of by-products resulting from of the wastewater treatment process, in particular solid waste, grit, grease and sludge, are presented in Annex III.3 (at the end)..

3.4.3.4.5 Equipment

The solution 3 includes the same treatment line as solution 2 except for cogeneration. As a result, all the considerations made for solution 2 concerning the existing equipment items and replacement needs, are also valid for this solution. For a fuller understanding of the comments, it is necessary to view the treatment scheme of the solution attached to the report.

Table 3.4-9: Electro-mechanical equipment, instruments and electrical installations

Designation	Diagnosis	Proposed solution	Characteristics
Preliminary treatment			
Grit extraction system by “air-lift”	The wastewater includes a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber.	We propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber. Grit extraction will be achieved via an “air-lift” system.	Estimated extraction flow rate = 18 m3/h
Archimedes screw n°1	The Archimedes screw is operational. It presents a high level of corrosion in the thread. The motor and the speed reducer are in a poor state of conservation.	The demonstrated state of degradation justifies their replacement.	Flow = 180 m3/h Height ≈ 3.5 mce(meters of water columns)
Archimedes screw n°2	The Archimedes screw is operational. It presents a high level of corrosion in the thread.	Replacement is not judged to be necessary.	Flow = 360 m3/h Height ≈ 3.5 mce(meters of water columns)
Mechanical multi-rake bar screen	The mechanical screen presents a widespread corrosion in stainless steel. Moreover, The occurrence of frequent breakdowns was reported to the consulting team	The demonstrated state of degradation justifies their replacement.	Maximum flow = 540 m3/h Spacing between bars = 6 mm
Measurement of the difference in water level (screening)	The electrical material and measurement instruments were upgraded in 2007. Automation should be improved, in particular in terms of integration between measurement of the level and operation of the mechanical screen.	Replacement is not judged to be necessary. Measurement by an ultrasonic level meter.	
Belt conveyor	The paintwork is a bit degraded and altered in certain places; nonetheless we can affirm that the equipment seems to be sufficiently painted in order to avoid further corrosion.	Replacement is not judged to be necessary.	Estimated volumetric flow rate of screenings = 0.2 m3/d

Designation	Diagnosis	Proposed solution	Characteristics
Scraper bridge (grit and grease extraction in a double aerated channel)	The scraper bridge has a deviation in its longitudinal movement. The wheels of the scraper bridge present a high level of degradation. The paintwork is a bit degraded and altered in certain places.	The demonstrated state of degradation justifies their replacement.	Installed in the existing work
Grit pumps (grit and grease extraction in a double aerated channel)	Moreover, The occurrence of frequent breakdowns was reported to the consulting team	We recommend the replacement of the equipment items. There are two pumps per scraper bridge.	Estimated flow for each pump = 18 m3/h.
Grit classifier (grit and grease extraction in a double aerated channel)	The grit classifier on the scraper bridge does not operate correctly. Moreover, the occurrence of frequent breakdowns of the scraper bridge was indicated to the consulting team.	The grit classification operation must be improved with installation of specialized equipment for this function. The equipment will be installed on the scraper bridge.	Estimated total capacity = 20 m3/h.
Compressors (grit and grease extraction in a double aerated channel)	The compressors present a certain level of degradation; they are dirty and covered in dust.	We recommend the replacement of the equipment items. There are three compressors for the double channel: 2+1.	Estimated volumetric flow rate of air for each compressor = 162 m3/h
Grease removal via a screw conveyor (grit and grease extraction in a double aerated channel)	The grease pumping circuit is out of service. The consulting team was informed that the circuit was immediately blocked after the start-up of the installation and was then abandoned.	Grease removal will be implemented via a screw conveyor installed in the grease tank.	Estimated volumetric flow rate of grease = 29 m3/d
Measurement of effluent flow	The electrical material and measurement instruments were upgraded in 2007. Measurement is made by an ultrasonic level meter.	Replacement is not judged to be necessary.	

Designation	Diagnosis	Proposed solution	Characteristics
Primary treatment			
Scraper bridges (primary sedimentation tanks)	In the framework of this solution for renovation of the WwTP, we propose the existence of a primary treatment.	The scraper bridge is constituted by a mobile transversal beam that serves as a walkway, two lateral guides, an articulated system for collecting the sludge and discharging the scum, a motor reduction unit for activating the two lateral guides, a control unit of the articulated system of bottom scraper/scum blade and a command and control panel.	
Primary sludge lift pumps (primary sedimentation tanks)		It is necessary to install submersible pumps. There is one pump per scraper bridge.	Estimated flow for each pump = 18 m3/h.
Secondary or biological treatment			
Aeration	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor. Also, in order to maximize the volume of the existing reaction it is necessary to implement a more effective aeration method. The tanks are too deep in order to obtain maximum performance of the existing surface aerators.	We recommend replacement of the surface aerators by a fine bubble aeration system. This system includes compressors endowed with speed variation, air ducts and diffusers installed in the tanks. There are two compressors: 1+1; one compressor for each line.	Estimated volumetric flow rate of air for each compressor = 4,389 m3/h.
Oxygen measurement (aeration tank)	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor.	We recommend installation of a programmable automation controller that permits integration of oxygen measurements with the aeration operation.	
Mixing	The submersible mixers are not in a good state of conservation.	Replacement is judged to be necessary.	

Designation	Diagnosis	Proposed solution	Characteristics
Scraper bridges (secondary clarifiers)	The scraper bridges are not in a good state of conservation. In the framework of this solution, it is necessary to add a scraper bridge to the new line.	Their complete replacement is judged to be necessary.	Installed in the existing work. (There are two scraper bridges with two sedimentation tanks)
Biological sludge lift pumps (secondary clarifiers)	The pumps present are in a reasonable state of conservation, given their working conditions.	Replacement is not judged to be necessary There are two pumps per scraper bridge.	Estimated flow for each pump = 182 m3/h.
Sludge recirculation pump	The distribution of the flow to the biological sludge recirculation circuits and purging of the excess sludge is achieved manually using a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process	We recommend the construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks.	Estimated flow for each pump = 354 m3/h.
Measurement of the flow of sludge recirculation	No measurement of the sludge recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Excess sludge extraction pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process.	We recommend the construction of a biological sludge pumping station equipped with submersible pumps in order to lift the excess sludge towards the thickener.	Estimated flow for each pump = 18 m3/h.
Measurement of the flow of excess sludge	No measurement of the excess sludge exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 80 mm

Designation	Diagnosis	Proposed solution	Characteristics
Tertiary treatment			
Nitrate recirculation pump	The Tunisian norm NT106.02 sets maximum limits for nitrate, nitrite, organic and ammoniacal nitrogen. Hence, it is necessary to modify the existing reactors to adapt them for biological elimination of nitrogen.	It is necessary to install submersible pumps (with frequency variation) for nitrate recirculation, in the existing aeration tanks - from the last aeration tank to the first	Estimated flow for each pump = 709 m3/h.
Measurement of the flow of nitrate recirculation	No measurement of the nitrate recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Dosing pump of aluminium sulfate and dosing circuit	Chemical precipitation of phosphorus with dosing of aluminium sulfate	We recommend a dosing circuit with dosing tank, retention chamber, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Estimated flow for each pump = 91 L/h.
Disinfection	The Tunisian norm NT 106.02 obliges observance of 2000/100 ml of fecal coliforms and 1000/100 ml of fecal streptococci in order to guarantee the microbiological quality of the public water supply.	Disinfection by ultraviolet radiation implemented upstream by the filtration operation via multicellular vertical feeding pumps linked to the filters, self-cleaning pressure filters and an ultraviolet radiation system in the open channel.	Maximum flow = 540 m3/h
Treatment of the sludge			
Scraper bridge (existing thickener)	The paintwork of the scraper bridge is a bit degraded and altered in certain places. In the framework of this solution for renovation of the WwTP, we propose the construction of another thickener.	Their complete replacement is not judged to be necessary. It is necessary to consider application of a new layer of paint.	The new thickener will be square-shaped like the existing one.
Thickened sludge pumps	In the framework of this solution, the pump that lifts sludge towards the digesters or to the sludge drying beds will be replaced.	In the framework of renovation of the WwTP it will be necessary to replace these pumps and to add another because of the new thickener. We recommend an excentric screw pump. There is one pump for each thickener.	Estimated flow per pump = 18 m3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Anaerobic digestion of the sludge	In the framework of this solution for renovation of the WwTP, we propose mesophilic anaerobic stabilization of the thickened sludge.	The anaerobic digestion of the sludge will be implemented using the digesters, agitation of the digesters via the Sludge recirculation pumps, pumps for the sludge heating circuit during digestion, gasholder and torch.	
Sludge heating system during digestion	For mesophilic anaerobic stabilization of the thickened sludge, it is necessary to foresee a sludge heating system during digestion.	We always recommend the use of a boiler and a hot water tank with recirculation pumps for these circuits.	The boiler must work with natural gas and biogas
Lift pump of the digested sludge to the centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer.	We recommend an excentric screw pump.	Estimated flow per pump = 23 m3/h.
Centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer	-	Capacity 23 m3/h.
Polymer preparation equipment	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer	We recommend installation of fully automatic continuous polymer solution preparation equipment. Dosing tank, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Capacity 1,000 L/h.
Polymer dosing pump	-	Membrane dosing pumps	Estimated flow per pump = 0.8 m3/h.
Lifting the dewatered sludge		The dewatered sludge will be lifted via a screw conveyor.	Estimated volumetric flow rate of the dewatered sludge = 18 m3/d
Treatment of odors			
Treatment of the contaminated air	We propose to extract the contaminated air from the grit retention tank, preliminary treatment building, thickener and dewatering building	The contaminated air will be deodorized via a bio filter and a piping circuit and fan	-

Designation	Diagnosis	Proposed solution	Characteristics
Electrical installations			
MV-LV transformation station	In the framework of the intervention proposed for the wastewater treatment plant, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Low voltage cupboard	In the framework of the intervention proposed for the wastewater treatment plant, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Command station with master control panel	In the framework of the intervention proposed for the wastewater treatment plant, these equipment items should be renovated.	We recommend installation of a programmable automation controller that permits integration between the measurement instruments and operation of the mechanical equipment.	-

3.4.4 Economic assessment

3.4.4.1 Investment costs

The estimate of the fixed capital investment costs associated with the civil engineering and equipment items is based on market consultations and information supplied by ONAS.

The following table presents a summary of the fixed capital investment costs associated with each treatment solution studied. Annex III.8 presents systematization of the partial values used for the values presented in the following table. The breaking down of prices for the proposed solution is given in Annex III.9.

Cost estimation takes 2011 as reference year for prices.

Table 3.3-10: Estimate of the initial investment costs

Treatment solutions	Civil engineering (TND)	Equipment and IE (TND)	Total (TND)
1	1,031,921	3,089,487	4,121,408
2	1,634,061	5,457,232	7,091,293
3	1,613,223	4,010,507	5,623,729

In conformity with the project implementation timetable described in chapter V, it is admitted that the initial investment will be made in 2016, which corresponds to the start of the construction works.

3.4.4.2 Operating costs and maintenance

For the estimation of the operating costs and maintenance, the unit costs supplied by ONAS have been used for the following aspects:

- maintenance;
- consumption of chemical reagents;
- consumption of electricity;
- transport and final deposit of the by-products and sludge.

The operating costs associated with analytic control of operation of the wastewater treatment plant has not been counted, since it depends upon the planning deadline set by ONAS and are common for all the treatment solutions studied.

The maintenance costs resulting from addition of the two parts, corresponds to the civil engineering and maintenance of the electromechanical equipment items. They have been estimated based upon application of a rate of 2.5% and 1.0% on the budgetary forecasts of the investment for the electromechanical equipment items and civil engineering, respectively.

In relation to the chemical reagents, the following unit prices are admitted:

- aluminium sulfate – 400 TND;
- cationic polyelectrolyte – 6500 TND;

- lime – 150 TND.

The electricity consumption has been estimated on the basis of the energy reports presented in Annex III.3, and a unit electricity cost of 0.13 TND/kWh has been admitted.

In order to estimate of the costs of transport and final deposit of the by-products and of the sludge, a unit cost of 40 TND/t has been taken into consideration.

In conformity with the project implementation timetable, the start date of operation of the WwTP after renovation will be 2019.

3.4.4.3 Updated total costs

Annex III.8 presents the updated total costs for the year 2016, through application of an updating rate of 3%. A summary of the results obtained is presented in the following table.

Table 3.3-11: Estimate of the fixed capital investment costs (FCIC), operating costs (OC) and updated total costs (UTC) for each solution studied

Treatment solutions	FCIC (TND)	OC (TND)	UTC (TND)
1	4,121,408	10,402,523	12,308,460
2	7,091,293	9,889,816	14,883,655
3	5,623,729	10,878,074	14,187,691

For each solution studied the ratio TND/m^3 is respectively, 0.67, 0.81 and 0.77.

3.4.5 Technical and economic comparison of the solutions

From the previous table, it is noted that Solution 2 is the most expensive solution, with the higher investment and operating costs. From a strictly economic perspective, the solution 1 is the most advantageous one, with the investment costs and total discounted costs the lowest.

During the missions in Tunisia, the consultant team tried to find examples of WwTP using the process of conventional aeration activated sludge, with mesophilic anaerobic digestion of sludge and energy recovery from biogas. Although it may not be a representative sample of such plants, the team visited Choutrana WwTP near Tunis. At the time of the visit the anaerobic digestion of sludge with energy recovery of biogas was out of service. The team notes that based on the training plans provided by ONAS, a major effort would be needed to implement Solution 2, for the integration of training of the operation team.

In contrast, Solution 1 uses an existing treatment process, which is much simpler and well controlled by the operation team.

Solution 3 is an intermediate option, between 1 and 2. However, it would involve operational difficulties almost as great as Solution 2.

The consultant team considers that the size of the Medjez El-Bab WwTP does not justify a change in its process, and so recommends that the rehabilitation of the WwTP be carried out according to Solution 1.

3.4.6 Conclusion and recommendations

As the conclusion through discussion with ONAS during the present Survey, Solution 1 is selected as the best solution for the Medjez El-Bab WwTP to be proceeded for detailed design.

3.4.6.1 Summary of key interventions for the selected solution

With regard to the solution adopted key interventions recommended include:

- Preliminary treatment
  - construction of a new grit retention tank including the grit extraction system by "air-lift";
  - replacement of the Archimedes screw nº1 ;
  - replacement of the mechanical multi-rake bar screen;
  - replacement of the scraper bridge;
  - replacement of the grit pumps (grit and grease extraction);
  - installation of a grit classifier;
  - replacement of the compressors;
  - installation of a screw conveyor for grit removal;
  - replacement of the measurement flow equipment;
- Secondary or biological treatment
  - replacement of the surface aerators by a fine bubble aeration system including compressors endowed with speed variation, air ducts and diffusers installed in the tanks;
  - replacement of submersible mixers;
  - replacement of the scraper bridges (secondary clarifiers);
  - construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks, and excess sludge extraction;
- Tertiary treatment
  - installation of nitrate recirculation pumps;
  - construction of an ultraviolet radiation disinfection system in the open channel implemented upstream by the filtration operation via multicellular vertical feeding pumps linked to the filters, self-cleaning pressure filters;
- Sludge treatment
  - construction and installation of all the civil works and equipment relative to the sludge

- Odor treatment
  - construction and installation of all the civil works and equipment associated with the contaminated air treatment system including the extraction Of the contaminated air from the grit retention tank, preliminary treatment building, thickener, thickened sludge storage tank and dewatering building.

3.4.6.2 Recommendation regarding continuation of normal activity during works

As it is necessary to maintain the operation of the WWTP it becomes essential to perform all work in a progressive manner. In this sense, it is recommended:

- interventions should be made as much as possible during the dry season, so that the affluent flow is smaller;
- construction of the sand retention tank sand should be a priority and be completed before interventions in the pre-treatment;
- interventions provided at the pre-treatment should be carried out alternately on each channel;
- interventions in the aeration tanks and secondary clarifiers must be done line by line to allow the rest to maintain in operation;
- interventions concerning the pre-treatment of wastewater from the yeast production, disinfection, sludge treatment and odor treatment, are not directly involved in the operation of STEP, so can be done sequentially.

3.4.6.3 Remarks on further studies

The results for the STEP of Medjez el Bab helped to find a solution for setting the budget of the operation of rehabilitation and extension.

However, the further studies, especially the Detailed Design, will have to validate in detail the technical choices proposed or to propose some technical amendments in the budget of the operation.

3.5 WWTP OF TABARKA

3.5.1 Current situation of the WwTP

3.5.1.1 General information

3.5.1.1.1 General localization and accessibility

The wastewater treatment plant of Tabarka is situated in the commune of Tabarka, governorate of Jendouba, beside the road of Ain Drahem, 1 km from the center of the city (see Figure 3.5-1). The following figure presents an aerial view of the WwTP and the receiving water of treated effluent.

Figure 3.5-1: Aerial view of the WwTP of Tabarka and the receiving water of treated effluent
(Source: Google Earth 2010)

Every perimeter of the WwTP is enclosed but we can access to the installation through a gate, directly from the road Ain Drahem. The fence was found degraded at some points, but the gate is still in good condition.

3.5.1.1.2 Environmental restrictions of the area and the surroundings

The WwTP of Tabarka is situated in a zone limited by an affluent of the Wadi El Kébir in the east and by the road Ain Drahem in the west. Moreover, given the proximity of the dwellings and the tourism zone, certain problems such as odors, mosquitoes and flies assume higher importance.

The Tabarka WwTP is located in a plot of land measuring around 4 ha. According to the Summary Concept Design (1985) supplied by ONAS, this terrain may easily be flooded, which determined the necessity to raise the height of the treatment structures. The terrain for any eventual extension is very small and confined by the enclosure.

3.5.1.1.3 Description of the existing infrastructures

The WwTP of Tabarka was brought into service in 1993 to treat the wastewater from the commune of Tabarka.

The installation was designed to treat the wastewater produced by 45,000 p.e. (population equivalent) corresponding to a flow of 5,500 m^3/day and to an organic load (BOD) of 1,825 kg/day.

Currently, the wastewater is routed by a combined system network, arriving at the WwTP by means of a rising main.

The WwTP of Tabarka was designed according to the extended aeration activated sludge process. The treatment line incorporates the following infrastructures:

- Pretreatment
    - Screening consisting of 1 mechanical bar screen, with bars spacing of 12 mm, a conveyor hopper and a trailer;
    - Manual bar screen installed in the recourse channel;
    - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge;
- Biological or secondary treatment
    - Oxidation of the organic matter in one treatment line, each one with 4 aeration tanks equipped with surface aerators and submersible agitators
    - Settling of sludge in one secondary clarifier of rectangular plan, equipped with a suction scraper bridge;
    - Sludge recycling at the beginning of the aeration tanks;
    - Excess activated sludge extraction into a pumping station from which the sludge is pumped into the thickener;
    - Measurement of the treated effluent flow;
- Tertiary treatment
    - Disinfection in 3 maturing lagoons;
- Treatment of sludge
    - Excess activated sludge thickening in 1 thickener of square plan, equipped with a scraper bridge;
    - Dewatering of the thickened sludge in 6 drying beds;
    - The thickener supernatant is directly conveyed to the screening upstream;
    - Pumping of the drying beds filtrate and the plant sewage drainage, by means of a pumping station, towards the grit and grease removal tank upstream.

A part of the effluent from the biological treatment is reused internally as wash water.

The treated effluent, after the maturation stage, has two possible destinations: the discharge into the Wadi Kébir or the reuse for irrigation of a golf course. In the second case, the treated effluent is pumped to the golf course, by means of a pumping station, and then it is stored in lakes until its use for irrigation.

The following figure displays the control and monitoring central panel of the plant (the maturing lagoons representation is missing) and, thereafter, some photographs of the plant are shown.

Figure 3.5-2: Treatment scheme of the WwTP of Tabarka

Figure 3.5-3: Photographs of the WwTP of Tabarka

1 – Pretreatment – Screening; 2 – Pretreatment – Grit and grease removal; 3 – Aeration tanks;
4 – Secondary clarifier; 5 – Maturing lagoon; 6 – Drying beds.

The main dimensions of the existing infrastructures are presented in Annex III (Annex III.4).

The maturing lagoons dimensions are not presented since the available data is inconsistent; it was possible to find depth values between 1 and 3 m.

Moreover, it should be noted that the WwTP is provided with three buildings: the first one, the main building, which houses the staff facilities with a laboratory, a control room and a store-workshop; the second one including the blowers' room, and the third one, which houses the transformation post, the main LV distribution and the power generator.

3.5.1.2 Current quantitative and qualitative characteristics of the wastewater and treated water

3.5.1.2.1 ONAS' Operating reports

The following tables summarize the quantitative and qualitative characterization of the wastewater influent to the WwTP of Tabarka, as well as the treated effluent, taking into account the operating reports of the years 2008, 2009 and 2010 provided by ONAS.

Table 3.5-1: Quantitative characterization of tributary wastewater from 2008 to 2010

Year	Value	Daily flow (m^3/day)	Monthly flow (m^3/month)	Annual flow (m^3/year)
2008	Minimum	2,218	66,544	1,236,564
	Average	3,378	103,047	
	Maximum	14,531	140,536	
2009*	Minimum	1,999	61,982	1,328,362
	Average	3,983	120,760	
	Maximum	15,606	158,882	
2010	Minimum	1,931	57,929	1,390,174
	Average	3,798	115,848	
	Maximum	14,450	268,267	

* data for December not available

Table 3.5-2: Qualitative characterization of tributary wastewater from 2008 to 2010

Year	Value	BOD (kg/day O_2)	COD (kg/day O_2)	TSS (kg/day)
2008	Minimum	909	1,007	849
	Average	1,289	2,264	1,221
	Maximum	1,661	3,139	1,657
2009*	Minimum	859	2,471	930
	Average	1,441	3,119	1,278
	Maximum	1,836	4,523	1,478
2010	Minimum	560	1,145	533
	Average	1,172	2,400	1,114
	Maximum	2,544	5,063	2,293

* data for December not available

Table 3.5-3: Qualitative characterization of the treated effluent from 2008 to 2010

Year	Value	BOD (mg/L O_2)	COD (mg/L O_2)	TSS (mg/L)
2008	Minimum	12	30	17
	Average	25	74	27
	Maximum	37	101	38
2009	Minimum	12	28	16
	Average	20	52	23
	Maximum	36	85	28
2010	Minimum	9	34	16
	Average	21	61	22
	Maximum	31	78	29

3.5.1.2.2 Sampling program implemented and discussion of the main results

In the framework of this project, a sampling program of the raw and treated wastewater was carried out, aimed at consolidating the conclusions of the analysis of the operating reports of the wastewater treatment plant.

The sampling was implemented in conformity with the premises described in paragraph 3.3.1.2.2.

The sampling for the Tabarka WwTP was implemented on the following dates:

- Friday 15/10/2010 – Saturday 16/10/2010: weekly market; it had rained on the previous Thursday evening;
- Monday 01/11/2010 – Tuesday 02/11/2010: start of the week; without rain;
- Saturday 06/11/2010 – Sunday 07/11/2010: week-end; very rainy day, with flooding;
- Wednesday 10/11/2010 – Thursday 11/11/2010: without rain.

The following table presents the main results of the sampling program carried out.

Table 3.5-4: Results of the sampling program

Parameters	From 15 to 16/10/2010		From 01 to 02/11/2010		From 06 to 07/11/2010		From 10 to 11 11/11/2010	
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow
Daily flow (m^3/d)		4,566		2,119		6,819		3,715
pH	7.1	7.3	7.08	7.68	7.42	7.64	7.4	7.7
Salinity (mg/L)	5,533	5,230	600	919	610	450	747	770
TSS (mg/L)	278	95	289	20	122	15	139	22
VSS (mg/L)	1.35	1	0.51	0.12	1.34	0.13	0.19	0.13
COD (mg/L O_2)	480	98	785	31	434	29	222	38
BOD_5 (mg/L O_2)	218	31	320	14	209	9	108	12
Carbonates (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bicarbonates (mg/L)	326	332	486	480	421	333	457	427
Hydroxides (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nitrogen Kjeldahl (mg/L N)	22	11.5	16.2	13.7	10.9	4.72	8.8	3.9
Nitrates (mg/L N)	<0.04	0.2	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Phosphorus total (mg/L P)	4.78	4.1	1.81	0.78	0.26	0.11	0.8	0.3
Oils & grease (mg/L)	8.4	2	61	<0.1	1.6	<0.1	104	<0.1
Hydrocarbons (mg/L)	16.7	<3.3	179.7	<3.3	22.8	<3.3	137	<3.3
Total coliforms	9.5×10^8	4.5×10^6	4.7×10^7	9.5×10^4	4.5×10^6	4.5×10^4	2.5×10^6	9.5×10^4
Fecal coliforms	1.5×10^8	4.5×10^6	9.5×10^6	4.5×10^4	2.5×10^6	4.5×10^4	2.5×10^6	2.5×10^4

Following analysis of the above results, it is necessary to emphasize the major influence of rainfall on the daily flow to the wastewater treatment plant. In effect, the daily flow recorded during the period from 06/11/2010 to 07/11/2010 is almost three times the average flow on a day without rain.

The obtained ratios - BOD_5/COD - vary between 0.41 and 0.49, which lies within the typical range for biodegradable effluents.

Furthermore, the effectiveness of the degradation of the organic aeration is very high, around 96%. Nonetheless, the effectiveness of the elimination of nitrogen is very weak, between 15.4% and 56.7% (for this calculation, we considered that the total value of nitrogen corresponds to the Kjeldahl nitrogen and to the nitrates, since nitrites in raw effluent are generally negligible).

Moreover, analysis of the ratio BOD_5:N:P indicates a lack of phosphorus in the raw wastewater, higher than the reference level of 100:5:1, in two of the four days of the sampling. Nonetheless, this does not necessarily undermine the effectiveness degradation of the organic aeration.

Comparing the mean results from the sampling program (undertaken during October and November 2010) with the mean analytical results from the 2010 Operation Report, it is concluded that:

- The mean of the mean daily flows recorded in the sampling program is about 13%

superior to the mean of the values recorded in the 2010 Operation Report;

- The results from the sampling program for concentrations of TSS, COD and BOD_5 in raw wastewater are, on average, 20% to 30% below the mean values from the Operation Report;
- The concentrations of COD and BOD_5 in treated effluent obtained from the sampling program are, on average, 20% below the mean values recorded in 2010, though the mean value for TSS is about 70% superior;

Comparing the mean results from the sampling program with the mean analytical results for only October and November from the 2010 Operation Report, it is concluded that:

- The mean daily flow data recorded in the sampling program are of the same order as the results indicated in the 2010 Operation Report;
- The results from the sampling program for concentrations of TSS, COD and BOD_5 in raw wastewater are of the same order as those recorded in the Operation Report;

The concentrations of TSS, COD and BOD_5 in treated effluent obtained from the sampling program are, generally, of the same order, except one TSS result which was about 5 times higher than the values in the Operation Report.

3.5.1.3 Evaluation of the existing plant operation

Analysis of the operating reports for the years 2008, 2009 and 2010, supplied by ONAS, indicate that the average daily flow has exceeded the design flow of the Tabarka WwTP, set at 5 500 m^3/d, in the month of January 2010 (a very rainy month), when it rose to 8 654 m^3/d. Nonetheless, the average value in 2010 is 3 798 m^3/d, corresponding to almost 69% of the installed capacity.

However, according to Table 3.5-1, the maximum flow actually exceeded the design flow in some cases, probably related to rainy days. According to the annual operation reports, the maximum values mentioned, namely 14 531 m^3/day in 2008, 15 606 m^3/day in 2009 and 14 450 m^3/day in 2010, were recorded during rainy days (on 01-04-2008, 09-11-2009 and 04-09-2010, respectively), exceeding more than 250% of the design flow.

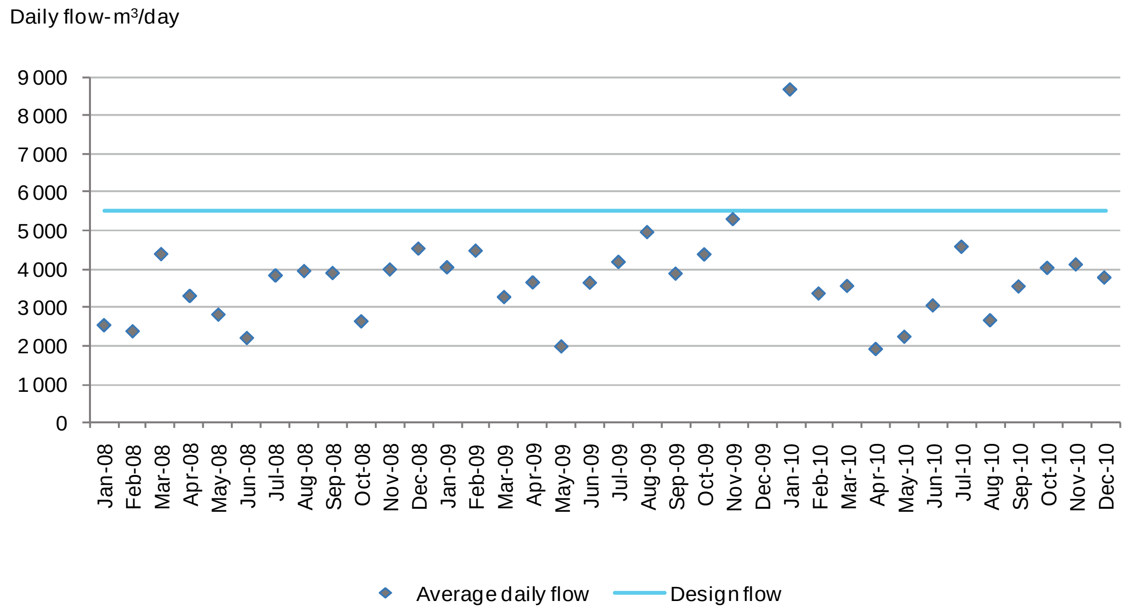


Figure 3.5-4: Variation of the average daily flow of the affluent between 2008 and 2010 and the design flow

According to the last figure, in spite of the flow variation, no seasonal trend can be observed, since the maximum values are observed either in winter, or in summer.

With regard to the affluent organic load (BOD) to the WwTP of Tabarka, the analyzed annual operation reports indicate that the average organic load reached in 2009 approximately 79% of the design load, 1,825 kg/day, the situations of excess being very rare and minor. This average value fell in 2010. It was 1 172 kg/d, around 64% of the scaled level for organic aeration. Moreover, the reports also reveal a very satisfactory treatment performance, with an average value of approximately 95% (relatively to the BOD), which guarantees the value of 30 mg/L O_2 imposed to BOD by the legislation in force at the outlet, except for some punctual situations(see Figure 3.5-6).

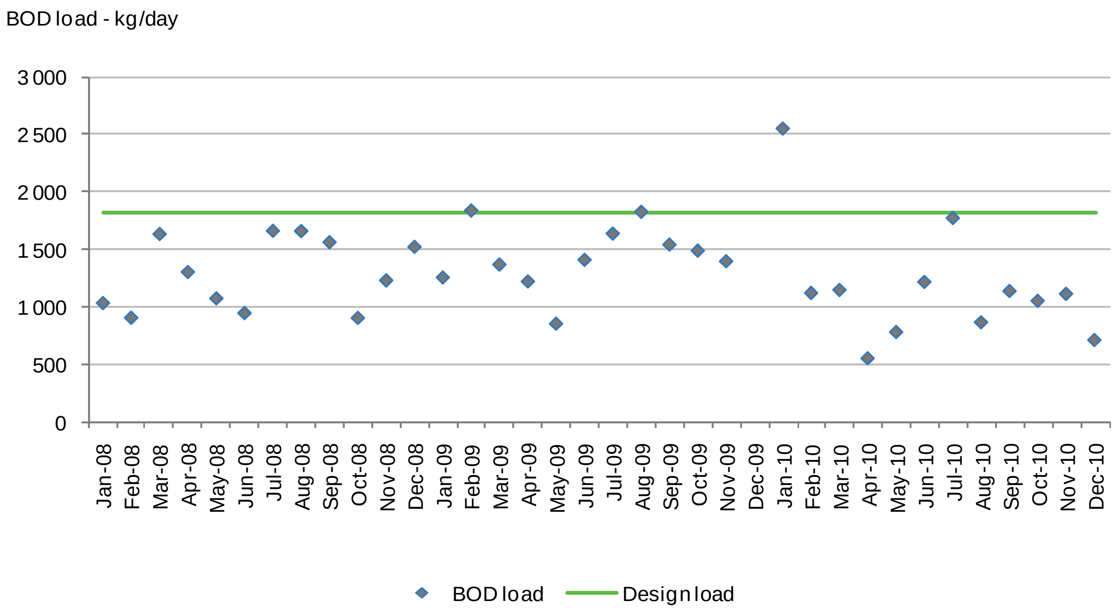


Figure 3.5-5: Variation of the affluent BOD load between 2008 and 2010 and the design load

By comparing the two previous figures, it should be noted that the load variation over time is similar with the flow variation; seasonal variations are not obvious though.

According to the annual operation reports, the limits of transparency, the solids settleability, TSS, BOD and COD were never exceeded within the period 2008-2009.

The ratio obtained between the organic matter and the nutritional elements (BOD_5:N:P), for the years 2008 and 2009, were lower than the reference ratio of 100:5:1, thus demonstrating good equilibrium conditions for development of bacterial biomass. The 2010 operating report, supplied by ONAS, does not include values for nitrogen or phosphorus at the entrance of the plant. However, we were able to ascertain, from the results of the sampling program, that it sometimes lacks phosphorus, as explained in paragraph 3.5.1.2.2.

The relation obtained between the organic matter and nutrients (BOD:N:P), being lower than the relation of reference of 100:5:1, shows good equilibrium conditions for the development of bacterial biomass.

Also, a relation of BOD/N always higher than 3.5 is compatible with the biological removal of nitrogen.

The wastewater to be treated presents urban characteristics, therefore the BOD/COD relation values are within the interval of 0.3 – 0.8, which allow to infer that such an effluent have a biodegradation compatible with the generality of biological treatments.

The following figure presents the variation of the concentration in BOD_5 at the exit of the plant, during the period under analysis; it is evident that the situations which exceed the limit value occur during the summer months.

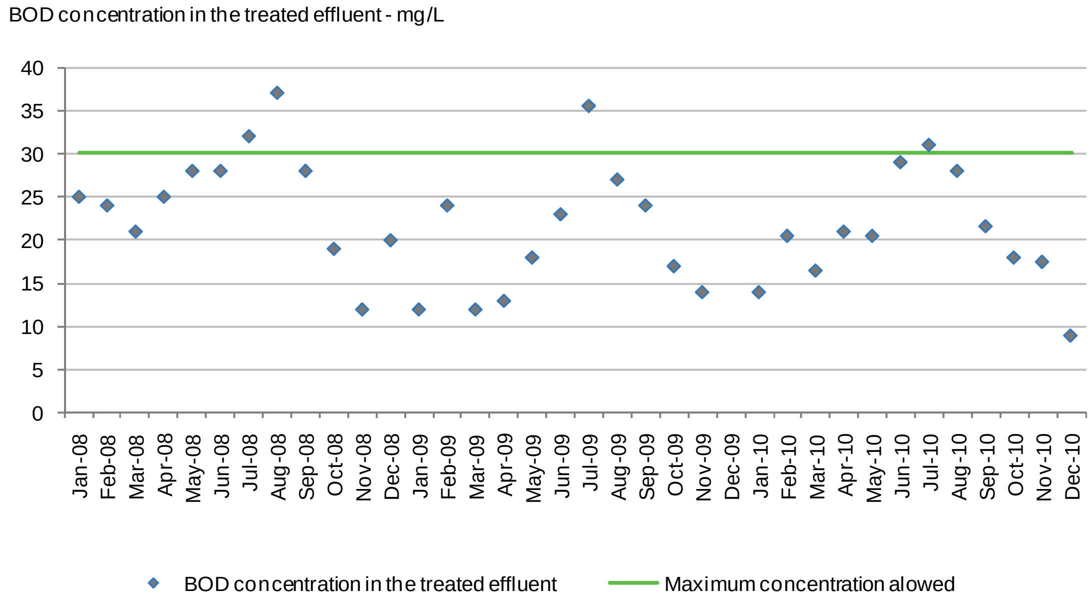


Figure 3.5-6: Variation of the BOD concentration in the treated effluent, between 2008 and 2010, and maximum concentration allowed

During the first visit to the WwTP of Tabarka, in July 2010, some information was collected and it was possible to identify certain irregularities on plant operation, which should be solved in the short term:

- The influx of sand in the WWTP is very important, which justifies the visit of a specializes removal unit once a year;
- The existing infrastructure does not allow a good management of the sludge recycling and the purge of excess activated sludge, which negatively affects the biological treatment efficiency;
- It was visible the phenomenon of foaming at the aeration tanks surface, which may be due to the presence of *Nocardia* and/or high levels of salinity and/or inadequate aeration.
- On the secondary clarifier surface, it was possible to observe floating sludge, which indicate the occurrence of denitrification in this infrastructure, with loss for the settling of sludge and for the treated effluent quality;
- During winter, the drying beds capacity is not sufficient for the sludge dewatering. In order to solve this problem, the sludge height on the drying beds is increased to more than 30 cm;
- The organic load is very variable and, according to the technician in charge, the plant is overload especially in summer;
- According to the WwTP technician in charge, the tributary wastewater has very high chloride concentrations;
- During the visit, there was a remarkable dry sludge smell, which may indicate this one was not well stabilized;
- According to the technician in charge, the depth of the maturing lagoons is greater than 2

m, which is considered excessive for effective disinfection of wastewater.

The work included a visit to the golf club because it uses a part of the treated effluent for watering the greens. The person in charge for the golf club highlighted issues arising from the use of treated wastewater for irrigation, including:

- Customers complaints regarding the strong bad odor when watering;
- The grass is very fragile due to watering with water having high salinity.

The following figure presents the variation of salinity at the exit of the plant, taking into consideration the values of the operating reports for the years 2008, 2009 and 2010.

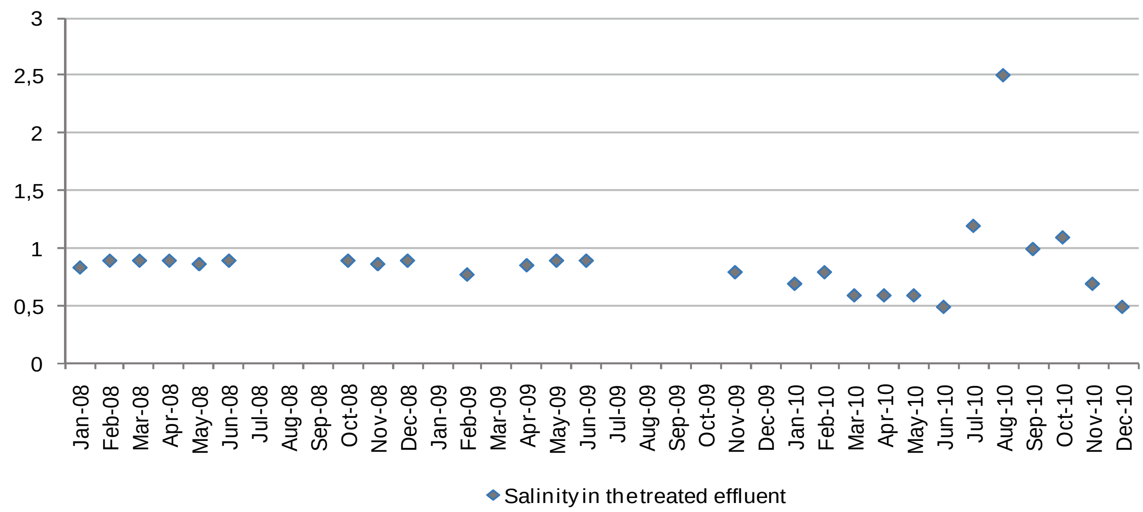


Figure 3.5-7: Variation of salinity in the treated wastewater between 2008 and 2010

In view of the last figure, between January 2008 and June 2010, the average values of salinity at the exit of the plant have always been lower than 1 g/L. Notwithstanding the absence of salinity values for the summer months in 2008 and 2009, the values of 2010 demonstrate the higher level of salinity during the summer months, which has made it possible to deduce that this increase may be due to higher use of thalassotherapy centers by tourists.

The consulting team visited the Tabarka WwTP for a second time in May 2011, and it was found that the problems identified at the time of the first visit still persist. Furthermore, the consulting team found that the general state of conservation of the equipment items and of the iron pieces had deteriorated since the first visit (the scraper bridges of the aerated grit chamber and sedimentation tank were under maintenance).

The technician in charge of operating the WwTP reported problems of gritting up the aerated grit chamber/aerated grease chamber, which justified emptying this chamber once per year (in the month of May).

At the time of the second visit, another operating problem was detected: the level of wastewater in the bypass channel was high and, given the proximity to the thickener, there was a hydraulic short-circuit towards the thickener, via its supernatant discharge pipe, with loss of effectiveness of the sludge thickening process.

With regard to the plant energy consumption, the annual operation reports indicate an average specific consumption of 0.31 kWh/m^3 of treated effluent in 2008, 0.28 kWh/m^3 in 2009 and 0.27 kWh/m^3 in 2010. The following table summarizes the values of energy consumption in the WwTP of Tabarka.

Table 3.5-5: Energy consumption

Year	Value	Energy consumption (kWh)	Energy consumption indicator (kWh/m^3)
2008	Minimum	26,866	0.31
	Average	31,637	
	Maximum	38,925	
2009	Minimum	26,675	0.28
	Average	33,664	
	Maximum	44,798	
2010	Minimum	24,344	0.27
	Average	31,741	
	Maximum	43,892	

The following figure shows the variation in energy consumption during the period analyzed, being evident the increase in energy consumption during the summer months.

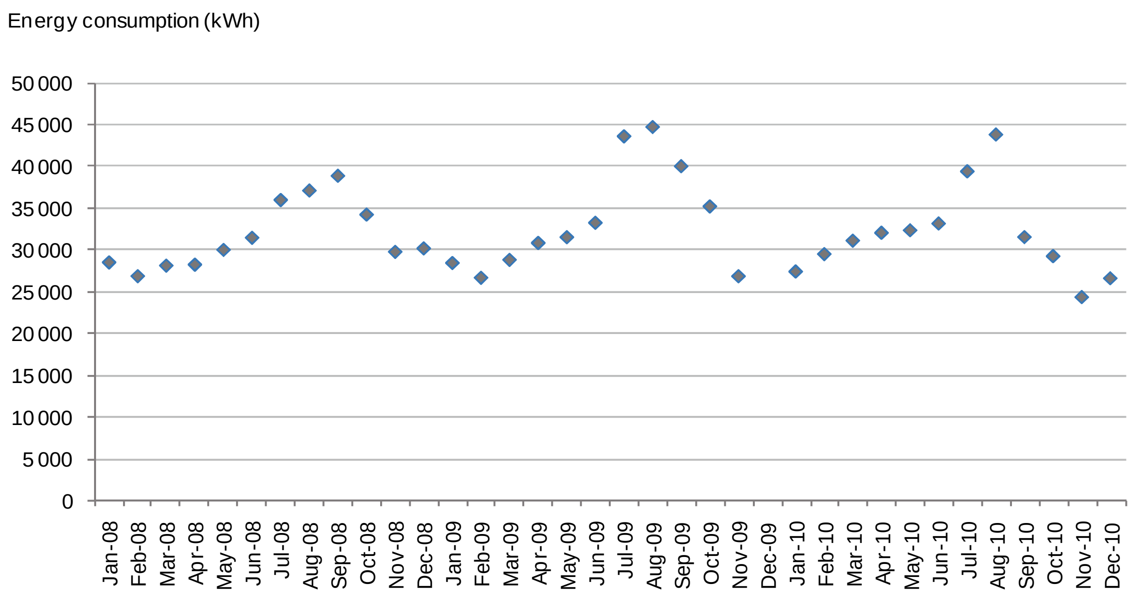


Figure 3.5-8: Variation of the energy consumption between 2008 and 2010

3.5.1.4 Greatest limitations found and the necessary actions

The greatest limitations found in the WwTP of Tabarka concern basically issues such as the accumulation of grit in the treatment tanks, the qualitative characteristics of wastewater influent, the aeration of the tanks, the biological removal of nitrogen, the management of the sludge recycle system, the excess sludge purging and the sludge dewatering during winter.

Accumulation of grit

The wastewater presents a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber, thus building up sediment in the aeration tanks. In order to resolve this problem, we propose the construction of a grit retention chamber upstream of the headwork that will work as a complement to the aerated grit and grease chamber.

Proliferation of odors

Given the proximity of the dwellings and of the tourism zones, this problem must be resolved by confining the zones that involve the highest production of odors, such as the headworks and sludge treatment zones. This aspect will be taken into consideration at the time of development of renovation solutions of the Tabarka WwTP.

Qualitative characteristics of wastewater

The large variation of the organic load of the affluent to the WwTP can trigger the phenomenon of bulking, activated by the imbalance and lack of nutrients (N, P). This phenomenon is due to the development of filamentous bacteria, increasing the volume occupied by sludge and especially damaging the secondary clarifier. However, the organic overload reported by the person in charge for the WwTP is not evident in the annual operation reports.

The variation in salinity prevents micro-organisms from adapting to either conditions of weak salinity, or conditions of high salinity. For more effective management of the treatment, it is necessary to reduce the level of variation in the salinity. It is necessary to verify whether tourism users respect the norm on discharging wastewater into the public sewerage network (NT 106.02).

Aeration of the tanks

Generally, the surface aerators have lower efficiencies than those obtained by the submersible aeration systems, such as diffused air (with fine bubbles). In addition, this surface aeration produces aerosols during operation, which affects the operating staff health. The replacement of the surface aerators by the air blowing system with fine bubbles is proposed. This system includes blowers with variable speed, air ducts and diffusers (tubular or disc). The blowers must be provided with a protection against noise and they must be installed in a building equipped with an overhead travelling crane and forced ventilation.

Nitrogen biological removal

The Tunisian standard NT 106.02 imposes limits for nitrate, nitrite, organic nitrogen and ammonia, which can be achieved by means of a biological treatment.

Thus, the existing reactors need to be modified to adapt them to the nitrogen biological removal, i.e., it is necessary to size the anoxia volume and to install nitrate recycling pumps (with frequency variation) for the nitrate recycling from the last basin to the first, including the installation of an electromagnetic flow meter on the recycle pipe.

Sludge recycle and excess activated sludge purge

In the WwTP of Tabarka, the flow partition for the biological sludge recycle and the excess activated sludge purge is carried out manually with a partition valve, without precision, which negatively affects the biological treatment.

In order to solve this problem, the construction of biological sludge pumping station(s) equipped with submersible pumps for pumping excess sludge to the thickener and sludge recycling to the aeration tanks upstream is planned.

Hydraulic short-circuit between the bypass channel and the thickener

Given its nearby location, the gutter carrying supernatant from the thickener is connected by gravity to the bypass channel of the headworks. When the wastewater level in the bypass channel is high, there is a hydraulic short-circuit towards the thickener, via its supernatant discharge pipe, with loss of the effectiveness of the sludge thickening process. This problem will be taken into consideration at the time of development of the renovation solutions of the Tabarka WwTP.

Sludge dewatering

During winter, the existing drying beds do not have sufficient capacity for dewatering the thickened sludge. In order to solve this problem, the sludge dewatering should be carried out by mechanical equipment, such as a filter band or a decanter centrifuge, with the addition of polyelectrolyte.

Disinfection

According to the standard NT 106.02 (1989) in force, the microbiological quality prescribed for the maritime and hydraulic public domain (achievement of 2,000/100 mL fecal coliforms and 1,000/100 mL of fecal streptococcus) implies the integration of a final stage for the effluent disinfection, independently of the uses associated with the receiving water.

However, the disinfection efficiency using maturing lagoons depends greatly on the climatic conditions (in particular the temperature and the solar radiation intensity). It is thus not possible to ensure the required bacteriological quality. Moreover, it was not possible to determine the dimensions of the existing maturation tanks, since the information available is incoherent, with values of depth found between 1 and 3 m. On the other hand, this represents an extensible solution, which is very demanding as for the occupation of ground.

In this case, the replacement of the existing lagoons by a disinfection system via ultraviolet radiation is expected, being served upstream by an operation of filtration in order to guarantee the necessary water transmittance so that an efficient radiation distribution is ensured.

Foaming on the aerated tanks surface

The actions described previously concerning the biological treatment, especially the aeration system improvement; the biological sludge recycle management and the excess activated sludge purge can solve this problem.

Condition and operation of electromechanical equipment

In general, the electromechanical equipment presents a high degree of corrosion, possibly due to the proximity of the sea in addition to the aggressive environment, a characteristic of the operation with wastewater.

In addition, many cases of degradation and malfunctioning were visible. For example, the scraper bridge of the secondary clarifier is suffering from a deflection on the longitudinal motion. There was a large gap between the guide wheels and the wall of the decanter.

The automation can be improved by installing additional instrumentation such as flow meters, providing integration between instrumentation and the operation of mechanical equipment.

The plant has a standby power generator which, based on information provided during the visit, is not used.

To complement this information, a table with the main comments on the WwTP electromechanical equipment is presented in Annex III (Annex III.4).

3.5.2 Design data

3.5.2.1 Planning year of the Project

The planning year of this study is 2029, assuming 2016 as the investment year and 2019 as the first year of operation.

3.5.2.2 Quantitative and qualitative characteristics of the foreseen effluent

The following table summarizes the estimated quantitative and qualitative characteristics for the raw wastewater to be treated in the Tabarka WwTP, in conformity with the basic data described in paragraph 3.2.

Table 3.5-6: Estimate of the characteristics of the raw wastewater

Parameter	Unit	2011	2029
Population			
Domestic	inhabitants	21,239	31,322
Industrial	EH	1,192	3,787
Touristic	beds	5,304	9,400
Total	EH	27,735	44,509
Flow			
Average daily flow	m^3/d	4,491	8,510
	L/s	52.0	98.5
Infiltration flow	m^3/d	770	1,485
	L/s	8.9	17.2
Average daily flow + infiltration	m^3/d	5,261	9,995
	L/s	60.9	115.7
Peak flow	m^3/h	370.8	700.1
	L/s	103.0	194.5
Maximum design flow	m^3/h	378.0	700.1
	L/s	105.0	194.5
Pollutant loads			
TSS	kg/d	2,460	3,892
BOD_5	kg/d	1,664	2,671
COD	kg/d	3,364	5,455
TN	kg/d	234	396
TP	kg/d	42	67
Fecal coliforms (FC)	NMP/d	$2.65x10^{15}$	$4.07x10^{15}$
Concentrations (without infiltration flow)			
TSS	mg/L	548	457
BOD_5	mg/L	371	314
COD	mg/L	749	641
TN	mg/L	52	47
TP	mg/L	9	8
Fecal coliforms (FC)	NMP/100mL	$5.91x10^{7}$	$4.78x10^{7}$

These amounts have been estimated taking into consideration of the junction of the new industrial zones planned by the AFI, described in Table 3.2-3, because the latter only represent 8.5% of the total equivalent population estimated for the year 2029 (44 509 EH).

In order to estimate the quantitative and qualitative characteristics of the industrial effluent, it was considered that the industrial users will have access to preliminary treatment of the effluents - thus making it possible to respect the discharge limits into the public sewerage network stipulated in prevailing legislation. In other words, the concentration of BOD_5 of the industrial effluents to be treated in the Tabarka wastewater treatment plant will be 400 mg/L. The estimate of the equivalent industrial population was carried out presuming a specific wastewater production of 40 m^3/ha/d and specific production of BOD_5 of 60 g/cap/d.

3.5.2.3 Legislative framework relating to the quality of the receiving water and required quality for the treated effluent

In general, it is necessary to observe wastewater discharge standards established in the applicable legislation, especially standard NT 106.02; however, this standard is under revision, a draft of the new decree having been supplied to the consultant team. In spite of this new decree, not yet in force, it should be noted that discharge standards will become differentiated in sensitive receiving water and other receiving water.

As mentioned, the treated effluent in the WwTP of Tabarka can be discharged into the Wadi Kébir or be reused for the watering of a golf course. Since the Wadi Kébir flows into the Mediterranean Sea on a swimming area, namely Tabarka beach, we consider that this receiving could be deemed, in the future, sensitive receiving water, particularly sensitive to water pollution caused by the microbiological substances.

Moreover, the use of the treated effluent for the watering of a golf course can create situations of direct contact of people with the treated water, causing a risk of contamination and justifying the inclusion of a stage of disinfection.

Nonetheless, while the new decree is not implemented, the treated wastewater in the WwTP of Tabarka must follow the quality framework presented in Table 3.3-1 of Chapter I.

3.5.2.4 Legislative framework concerning the final destination of sludge

According to the strategy defined by ONAS, the final destination of the dewatered sludge should observe the following priorities:

1. Green sector – agricultural re-use;
2. Red sector – incineration;
3. Black sector – controlled discharge.

The wastewater treated in the WwTP of Tabarka presents characteristics that are definitely domestic, therefore it is expected that the wastewater does not contain heavy metals or other harmful elements for the application of sludge in agriculture. Moreover, the qualitative characteristics of the wastewater produced in the new industrial zone to be connected to the wastewater treatment plant are not known. In this case, it is assumed that treated sludge complies with all the provisions of existing legislation (see Chapter I, 1.3.3.3.3) and can be recovered for agriculture.

3.5.3 Eligible solutions of rehabilitation and extension

3.5.3.1 General considerations

For the rehabilitation of Tabarka treatment plant, three alternative solutions are proposed, which have been already described in paragraph 3.5.3.1.

For all the three solutions, as it has been recommended for the preceding WwTP, the construction of a grit retention tank, replacement of the surface aerators by the diffused air system, the installation of the internal nitrate recycling system, the construction of pumping stations for the sludge recycle and excess sludge extraction, the construction of a new stage for thickened sludge mechanical dewatering and the installation of a system of pathogenic microorganisms removal (final disinfection) via ultraviolet radiation will also take place in Tabarka.

Given the proximity of the dwellings and of the tourism zone, odor treatment of the structures and buildings associated with emission of the odors will be included, thus minimizing any disturbances to the neighboring population of the WwTP.

In relation to the security conditions for the workers of the plant, we recommend installation of a guard rail around all treatment structures with a liquid depth higher than 1 m, in particular: the aerated grit and grease chamber, biological reactors (in addition to the existing rails), clarifiers, thickeners, *etc*.

The description of the treatment lines, the advantages and disadvantages for each of these biological treatment systems are presented in the following chapters. The main design criteria, design results and operational conditions are presented in Annex III (Annex III.4).

The treatment schemes of each solution being studied are presented in the Annex III (Annex III.7).

In the future development of the work the issue of changing the site of the WwTP, due to its proximity to urban areas and pollution generated should be considered.

3.5.3.2 Solution 1

3.5.3.2.1 Detailed description of the treatment sequence – design and criteria

For Solution 1, the rehabilitation of the WwTP according to the same existing treatment process, i.e., activated sludge in extended aeration regime, will be studied.

The advantages and disadvantages of this solution are described in paragraph 3.3.3.2.1.

According to the design data described in paragraph 3.5.2.2, it was estimated that, in year 2029, the WwTP of Tabarka must have the capacity to treat wastewater corresponding to 44,509 equivalent inhabitants. The pre-design that has been carried out within this project framework allows concluding that it is necessary to increase the installed treatment capacity. Therefore, the average daily flow to treat in the year 2029 will be 8,510 m^3/day (the capacity installed is 5,500 m^3/day) and the average organic load will be 2,671 kg/day (the capacity installed is 1,825 kg/day).

The maximum estimated inflow in this study (700 m^3/h) is higher than the flow of the pumping stations upstream of the WwTP (378 m^3/h). As a result, this first value will be taken into consideration as the maximum design flow at the planning year. In year zero, the maximum inflow will correspond to the maximum flow of the pumping station (378 m^3/h).

Given the high level of grit flowing into the WwTP, a grit retention tank upstream of the pre-treatment process is foreseen for the three solutions. This retention will be achieved using the existing thickener, where the localization is very favorable and the efficiency of the sludge thickening process is very poor.

According to the Summary Concept Design of the Tabarka WwTP, the pre-treatment structures have been scaled for a maximum flow of 756 m^3/h. The verification of the operating conditions has revealed that all the pre-treatment structures have sufficient capacity (the height of the wastewater in the screening channel does not exceed 0.8 m and the retention time in the aerated grit and grease chamber with maximum flow is more than 15 minutes).

Using the criteria presented in Annex III (Annex III.4) for the biological treatment, the design revealed that the activated sludge available volume is not sufficient for the biological treatment in the planning year, in extended aeration mode, that is to say, keeping the operation parameter mass loading (F/M) in the theoretical range (0.05 - 0.15 kg BOD_5/kg MLSS /day). It is therefore necessary to increase the biological volume by building a new treatment line, which will serve as a complement to the existing line. Hence, after the headworks, the inflow will be divided by channeling 60% towards the existing line and 40% towards the new line.

In relation to secondary clarification, verification of the operating conditions of the existing line, with 60% of the flow towards the wastewater treatment plant (at the planning year), makes it possible to conclude that the latter will function correctly with the existing sedimentation tank. The new treatment line will include a single secondary clarifier, scaled to treat 40% of the flow into the wastewater treatment plant, at the planning year.

As mentioned previously, the construction of two biological sludge pumping stations (one for each treatment line) is planned, provided with submersible pumps for the rise of sludge in excess towards the thickener and for the sludge recycling to the aeration tanks upstream. The sludge recycling pumps must allow the pumping of a flow between 50% and 150% of the average daily flow affluent to the WwTP. In order to facilitate the sludge management control, the pumps will be provided with variable speed and electromagnetic flow meters will be installed in the circuit rising mains.

A tertiary treatment stage will be provided downstream the secondary clarifier, aiming at the reduction of the bacteriological load to fulfill the requirements of standard NT 106.02, by means of a filtration followed through disinfection by UV.

As for the stage of thickening, the existing thickener operation was evaluated for the estimated excess sludge flow considering the year zero and the project planning year. This evaluation showed that the existing thickener does not have sufficient capacity, as the solids loading and the hydraulic loading rate exceeds the allowable values (40 kg/m^2/day and 5 m^3/m^2/day, respectively). Taking into account all the deficiencies of the existing thickener, it is necessary to build two new thickeners in detriment of the existing.

The pre-design that has been carried out showed that the drying beds are not sufficient in order to dewater the thickened sludge estimated either for year zero, or for the project planning year. This problem can be solved using the sludge mechanical dewatering by means of the decanter centrifuge machine. Storing sludge is recommended prior to dewatering with capacity for three days of production, in order to cope with an eventual equipment failure. The addition on line of a polyelectrolyte solution to the sludge to be dewatered is planned. On the other hand, the dewatered sludge will be stored in containers that will be a driving regularization for sending it to their final destination.

The treatment line of Solution 1 for the rehabilitation of the WwTP of Tabarka shows the following stages:

- Preliminary treatment
  - Grit retention tank (new);
  - Screening consisting of 1 mechanical bar screen, with bars spacing of 12 mm, a conveyor hopper and a trailer (existing);
  - Manual bar screen installed in the recourse channel (existing);
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing).
- Biological or secondary treatment
  - Oxidation of the organic matter in 2 treatment lines, with a total volume of approximately 7,762 m^3 aerated by a new air diffused system supplied by blowers equipped with variable speed (one existing and one new);
  - Settling of sludge in 2 secondary rectangular plant clarifiers, with a total surface of 700 m^2, equipped with a suction scraper bridge (one existing and one new);
  - Conveying of the biological sludge towards two pumping stations, one pumping station for each treatment line (new);
  - Sludge directing for a pumping station (new);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
  - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (new);
  - Extraction of the floating sludge towards the thickeners (new);
  - Measurement of treated effluent flow (new);
- Tertiary treatment
  - Biological removal of nitrogen in each line through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
  - Chemical precipitation of phosphorus with aluminum sulfate dosing (new);
  - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
  - Excess activated sludge thickening in 2 thickeners of square plant, equipped with a scraper bridge (existing);
  - Temporary storage of the thickened sludge in a tank upstream of the dewatering (new);

  - Dewatering of the thickened sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
  - Storage of dewatered sludge in containers (new);
  - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are returned through a pumping station to the biological treatment facility (new).
- Treatment of odors
  - Treatment of the contaminated air, extracted from the grit retention tank, preliminary treatment building, thickeners, thickened sludge storage tank and dewatering building, by biofilter (new).

3.5.3.2.2 Energy report

The average electricity consumption (solution 1, planning year) is presented in annex (see Annex III, Annex III.4 (at the end)).

3.5.3.2.3 Consumption of chemical reagents

The chemical reagents consumed in the wastewater treatment process are aluminium sulfate and polyelectrolyte. The quantities of chemical reagents consumed in year zero and in the planning year are presented in Annex III.4 (at the end).

3.5.3.2.4 Management of by-products

The quantities of by-products resulting from the wastewater treatment process, in particular solid screenings, grit, grease and sludge, are presented in Annex III.4 (at the end).

3.5.3.2.5 Equipment

In general, the electromechanical equipment has a high level of corrosion and presents numerous cases of malfunctioning and degradation.

The following table summarizes the solutions proposed in terms of replacement of the existing equipment items in the Tabarka wastewater treatment plant, in the framework of solution 1. For a fuller understanding of the following comments, it is necessary to view the treatment scheme of the solution attached to the report.

Table 3.5-7: Electro-mechanical equipment, instruments and electrical installations

Designation	Diagnosis	Proposed solution	Characteristics
Preliminary treatment			
Grit extraction system by “air-lift”	The wastewater includes a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber.	We propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber. Grit extraction will be achieved via an “air-lift” system. The treatment will be developed in the existing thickener.	Estimated extraction flow rate = 18 m^3/h
Mechanical multi-rake bar screen	The mechanical screen presents a high level of large scale corrosion, probably due to the proximity to the sea and its wastewater working environment wastewater. All mechanisms are exposed to the meteorological conditions. The screenings are channeled towards the transport via a stainless steel hopper. The latter has corrosion and does not seem to be the best solution for this function. The valves present a high level of deterioration.	The demonstrated state of degradation justifies the replacement of all these equipment items.	Maximum flow via the mechanical screen = 700 m^3/h Spacing between bars = 6 mm
Measurement of the difference in water level (screening)	The demonstrated state of degradation justifies replacement.	Automation should be improved, in particular in terms of integration between measurement of the level and operation of the mechanical screen.	-
Scraper bridge (grit and grease extraction in a double aerated channel)	In general, the scraper bridge presents a very high level of deterioration. The scraper bridge has a deviation in its longitudinal movement. The wheels of the scraper bridge present a high level of degradation. The electrical elements of the equipment present a high level of degradation.	The demonstrated state of degradation justifies their replacement.	A to install in the existing work

Designation	Diagnosis	Proposed solution	Characteristics
Grit pumps (grit and grease extraction in a double aerated channel)	The poor performance of the Grit pumps was reported to the consulting team.	We recommend the replacement of the equipment items.	Estimated flow for each pump = 18 m^3/h.
Grit classifier (grit and grease extraction in a double aerated channel)	There is no grit classifier. The grit trailer carries a high quantity of water.	The grit classification operation must be improved with installation of specialized equipment for this function. The equipment will be installed on the scraper bridge.	Estimated total capacity = 20 m^3/h.
Secondary or biological treatment			
Aeration	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor. Also, in order to maximize the volume of the existing reaction it is necessary to implement a more effective aeration method. The tanks are too deep in order to obtain maximum performance of the existing surface aerators.	We recommend replacement of the surface aerators by a fine bubble aeration system. This system includes compressors endowed with speed variation, air ducts and diffusers installed in the tanks. In the framework of this solution, it is necessary to construct a new treatment line, therefore there will be three compressors: 2+1; one compressor for each line.	Estimated volumetric flow rate of air for each compressor Existing line = 4,091 m3/h New line = 2,582 m3/h
Oxygen measurement (aeration tank)	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor.	We recommend installation of a programmable automation controller that permits integration of oxygen measurements with the aeration operation.	

Designation	Diagnosis	Proposed solution	Characteristics
Mixing	There are no submersible mixers.	In the framework of this solution, it is necessary to add submersible mixers.	Installed in the tanks of the submersible mixers.
Scraper bridges (secondary clarifiers)	In general, the scraper bridge presents a high level of deterioration. The scraper bridge has a deviation in its longitudinal movement. There is a grand deviation between its guide wheel and the clarifier partition wall. The wheels of the scraper bridge present a high level of degradation.	We recommend the replacement of the equipment items and, in the framework of this solution, it is necessary to add a scraper bridge to the new line.	Installed in the existing secondary clarifier and in the new secondary clarifier.
Biological sludge lift pumps (secondary clarifiers)	The poor performance of the Biological sludge lift pumps was reported to the consulting team.	In the framework of this solution, it is necessary to add submersible pumps in order to lift the biological sludge. There are three pumps per scraper bridge.	Estimated flow for each pump Existing line = 114 m3/h New line = 76 m3/h
Sludge recirculation pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process. In the framework of this solution, it is necessary to add Sludge recirculation pumps to the new line.	We recommend the construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks. We recommend the construction of a pumping station dedicated to the new line.	Estimated flow for each pump Existing line = 332 m3/h New line = 221 m3/h

Designation	Diagnosis	Proposed solution	Characteristics
Measurement of the flow of sludge recirculation	No measurement of the sludge recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Excess sludge extraction pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process. Also, the pumping station that pumps sludge towards the thickener presents hydraulic problems. Certain questions of overflow and malfunctioning of the submersible pumps were reported to the consulting team.	We recommend the construction of a biological sludge pumping station equipped with submersible pumps in order to lift the excess sludge towards the thickener. We recommend the construction of a pumping station dedicated to each line.	Estimated flow for each pump = 18 m3/h.
Measurement of the flow of excess sludge	No measurement of the excess sludge exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 80 mm
Tertiary treatment			
Nitrate recirculation pump	The Tunisian norm NT106.02 sets maximum limits for nitrate, nitrite, organic and ammoniacal nitrogen. Hence, it is necessary to modify the existing reactors to adapt them for biological elimination of nitrogen. In the framework of this solution, it is necessary to add a Nitrate recirculation pump to the new line.	It is necessary to install submersible pumps (with frequency variation) for nitrate recirculation, in the existing aeration tanks - from the last aeration tank to the first	Estimated flow for each pump Existing line = 664 m3/h New line = 443 m3/h

Designation	Diagnosis	Proposed solution	Characteristics
Measurement of the flow of nitrate recirculation	No measurement of the nitrate recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Dosing pump of aluminium sulfate and dosing circuit	Chemical precipitation of phosphorus with dosing of aluminium sulfate	We recommend a dosing circuit with dosing tank, retention chamber, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Estimated flow for each pump = 42 L/h.
Disinfection	The Tunisian norm NT 106.02 obliges observance of 2000/100 ml of faecal coliforms and 1000/100 ml of faecal streptococci in order to guarantee the microbiological quality of the public water supply.	Disinfection by ultraviolet radiation implemented upstream by the filtration operation via multicellular vertical feeding pumps linked to the filters, self-cleaning pressure filters and an ultraviolet radiation system in the open channel.	Maximum flow = 700 m3/h
Treatment of the sludge			
Scraper bridge (thickener)	The paintwork of the existing scraper bridge is a bit degraded and altered in certain places. The pumping station that pumps sludge towards the thickener presents hydraulic problems. Certain questions of overflow and malfunctioning of the submersible pumps were reported to the consulting team. In the framework of this solution for renovation of the WwTP, we propose the construction of new thickeners.	The thickening of the sludge will be implemented in two new circular-shaped thickeners, equipped with new scraper bridges.	

Designation	Diagnosis	Proposed solution	Characteristics
Thickened sludge pumps	The sludge pumps (which lift the sludge towards the thickened sludge storage tank or towards the sludge drying beds) present a high level of deterioration.	In the framework of renovation of the WwTP, it will be necessary to replace these pumps. An excentric screw pump is recommended. There is one pump for each thickener.	Estimated flow per pump = 18 m3/h.
Submersible mixer (thickened sludge storage tank)	In the framework of renovation of the WwTP, we propose temporary storage of the thickened sludge in a tank upstream of the dewatering stage.	It is necessary to install a submersible mixer in order to avoid sedimentation of the sludge.	-
Lift pump to raise the thickened sludge to the centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend an excentric screw pump.	Estimated flow per pump = 23 m3/h.
Centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of an equipment item.	Capacity 23 m3/h
Polymer preparation equipment	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of fully automatic continuous polymer solution preparation equipment. Dosing tank, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Capacity 1,000 L/h.

Designation	Diagnosis	Proposed solution	Characteristics
Polymer dosing pump	-	We recommend membrane dosing pumps.	Estimated flow per pump = 0.8 m3/h.
Lifting the dewatered sludge	-	The dewatered sludge will be lifted via a screw conveyor.	Estimated volumetric flow rate of the dewatered sludge = 19 m3/d
Treatment of odors			
Contaminated air treatment system	We propose to extract the contaminated air from the grit retention tank, preliminary treatment building, thickener, thickened sludge storage tank and dewatering building	The contaminated air will be deodorized via a bio filter and a piping circuit and fan	
Electrical installations			
MV-LV transformation station	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	
Low voltage cupboard	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item	

Designation	Diagnosis	Proposed solution	Characteristics
Command station with master control panel	In the framework of the intervention proposed for the WwTP, these equipment items should be renovated.	We recommend installation of a programmable automation controller that permits integration between the measurement instruments and operation of the mechanical equipment.	

3.5.3.3 Solution 2

3.5.3.3.1 Detailed description of the treatment sequence – design and criteria

Solution 2 integrates the biological treatment by activated sludge in conventional aeration, with sludge anaerobic digestion and biogas energy recovery. The treatment line integrates new facilities, the primary treatment equipment and the sludge mesophilic anaerobic stabilization, namely anaerobic digester, gasholder, flare, equipment for biogas treatment, motor generators, boiler and heat exchanger. This solution integrates a high number of operations; therefore the complexity of operation and maintenance is remarkable. In order to overcome this difficulty, the operators must be specially trained for operating the new equipment. On the other hand, this is an advantageous solution concerning energy consumption, considering the lower power consumption relating to the extended aeration systems and the possibility to recover energy from the produced biogas.

As mentioned for the solution 1, the maximum estimated inflow is lower than the design flow of the existing pre-treatment structures and its capacity is therefore sufficient. Nonetheless, the introduction of 2 primary sedimentation tanks makes it necessary to modify the hydraulic profile of the preliminary treatment structures; we therefore propose raising the coping of the preliminary treatment structures and respective changing of the overflows.

The design carried out revealed that in a conventional aeration regime, the biological volume of three of the four existing tanks (3 693 m^3) is sufficient for biological treatment of the wastewater flowing into the plant at the planning year. At year zero, the operating team could operate solely with two tanks (2 462 m^3), thus improving the operating conditions of the biological treatment. The anoxic volume foreseen for year zero corresponds of half of the existing tank and the construction of a perimeter wall in this first tank is therefore necessary. Nonetheless, at the planning year, the totality of the volume of this tank is necessary for denitrification. In this case, this tank must be prepared to operate in two manners: half-anoxic and half-aerobic, or totally anoxic. In relation to secondary sedimentation and the sludge pumping stations, the considerations made for solution 1 are also valid for solution 2; we therefore foresee the need to build a new secondary clarifier in order to treat 40% of the flow into the WwTP. It is therefore necessary to include a structure for distribution of the flow after the aeration tanks (60% of the flow towards the existing sedimentation tank and 40% towards the new sedimentation tank).

Downstream of the secondary sedimentation, a new tertiary treatment stage in the form of filtration followed by UV disinfection is foreseen, aimed at reduction of bacteriological aeration in order to respond to the requirements of the norm NT 106.02.

As verified for solution 1, the existing thickener does not have sufficient capacity and presents serious operating problems (in particular the entrance of raw wastewater in the supernatant gutter and in the volume of the thickening process). It is therefore necessary to build two new thickeners. As was concluded for solution 1, the sludge drying beds are not sufficient in order to dewater the estimated flow of digested sludge; we therefore foresee the installation of a mechanical dewatering stage, using a centrifuge.

Thus, the treatment line of Solution 2 for the rehabilitation of the WwTP of Tabarka includes the following stages:

- Preliminary treatment
    - Elevation of the raw wastewater, due to the raise of the coping of the pre-treatment structures (new);

  - Grit retention tank (new);
  - Screening consisting of 1 mechanical bar screen, with bars spacing of 6 mm, a conveyor hopper and a trailer (existing);
  - Manual bar screen installed in the recourse channel (existing);
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing).
- Primary treatment
  - Primary settling in 1 clarifier, of rectangular plant, with bottom and surface scrapers bridge (new);
  - Feeding of floats into the thickeners (new);
  - Extraction of primary sludge for the thickeners (new);
- Biological treatment
  - Oxidation of the organic matters in the existing treatment line (by using a total volume of 2,462 m^3 at year zero and of 3,693 m^3 in the project planning year), aerated by a new air diffused system supplied by blowers equipped with variable speed (new);
  - Settling of sludge in 2 secondary rectangular plant clarifiers, equipped with a suction scraper bridge, with a total surface of 700 m^2;
  - Sludge directing for the pumping stations (new);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
  - Feeding of floats into the thickeners (new);
  - Rise of excess sludge to the thickener (new);
  - Measurement of the treated water flow;
- Tertiary treatment
  - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
  - Chemical precipitation of phosphorus with aluminum sulfate dosing (new);
  - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
  - Thickening of the primary sludge, excess sludge and physicochemical sludge in 2 thickeners provided with a scraping bridge(new);
  - Mesophilic anaerobic stabilization of thickened sludge (new);

  - Storage of biogas in a gasholder (new);
  - Biogas energy recovery by a motor generator with production of thermal and electrical energy (new);
  - Heating of sludge in digestion with heat produced by cogeneration (new);
  - Burning the biogas in excess and the bad quality biogas in the flare (new);
  - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
  - Storage of dewatered sludge in containers (new);
  - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filters, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility (new).
- Treatment of odors:
  - treatment of the contaminated air, extracted from the preliminary treatment building, thickeners and dewatering building, by biofilter (new).

3.5.3.3.2 Energy report

The average electricity consumption (solution 2, planning year) is presented in the annex (see Annex III, Annex III.4 at the end). The energy report of solution 2 includes electricity produced by cogeneration.

3.5.3.3.3 Consumption of chemical reagents

The chemical reagents consumed in the wastewater treatment process are aluminium sulfate, hydrated lime and polyelectrolyte. The quantities of chemical reagents consumed in year zero and in the planning year are presented in Annex III.4 (at the end).

3.5.3.3.4 Management of by-products

The quantities of by-products resulting from the wastewater treatment process, in particular solid screenings, grit, grease and sludge, are presented in Annex III.4 (at the end).

3.5.3.3.5 Equipment

The following table summarizes the solutions proposed in terms of replacement of the existing equipment items in the Tabarka WWTP, in the framework of solution 2. For a fuller understanding of the following comments, it is necessary to view the treatment scheme of the solution attached to the report.

Table 3.5-8: Electro-mechanical equipment, instruments and electrical installations

Designation	Diagnosis	Proposed solution	Characteristics
Preliminary treatment			
Initial elevation of wastewater	In the framework of this solution, the introduction of the primary sedimentation tanks requires a modification to the hydraulic profile of the preliminary treatment structures.	We therefore propose the construction of an initial wastewater pumping station and raising of the coping of the preliminary treatment structures. We propose lifting the wastewater using 2+1 submersible pumps.	Maximum design flow = 700 m3/h
Grit extraction system by “air-lift”	The wastewater includes a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber.	We propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber. Grit extraction will be achieved via an “air-lift” system..	Estimated extraction flow rate = 18 m3/h
Mechanical multi-rake bar screen	The mechanical screen presents a high level of large scale corrosion, probably due to the proximity of the sea and the impact of wastewater in its working environment. All mechanisms are exposed to the meteorological conditions. The screenings are channeled towards the transport via a stainless steel hopper. The latter has corrosion and does not seem to be the best solution for this function. The valves present a high level of deterioration.	The demonstrated state of degradation justifies the replacement of all these equipment items. These equipment items should be assembled in the new preliminary treatment work.	Maximum flow via the mechanical screen = 700 m3/h Spacing between bars = 6 mm
Measurement of the difference in water level (screening)	The demonstrated state of degradation justifies replacement.	Automation should be improved, in particular in terms of integration between measurement of the level and operation of the mechanical screen.	

Designation	Diagnosis	Proposed solution	Characteristics
Scraper bridge (grit and grease extraction in a double aerated channel)	In general, the scraper bridge presents a very high level of deterioration. The scraper bridge has a deviation in its longitudinal movement. The wheels of the scraper bridge present a high level of degradation. The electrical elements of the equipment present a high level of degradation.	The demonstrated state of degradation justifies their replacement. These equipment items should be assembled in the new preliminary treatment work.	To be installed in the new structure
Grit pumps (grit and grease extraction in a double aerated channel)	The poor performance of the Grit pumps was reported to the consulting team.	We recommend the replacement of the equipment items.	Estimated flow for each pump = 18 m3/h.
Grit classifier (grit and grease extraction in a double aerated channel)	There is no grit classifier. The grit trailer carries a high quantity of water.	The grit classification operation must be improved with installation of specialized equipment for this function. The equipment will be installed on the scraper bridge.	Estimated total capacity = 20 m3/h.
Compressors (grit and grease extraction in a double aerated channel)	The aeration compressors are in working order and a reasonable state of preservation.	Replacement is not judged to be necessary.	

Designation	Diagnosis	Proposed solution	Characteristics
Primary treatment			
Scraper bridges (primary sedimentation tanks)	In the framework of this solution for renovation of the WwTP, we propose the existence of primary treatment.	The scraper bridge is constituted by a mobile transversal beam that serves as a walkway, two lateral guides, an articulated system for collecting the sludge and discharging the scum, a motor reduction unit for activating the two lateral guides, a control unit of the articulated system of bottom scraper/scum blade and a command and control panel.	-
Primary sludge lift pumps (primary sedimentation tanks)		It is necessary to install submersible pumps. There is one pump per scraper bridge.	Estimated flow for each pump = 18 m3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Secondary or biological treatment			
Aeration	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor. Also, in order to maximize the volume of the existing reaction it is necessary to implement a more effective aeration method. The tanks are too deep in order to obtain maximum performance of the existing surface aerators.	We recommend replacement of the surface aerators by a fine bubble aeration system. This system includes compressors endowed with speed variation, air ducts and diffusers installed in the tanks. There are two compressors: 1+1.	Estimated volumetric flow rate of air for each compressor = 4,954 m3/h.
Oxygen measurement (aeration tank)	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor.	We recommend installation of a programmable automation controller that permits integration of oxygen measurements with the aeration operation.	
Mixing	There are no submersible mixers.	In the framework of this solution, it is necessary to add submersible mixers.	To install of the submersible mixers in the tanks
Scraper bridges (secondary clarifiers)	In general, the scraper bridge presents a high level of deterioration. The scraper bridge has a deviation in its longitudinal movement. There is a large deviation between the guide wheel and the clarifier partition wall. The wheels of the scraper bridge present a high level of degradation.	We recommend the replacement of the equipment items and, in the framework of this solution, it is necessary to add a scraper bridge to the new line.	Installed in the existing secondary clarifier and in the new secondary clarifier.

Designation	Diagnosis	Proposed solution	Characteristics
Biological sludge lift pumps (secondary clarifiers)	The poor performance of the Biological sludge lift pumps was reported to the consulting team.	In the framework of this solution, it is necessary to add submersible pumps in order to lift the biological sludge. There are three pumps per scraper bridge.	Estimated flow for each pump Existing line = 114 m3/h New line = 76 m3/h
Sludge recirculation pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process	We recommend the construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks.	Estimated flow for each pump = 548 m3/h.
Measurement of the flow of sludge recirculation	No measurement of the sludge recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Excess sludge extraction pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process Hence the pumping station that pumps sludge towards the thickener presents hydraulic problems. Certain questions of overflow and malfunctioning of the submersible pumps were reported to the consulting team.	We recommend the construction of a biological sludge pumping station equipped with submersible pumps in order to lift the excess sludge towards the thickener.	Estimated flow for each pump = 18 m3/h.
Measurement of the flow of excess sludge	No measurement of the excess sludge exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 80 mm

Designation	Diagnosis	Proposed solution	Characteristics
Tertiary treatment			
Nitrate recirculation pump	The Tunisian norm NT106.02 sets maximum limits for nitrate, nitrite, organic and ammoniacal nitrogen. Hence, it is necessary to modify the existing reactors to adapt them for biological elimination of nitrogen.	It is necessary to install submersible pumps (with frequency variation) for nitrate recirculation, in the existing aeration tanks - from the last aeration tank to the first	Estimated flow for each pump = 1,097 m3/h.
Measurement of the flow of nitrate recirculation	No measurement of the nitrate recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Dosing pump of aluminium sulfate and dosing circuit	Chemical precipitation of phosphorus with dosing of aluminium sulfate	We recommend a dosing circuit with dosing tank, retention chamber, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Estimated flow for each pump = 103 L/h.
Disinfection	The Tunisian norm NT 106.02 obliges observance of 2000/100 ml of fecal coliforms and 1000/100 ml of fecal streptococci in order to guarantee the microbiological quality of the public water supply.	Disinfection by ultraviolet radiation implemented upstream by the filtration operation using vertical multicellular pumps, self-cleaning pressure filters, and ultraviolet radiation system in the open channel.	Maximum flow = 700 m3/h

Designation	Diagnosis	Proposed solution	Characteristics
Treatment of the sludge			
Scraper bridge (thickener)	The paintwork of the existing scraper bridge is a bit degraded and altered in certain places. The pumping station that pumps sludge towards the thickener presents hydraulic problems. Certain questions of overflow and malfunctioning of the submersible pumps were reported to the consulting team. In the framework of this solution for renovation of the WwTP, we propose the construction of new thickeners.	The thickening of the sludge will be implemented in two new circular-shaped thickeners, equipped with new scraper bridges.	
Thickened sludge pumps	The sludge pumps (which lift the sludge towards the thickened sludge storage tank or towards the sludge drying beds) presents a high level of deterioration	In the framework of renovation of the WwTP it will be necessary to replace these pumps. We recommend an excentric screw pump. There is one pump for each thickener.	Estimated flow per pump = 18 m3/h.
Anaerobic digestion of the sludge	In the framework of this solution for renovation of the WwTP, we propose mesophilic anaerobic stabilization of the thickened sludge.	The anaerobic digestion of the sludge will be implemented using the digesters, agitation of the digesters via the Sludge recirculation pumps, pumps for the sludge heating circuit during digestion, gasholder and torch.	
Sludge heating system during digestion	For mesophilic anaerobic stabilization of the thickened sludge, it is necessary to foresee a sludge heating system during digestion.	We always recommend the use of a boiler and a hot water tank with recirculation pumps for these circuits.	The boiler must work with natural gas and biogas

Designation	Diagnosis	Proposed solution	Characteristics
Cogeneration	The cogeneration system enables energy use of the biogas produced and also heating of the sludge during digestion with the heat produced by the motor-generator.	In addition to the sludge heating system during digestion using the boiler, we propose a cogeneration system constituted by elements such as the biogas-driven motor-generator.	
Lift pump of the digested sludge for the centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer.	We recommend an excentric screw pump.	Estimated flow per pump = 26 m3/h.
Centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of an equipment item.	Capacity 26 m3/h
Polymer preparation equipment	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of fully automatic continuous polymer solution preparation equipment. Dosing tank, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Capacity 1,000 L/h.
Polymer dosing pump	-	We recommend use of membrane dosing pumps.	Estimated flow per pump = 0.8 m3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Lifting the dewatered sludge		The dewatered sludge will be lifted via a screw conveyor.	Estimated volumetric flow rate of the dewatered sludge = 21 m3/d
Treatment of odors			
Contaminated air treatment system	We propose to extract the contaminated air from the grit retention tank, preliminary treatment building, thickener and dewatering building	The contaminated air will be deodorized via a bio filter and a piping circuit and fan	
Electrical installations			
MV-LV transformation station	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Low voltage cupboard	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Command station with master control panel	In the framework of the intervention proposed for the WwTP, these equipment items should be renovated.	We recommend installation of a programmable automation controller that permits integration between the measurement instruments and operation of the mechanical equipment.	-

3.5.3.4 Solution 3

3.5.3.4.1 Detailed description of the treatment sequence – design and criteria

Solution 3 integrates the biological treatment by activated sludge in conventional aeration, with mesophilic anaerobic digestion of sludge. Biogas is frequently used as combustible for the boiler which provides the necessary power to the reheating of sludge. Biogas in excess will be incinerated in the flare.

The treatment line integrates the new facilities, the primary treatment equipment and the sludge mesophilic anaerobic stabilization, namely anaerobic digester, gasholder, flare, equipment for biogas treatment, boiler and heat exchanger.

Generally, all the considerations made for solution 2, concerning the capacity of the existing structures and the need for extension, are also valid for this solution 3.

The treatment line of Solution 3 for the rehabilitation of the WwTP of Tabarka includes the following stages:

- Preliminary treatment
    - Elevation of the raw wastewater, due to the raise of the coping of the pre-treatment structures (new);
    - Grit retention in tank (new);
    - Screening consisting of 1 mechanical bar screen, with bars spacing of 6 mm, a conveyor hopper and a trailer (existing);
    - Manual bar screen installed in the recourse channel (existing);
    - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing).
- Primary treatment
    - Primary settling in 1 clarifier, of rectangular plant, with bottom and surface scrapers bridge (new);
    - Feeding of floats into the thickeners (new);
    - Extraction of primary sludge for the thickeners (new);
- Biological treatment
    - Oxidation of the organic matters in the existing treatment line (by using a total volume of 2,462 m^3 at year zero and of 3,693 m^3 in the project planning year), aerated by a new air diffused system supplied by blowers equipped with variable speed (new);
    - Settling of sludge in 2 secondary rectangular plant clarifiers, equipped with a suction scraper bridge, with a total surface of 700 m^2;
    - Sludge directing for the pumping stations (new);
    - Sludge recycling at the beginning of the aeration tanks and flow measurement

using an electromagnetic flow meter (new);

- Feeding of floats into the thickeners (new);
- Rise of excess sludge to the thickener (new);
- Measurement of the treated water flow;

- Tertiary treatment
  - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
  - Chemical precipitation of phosphorus with aluminum sulfate dosing (new);
  - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
  - Thickening of the primary sludge, excess sludge and physicochemical sludge in 2 thickeners, of square plant, provided with a scraper bridge (new);
  - Mesophilic anaerobic stabilization of thickened sludge (new);
  - Storage of biogas in a gasholder (new);
  - Heating of sludge in digestion with heat produced by the boiler (new);
  - Burning the biogas in excess and the bad quality biogas in the flare (new);
  - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
  - Storage of dewatered sludge in containers (new);
  - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filters, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility (new);
- Treatment of odors:
  - treatment of the contaminated air, extracted from the preliminary treatment building, thickeners and dewatering building, by biofilter (new).

3.5.3.4.2 Energy report

The average electricity consumption (solution 3, planning year) is presented in the annex (see Annex III, Annex III.4 at the end).

3.5.3.4.3 Consumption of chemical reagents

The chemical reagents consumed in the wastewater treatment process are aluminium sulfate, hydrated lime and polyelectrolyte. The quantities of chemical reagents consumed in year zero and in the planning year are presented in Annex III.4 (at the end).

3.5.3.4.4 Management of by-products

The quantities of by-products resulting from the wastewater treatment process, in particular solid screenings, grit, grease and sludge, are presented in Annex III.4 (at the end).

3.5.3.4.5 Equipment

Solution 3 includes the same treatment line as solution 2, except for cogeneration. As a result, all the considerations made for solution 2 concerning the existing equipment items and replacement needs, are also valid for this solution. For a fuller understanding of the comments, it is necessary to view the treatment scheme of the solution attached to the report.

Table 3.5-9: Electro-mechanical equipment, instruments and electrical installations

Designation	Diagnosis	Proposed solution	Characteristics
Preliminary treatment			
Initial elevation of wastewater	In the framework of this solution, the introduction of the primary sedimentation tanks requires a modification to the hydraulic profile of the preliminary treatment structures.	We therefore propose the construction of an initial wastewater pumping station and raising of the coping of the preliminary treatment structures. We propose lifting the wastewater using 2+1 submersible pumps.	Maximum design flow = 700 m3/h
Grit extraction system by “air-lift”	The wastewater includes a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber.	We propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber. Grit extraction will be achieved via an “air-lift” system..	Estimated extraction flow rate = 18 m3/h
Mechanical multi-rake bar screen	The mechanical screen presents a high level of large scale corrosion, probably due to the proximity of the sea and the impact of wastewater in its working environment. All mechanisms are exposed to the meteorological conditions. The screenings are channeled towards the transport via a stainless steel hopper. The latter has corrosion and does not seem to be the best solution for this function. The valves present a high level of deterioration.	The demonstrated state of degradation justifies the replacement of all these equipment items. These equipment items should be assembled in the new preliminary treatment work.	Maximum flow via the mechanical screen = 700 m3/h Spacing between bars = 6 mm
Measurement of the difference in water level (screening)	The demonstrated state of degradation justifies replacement.	Automation should be improved, in particular in terms of integration between measurement of the level and operation of the mechanical screen.	

Designation	Diagnosis	Proposed solution	Characteristics
Scraper bridge (grit and grease extraction in a double aerated channel)	In general, the scraper bridge presents a very high level of deterioration. The scraper bridge has a deviation in its longitudinal movement. The wheels of the scraper bridge present a high level of degradation. The electrical elements of the equipment present a high level of degradation.	The demonstrated state of degradation justifies their replacement. These equipment items should be assembled in the new preliminary treatment work.	To be installed in the new structure
Grit pumps (grit and grease extraction in a double aerated channel)	The poor performance of the Grit pumps was reported to the consulting team.	We recommend the replacement of the equipment items.	Estimated flow for each pump = 18 m3/h.
Grit classifier (grit and grease extraction in a double aerated channel)	There is no grit classifier. The grit trailer carries a high quantity of water.	The grit classification operation must be improved with installation of specialized equipment for this function. The equipment will be installed on the scraper bridge.	Estimated total capacity = 20 m3/h.
Compressors (grit and grease extraction in a double aerated channel)	The aeration compressors are in working order and a reasonable state of preservation.	Replacement is not judged to be necessary.	

Designation	Diagnosis	Proposed solution	Characteristics
Primary treatment			
Scraper bridges (primary sedimentation tanks)	In the framework of this solution for renovation of the WwTP, we propose the existence of primary treatment.	The scraper bridge is constituted by a mobile transversal beam that serves as a walkway, two lateral guides, an articulated system for collecting the sludge and discharging the scum, a motor reduction unit for activating the two lateral guides, a control unit of the articulated system of bottom scraper/scum blade and a command and control panel.	-
Primary sludge lift pumps (primary sedimentation tanks)		It is necessary to install submersible pumps. There is one pump per scraper bridge.	Estimated flow for each pump = 18 m3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Secondary or biological treatment			
Aeration	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor. Also, in order to maximize the volume of the existing reaction it is necessary to implement a more effective aeration method. The tanks are too deep in order to obtain maximum performance of the existing surface aerators.	We recommend replacement of the surface aerators by a fine bubble aeration system. This system includes compressors endowed with speed variation, air ducts and diffusers installed in the tanks. There are two compressors: 1+1.	Estimated volumetric flow rate of air for each compressor = 4,954 m3/h.
Oxygen measurement (aeration tank)	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor.	We recommend installation of a programmable automation controller that permits integration of oxygen measurements with the aeration operation.	
Mixing	There are no submersible mixers.	In the framework of this solution, it is necessary to add submersible mixers.	To install of the submersible mixers in the tanks
Scraper bridges (secondary clarifiers)	In general, the scraper bridge presents a high level of deterioration. The scraper bridge has a deviation in its longitudinal movement. There is a large deviation between the guide wheel and the clarifier partition wall. The wheels of the scraper bridge present a high level of degradation.	We recommend the replacement of the equipment items and, in the framework of this solution, it is necessary to add a scraper bridge to the new line.	Installed in the existing secondary clarifier and in the new secondary clarifier.

Designation	Diagnosis	Proposed solution	Characteristics
Biological sludge lift pumps (secondary clarifiers)	The poor performance of the Biological sludge lift pumps was reported to the consulting team.	In the framework of this solution, it is necessary to add submersible pumps in order to lift the biological sludge. There are three pumps per scraper bridge.	Estimated flow for each pump Existing line = 114 m3/h New line = 76 m3/h
Sludge recirculation pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process	We recommend the construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks.	Estimated flow for each pump = 548 m3/h.
Measurement of the flow of sludge recirculation	No measurement of the sludge recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Excess sludge extraction pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process Hence the pumping station that pumps sludge towards the thickener presents hydraulic problems. Certain questions of overflow and malfunctioning of the submersible pumps were reported to the consulting team.	We recommend the construction of a biological sludge pumping station equipped with submersible pumps in order to lift the excess sludge towards the thickener.	Estimated flow for each pump = 18 m3/h.
Measurement of the flow of excess sludge	No measurement of the excess sludge exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 80 mm

Designation	Diagnosis	Proposed solution	Characteristics
Tertiary treatment			
Nitrate recirculation pump	The Tunisian norm NT106.02 sets maximum limits for nitrate, nitrite, organic and ammoniacal nitrogen. Hence, it is necessary to modify the existing reactors to adapt them for biological elimination of nitrogen.	It is necessary to install submersible pumps (with frequency variation) for nitrate recirculation, in the existing aeration tanks - from the last aeration tank to the first	Estimated flow for each pump = 1,097 m3/h.
Measurement of the flow of nitrate recirculation	No measurement of the nitrate recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Dosing pump of aluminium sulfate and dosing circuit	Chemical precipitation of phosphorus with dosing of aluminium sulfate	We recommend a dosing circuit with dosing tank, retention chamber, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Estimated flow for each pump = 103 L/h.
Disinfection	The Tunisian norm NT 106.02 obliges observance of 2000/100 ml of faecal coliforms and 1000/100 ml of faecal streptococci in order to guarantee the microbiological quality of the public water supply.	Disinfection by ultraviolet radiation implemented upstream by the filtration operation using vertical multicellular pumps, self-cleaning pressure filters, and ultraviolet radiation system in the open channel.	Maximum flow = 700 m3/h

Designation	Diagnosis	Proposed solution	Characteristics
Treatment of the sludge			
Scraper bridge (thickener)	The paintwork of the existing scraper bridge is a bit degraded and altered in certain places. The pumping station that pumps sludge towards the thickener presents hydraulic problems. Certain questions of overflow and malfunctioning of the submersible pumps were reported to the consulting team. In the framework of this solution for renovation of the WwTP, we propose the construction of new thickeners.	The thickening of the sludge will be implemented in two new circular-shaped thickeners, equipped with new scraper bridges.	
Thickened sludge pumps	The sludge pumps (which lift the sludge towards the thickened sludge storage tank or towards the sludge drying beds) presents a high level of deterioration	In the framework of renovation of the station it will be necessary to replace these pumps. We recommend an excentric screw pump. There is one pump for each thickener.	Estimated flow per pump = 18 m3/h.
Anaerobic digestion of the sludge	In the framework of this solution for renovation of the WwTP, we propose mesophilic anaerobic stabilization of the thickened sludge.	The anaerobic digestion of the sludge will be implemented using the digesters, agitation of the digesters via the Sludge recirculation pumps, pumps for the sludge heating circuit during digestion, gasholder and torch.	
Sludge heating system during digestion	For mesophilic anaerobic stabilization of the thickened sludge, it is necessary to foresee a sludge heating system during digestion.	We always recommend the use of a boiler and a hot water tank with recirculation pumps for these circuits.	The boiler must work with natural gas and biogas

Designation	Diagnosis	Proposed solution	Characteristics
Lift pump of the digested sludge for the centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer.	We recommend an excentric screw pump.	Estimated flow per pump = 26 m3/h.
Centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of an equipment item.	Capacity 26 m3/h
Polymer preparation equipment	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of fully automatic continuous polymer solution preparation equipment. Dosing tank, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Capacity 1,000 L/h.
Polymer dosing pump	-	We recommend use of membrane dosing pumps.	Estimated flow per pump = 0.8 m3/h.
Lifting the dewatered sludge		The dewatered sludge will be lifted via a screw conveyor.	Estimated volumetric flow rate of the dewatered sludge = 21 m3/d

Designation	Diagnosis	Proposed solution	Characteristics
Treatment of odors			
Contaminated air treatment system	We propose to extract the contaminated air from the grit retention tank, preliminary treatment building, thickener and dewatering building	The contaminated air will be deodorized via a bio filter and a piping circuit and fan	
Electrical installations			
MV-LV transformation station	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Low voltage cupboard	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Command station with master control panel	In the framework of the intervention proposed for the WwTP, these equipment items should be renovated.	We recommend installation of a programmable automation controller that permits integration between the measurement instruments and operation of the mechanical equipment.	-

3.5.4 Economic assessment

3.5.4.1 Investment costs

The estimate of the fixed capital investment costs associated with the civil engineering and equipment items is based on market consultations and information supplied by ONAS.

The following table presents a summary of the fixed capital investment costs associated with each treatment solution studied. Annex III.8 presents systematization of the partial values used for the values presented in the following table. The breaking down of prices for the proposed solution is given in Annex III.9.

Cost estimation takes 2011 as reference year for prices.

Table 3.5-10: Estimate of the initial investment costs

Treatment solutions	Civil engineering (TND)	Equipment items and IE (TND)	Total (TND)
1	1,708,172	3,199,741	4,907,913
2	2,185,946	5,685,285	7,871,231
3	2,171,621	4,158,181	6,329,802

In conformity with the project implementation timetable described in chapter V, it is admitted that the initial investment will be made in 2016, which corresponds to the start of the construction works.

3.5.4.2 Operating and maintenance costs

In order to estimate the operating and maintenance costs, the unit costs supplied by ONAS have been used, in relation to:

- maintenance;
- consumption of chemical reagents;
- electricity consumption;
- transport and final deposit of the by-products and sludge.

The operating costs associated with analytic control of operation of the WwTP have not been counted, since they depend upon the planning defined by ONAS and are common to all the treatment solutions studied.

The maintenance costs resulting from addition of the two parts corresponding to the civil engineering and maintenance of the electromechanical equipment. They have been estimated through application of a rate of 2.5% and 1.0% on the budgetary forecasts of the investment for the electromechanical equipment items and civil engineering, respectively.

In relation to the chemical reagents, the following unit prices are admitted:

- aluminium sulfate – 400 TND;
- cationic polyelectrolyte – 6500 TND;

- lime – 150 TND.

The electricity consumption has been estimated on the basis of the energy reports presented in Annex III.4, and a unit electricity cost of 0.13 TND/kWh was admitted.

In order to estimate the costs de transport and final deposit of the by-products and of the sludge, a unit cost of 40 TND/t has been taken into consideration.

In conformity with the project implementation timetable, the start date of operation of the station after renovation will be 2019.

3.5.4.3 Updated total costs

Annex III.8 presents the updated total costs for the year 2016, through application of an updating rate of 3%. A summary of the results obtained is presented in the following table.

Table 3.5-11: Estimate of the fixed capital investment costs (FCIC), of the operating costs (OC) and of the updated total costs (UTC) for each solution studied

Treatment solutions	FCIC (TND)	OC (TND)	UTC (TND)
1	4,907,913	10,149,080	12,904,406
2	7,871,231	12,026,605	17,351,570
3	6,329,802	12,813,668	16,425,634

For each solution studied the ratio TND/m^3 is respectively, 0.44, 0.58 and 0.55.

3.5.5 Economic and technical comparison of the solutions

From the previous table, it is noted that Solution 2 is the most expensive over the duration of the project, in terms of capital investment costs, operating costs and total discounted costs. Solution 1 is the most advantageous from a strictly economic perspective, with the lowest capital investment costs, operating costs and total discounted costs.

During the missions in Tunisia, the consultant team tried to find examples of WwTP using the process of conventional aeration activated sludge, with mesophilic anaerobic digestion of sludge and energy recovery from biogas. Although it may not be a representative sample of such plants, the team visited Choutrana WwTP near Tunis. At the time of the visit the anaerobic digestion of sludge with energy recovery of biogas was out of service. The team notes that based on the training plans provided by ONAS, a major effort would be needed to implement Solution 2, for the integration of training of the operation team.

In contrast, Solution 1 uses an existing treatment process, which is much simpler and well controlled by the operation team.

Solution 3 is an intermediate option, between 1 and 2. However, it would involve operational difficulties almost as great as Solution 2.

The consultant team considers that the size of the Tabarka WwTP does not justify a change in its process, and so recommends that the rehabilitation of the WwTP be carried out according to Solution 1.

3.5.6 Conclusion and recommendations

As the conclusion through discussion with ONAS during the present Survey, Solution 1 is selected as the best solution for the Tabarka WwTP to be proceeded for detailed design.

3.5.6.1 Summary of key interventions for the selected solution

With regard to the solution adopted key interventions recommended include:

- Preliminary treatment
  - construction of a new grit retention tank including the grit extraction system by "air-lift";
  - replacement of the mechanical multi-rake bar screen;
  - replacement of the scraper bridge;
  - replacement of the grit pumps (grit and grease extraction);
  - installation of a grit classifier;
  - replacement of the measurement flow equipment;
- Secondary or biological treatment
  - construction of a new aeration tank and a new secondary clarifier;
  - replacement of the surface aerators by a fine bubble aeration system including compressors endowed with speed variation, air ducts and diffusers installed in the tanks;
  - installation of submersible mixers;
  - replacement of the scraper bridges (secondary clarifiers);
  - construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks, and excess sludge extraction;
- Tertiary treatment
  - installation of nitrate recirculation pumps;
  - construction of an ultraviolet radiation disinfection system in the open channel implemented upstream by the filtration operation via multicellular vertical feeding pumps linked to the filters, self-cleaning pressure filters;
- Sludge treatment
  - construction of two new thickeners ;
  - construction and installation of all the civil works and equipment relative to the sludge

- Odor treatment
  - construction and installation of all the civil works and equipment associated with the contaminated air treatment system including the extraction Of the contaminated air from the grit retention tank, preliminary treatment building, thickener, thickened sludge storage tank and dewatering building.

3.5.6.2 Recommendation regarding continuation of normal activity during works

As it is necessary to maintain the operation of the WWTP it becomes essential to perform all work in a progressive manner. In this sense, it is recommended:

- interventions should be made as much as possible during the dry season, so that the affluent flow is smaller;
- construction of the sand retention tank sand should be a priority and be completed before interventions in the pre-treatment;
- interventions provided at the pre-treatment should be carried out alternately on each channel;
- construction of the new aeration tank and secondary clarifier should precede the intervention in the existing biological treatment
- interventions concerning the pre-treatment of wastewater from the yeast production, disinfection, sludge treatment and odor treatment, are not directly involved in the operation of STEP, so can be done sequentially.

3.5.6.3 Remarks on further studies

The results for the STEP of Tabarka helped to find a solution for setting the budget of the operation of rehabilitation and extension.

However, the further studies, especially the Detailed Design, will have to validate in detail the technical choices proposed or to propose some technical amendments in the budget of the operation.

3.6 WWTP OF JENDOUBA

3.6.1 Current situation of the WwTP

3.6.1.1 General information

3.6.1.1.1 General localization and accessibility

The wastewater treatment plant of Jendouba is situated in the Commune of Jendouba, governorate of Jendouba, in the Ettouahria Area at 2 km from the center of the city (see Figure 3.6-1). The following figure presents an aerial view of the WwTP and the receiving water of treated effluent (Wadi Medjerda).

Figure 3.6-1: Aerial view of the WwTP of Jendouba and the receiving water of treated effluent
(Source: Google Earth 2010)

Every perimeter of the WwTP is enclosed (there is no masonry) but we can access to the plant through a gate from an unpaved secondary road, which is found in a reasonable state.

3.6.1.1.2 Environmental Restrictions of the area and the surroundings

The WwTP of Jendouba extends on a surface of approximately 4 ha and it has the necessary space for extension. The WwTP is situated at 2 km from the center of the city, in an agricultural area, with its fence found at less than 50 m from the receiving water.

3.6.1.1.3 Description of the Existing facilities

The WwTP of Jendouba has operated since 1994 to treat the wastewater from the Commune of Jendouba, as well as industrial wastewater from the food sector. The plant was dimensioned to treat the wastewater produced by 70,000 p.e. (population equivalent) corresponding to a flow of 8,000 m^3/day and to an organic load (BOD) of 3,400 kg/day.

Currently, the wastewater arrives gravitationally to the WwTP and is pumped to the inlet facility by two Archimedean screws.

The WwTP of Jendouba was designed according to the extended aeration activated sludge process. The treatment line incorporates the following facilities:

- Pretreatment
    - Effluent pumping by 3 Archimedean screws;
    - Screening consisting of 1 mechanical bar screen, with bars spacing of 12 mm, a conveyor belt and a trailer;
    - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge;
    - Flow measurement in a Venturi channel using an ultrasonic level meter;
- Biological or secondary treatment
    - Oxidation of the organic matter in 2 treatment lines, each one with 2 aeration tanks consisting of 3 basins in series (totalizing 12 basins) equipped with surface aerators and submersible agitators
    - Settling of sludge in 2 secondary clarifiers of rectangular plan (4 basins), equipped with a suction scraper bridge;
    - Pumping of scum to a trailer;
    - Sludge recycle to the beginning of the aeration tanks and flow measurement in a Venturi channel using an ultrasonic level meter;
    - Excess activated sludge extraction and feeding into the thickener;
- Tertiary treatment
    - dosing of aluminum sulfate for the chemical precipitation of phosphorus;
- Treatment of sludge
    - Excess activated sludge thickening in 1 thickener of square plan, equipped with a scraper bridge;
    - Dewatering of the thickened sludge in 26 drying beds;
    - Pumping of the thickener supernatant and the drying beds filtrate, by means of a pumping station, towards the sludge recycle channel.

The treated effluent is discharged into the Wadi Medjerda by means of gravity drainage pipe.

The following figures present the plant general layout and some photographs of the WwTP of Jendouba.

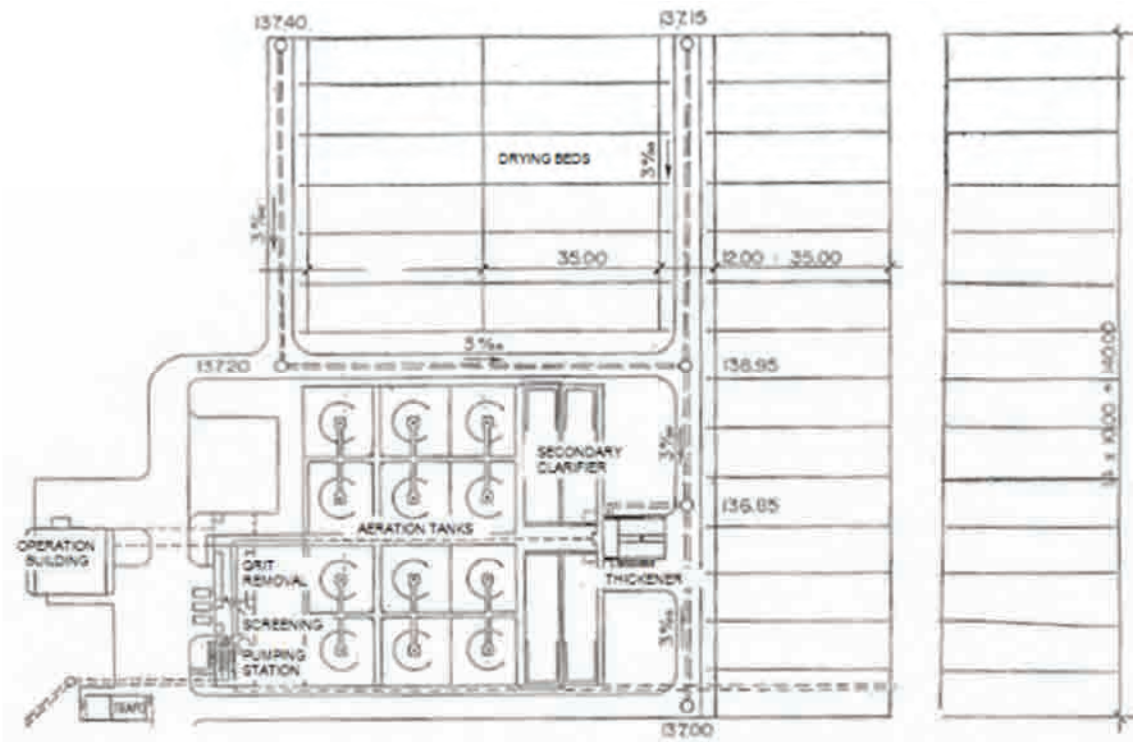


Figure 3.6-2: General Layout of the WwTP of Jendouba

Figure 3.6-3: Photographs of the WwTP of Jendouba

1 – Overall view; 2 – Pretreatment – Grit and grease removal; 3 – Aeration tanks; 4 – Secondary clarifier; 5 – Drying beds; 6 – Main building.

The main dimensions of the existing facilities are presented in Annex III (Annex III.5).

The main building has a total surface of approximately 360 m^2 distributed over two floors. On the ground floor, there are a WC, showers and locker rooms, a canteen, a laboratory, a store and a workshop. On the second floor, there are also WC and showers, as well as an office, a meeting room and the control room with the synoptic board and a general view over the WwTP.

3.6.1.2 Current quantitative and qualitative characteristics of the wastewater and treated water

3.6.1.2.1 ONAS' operating reports

The following tables summarize the quantitative and qualitative characterization of the wastewater influent to the WwTP of Jendouba, as well as the treated effluent, taking into account the annual operation reports of the years 2008, 2009 and 2010 provided by ONAS.

Table 3.6-1: Quantitative characterization of tributary wastewater from 2008 to 2010

Year	Value	Daily flow (m^3/day)	Monthly flow (m^3/month)	Annual flow (m^3/year)
2008	Minimum	3,863	115,890	1,831,830
	Average	5,014	152,653	
	Maximum	7,950	179,200	
2009	Minimum	4,348	116,760	1,961,380
	Average	5,500	163,448	
	Maximum	6,650	184,030	
2010	Minimum	5,497	153,920	2,140,030
	Average	5,844	178,336	
	Maximum	7,950	195,100	

Table 3.6-2: Qualitative characterization of tributary wastewater from 2008 to 2010

Year	Value	BOD (kg/day O_2)	COD (kg/day O_2)	TSS (kg/day)
2008	Minimum	1,549	3,233	1,748
	Average	2,076	4,332	2,269
	Maximum	2,455	6,829	2,899
2009	Minimum	1,766	3,135	1,444
	Average	2,287	4,430	2,244
	Maximum	2,611	5,480	2,826
2010	Minimum	2,014	3,963	2,135
	Average	2,395	4,526	2,354
	Maximum	2,647	5,526	2,660

Table 3.6-3: Characterization of the treated effluent from 2008 to 2010

Year	Value	BOD (mg/L O_2)	COD (mg/L O_2)	TSS (mg/L)
2008	Minimum	19	64	19
	Average	24	77	22
	Maximum	32	107	27
2009	Minimum	13	42	13
	Average	21	61	22
	Maximum	29	89	40
2010	Minimum	12	47	13
	Average	22	67	21
	Maximum	29	85	25

3.6.1.2.2 Sampling program implemented and discussion of the main results

In the framework of this project, a sampling program of the raw and treated wastewater was carried out, aimed at consolidating the conclusions of the analysis of the operating reports of the WwTP.

The sampling was implemented in conformity with the premises described in paragraph 3.3.1.2.2.

The sampling of the Jendouba WwTP was implemented on the following dates:

- Friday 29/10/2010 – Saturday 30/10/2010 : a normal weekday, without rain;
- Wednesday 03/11/2010 – Thursday 04/11/2010: weekly market; rain at 11:00;
- Saturday 06/11/2010 – Sunday 07/11/2010: week-end;
- Wednesday 10/11/2010 – Thursday 11/11/2010: weekly market; without rain.

The following table presents the main results of the sampling program carried out.

Table 3.6-4: Results of the sampling program

Parameters	From 29 to the 30/10/2010		From 03 to 04/11/2010		From 06 to 07/11/2010		From 10 to the 11/11/2010	
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow
Daily flow (m^3/d)	-		-		-		-	
pH	7.1	7.12	7.17	7.48	7.17	7.1	7.35	7.7
TSS (mg/L)	423	12.5	597	8	247	12	1,080	14
VSS (mg/L)	0.1	0.01	0.17	0.14	0.17	0.05	1.2	0.18
COD (mg/L O_2)	1,279	37	658	49	548	42	1,554	40
BOD_5 (mg/L O_2)	569	15	273	18	236	14	720	14
Carbonates (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bicarbonates (mg/L)	582.6	233	235	226	546	183	622	290
Hydroxides (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kjeldahl Nitrogen (mg/L N)	34.4	6	14.4	4.9	27	1.4	44.8	8.3
Nitrates (mg/L N)	<0.04	3.82	<0.04	6.31	<0.04	8.12	<0.04	4.8
Phosphorus total (mg/L P)	4.5	2.2	1.54	0.65	6.8	2.5	7.8	1.87
Oils & grease (mg/L)	22.4	<0.1	44	<0.1	24	<0.1	353	<0.1
Hydrocarbons (mg/L)	71.7	<3.3	487	<3.3	280	<3.3	323	<3.3
Total coliforms	9.5×10^7	7.5×10^5	4.5×10^7	2.5×10^5	9.5×10^7	4.5×10^5	7.5×10^7	2.5×10^5
Fecal coliforms	1.5×10^7	2.5×10^5	4.5×10^6	4.5×10^4	9.5×10^7	2.5×10^4	9.5×10^6	2.5×10^4

The sampling program carried out does not include flow values, due to problems with the flow-meter. Nonetheless, the instantaneous flow-meter produced values between 60 m^3 and 400 m^3, on average, during the 24 hours of sampling.

The ratios BOD_5/COD obtained vary between 0.41 à 0.46, which lies within the typical range for biodegradable effluents.

Furthermore, the effectiveness of degradation of the organic aeration is very high, around 98%. The effectiveness of elimination of nitrogen is between 22 % and 71.5 % (for this calculation, we considered that the total value of nitrogen corresponds to the Kjeldahl nitrogen and to the nitrates, since nitrites in raw effluent are generally negligible).

Moreover, analysis of the ratio BOD_5:N:P indicated the lack of phosphorus in the raw wastewater, given that the ratio was higher than the reference of 100:5:1, on two of the four sampling days. Nonetheless, this does not have to undermine the effectiveness degradation of the organic aeration.

Comparing the mean results from the sampling program (undertaken during October and November 2010) with the mean analytical results from the 2010 Operation Report, it is concluded that:

- The results from the sampling program for concentrations of TSS, COD and BOD_5 in raw wastewater are, on average, 10% to 45% above the mean values from the Operation Report;

- The concentrations of TSS, COD and BOD_5 in treated effluent obtained from the sampling program are, on average, 30 to 45% below the mean values recorded in 2010.

Comparing the mean results from the sampling program with the mean analytical results for only October and November from the 2010 Operation Report, it is concluded that:

- The results from the sampling program for concentrations of COD and BOD_5 in raw wastewater are of the same order as those recorded in the Operation Report; two of the results for TSS are of the same order, but the other two are very variable: one is about 184% above and the other is about 35% lower;

- The concentrations of TSS, COD and BOD_5 in treated effluent obtained from the sampling program are, generally, 30% to 50% below the values recorded in the Operation Report.

3.6.1.3 Evaluation of the existing plant operation

The annual operation reports provided by ONAS indicate that in 2008, 2009 and 2010, the wastewater flow tributary to the WwTP was always lower than the plant design flow (8,000 m^3/day), with an average value of the average daily flows of 2010 being approximately 73% of the hydraulic capacity of the WwTP.

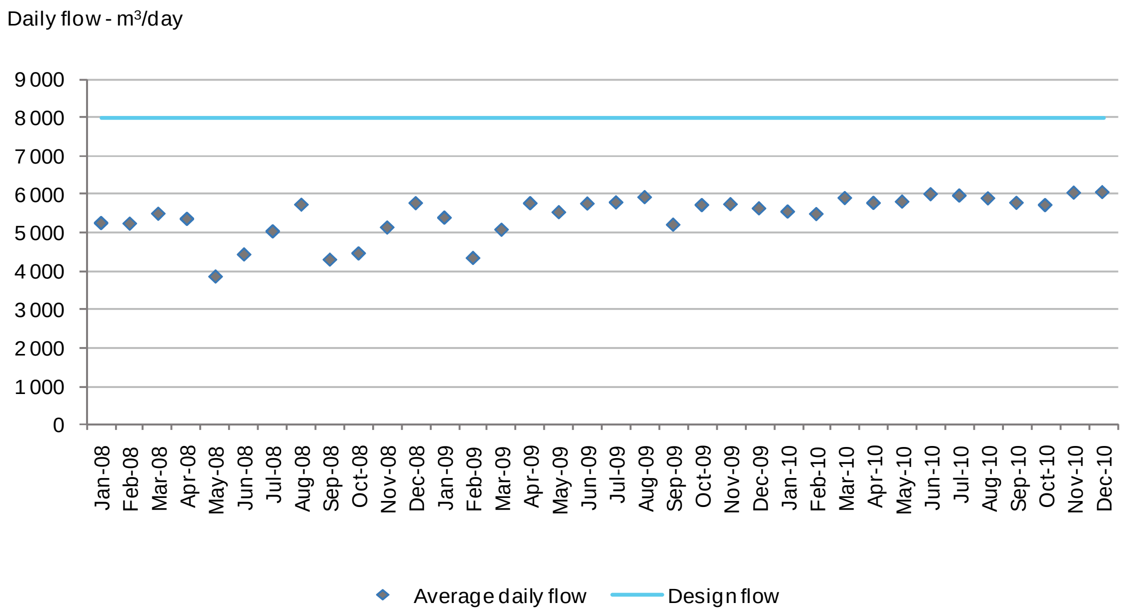


Figure 3.6-4: Variation of the average daily flow of the affluent between 2008 and 2010 and design flow

Viewing the last figure, the reduction in the annual variation of the inflow during 2010 is clearly visible.

In terms of organic load (BOD) tributary to the WwTP of Jendouba, the analyzed annual operation reports in 2010 indicates that the average organic load achieved 70% of the design load, 3,400 kg/day, with the value being always lower than this one.

Moreover, the reports also reveal a very satisfactory purifying output, with an average value of approximately 94% (with respect to the BOD), which makes it possible to ensure, at the outlet, a value of 30 mg/L O_2 prescribed by the legislation in force.

Moreover, the reports also reveal a very satisfactory treatment performance, with an average value of approximately 95% (with respect to the BOD), which ensures, at the outlet, the value of 30 mg/L O_2 prescribed by the legislation in force, in spite of some rare situations where the limit was exceeded.

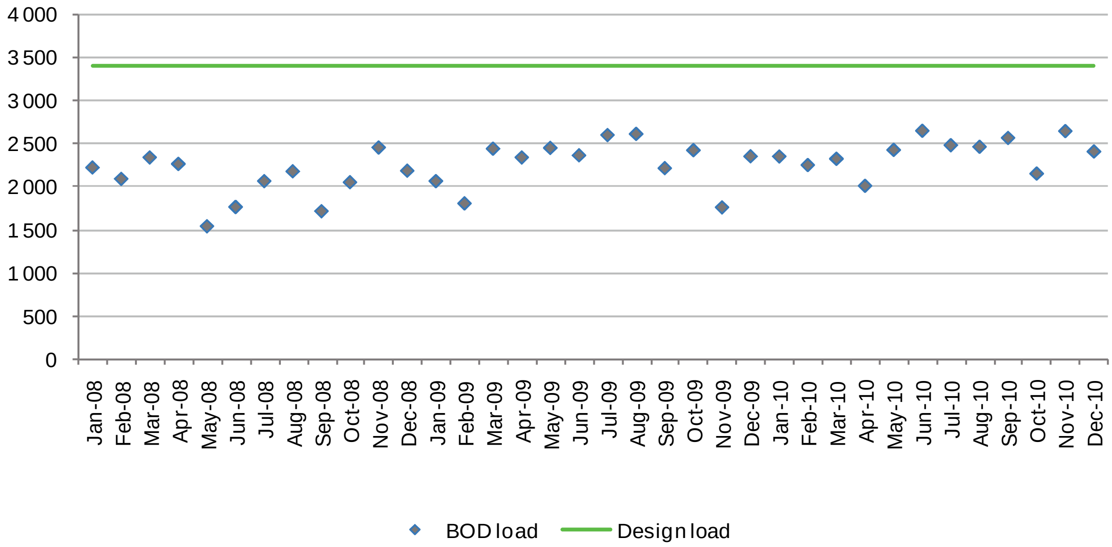


Figure 3.6-5: Variation of the affluent BOD load between 2008 and 2010 and the design load

By comparing the two former figures, it should be noted that the load variation over time is similar to the flow variation.

According to the operating reports, the limits in relation to transparency, clarifiable materials and TSS, were never exceeded during the period studied. Moreover, the limits of the parameters BOD_5 and COD have been surpassed in several situations, but due to the weak number of monthly results of these parameters, it is not possible to ascertain whether these are recurrent or one-off situations.

The relation obtained between the organic matter and nutrients (BOD:N:P), being lower than the relation of reference of 100:5:1, shows good equilibrium conditions for the development of bacterial biomass. On the other hand, a relation of BOD/NR higher than 3.5 is compatible with the biological removal of nitrogen.

The wastewater to be treated presents urban and industrial characteristics, therefore the BOD/COD relation values are within the interval of 0.3 – 0.8, which allow to infer that such an effluent have a biodegradation compatible with the generality of biological treatments.

The following figure presents the variation in the concentration of BOD_5 at the exit of the plant, during the period under analysis. It is clear that the highest values are recorded during the summer months.

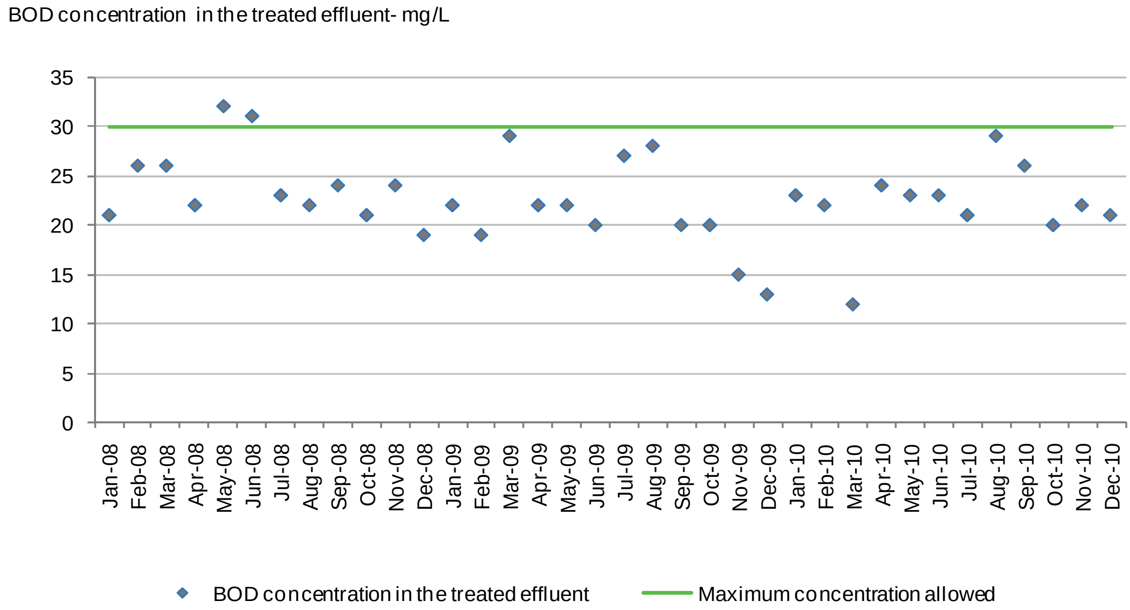


Figure 3.6-6: Variation of the concentration of BOD_5 in the treated effluent between 2008 and 2010, and discharge limit value

During the two visits to the WwTP of Jendouba, some information was collected and it was possible to identify certain irregularities on plant operation, which should be solved in the short term:

- The accumulation of grit in the first aeration tank rose to around 80 cm in the corner, which justifies emptying of the tanks once every three years;
- The existing infrastructure does not allow a good management of the sludge recycling and the purge of excess activated sludge, which becomes harmful to the biological treatment efficiency;
- On the secondary clarifier surface, it was possible to observe floating sludge, which indicate the occurrence of denitrification in this infrastructure, with loss for the settling of sludge and for the treated effluent quality;
- The dewatered sludge does not have a final destination being stored on the ground available in the WwTP.

With regard to the plant energy consumption, the annual operation reports indicate an average specific consumption of 0.33 kWh/m^3 of treated effluent, in 2008, 0.29 kWh/m^3 in 2009, and 0.28 kWh/m^3 in 2010. The following table summarizes the values of energy consumption in the WwTP of Jendouba.

Table3.6-5: Energy consumption

Year	Value	Energy consumption (kWh)	Energy consumption indicator (kWh/m^3)
2008	Minimum	41,553	
	Average	50,921	0.33
	Maximum	61,828	
2009	Minimum	41,239	
	Average	47,758	0.29
	Maximum	52,992	
2010	Minimum	36,817	
	Average	49,460	0.28
	Maximum	57,265	

The following figure shows the variation in energy consumption during the period analyzed.

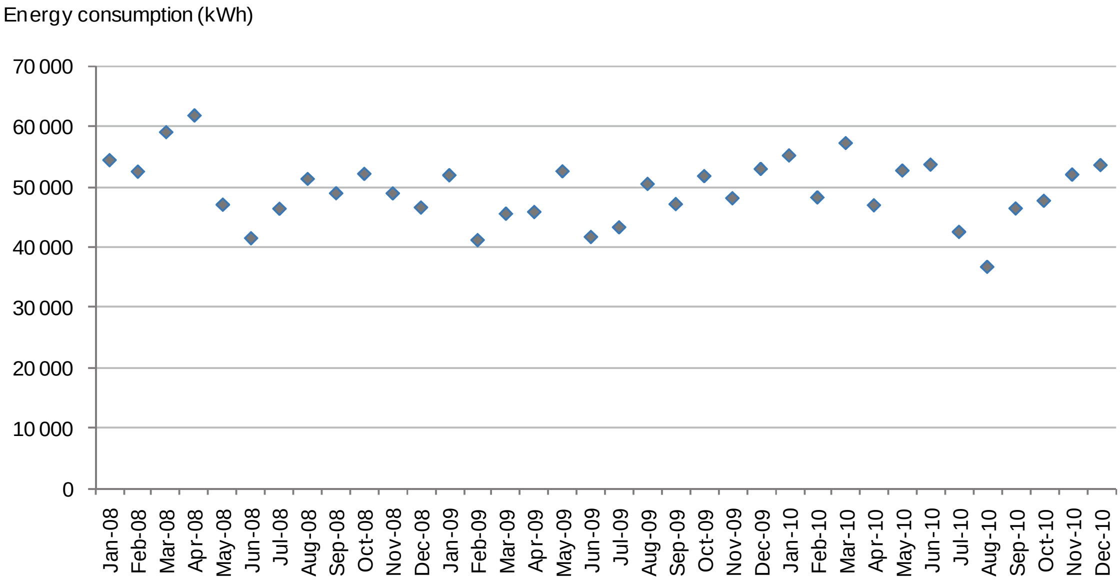


Figure 3.6-7: Variation of the energy consumption, between 2008 and 2010

3.6.1.4 Greatest limitations found and the necessary actions

The greatest limitations found with the WwTP of Jendouba concern basically issues such as the biological removal of nitrogen and the management of the sludge recycling system and the excess sludge purging.

Accumulation of grit

The wastewater presents a high quantity of grit, which is not eliminated in the existing aerated grit and grease chamber, thus causing sedimentation in the aeration tanks and making it necessary to empty the first tank once every three years. In order to resolve this problem, we propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber.

Sludge recycle and excess activated sludge purge

In the WwTP of Jendouba, the flow partition for the biological sludge recycle and the excess activated sludge purge is carried out manually with a partition valve, without precision, which negatively affects the biological treatment.

In order to solve this problem, it is planned the construction of two biological sludge pumping stations (one per each treatment line) equipped with submersible pumps for the excess sludge extraction to the thickener and the sludge recycling to the aeration tank upstream.

Biological nitrogen removal

The Tunisian standard of NT 106.02 provides limits for nitrate, nitrite, organic nitrogen and ammonia, which can be achieved by means of a biological treatment.

Thus, the existing reactors need to be modified to adapt them to the nitrogen biological removal, i.e., it is necessary to size the anoxia volume and to install nitrate recycling pumps (with frequency variation) for the nitrate recycling from the last basin to the first, including the installation of an electromagnetic flow meter on the recycle pipe.

Disinfection

In order to ensure the conformity to the standard in force, NT 106.02 (1989), it is planned to implement a disinfection system via ultraviolet radiation, being served upstream by an operation of filtration in order to guarantee the water necessary transmittance so that assures an efficient radiation distribution.

Aeration of the tanks

The height of water in the aeration tanks (4.6 m) is higher than the recommended for the good efficiency of the surface aerators. Generally, the surface aerators have lower efficiencies than those obtained by the submersible aeration systems, such as diffused air (with fine bubbles). In addition, this surface aeration produces aerosols during operation, which affects the operating staff health. For all these reasons, it is proposed the replacement of the surface aerators by the air blowing system with fine bubbles. This system includes blowers with variable speed, air ducts and diffusers (tubular or disc). The blowers must be provided with a protection against noise and they must be installed in a building equipped with an overhead travelling crane and forced ventilation.

Condition and operation of electromechanical equipment

In general, the electromechanical equipment has a reasonable level of maintenance in accordance with its working conditions. It was visible on the wall a board with the preventive maintenance plan which includes lubricating frequency and lubricating level verification for different equipment. In fact, during the visit to the plant, the Archimedean screws were under a replacement operation.

To complement this information, it is presented in Annex III (Annex III.5) a table with the main comments on the WwTP electromechanical equipment.

3.6.2 Design data

3.6.2.1 Planning year of the Project

The planning year of this study is 2029, assuming 2016 as the investment year and 2019 as the first year of operation.

3.6.2.2 Quantitative and qualitative characteristics of the foreseen effluent

The following table summarizes the estimated quantitative and qualitative characteristics for the raw wastewater to be treated in the Jendouba WwTP, in conformity with the basic data described in paragraph 3.2.

Table 3.6-6: Estimate of the characteristics of the raw wastewater

Parameter	Unit	2011	2029
Population			
Domestic	inhabitants	54,088	64,988
Industrial	e.p.	2,196	40,000
Touristic	beds	0	0
Total	e.p.	56,284	104,988
Flow			
Average daily flow	m^3/d	5,123	11,703
	L/s	59.3	135.5
Infiltration flow	m^3/d	1,162	1,826
	L/s	13.5	21.1
Average daily flow + infiltration	m^3/d	6,285	13,528
	L/s	72.7	156.6
Peak flow	m^3/h	380.5	900.0
	L/s	105.7	250.0
Maximum design flow	m^3/h	900.0	900.0
	L/s	250.0	250.0
Pollutant loads			
TSS	kg/d	4,956	7,449
BOD_5	kg/d	2,251	4,200
COD	kg/d	6,710	11,799
TN	kg/d	460	1,014
TP	kg/d	83	137
Fecal coliforms (FC)	NMP/d	$5.41x10^{15}$	$6.50x10^{15}$
Concentrations (without infiltration flow)			
TSS	mg/L	967	637
BOD_5	mg/L	439	359
COD	mg/L	1,310	1,008
TN	mg/L	90	87
TP	mg/L	16	12
Fecal coliforms (FC)	NMP/100mL	$1.06x10^8$	$5.55x10^7$

These amounts have been estimated taking into consideration the junction of the new industrial zones planned by AFI, described in Table 3.2-3, because the pre-design carried out has made it possible to conclude that the capacity of the existing structures is sufficient.

In order to estimate the quantitative and qualitative characteristics of the industrial effluent, it was considered that the industrial users will have a preliminary treatment stage of the effluents, permitting respect of discharge limits in the public sewerage network stipulated by the prevailing legislation. In other words, the concentration of BOD_5 of the industrial effluents to be treated in the Jendouba wastewater treatment plant will be de 400 mg/L. The estimate of the equivalent industrial population was carried out, admitting specific production of wastewater of 40 m^3/ha/d and specific production of BOD_5 of 40 g/cap/d.

3.6.2.3 Legislative framework relating to the quality of the receiving water and required quality for the treated effluent

In general, it is necessary to observe wastewater discharge standards established in the applicable legislation, especially standard NT 106.02; however, this standard is under revision, having been supplied to the consultant team a draft of the new decree. In spite of this new decree which is not yet in force, it should be noted that discharge standards will become differentiated in sensitive receiving water and other receiving water.

As mentioned, the treated effluent discharged into the Wadi Medjerda, at more than 80 km upstream from the dam of Sidi Salem, a very important source for drinking water supply and irrigation. In spite of the distance from the dam, we consider that, in the future and in the light of the new decree (still under preparation), this receiving water could be deemed a sensitive receiving water, to be particularly sensitive to the water pollution caused by substances contributing to eutrophication, especially nitrates, phosphorus and nitrogen, substances exerting an adverse influence on oxygen balance and measurable by parameters such as BOD, COD, suspended solids and the microbiological substances.

Nonetheless, while the new decree is not implemented, the treated wastewater in the WwTP of Jendouba must observe the quality framework presented in Table 1.3-4 of Chapter I.

3.6.2.4 Legislative framework concerning the final destination of sludge

According to the strategy defined by ONAS, the final destination of the dewatered sludge should observe the following priorities:

1. Green sector – agricultural re-use;
2. Red sector – incineration;
3. Black sector – controlled discharge.

The wastewater flowing into the Jendouba wastewater treatment plant is essentially urban and although the qualitative characteristics of the wastewater produced in the new industrial zone to be connected to the wastewater treatment plant are not yet known, it is admitted that the sludge that results from the treatment will respect all the provisions stipulated in prevailing legislation (see chapter I, 1.3.3.3.3) and may be re-used for agriculture.

3.6.3 Eligible solutions of rehabilitation and extension

3.6.3.1 General considerations

For the rehabilitation of Jendouba treatment plant are identified three alternative solutions, which have been already described in paragraph 3.4.3.1.

For all the three solutions, there will be the construction of a grit retention tank, the replacement of the surface aerators by the diffused air system, the installation of the internal nitrate recycling system, the construction of pumping stations for the sludge recycle and excess sludge extraction, the construction of a new stage for thickened sludge mechanical dewatering and the installation of a system of pathogenic microorganisms removal (final disinfection) via ultraviolet radiation.

At the request of ONAS, odor treatment of the structures and buildings associated with the emission of the odors will be included.

In relation to the security conditions for the workers of the wastewater treatment plant, we recommend the installation of a guard rail around all structures with a liquid depth higher than 1 m, in particular: the aerated grit and grease chamber, biological reactors (in addition to the existing rails), clarifiers, thickeners, *etc*.

The description of the treatment lines, the advantages and disadvantages for each of these biological treatment systems are presented in the following chapters. The design criteria, the design results and the operational conditions are presented in Annex III (Annex III.5).

The treatment schemes of each solution being studied are presented in the Annex III (Annex III.7).

3.6.3.2 Solution 1

3.6.3.2.1 Detailed description of the treatment sequence – design and criteria

For Solution 1, the rehabilitation of the WwTP according to the same existing treatment process, i.e., activated sludge in extended aeration regime, will be studied.

The advantages and disadvantages of this solution are described in paragraph 3.3.3.2.1.

According to the design data described in paragraph 3.6.2.2, it was estimated that, in the year 2029, the WwTP of Jendouba must have the capacity to treat wastewater corresponding to 104,988 population equivalent. Though the number of this population equivalent is higher than the 70,000 designed for the WwTP, the design that has been carried out within this project framework allowed to conclude, based on the verification of the operation conditions of the existing structures, that the existing treatment capacity will be sufficient for the project planning year, since the load specific factors used for this study are always lower than those used for the existing facilities design. Therefore, the average daily flow to treat in the year 2029 will be 11,703 m^3/day (the installed capacity is 8,000 m^3/day) and the average organic load will be 4,200 kg/day (the installed capacity is 3,400 kg/day).

Currently, the wastewater reaches the WwTP gravitationally and is raised to the inlet infrastructure by means of three Archimedean screws, with a maximum capacity of 900 m^3/h while operating simultaneously. The estimated maximum inflow in this study (418 m^3/h) is lower than the maximum capacity of the Archimedean screws; therefore the value 900 m^3/h will be deemed as the design maximum flow.

Given the high inflow of grit into the wastewater treatment plant, a grit retention tank is foreseen, to be built upstream of the preliminary treatment.

The existing preliminary treatment structures were designed to treat the maximum flow, which was confirmed by the verification of the operating conditions. Thus, considering the operation of the existing Archimedean screws, all preliminary treatment structures have enough capacity to treat the planning year's flow.

The design that has been carried out revealed that the available biological volume is sufficient for the biological treatment, in extended aeration mode, of the wastewater affluent in the project planning year, with the operation mass loading rate of 0.103 kg BOD/kg MVS/day, within the theoretical range (0.05 – 0.15 kg BOD/kg MVS/day). With regard to the secondary clarifier, since it has been designed for the maximum capacity, it is expected that they have the sufficient capacity, which is confirmed by verification of operating conditions resulting from the design that has been carried out.

It is planned to undertake the construction of a biological sludge pumping stations, provided with submersible pumps for the rise of sludge in excess towards the thickeners and for the sludge recycling to the aeration tanks upstream. The sludge recycling pumps must allow the rise of a flow between 50% and 150% of the average daily flow affluent to the WwTP. In order to facilitate the sludge management control, the pumps will be provided with variation speed and will be installed electromagnetic flow meters in the circuit rising mains.

Downstream the secondary clarifier, it is planned to undertake a tertiary treatment stage, aiming at the reduction of the bacteriological load in order to fulfill the requirements of the standard NT 106.02, by means of a filtration followed through disinfection by UV.

As for the stage of thickening, the existing thickener operation was evaluated for the estimated excess sludge flow considering the year zero and the project planning year. This evaluation showed that the existing thickener does not have sufficient capacity, as the solids loading and the hydraulic loading rate exceeds the admissible values. We therefore foresee the construction of a new thickener, with dimensions equal to the existing thickener. Nonetheless, in order to improve the operating conditions, in year zero the operating team can operate with a single thickener.

The design that has been carried out revealed that the drying beds are not sufficient for the dewatering of sludge either for year zero, or for the project planning year. This problem can be solved using the sludge mechanical dewatering by means of the decanter centrifuge machine. It is recommended that, prior to dewatering it would be possible of storing sludge, with capacity for three days of production, with the aim to cope with a possible situation of equipment failure. It is planned to add on line a polyelectrolyte solution to the sludge to be dewatered. On the other hand, the dewatered sludge will be stored in containers that will be a driving regularization for sending it to their final destination.

The treatment line of Solution 1 for the rehabilitation of the WwTP of Jendouba shows the following stages:

- Preliminary treatment
    - Grit retention tank (new);
    - Water rise by 3 Archimedean screws (existing);
    - Manual bar screen installed in the recourse channel (existing);
    - Screening consisting of 1 mechanical bar screen in parallel, with bars spacing of

6 mm, a conveyor belt and a trailer (existing);

- Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);
- Flow measurement in a Venturi channel using an ultrasonic level meter (existing);

- Biological or secondary treatment
    - Oxidation of the organic matter in the existing treatment lines, with a total volume of approximately 11,928 m^3 aerated by a new air diffused system supplied by blowers equipped with variable speed (existing);
    - Settling of sludge in the existing secondary rectangular plant clarifiers, equipped with a suction scraper bridge (existing);
    - Sludge directing for a pumping station (new);
    - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
    - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (new);
    - Extraction of supernatant sludge towards the thickeners (new) ;
- Tertiary treatment
    - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
    - Chemical precipitation of phosphorus with aluminum sulfate dosing (existing);
    - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
    - Excess activated sludge thickening in two thickeners, equipped with a scraper bridge (one existing and one new);
    - Temporary storage of the thickened sludge in a tank upstream the dewatering (new);
    - Dewatering of the thickened sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
    - Storage of dewatered sludge in containers (new);
    - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are returned through a pumping station to the biological treatment facility (new).

- Treatment of odors
    - treatment of the contaminated air, extracted from the grit retention tank, preliminary treatment building, thickeners, thickened sludge storage tank and dewatering building, by bio filter (new).

3.6.3.2.2 Energy report

The average electricity consumption (solution 1, planning year) is presented in the annex (see Annex III, Annex III.5 at the end).

3.6.3.2.3 Consumption of chemical reagents

The chemical reagents consumed in the wastewater treatment process are aluminium sulfate and polyelectrolyte. The quantities of chemical reagents consumed in year zero and in the planning year are presented in Annex III.5 (at the end).

3.6.3.2.4 Management of by-products

The quantities of by-products resulting from the wastewater treatment process, in particular solid screenings, grit, grease and sludge, are presented in Annex III.5 (at the end).

3.6.3.2.5 Equipment

In general, the electromechanical equipment items present a high level of maintenance, if one takes into consideration their working conditions and maintenance level. In fact, on the day of the technical visit to the plant (2010), three Archimedes screws were undergoing replacement.

The following table summarizes the solutions proposed in terms of replacement of the existing equipment items in the Jendouba WwTP, in the framework of solution 1. For a fuller understanding of the following comments, it is necessary to view the treatment scheme of the solution attached to the report.

Table 3.6-7: Electro-mechanical equipment, instruments and electrical installations

Designation	Diagnosis	Proposed solution	Characteristics
Preliminary treatment			
Grit extraction system by “air-lift”	The wastewater includes a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber.	We propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber. Grit extraction will be achieved via an “air-lift” system.	Estimated extraction flow rate = 18 m3/h
Archimedes screw n°1	The Archimedes screws were undergoing replacement. All the screws presented an advanced state of corrosion and degradation. The construction did not seem to be adapted (it is too large) to the size of the Archimedes screw. It is possible to view many screenings deposited on the sides of the screw.	The demonstrated state of degradation justifies their replacement. The replacement was in progress.	Flow = 180 m3/h Height ≈ 4.5 mce(meters of water columns)
Archimedes screw nº2	The Archimedes screws were undergoing replacement. All the screws presented an advanced state of corrosion and degradation. The construction did not seem to be adapted (it is too large) to the size of the Archimedes screw. It is possible to view many screenings deposited on the sides of the screw.	The demonstrated state of degradation justifies their replacement. The replacement was in progress.	Flow = 360 m3/h Height ≈ 4.5 mce(meters of water columns)
Mechanical multi-rake bar screen	The mechanical screen presents widespread corrosion in stainless steel. Furthermore, the consulting team was informed that the mechanical cleaning of the mechanical screen operates in manual mode, given that the automatic mode is not available in the market.	The demonstrated state of degradation justifies its replacement.	Maximum flow = 900 m3/h Spacing between bars = 6 mm
Measurement of the difference in water level (screening)	The demonstrated state of degradation justifies replacement.	Automation should be improved, in particular in terms of integration between measurement of the level and operation of the mechanical screen.	

Designation	Diagnosis	Proposed solution	Characteristics
Belt conveyor	The paintwork is a bit degraded and altered in certain places. Nonetheless, the equipment does appear to be painted in order to avoid further corrosion.	Replacement is not judged to be necessary.	Estimated volumetric flow rate of screenings = 1.0 m3/d
Scraper bridge (grit and grease extraction in a double aerated channel)	The scraper bridge has a deviation in its longitudinal movement. The wheels of the scraper bridge present a high level of degradation. The electrical component of the equipment presents a high level of degradation.	The demonstrated state of degradation justifies their replacement.	Installed in the existing work
Grit pumps (grit and grease extraction in a double aerated channel)	The occurrence of frequent breakdowns was reported to the consulting team	We recommend the replacement of the equipment items. There are two pumps per scraper bridge.	Estimated flow for each pump = 18 m3/h.
Grit classifier (grit and grease extraction in a double aerated channel)	The grit classifier on the scraper bridge does not operate correctly and presents a certain amount of degraded paintwork.	The grit classification operation must be improved with installation of specialized equipment for this function. The equipment will be installed on the scraper bridge.	Estimated total capacity = 20 m3/h.
Compressors (grit and grease extraction in a double aerated channel)	The compressors present a certain level of degradation; they are dirty and covered in dust.	We recommend the replacement of the equipment items. There are three compressors for the double channel: 2+1.	Estimated volumetric flow rate of air for each compressor = 162 m3/h
Grease removal via a screw conveyor (grit and grease extraction in a double aerated channel)	The grease pumping circuit is out of service. The consulting team was informed that the circuit was immediately blocked after the start-up of the installation and was then abandoned.	Grease removal will be implemented via a screw conveyor installed in the grease tank.	Estimated volumetric flow rate of grease = 68 m3/d
Measurement of effluent flow	Measurement is made by an ultrasonic level meter.	Replacement is not judged to be necessary.	

Designation	Diagnosis	Proposed solution	Characteristics
Secondary or biological treatment			
Aeration	The operation of the surface aerators is not automated as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor. Also, in order to maximize the volume of the existing reaction, it is necessary to implement a more effective aeration method. The tanks are too deep in order to obtain maximum performance of the existing surface aerators.	We recommend replacement of the surface aerators by a fine bubble aeration system. This system includes compressors endowed with speed variation, air ducts and diffusers installed in the tanks. There are five compressors: 4+1; one compressor for each line.	Estimated volumetric flow rate of air for each compressor = 2,794 m^3/h.
Oxygen measurement (aeration tank)	The operation of the surface aerators is not automated as in an automation system which includes measurement of the oxygen broken down in the biological reactor.	We recommend installation of a programmable automation controller that permits integration between the oxygen measurements and operation of the aeration equipment.	
Mixing	The submersible mixers are not in a good state of conservation. In the framework of this solution, it is necessary to add submersible mixers to the new line.	Replacement is judged to be necessary, and it is necessary to add submersible mixers to the new line.	Installed in the existing tanks and in an identical number to the existing items.
Scraper bridges (secondary clarifiers)	The scraper bridges are not in a good state of conservation. In the framework of this solution, it is necessary to add a scraper bridge to the new line.	Their complete replacement is judged to be necessary.	
Biological sludge lift pumps (secondary clarifiers)	The pumps present a reasonable state of conservation in view of their working conditions.	Their complete replacement is not judged to be necessary. There are two pumps per scraper bridge.	Estimated flow for each pump = 144 m^3/h.
Sludge recirculation pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process	We recommend the construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks.	Estimated flow for each pump = 765 m^3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Measurement of the flow of sludge recirculation	No measurement of the sludge recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Excess sludge extraction pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process	We recommend the construction of a biological sludge pumping station equipped with submersible pumps in order to lift the excess sludge towards the thickener.	Estimated flow for each pump = 27 m^3/h.
Measurement of the flow of excess sludge	No measurement of the excess sludge exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 80 mm
Tertiary treatment			
Nitrate recirculation pump	The Tunisian norm NT106.02 sets maximum limits for nitrate, nitrite, organic and ammoniacal nitrogen. Hence, it is necessary to modify the existing reactors to adapt them for biological elimination of nitrogen.	It is necessary to install submersible pumps (with frequency variation) for nitrate recirculation, in the existing aeration tanks - from the last aeration tank to the first.	Estimated flow for each pump = 383 m^3/h.
Measurement of the flow of nitrate recirculation	No measurement of the nitrate recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Dosing pump of aluminium sulfate and dosing circuit	Chemical precipitation of phosphorus with dosing of aluminium sulfate	We recommend a dosing circuit with dosing tank, retention chamber, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Estimated flow for each pump = 241 L/h.
Disinfection	The Tunisian norm NT 106.02 obliges observance of 2000/100 ml of fecal coliforms and 1000/100 ml of fecal streptococci in order to guarantee the microbiological quality of the public water supply.	Disinfection by ultraviolet radiation implemented upstream by the filtration operation via multicellular vertical feeding pumps linked to the filters, self-cleaning pressure filters and an ultraviolet radiation system in the open channel.	Maximum flow = 900 m^3/h

Designation	Diagnosis	Proposed solution	Characteristics
Treatment of the sludge			
Scraper bridge (thickener)	The paintwork of the scraper bridge is a bit degraded and altered in certain places. In the framework of this solution for renovation of the WwTP, we propose construction of another thickener.	Their complete replacement is not judged to be necessary. It is necessary to consider application of a new layer of paint. There will be two scraper bridges in service.	The new thickener will be square-shaped like the existing one.
Thickened sludge pumps	The sludge pumps (which lift the sludge towards the thickened sludge storage tank or towards the sludge drying beds) present a high level of deterioration.	In the framework of renovation of the WwTP it will be necessary to replace these pumps and to add another because of the new thickener. We recommend an excentric screw pump. There is one pump for each thickener.	Estimated flow per pump = 18 m^3/h.
Submersible mixer (thickened sludge storage tank)	In the framework of renovation of the WwTP, we propose temporary storage of the thickened sludge in a tank upstream of the dewatering stage.	It is necessary to install a submersible mixer in order to avoid sedimentation of the sludge.	-
Lift pump to raise the thickened sludge to the centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend an excentric screw pump.	Estimated flow per pump = 20 m^3/h.
Centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of two equipment items.	Capacity estimated = 20 m^3/h.
Polymer preparation equipment	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of fully automatic continuous polymer solution preparation equipment. Dosing tank, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Capacity 2,000 L/h
Polymer dosing pump	-	We recommend membrane dosing pumps.	Estimated flow per pump = 1.4 m^3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Lifting the dewatered sludge		The dewatered sludge will be lifted via a screw conveyor.	Estimated volumetric flow rate of the dewatered sludge = 18 m^3/d
Treatment of odors			
Contaminated air treatment system	We propose to extract the contaminated air from the grit retention tank, preliminary treatment building, thickener, thickened sludge storage tank and dewatering building	The contaminated air will be deodorized via a bio filter and a piping circuit and fan	
Electrical installations			
MV-LV transformation station	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	
Low voltage cupboard	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	
Command station with master control panel	In the framework of the intervention proposed for the WwTP, these equipment items should be renovated.	We recommend installation of a programmable automation controller that permits integration between the measurement instruments and operation of the mechanical equipment.	

3.6.3.3 Solution 2

3.6.3.3.1 Detailed description of the treatment sequence – design and criteria

Solution 2 integrates the biological treatment by activated sludge in conventional aeration, with sludge anaerobic digestion and biogas energy recovery. The treatment line integrates new facilities, the primary treatment equipment and the sludge mesophilic anaerobic stabilization, namely anaerobic digester, gasholder, flare, equipment for biogas treatment, motor generators, boiler and heat exchanger. This solution integrates a high number of operations, so the complexity of operating and maintenance is remarkable. In order to overcome this difficulty, the operators must be trained in for exploiting the new equipment and its operations. Moreover, this is an advantageous solution as for the energy matter, considering the lowest power consumption relating to the extended aeration systems and the possibility to recover energy from the produced biogas.

The considerations made in paragraph 3.6.3.2.1 (solution 1) for the preliminary treatment structures (including the grit retention tank) and secondary clarification are also valid for solution 2. According to the Concept Design of the Jendouba wastewater treatment plant, expansion of the plant may be achieved through transformation of the extended aeration process into conventional aeration, through construction of primary sedimentation structures and aerobic or anaerobic stabilization of the sludge. As a result, we admit that the hydraulic profile of the wastewater treatment plant was designed, from the outset, in order to enable inclusion of a primary sedimentation stage. This conclusion was confirmed by the topographic survey of the plant.

The design carried out revealed that in a conventional aeration regime, half of the existing biological volume (6 tanks, 5 964 m^3) is sufficient for biological treatment of the incoming wastewater at the planning year. For year zero, the operating team can operate solely with three tanks (2 982 m^3), thus improving the operating conditions of the biological treatment. The anoxic volume foreseen for year zero corresponds to 1 ½ tanks and it is therefore necessary to construct a partition wall in the second tank. Nonetheless, at the planning year, the totality of the volume of this tank is necessary for denitrification. In this case, this tank must be prepared to operate in two manners: half-anoxic and half-aerobic, or totally anoxic. Downstream of the secondary sedimentation, a new tertiary treatment stage in the form of filtration followed by UV disinfection is foreseen, aimed at reduction of bacteriological aeration in order to respond to the requirements of the norm NT 106.02.

The considerations carried out in Solution 1 on the pretreatment structures and the secondary clarification are also valid for Solution 2.

The pre-design that has been carried out revealed that half the existing biological volume (5,964 m^3) will be sufficient for the biological treatment, in the conventional aeration mode, of wastewater affluent in the project planning year.

As it has been verified for Solution 1, the existing thickener does not have the sufficient capacity, so it should be increased. It should be noted that the thickener of Solution 2 will be larger than that of Solution 1, due to the higher production of sludge while operating at conventional aeration mode.

Thus, the treatment line of Solution 2 for the rehabilitation of the WwTP of Jendouba includes the following stages:

- Preliminary treatment
    - Grit retention tank (new);

  - Water rise by 3 Archimedean screws (existing);
  - Screening consisting of 1 mechanical bar screen in parallel, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
  - Manual screen installed in the channel of recourse (existing);
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);
  - Flow measurement in a Venturi channel using an ultrasonic level meter (existing).

- Primary treatment
  - Primary settling in 2 rectangular plant clarifiers, with bottom and surface scrapers bridge (new);
  - Feeding of floats into the thickeners (new);
  - Extraction of primary sludge for the thickeners (new);
- Biological treatment
  - Oxidation of the organic matter in half of the existing treatment line, totaling 5,964 m^3, aerated by a new air diffused system supplied by blowers equipped with variable speed (existing);
  - Settling of sludge in the existing secondary settling tanks, of rectangular plant, provided with a suction scraper bridge (existing);
  - Sludge directing for the pumping station (new);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (new);
  - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (new);
- Tertiary treatment
  - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
  - Chemical precipitation of phosphorus with aluminum sulfate dosing (existing);
  - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
  - Thickening of the primary sludge, excess sludge and physicochemical sludge, in 2 thickeners of square plant, with scraper bridge (1 existing and 1 new);
  - Mesophilic anaerobic stabilization of thickened sludge (new);
  - Storage of biogas in a gasholder (new);

  - Biogas energy recovery by a motor generator with production of thermal and electrical energy (new);
  - Heating of sludge in digestion with heat produced by cogeneration (new);
  - Burning the biogas in excess and the bad quality biogas in the flare (new);
  - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of recourse, dewatering of the thickened sludge in drying beds (existing);
  - Storage of dewatered sludge in containers (new);
  - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility (new).
- Treatment of odors :
  - Treatment of the contaminated air, extracted from the grit retention tank, from the preliminary treatment building, thickeners and dewatering building, by biofilter (new).

3.6.3.3.2 Energy report

The average electricity consumption (solution 2, planning year) is presented in annex (see Annex III, Annex III.5 at the end) The energy report of solution 2 includes electricity produced by cogeneration.

3.6.3.3.3 Consumption of chemical reagents

The chemical reagents consumed in the wastewater treatment process are aluminium sulfate, hydrated lime and polyelectrolyte. The quantities of chemical reagents consumed in year zero and in planning year are presented in Annex III.5 (at the end).

3.6.3.3.4 Management of by-products

The quantities of by-products resulting from the wastewater treatment process, in particular solid screenings, grit, grease and sludge, are presented in Annex III.5 (at the end).

3.6.3.3.5 Equipment

The following table summarizes the solutions proposed in terms of replacement of the existing equipment items in the Jendouba WwTP, in the framework of solution 2. For a fuller understanding of the following comments, it is necessary to view the treatment scheme of the solution attached to the report.

Table 3.6-8: Electro-mechanical equipment, instruments and electrical installations

Designation	Diagnosis	Proposed solution	Characteristics
Preliminary treatment			
Grit extraction system by “air-lift”	The wastewater includes a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber.	We propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber. Grit extraction will be achieved via an “air-lift” system.	Estimated extraction flow rate = 18 m3/h
Archimedes screw nº1	The Archimedes screws were undergoing replacement. All the screws presented an advanced state of corrosion and degradation. The construction did not seem to be adapted (it is too large) to the size of the Archimedes screw. It is possible to view many screenings deposited on the sides of the screw.	The demonstrated state of degradation justifies their replacement. The replacement was in progress.	Flow = 180 m^3/h Height ≈ 4.5 mce(meters of water columns)
Archimedes screw nº2	The Archimedes screws were undergoing replacement. All the screws presented an advanced state of corrosion and degradation. The construction did not seem to be adapted (it is too large) to the size of the Archimedes screw. It is possible to view many screenings deposited on the sides of the screw.	The demonstrated state of degradation justifies their replacement. The replacement was in progress.	Flow = 360 m^3/h Height ≈ 4.5 mce(meters of water columns)
Mechanical multi-rake bar screen	The mechanical screen presents widespread corrosion in stainless steel. Furthermore, the consulting team was informed that the mechanical cleaning of the mechanical screen operates in manual mode, given that the automatic mode is not available in the market.	The demonstrated state of degradation justifies their replacement.	Maximum flow = 900 m^3/h Spacing between bars = 6 mm
Measurement of the difference in water level (screening)	The demonstrated state of degradation justifies replacement.	Automation should be improved, in particular in terms of integration between measurement of the level and operation of the mechanical screen.	

Designation	Diagnosis	Proposed solution	Characteristics
Belt conveyor	The paintwork is a bit degraded and altered in certain places. Nonetheless, we can affirm that the equipment seems to be sufficiently painted in order to avoid further corrosion.	Replacement is not judged to be necessary.	Estimated volumetric flow rate of screenings = 0.2 m^3/d
Scraper bridge (grit and grease extraction in a double aerated channel)	The scraper bridge has a deviation in its longitudinal movement. The wheels of the scraper bridge present a high level of degradation. The electrical component of the equipment presents a high level of degradation.	The demonstrated state of degradation justifies their replacement.	Installed in the existing work
Grit pumps (grit and grease extraction in a double aerated channel)	The occurrence of frequent breakdowns was reported to the consulting team	We recommend the replacement of the equipment items. There are two pumps per scraper bridge.	Estimated flow for each pump = 18 m3/h.
Grit classifier (grit and grease extraction in a double aerated channel)	The grit classifier on the scraper bridge does not operate correctly and presents a certain amount of degraded paintwork.	The grit classification operation must be improved with installation of specialized equipment for this function. The equipment will be installed on the scraper bridge.	Estimated total capacity = 20 m3/h.
Compressors (grit and grease extraction in a double aerated channel)	The compressors present a certain level of degradation; they were dirty and covered in dust.	We recommend the replacement of the equipment items. There are three compressors for the double channel: 2+1.	Estimated volumetric flow rate of air for each compressor = 162 m3/h
Grease removal via a screw conveyor (grit and grease extraction in a double aerated channel)	The grease pumping circuit is out of service. The consulting team was informed that the circuit was immediately blocked after the start-up of the installation and was then abandoned.	Grease removal will be implemented via a screw conveyor installed in the grease tank.	Estimated volumetric flow rate of grease = 68 m3/d
Measurement of effluent flow	Measurement is made by an ultrasonic level meter.	Replacement is not judged to be necessary.	

Designation	Diagnosis	Proposed solution	Characteristics
Primary treatment			
Scraper bridges (primary sedimentation tanks)	In the framework of this solution for renovation of the WwTP, we propose the existence of primary treatment.	The scraper bridge is constituted by a mobile transversal beam that serves as a walkway, two lateral guides, an articulated system for collecting the sludge and discharging the scum, a motor reduction unit for activating the two lateral guides, a control unit of the articulated system of bottom scraper/scum blade and a command and control panel.	
Primary sludge lift pumps (primary sedimentation tanks)		It is necessary to install submersible pumps. There is one pump per scraper bridge.	Estimated flow for each pump = 18 m^3/h.
Secondary or biological treatment			
Aeration	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor. Also, in order to maximize the volume of the existing reaction it is necessary to implement a more effective aeration method. The tanks are too deep in order to obtain maximum performance of the existing surface aerators.	We recommend replacement of the surface aerators by a fine bubble aeration system. This system includes compressors endowed with speed variation, air ducts and diffusers installed in the tanks. There are three compressors: 2+1; one compressor for each line.	Estimated volumetric flow rate of air for each compressor = 4,438 m^3/h.
Oxygen measurement (aeration tank)	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor.	We recommend installation of a programmable automation controller that permits integration of oxygen measurements with the aeration operation.	
Mixing	The submersible mixers are not in a good state of conservation. In the framework of this solution, it is necessary to add submersible mixers to the new line.	Replacement is judged to be necessary, and it is necessary to add submersible mixers to the new line.	

Designation	Diagnosis	Proposed solution	Characteristics
Scraper bridges (secondary clarifiers)	The scraper bridges are not in a good state of conservation. In the framework of this solution, it is necessary to add a scraper bridge to the new line.	Their complete replacement is judged to be necessary.	Installed in the existing work. (There are two scraper bridges with two sedimentation tanks)
Biological sludge lift pumps (secondary clarifiers)	The pumps are in a reasonable state of conservation given their working conditions.	Replacement is not judged to be necessary There are two pumps per scraper bridge.	Estimated flow for each pump = 144 m3/h.
Sludge recirculation pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process	We recommend the construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks.	Estimated flow for each pump = 761 m^3/h.
Measurement of the flow of sludge recirculation	No measurement of the sludge recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Excess sludge extraction pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process.	We recommend the construction of a biological sludge pumping station equipped with submersible pumps in order to lift the excess sludge towards the thickener.	Estimated flow for each pump = 24 m^3/h.
Measurement of the flow of excess sludge	No measurement of the excess sludge exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 80 mm
Tertiary treatment			
Nitrate recirculation pump	The Tunisian norm NT106.02 sets maximum limits for nitrate, nitrite, organic and ammoniacal nitrogen. Hence, it is necessary to modify the existing reactors to adapt them for biological elimination of nitrogen.	It is necessary to install submersible pumps (with frequency variation) for nitrate recirculation, in the existing aeration tanks - from the last aeration tank to the first.	Estimated flow for each pump = 761 m^3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Measurement of the flow of nitrate recirculation	No measurement of the nitrate recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Dosing pump of aluminium sulfate and dosing circuit	Chemical precipitation of phosphorus with dosing of aluminium sulfate	We recommend a dosing circuit with dosing tank, retention chamber, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Estimated flow for each pump = 231 L/h.
Disinfection	The Tunisian norm NT 106.02 obliges observance of 2000/100 ml of fecal coliforms and 1000/100 ml of fecal streptococci in order to guarantee the microbiological quality of the public water supply.	Disinfection by ultraviolet radiation implemented upstream by the filtration operation using vertical multicellular pumps, self-cleaning pressure filters, and ultraviolet radiation system in the open channel.	Maximum flow = 900 m^3/h
Treatment of the sludge			
Scraper bridge (existing thickener)	The paintwork of the scraper bridge is a bit degraded and altered in certain places. In the framework of this solution for renovation of the WwTP, we propose construction of another thickener.	Their complete replacement is not judged to be necessary. It is necessary to consider application of a new layer of paint.	The new thickener will be square-shaped like the existing one.
Thickened sludge pumps	The sludge pumps (which lift the sludge towards the thickened sludge storage tank or towards the sludge drying beds) present a high level of deterioration.	In the framework of renovation of the WwTP it will be necessary to replace these pumps and to add another because of the new thickener. We recommend an excentric screw pump. There is one pump for each thickener.	Estimated flow per pump = 18 m3/h.
Anaerobic digestion of the sludge	In the framework of this solution for renovation of the WwTP, we propose mesophilic anaerobic stabilization of the thickened sludge.	The anaerobic digestion of the sludge will be implemented using the digesters, agitation of the digesters via the sludge recirculation pumps, pumps for the sludge heating circuit during digestion, gasholder and torch.	
Sludge heating system during digestion	For mesophilic anaerobic stabilization of the thickened sludge, it is necessary to foresee a sludge heating system during digestion.	We always recommend the use of a boiler and a hot water tank with recirculation pumps for these circuits.	The boiler must work with natural gas and biogas

Designation	Diagnosis	Proposed solution	Characteristics
Cogeneration	The cogeneration system enables energy use of the biogas produced and also heating of the sludge during digestion with the heat produced by the motor-generator.	In addition to the sludge heating system during digestion using the boiler, we propose a cogeneration system constituted by elements such as the biogas-driven motor-generator.	
Lift pump of the digested sludge for the centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer.	We recommend an excentric screw pump.	Estimated flow per pump = 25 m^3/h.
Centrifugal clarifier	In the framework of renovation of the WwTP we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of two equipment items.	Capacity estimated = 25 m^3/h.
Polymer preparation equipment	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of fully automatic continuous polymer solution preparation equipment. Dosing tank, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Capacity 2,000 L/h
Polymer dosing pump	-	We recommend membrane dosing pumps.	Estimated flow per pump = 1.6 m^3/h.
Lifting the dewatered sludge		The dewatered sludge will be lifted via a screw conveyor.	Estimated volumetric flow rate of the dewatered sludge = 39 m^3/d
Treatment of odors			
Contaminated air treatment system	We propose to extract the contaminated air from the grit retention tank, preliminary treatment building, thickener and dewatering building	The contaminated air will be deodorized via a bio filter and a piping circuit and fan	-

Designation	Diagnosis	Proposed solution	Characteristics
Electrical installations			
MV-LV transformation station	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Low voltage cupboard	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Command station with master control panel	In the framework of the intervention proposed for the WwTP, these equipment items should be renovated.	We recommend installation of a programmable automation controller that permits integration between the measurement instruments and operation of the mechanical equipment.	-

3.6.3.4 Solution 3

3.6.3.4.1 Detailed description of the treatment sequence – design and criteria

Solution 3 integrates the biological treatment by activated sludge in conventional aeration, with mesophilic anaerobic digestion of sludge. Biogas is frequently used as combustible for the boiler which provides the necessary power to the reheating of sludge. Biogas in excess will be incinerated in the flare.

The treatment line integrates the new facilities, the primary treatment equipment and the sludge mesophilic anaerobic stabilization, namely anaerobic digester, gasholder, flare, equipment for biogas treatment, boiler and heat exchanger.

Generally, all the considerations made for solution 2, concerning the capacity of the existing structures and the need for extension, are also valid for this solution 3.

The treatment line of Solution 3 for the rehabilitation of the WwTP of Jendouba includes the following stages:

- Preliminary treatment
  - Grit retention tank (new);
  - Water rise by 3 Archimedean screws (existing);
  - Screening consisting of 1 mechanical bar screen in parallel, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
  - Manual screen installed in the channel of recourse (existing);
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing);
  - Flow measurement in a Venturi channel using an ultrasonic level meter (existing);
- Primary treatment
  - Primary settling in 2 rectangular plant clarifiers, with bottom and surface scrapers bridge (new);
  - Feeding of floats into the thickeners (new);
  - Extraction of primary sludge for the thickeners (new);
- Biological treatment
  - Oxidation of the organic matter in half of the existing treatment line, totaling 5,964 m^3, aerated by a new air diffused system supplied by blowers equipped with variable speed (existing);
  - Settling of sludge in the existing secondary settling tanks, of rectangular plant, provided with a suction scraper bridge (existing);
  - Sludge directing for the pumping station (new);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement

using an electromagnetic flow meter (new);

- Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (new);

- Tertiary treatment
    - Biological removal of nitrogen through the nitrate internal recycling system which flows from the outlet of the nitrifying tank (the last compartments) towards the beginning of the anoxic tank (the first compartments); flow measurement using an electromagnetic flow meter (new);
    - Chemical precipitation of phosphorus with aluminum sulfate dosing (existing);
    - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
    - Thickening of the primary sludge, excess sludge and physicochemical sludge, in 2 thickeners of square plant, with scraper bridge (1 existing and 1 new);
    - Mesophilic anaerobic stabilization of thickened sludge (new);
    - Storage of biogas in a gasholder (new);
    - Heating of sludge in digestion with heat produced by the boiler (new);
    - Burning the biogas in excess and the bad quality biogas in the flare (new);
    - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
    - Storage of dewatered sludge in containers (new);
    - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility (new).
- Treatment of odors :
    - treatment of the contaminated air, extracted from the grit retention tank, the preliminary treatment building, thickeners and dewatering building, by biofilter (new).

3.6.3.4.2 Energy report

The average electricity consumption (solution 3, planning year) is presented in the annex (see Annex III, Annex III.5 at the end)

3.6.3.4.3 Consumption of chemical reagents

The chemical reagents consumed in the wastewater treatment process are aluminium sulfate, hydrated lime and polyelectrolyte. The quantities of chemical reagents consumed in year zero and in the planning year are presented in Annex III.5 (at the end).

3.6.3.4.4 Management of by-products

The quantities of by-products resulting from the wastewater treatment process, in particular solid screenings, grit, grease and sludge, are presented in Annex III.5 (at the end)

3.6.3.4.5 Equipment

The solution 3 includes the same treatment line as solution 2 except for cogeneration. As a result, all the considerations on the solution 2, concerning the existing equipment items and replacement needs, are also valid for this solution. For a fuller understanding of the comments, it is necessary to view the treatment scheme of the solution attached to the report.

Table 3.6-9: Electro-mechanical equipment, instruments and electrical installations

Designation	Diagnosis	Proposed solution	Characteristics
Preliminary treatment			
Grit extraction system by “air-lift”	The wastewater includes a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber.	We propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber. Grit extraction will be achieved via an “air-lift” system.	Estimated extraction flow rate = 18 m3/h
Archimedes screw nº1	The Archimedes screws were undergoing replacement. All the screws presented an advanced state of corrosion and degradation. The construction did not seem to be adapted (it is too large) to the size of the Archimedes screw. It is possible to view many screenings deposited on the sides of the screw.	The demonstrated state of degradation justifies their replacement. The replacement was in progress.	Flow = 180 m^3/h Height ≈ 4.5 mce(meters of water columns)
Archimedes screw nº2	The Archimedes screws were undergoing replacement. All the screws presented an advanced state of corrosion and degradation. The construction did not seem to be adapted (it is too large) to the size of the Archimedes screw. It is possible to view many screenings deposited on the sides of the screw.	The demonstrated state of degradation justifies their replacement. The replacement was in progress.	Flow = 360 m^3/h Height ≈ 4.5 mce(meters of water columns)
Mechanical multi-rake bar screen	The mechanical screen presents widespread corrosion in stainless steel. Furthermore, the consulting team was informed that the mechanical cleaning of the mechanical screen operates in manual mode, given that the automatic mode is not available in the market.	The demonstrated state of degradation justifies their replacement.	Maximum flow = 900 m^3/h Spacing between bars = 6 mm
Measurement of the difference in water level (screening)	The demonstrated state of degradation justifies replacement.	Automation should be improved, in particular in terms of integration between measurement of the level and operation of the mechanical screen.	

Designation	Diagnosis	Proposed solution	Characteristics
Belt conveyor	The paintwork is a bit degraded and altered in certain places. Nonetheless, we can affirm that the equipment seems to be sufficiently painted in order to avoid further corrosion.	Replacement is not judged to be necessary.	Estimated volumetric flow rate of screenings = 0.2 m^3/d
Scraper bridge (grit and grease extraction in a double aerated channel)	The scraper bridge has a deviation in its longitudinal movement. The wheels of the scraper bridge present a high level of degradation. The electrical component of the equipment presents a high level of degradation.	The demonstrated state of degradation justifies their replacement.	Installed in the existing work
Grit pumps (grit and grease extraction in a double aerated channel)	The occurrence of frequent breakdowns was reported to the consulting team	We recommend the replacement of the equipment items. There are two pumps per scraper bridge.	Estimated flow for each pump = 18 m3/h.
Grit classifier (grit and grease extraction in a double aerated channel)	The grit classifier on the scraper bridge does not operate correctly and presents a certain amount of degraded paintwork.	The grit classification operation must be improved with installation of specialized equipment for this function. The equipment will be installed on the scraper bridge.	Estimated total capacity = 20 m3/h.
Compressors (grit and grease extraction in a double aerated channel)	The compressors present a certain level of degradation; they were dirty and covered in dust.	We recommend the replacement of the equipment items. There are three compressors for the double channel: 2+1.	Estimated volumetric flow rate of air for each compressor = 162 m3/h
Grease removal via a screw conveyor (grit and grease extraction in a double aerated channel)	The grease pumping circuit is out of service. The consulting team was informed that the circuit was immediately blocked after the start-up of the installation and was then abandoned.	Grease removal will be implemented via a screw conveyor installed in the grease tank.	Estimated volumetric flow rate of grease = 68 m3/d
Measurement of effluent flow	Measurement is made by an ultrasonic level meter.	Replacement is not judged to be necessary.	

Designation	Diagnosis	Proposed solution	Characteristics
Primary treatment			
Scraper bridges (primary sedimentation tanks)	In the framework of this solution for renovation of the WwTP, we propose the existence of primary treatment.	The scraper bridge is constituted by a mobile transversal beam that serves as a walkway, two lateral guides, an articulated system for collecting the sludge and discharging the scum, a motor reduction unit for activating the two lateral guides, a control unit of the articulated system of bottom scraper/scum blade and a command and control panel.	
Primary sludge lift pumps (primary sedimentation tanks)		It is necessary to install submersible pumps. There is one pump per scraper bridge.	Estimated flow for each pump = 18 m^3/h.
Secondary or biological treatment			
Aeration	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor. Also, in order to maximize the volume of the existing reaction it is necessary to implement a more effective aeration method. The tanks are too deep in order to obtain maximum performance of the existing surface aerators.	We recommend replacement of the surface aerators by a fine bubble aeration system. This system includes compressors endowed with speed variation, air ducts and diffusers installed in the tanks. There are three compressors: 2+1; one compressor for each line.	Estimated volumetric flow rate of air for each compressor = 4,438 m^3/h.
Oxygen measurement (aeration tank)	The operation of the surface aerators is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor.	We recommend installation of a programmable automation controller that permits integration of oxygen measurements with the aeration operation.	
Mixing	The submersible mixers are not in a good state of conservation. In the framework of this solution, it is necessary to add submersible mixers to the new line.	Replacement is judged to be necessary, and it is necessary to add submersible mixers to the new line.	

Designation	Diagnosis	Proposed solution	Characteristics
Scraper bridges (secondary clarifiers)	The scraper bridges are not in a good state of conservation. In the framework of this solution, it is necessary to add a scraper bridge to the new line.	Their complete replacement is judged to be necessary.	Installed in the existing work. (There are two scraper bridges with two sedimentation tanks)
Biological sludge lift pumps (secondary clarifiers)	The pumps are in a reasonable state of conservation given their working conditions.	Replacement is not judged to be necessary There are two pumps per scraper bridge.	Estimated flow for each pump = 144 m3/h.
Sludge recirculation pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process	We recommend the construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks.	Estimated flow for each pump = 761 m^3/h.
Measurement of the flow of sludge recirculation	No measurement of the sludge recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Excess sludge extraction pump	The distribution of the flow to the biological sludge recirculation circuits and purging of excess sludge is carried out manually via a distribution valve, without precision, which impedes correct management of distribution of the sludge and undermines the treatment process.	We recommend the construction of a biological sludge pumping station equipped with submersible pumps in order to lift the excess sludge towards the thickener.	Estimated flow for each pump = 24 m^3/h.
Measurement of the flow of excess sludge	No measurement of the excess sludge exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 80 mm
Tertiary treatment			
Nitrate recirculation pump	The Tunisian norm NT106.02 sets maximum limits for nitrate, nitrite, organic and ammoniacal nitrogen. Hence, it is necessary to modify the existing reactors to adapt them for biological elimination of nitrogen.	It is necessary to install submersible pumps (with frequency variation) for nitrate recirculation, in the existing aeration tanks - from the last aeration tank to the first.	Estimated flow for each pump = 761 m^3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Measurement of the flow of nitrate recirculation	No measurement of the nitrate recirculation exists.	Installation of a flow-meter on the rising main (electro-magnetic flow-meter).	Estimated diameter = 200 mm
Dosing pump of aluminium sulfate and dosing circuit	Chemical precipitation of phosphorus with dosing of aluminium sulfate	We recommend a dosing circuit with dosing tank, retention chamber, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Estimated flow for each pump = 231 L/h.
Disinfection	The Tunisian norm NT 106.02 obliges observance of 2000/100 ml of fecal coliforms and 1000/100 ml of fecal streptococci in order to guarantee the microbiological quality of the public water supply.	Disinfection by ultraviolet radiation implemented upstream by the filtration operation using vertical multicellular pumps, self-cleaning pressure filters, and ultraviolet radiation system in the open channel.	Maximum flow = 900 m^3/h
Treatment of the sludge			
Scraper bridge (existing thickener)	The paintwork of the scraper bridge is a bit degraded and altered in certain places. In the framework of this solution for renovation of the WwTP, we propose construction of another thickener.	Their complete replacement is not judged to be necessary. It is necessary to consider application of a new layer of paint.	The new thickener will be square-shaped like the existing one.
Thickened sludge pumps	The sludge pumps (which lift the sludge towards the thickened sludge storage tank or towards the sludge drying beds) present a high level of deterioration.	In the framework of renovation of the WwTP it will be necessary to replace these pumps and to add another because of the new thickener. We recommend an excentric screw pump. There is one pump for each thickener.	Estimated flow per pump = 18 m3/h.
Anaerobic digestion of the sludge	In the framework of this solution for renovation of the WwTP, we propose mesophilic anaerobic stabilization of the thickened sludge.	The anaerobic digestion of the sludge will be implemented using the digesters, agitation of the digesters via the sludge recirculation pumps, pumps for the sludge heating circuit during digestion, gasholder and torch.	
Sludge heating system during digestion	For mesophilic anaerobic stabilization of the thickened sludge, it is necessary to foresee a sludge heating system during digestion.	We always recommend the use of a boiler and a hot water tank with recirculation pumps for these circuits.	The boiler must work with natural gas and biogas

Designation	Diagnosis	Proposed solution	Characteristics
Lift pump of the digested sludge for the centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer.	We recommend an excentric screw pump.	Estimated flow per pump = 25 m^3/h.
Centrifugal clarifier	In the framework of renovation of the WwTP we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of two equipment items.	Capacity estimated = 25 m^3/h.
Polymer preparation equipment	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of fully automatic continuous polymer solution preparation equipment. Dosing tank, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Capacity 2,000 L/h
Polymer dosing pump	-	We recommend membrane dosing pumps.	Estimated flow per pump = 1.6 m^3/h.
Lifting the dewatered sludge		The dewatered sludge will be lifted via a screw conveyor.	Estimated volumetric flow rate of the dewatered sludge = 39 m^3/d
Treatment of odors			
Contaminated air treatment system	We propose to extract the contaminated air from the grit retention tank, preliminary treatment building, thickener and dewatering building	The contaminated air will be deodorized via a bio filter and a piping circuit and fan	-
Electrical installations			
MV-LV transformation station	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Low voltage cupboard	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-

Designation	Diagnosis	Proposed solution	Characteristics
Command station with master control panel	In the framework of the intervention proposed for the WwTP, these equipment items should be renovated.	We recommend installation of a programmable automation controller that permits integration between the measurement instruments and operation of the mechanical equipment.	-

3.6.4 Economic assessment

3.6.4.1 Investment costs

The estimate of the fixed capital investment costs associated with the civil engineering and equipment items is based on market consultations and information supplied by ONAS.

The following table presents a summary of the fixed capital investment costs associated with each treatment solution studied. Annex III.8 presents systematization of the partial values used for the values presented in the following table. The breaking down of prices for the proposed solution is given in Annex III.9.

Table 3.6-10: Estimate of the initial investment costs

Treatment solutions	Civil engineering (TND)	Equipment items and IE (TND)	Total (TND)
1	1,918,721	4,685,661	6,604,382
2	2,973,907	8,055,684	11,029,592
3	2,943,992	5,795,291	8,739,282

In conformity with the project implementation timetable described in chapter V, it is admitted that the initial investment will be made in 2016, which corresponds to the start of the construction works.

3.6.4.2 Operating and maintenance costs

In order to estimate of the operating and maintenance costs, the unit costs supplied by ONAS have been used, in relation to:

- maintenance;
- consumption of chemical reagents;
- electricity consumption;
- transport and final deposit of the by-products and sludge.

The operating costs associated with analytic control of operation of the wastewater treatment plant have not been counted, since they depend upon the planning defined by ONAS and are common to all the treatment solutions studied.

The maintenance costs resulting from addition of the two parts corresponding to the civil engineering and maintenance of the electromechanical equipment. They have been estimated through application of a rate of 2.5% and 1.0% on the budgetary forecasts of the investment for the electromechanical equipment items and civil engineering, respectively.

In relation to the chemical reagents, the following unit prices are admitted:

- aluminium sulfate – 400 TND;
- cationic polyelectrolyte – 6500 TND;

- lime – 150 TND.

The electricity consumption has been estimated on the basis of the energy reports presented in Annex III.5, and a unit electricity cost of 0.13 TND/kWh was admitted.

In order to estimate the costs de transport and final deposit of the by-products and of the sludge, a unit cost of 40 TND/t has been taken into consideration.

In conformity with the project implementation timetable, the start date of operation of the plant after renovation will be 2019.

3.6.4.3 Updated total costs

Annex III.8 presents the updated total costs for the year 2016, through application of an updating rate of 3%. A summary of the results obtained is presented to the following table.

Table 3.6-11: Estimate of the fixed capital investment costs (FCIC), of the operating costs (OC) and of the updated total costs (UTC) for each solution studied

Treatment solutions	FCIC (TND)	OE (TND)	UTC (TND)
1	6,598,382	22,508,872	24,315,630
2	11,023,592	21,543,049	27,995,433
3	8,733,282	23,068,488	26,895,967

For each solution studied the ratio TND/m^3 is respectively, 0.61, 0.71 and 0.68.

3.6.5 Technical and economic and comparison of the solutions

From the previous table, it is noted that although Solution 2 has lower operating costs, its total discounted costs are the highest due to the high initial capital investment costs. From a strictly economic perspective, the solution 1 is the most advantageous one, with the investment costs and total discounted costs the lowest.

During the missions in Tunisia, the consultant team tried to find examples of WwTP using the process of conventional aeration activated sludge, with mesophilic anaerobic digestion of sludge and energy recovery from biogas. Although it may not be a representative sample of such plants, the team visited Choutrana WwTP near Tunis. At the time of the visit the anaerobic digestion of sludge with energy recovery of biogas was out of service. The team notes that based on the training plans provided by ONAS, a major effort would be needed to implement Solution 2, for the integration of training of the operation team.

In contrast, Solution 1 uses an existing treatment process, which is much simpler and well controlled by the operation team.

Solution 3 is an intermediate option, between 1 and 2. However, it would involve operational difficulties almost as great as Solution 2.

Thus, it is recommended that the rehabilitation of the Jendouba WwTP be carried out according to Solution 1.

3.6.6 Conclusion and recommendations

As the conclusion through discussion with ONAS during the present Survey, Solution 1 is selected as the best solution for the Jendouba WwTP to be proceeded for d**e**tailed design.

3.6.6.1 Summary of key interventions for the selected solution

With regard to the solution adopted key interventions recommended include:

- Preliminary treatment
    - construction of a new grit retention tank including the grit extraction system by “air-lift”;
    - replacement of the mechanical multi-rake bar screen;
    - replacement of the scraper bridge;
    - replacement of the grit pumps (grit and grease extraction);
    - installation of a grit classifier;
    - replacement of the compressors;
    - installation of a screw conveyor for grit removal;
    - replacement of the measurement flow equipment;
- Secondary or biological treatment
    - replacement of the surface aerators by a fine bubble aeration system including compressors endowed with speed variation, air ducts and diffusers installed in the tanks;
    - replacement of submersible mixers;
    - replacement of the scraper bridges (secondary clarifiers);
    - construction of a biological sludge pumping station equipped with submersible pumps for recirculation of the sludge upstream of the aeration tanks, and excess sludge extraction;
- Tertiary treatment
    - installation of nitrate recirculation pumps;
    - construction of an ultraviolet radiation disinfection system in the open channel implemented upstream by the filtration operation via multicellular vertical feeding pumps linked to the filters, self-cleaning pressure filters;
- Sludge treatment
    - construction and installation of all the civil works and equipment relative to the sludge

- Odor treatment
    - construction and installation of all the civil works and equipment associated with the contaminated air treatment system including the extraction Of the contaminated air from the grit retention tank, preliminary treatment building, thickener, thickened sludge storage tank and dewatering building.

3.6.6.2 Recommendation regarding continuation of normal activity during works

As it is necessary to maintain the operation of the WWTP it becomes essential to perform all work in a progressive manner. In this sense, it is recommended:

- interventions should be made as much as possible during the dry season, so that the affluent flow is smaller;
- construction of the sand retention tank sand should be a priority and be completed before interventions in the pre-treatment;
- interventions provided at the pre-treatment should be carried out alternately on each channel;
- interventions in the aeration tanks and secondary clarifiers must be done line by line to allow the rest to maintain in operation;
- interventions concerning the pre-treatment of wastewater from the yeast production, disinfection, sludge treatment and odor treatment, are not directly involved in the operation of STEP, so can be done sequentially.

3.5.6.3 Remarks on further studies

The results for the STEP of Jendouba helped to find a solution for setting the budget of the operation of rehabilitation and extension.

However, the further studies, especially the Detailed Design, will have to validate in detail the technical choices proposed or to propose some technical amendments in the budget of the operation.

3.7 WWTP OF SILIANA

3.7.1 Current situation of the WwTP

3.7.1.1 General information

3.7.1.1.1 General localization and accessibility

The wastewater treatment plant of Siliana is situated at the North-East of Siliana, governorate of Siliana, at 3.4 km from the center of the city. The site is located on the left of the secondary road Siliana – Bou Arada, separated by the latter through a narrow ditch (see Figure 3.7-1). The following figure presents the aerial view of the WwTP and the receiving water of treated effluent.

Figure 3.7-1: Aerial view of the WwTP of Siliana and receiving water of treated effluent
(Source: Google Earth 2010)

The perimeter of the WwTP is enclosed and the access to the plant can is made through a gate. The fence and gate are in good condition.

3.7.1.1.2 Environmental restrictions of the area and the surroundings

The WwTP is situated on a ground of approximately 4 ha, including the surfaces for a future extension that must be carried out to comply with the requirements for the year 2016.

The reservoir of the dam of Siliana is located 5 km from the point of discharge of treated effluent which constitutes a source of water for the agricultural irrigation.

3.7.1.1.3 Description of the existing facilities

The WwTP of Siliana was brought into service in January of 2000 and was dimensioned to treat wastewater corresponding to 51,000 population equivalent to the year 2011. According to the responsible technician for the WwTP exploitation, the plant also receives an industrial effluent from a poultry industry, on which it was not possible to find more detailed information.

This treatment capacity corresponds to a flow of 4,530 m^3/day and to an organic load (BOD) of 2,450 kg/day.

The existing sewage network in Siliana is of two types:

- Combined system network in the town core;
- Separate system network outside the town core.

The wastewater arrives at the WwTP by means of a rising main.

The WwTP of Siliana was designed according to the extended aeration activated sludge process. The treatment line incorporates the following facilities:

- Pretreatment
  - Screening consisting of 1 mechanical bar screen, with bars spacing of 6 mm, a conveyor belt and a trailer;
  - Manual bar screen, with bars spacing of 10 mm, installed in the recourse channel;
  - Rotating sieve for micro filtering the grease from the grit and grease removal operation and from the secondary clarifier scum;
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge;
  - Flow measurement in a Venturi channel using an ultrasonic level meter;
- Biological or secondary treatment
  - Oxidation of the organic matter in 2 treatment lines, each one with 2 oxidation ditches equipped with aeration rotors;
  - Settling of sludge in 2 circular secondary clarifiers, equipped with a rotating scraper bridge, central feeding and clarified effluent peripheral exit by weir;
  - Recirculation of sludge at the beginning of the aeration tanks, from the sludge pumping station;
  - Sludge recycle to the beginning of the oxidation ditches by means of a sludge pumping station and flow measurement using an electromagnetic flow meter;
  - Excess activated sludge extraction and feeding into the thickener by means of a sludge pumping station;
  - Scum extraction from the secondary clarifier via a sludge pump (installed on the rotating scraper bridge) to the rotating sieve;
- Tertiary treatment
  - Nitrogen biological removal, materialized in the oxidation ditch, which is possible due to the dissolved oxygen concentration in the basin (allowing to have areas of anoxia for denitrification);
  - Chemical precipitation of phosphorus with aluminum sulfate dosage (currently out of service);

- Treatment of sludge
  - Excess activated sludge thickening in 1 thickener of circular plan, equipped with a scraper bridge;
  - Dewatering of the thickened sludge in 56 drying beds;
  - Pumping of the thickener supernatant and the drying beds filtrate, by means of a pumping station, towards the WwTP inlet before screening.

A part of the effluent from the biological treatment is reused internally as wash water. The treated effluent, exceeding the WwTP needs of wash water, is discharged into the receiving water, the Wadi Siliana (tributary to Siliana dam), and is partially reused for the complementary irrigation of 70 ha of agricultural land.

The following figure shows the plant general layout of the WwTP of Siliana, where the future expansion zones, already planned for 2016, are represented (shaded zones) and some photographs of the plant are shown thereafter.

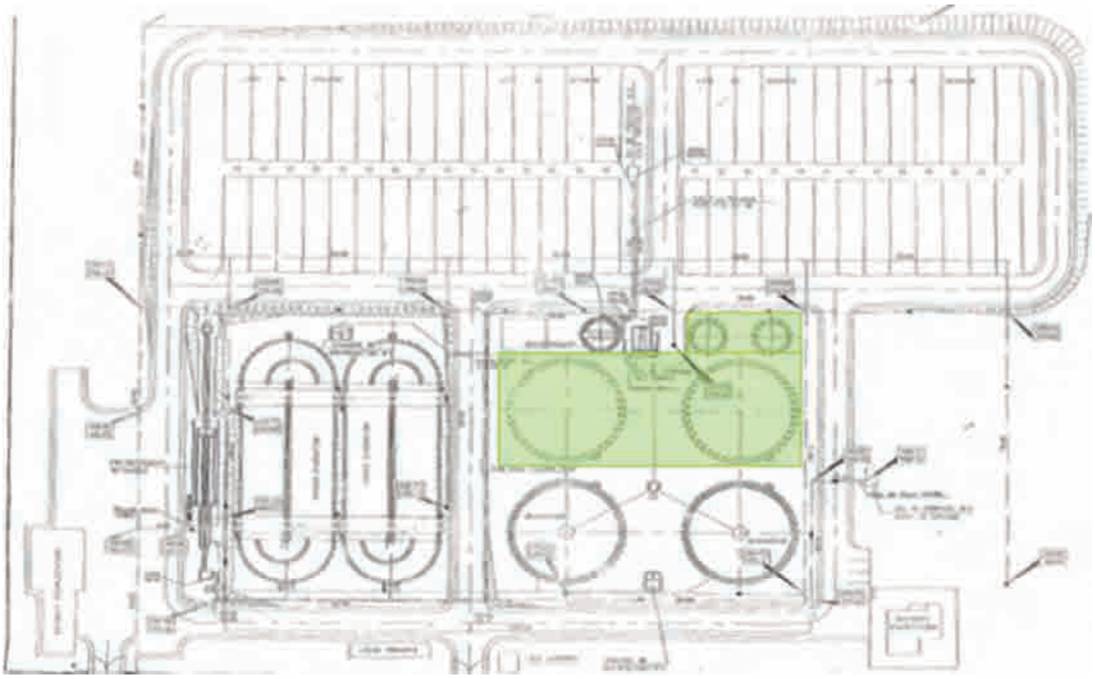


Figure 3.7-2: General layout of the WwTP of Siliana

Figure 3.7-3: Photographs of the WwTP of Siliana

1 – Pretreatment – Inlet channels; 2 – Pretreatment – Step screen, rotating sieve and conveyor belt; 3 – Flow measurement; 4 – Aeration tank – Oxidation ditch; 5 – Pumping station of sludge recirculation, sludge in excess and thickened sludge; 6 – Thickener.

The main dimensions of the existing facilities are presented in Annex III (Annex III.6).

Moreover, the WwTP is provided with three buildings and a cabin for the guardian (close to the entrance, with a surface of 9 m^2). The main building is composed of two offices (one of them includes the main control panel), a laboratory, a workshop and an electromechanical accessories store, communication central, a room for the chemicals storage, a refectory and toilets (WC/showers). The main building wastewater is pumped to the screening upstream.

The apartment building has been designed to ensure the permanent presence of the head of the WwTP and consists of three bed rooms, a living room, a dining room, a kitchen, a bathroom, and a terrace. This building sewage is drained towards the same pumping station that receives the wastewater from the main building, being the whole pumped to the WwTP inlet.

The transformation building includes a room for the power generator, the main LV distribution room, a room for the transformer post and a room for the medium voltage reception.

3.7.1.2 Characteristics of the current quantity and quality of wastewater and treated effluent

3.7.1.2.1 ONAS' Operating reports

The following tables summarize the quantitative and qualitative characterization of the wastewater influent to the WwTP of Siliana, as well as the treated effluent, taking into account the annual operation reports of the years 2008, 2009 and 2010 provided by ONAS.

Table 3.7-1: Quantitative characterization of tributary wastewater between 2008 and 2010

Year	Value	Daily flow (m^3/day)	Monthly flow (m^3/month)	Annual flow (m^3/year)
2008	Minimum	1,345	36,261	847,144
	Average	2,364	70,595	
	Maximum	3,303	114,452	
2009	Minimum	1,821	54,639	738,639
	Average	2,026	61,553	
	Maximum	4,320	7,418	
2010	Minimum	1,740	50,533	780,774
	Average	2,137	65,065	
	Maximum	4,523	80,183	

Table 3.7-2: Qualitative characterization of tributary wastewater between 2008 and 2010

Year	Value	BOD (kg/day O_2)	COD (kg/day O_2)	TSS (kg/day)
2008	Minimum	569	1,484	572
	Average	987	2,432	1,105
	Maximum	1,743	3,710	2,514
2009	Minimum	721	1,728	702
	Average	882	1,970	834
	Maximum	1,023	2,255	910
2010	Minimum	804	1,635	646
	Average	976	2,189	937
	Maximum	1,288	2,894	1,768

Table 3.7-3: Qualitative characterization of the treated effluent between 2008 and 2010

Year	Value	BOD (mg/L O_2)	COD (mg/L O_2)	TSS (mg/L)
2008	Minimum	23	75	14
	Average	56	134	63
	Maximum	133	233	125
2009	Minimum	19	73	19
	Average	26	88	26
	Maximum	41	135	45
2010	Minimum	20	78	13
	Average	27	86	24
	Maximum	36	106	35

3.7.1.2.2 Sampling program implemented and discussion of the main results

In the framework of this project, a sampling program of the raw and treated wastewater was carried out, aimed at consolidating the conclusions drawn after analysis of the wastewater treatment plant's operating reports.

The sampling was implemented in conformity with the premises described in paragraph 3.3.1.2.2.

The sampling for the Siliana WwTP was implemented on the following dates:

- Thursday 21/10/2010 – Friday 22/10/2010: day of the weekly market;
- Monday 25/10/2010 – Tuesday 26/10/2010: day when the chickens are slaughtered, the slaughter takes place upstream of the wastewater treatment plant (the OMAR slaughterhouse) and raw wastewater is discharged directly into ONAS' network, thus causing serious disturbances to operation of the plant;
- Thursday 04/11/2010 – Friday 05/11/2010: rainy day which coincided with the day of the weekly market;
- Saturday 06/11/2010 – Sunday 07/11/2010: week-end.

The following table present the main results of the sampling program carried out.

Table 3.7-4: Results of the sampling program

Parameters	From 21 to the 22/10/2010		From 25 to the 26/10/2010		From 04 to the 05/11/2010		From 06 to the 07/11/2010	
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow
Daily flow (m^3/d)	3,120		2,732		5,212		2,396	
pH	7.3	7.6	7.46	7.62	7.12	7.6	7.15	7.29
TSS (mg/L)	313	8	455	8	495	21	372	41
VSS (mg/L)	0.63	0.26	0.85	0.28	0.28	0.1	1.56	0.21
COD (mg/L O_2)	800	35	1240	37	659	33	843	65
BOD_5 (mg/L O_2)	314	14	485	16	281	14	370	25
Carbonates (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bicarbonates (mg/L)	813	610	866	631	272	583	421	409
Hydroxides (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kjeldahl Nitrogen (mg/L N)	62.2	25.3	54	25	40	16.3	74.2	32.2
Nitrates (mg/L N)	<0.04	0.36	<0.04	0.17	<0.04	0.36	<0.04	0.42
Phosphorus total (mg/L P)	11.2	1.36	6.8	1.63	4.76	1.69	3.4	2.9
Oils & grease (mg/L)	31.2	<0.1	158	<0.1	36.4	<0.1	39.2	<0.1
Hydrocarbons (mg/L)	179.4	<3.3	169.4	<3.3	81.54	<3.3	88.8	3.3
Total coliforms	9.5×10^7	2.5×10^7	4.5×10^6	9.5×10^5	2.5×10^7	4.5×10^5	4.5×10^7	9.5×10^4
Fecal coliforms	2.5×10^7	9.5×10^6	4.5×10^6	4.5×10^5	2.5×10^7	2.5×10^5	4.5×10^6	9.5×10^4

Following analysis of the above results, it is necessary to emphasize the major influence of rainfall on the daily flow to the wastewater treatment plant. In effect, the daily flow recorded during the period from 04/11/2010 to 05/11/2010 is almost twice as high as a day without rain.

The obtained ratios BOD_5/COD vary between 0.39 and 0.44, which lies within the typical range for biodegradable effluents.

Furthermore, the effectiveness of the degradation of the organic aeration is very high, around 97%. The effectiveness of elimination of nitrogen is between 56 % and 59 % (for this calculation, we considered that the total value of nitrogen corresponds to the Kjeldahl nitrogen and to the nitrates, since nitrites in raw effluent are generally negligible).

Moreover, analysis of the ratio BOD_5:N:P was lower than the reference of 100:5:1, indicating good equilibrium conditions for the development of bacteriological biomass.

Comparing the mean results from the sampling program (undertaken during October and November 2010) with the mean analytical results from the 2010 Operation Report, it is concluded that:

- The mean of the mean daily flows recorded in the sampling program is about 57% superior to the mean of the values recorded in the 2010 Operation Report;
- The results from the sampling program for concentrations of TSS, COD and BOD_5 in raw wastewater are, on average, 8% to 20% below the mean values from the Operation Report;

- The concentrations of TSS, COD and BOD_5 in treated effluent obtained from the sampling program are, on average, 17 to 50% below the mean values recorded in 2010.

Comparing the mean results from the sampling program with the mean analytical results for only October and November from the 2010 Operation Report, it is concluded that:

- The mean daily flow data recorded in the sampling program are of the same order as the results indicated in the 2010 Operation Report, except one value which is over twice as large as that in the Operation Report;
- The results from the sampling program for concentrations of TSS, COD and BOD_5 in raw wastewater are of the same order as those recorded in the Operation Report;
- The concentrations of COD and BOD_5 in treated effluent obtained from the sampling program are, generally, of the same order as those recorded in the 2010 Operation Report; one TSS concentration is also of the same order of magnitude, but the other three are very variable: one is about 100% higher, while the other two are about 60% lower;

3.7.1.3 Evaluation of the existing plant operation

According to the annual operation reports of years 2008, 2009 and 2010, provided by ONAS, the flow affluent to the WwTP of Siliana has never exceeded the design flow of 4,530 m^3/day, with the average value of the daily average flows of 2010 of approximately 47% of the hydraulic capacity of the WwTP.

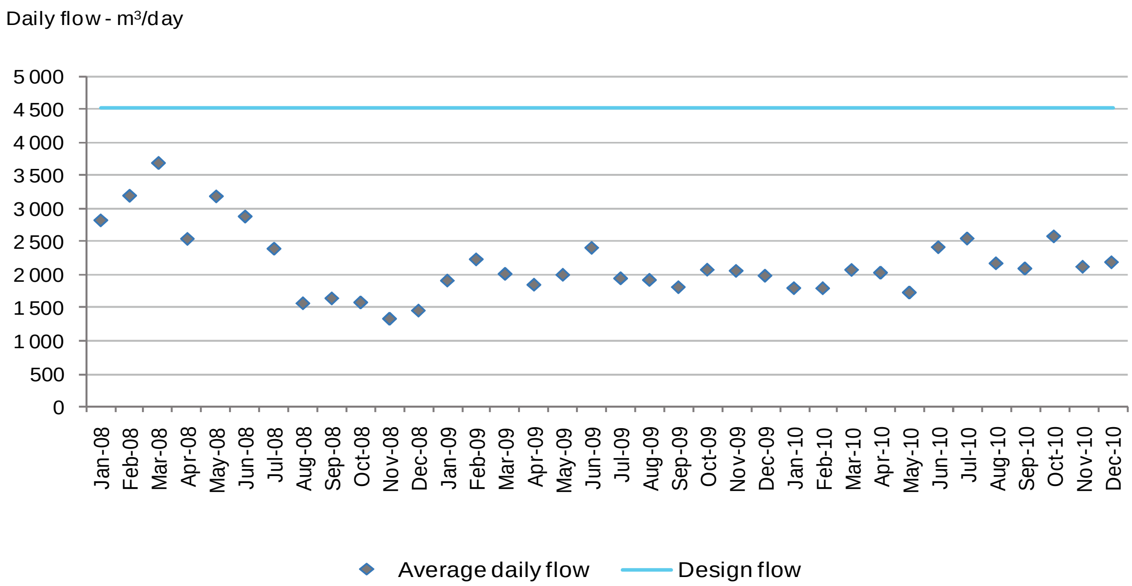


Figure 3.7-4: Variation of the average daily flow of the affluent between 2008 and 2010 and the design flow

According to the last figure, in spite of the variation of the flows, no seasonal evolution is evident, because the maximum values take place in winter, or in summer.

Concerning the organic load (BOD) affluent to the WwTP of Siliana, the analyzed annual operation reports indicate that the average organic load reached, in 2008, 40% of the design load, 2,450 kg/day, which was maintained in 2010 (despite a slight decrease in 2009), with no situation of excess being recorded for the analyzed period. Moreover, the reports reveal also a very satisfactory purifying output, with an average value of approximately 92% (with respect to BOD). Notwithstanding, the concentration of BOD in the treated effluent, in 2008, achieved very high values, with an average value of 56 mg/L, which exceeds approximately 87% of the standard of evacuation (30 mg/L). This value was lower in 2009 and 2010, in spite of some cases of excess, with the maximum recorded value of 41 mg/L (37% higher than the standard of evacuation).

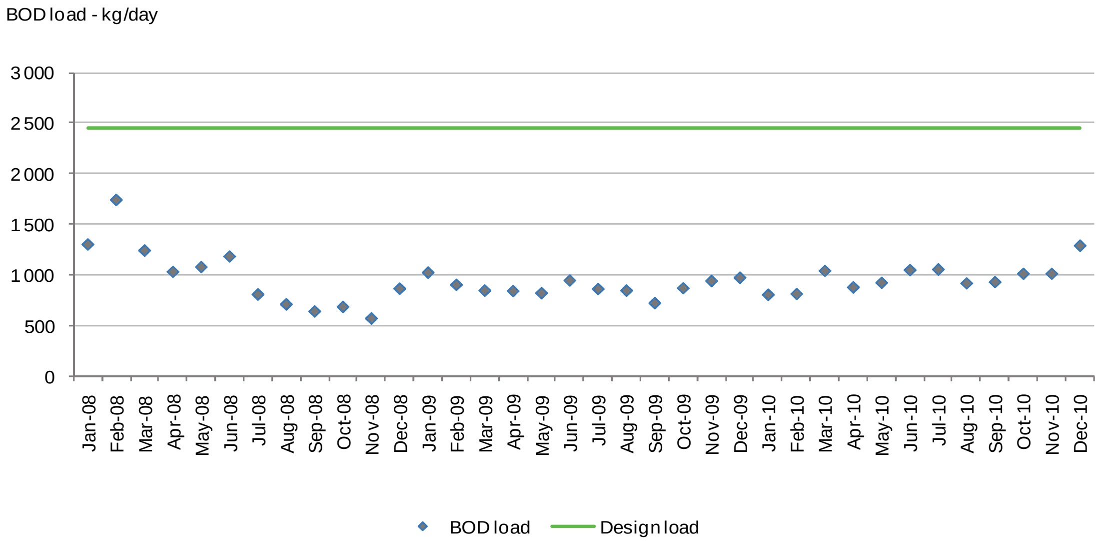


Figure 3.7-5 : Variation of the affluent BOD load between 2008 and 2010 and the design load

By comparing the two former figures, it should be noted that the load variation in the course of time is equivalent to the variation of the flow, with some seasonal variation not being evident.

According to the annual operation reports, the transparency limits, solids settleability, TSS, BOD_5 and COD were often exceeded during the period being analyzed, although the results in 2009 and 2010 were better.

The ratio obtained between the organic matter and the nutritive elements (BOD_5:N:P), by using the values of years 2008 and 2010, being lower than the reference ratio (100:5:1), shows good equilibrium conditions for the development of bacterial biomass. Moreover, a ratio of BOD_5/N higher than 3.5 is compatible with the biological displacement of nitrogen. The reports of year 2009 do not provide sufficient information to make this evaluation, with the values of parameters N_T, N-NO_3 and N-NO_2 being missed. However, the wastewater to be treated present characteristics that are basically urban, therefore the values of ratio of BOD_5/COD are found within the interval of 0.3 – 0.8, which allows to conclude that these effluents have a biodegradation compatible with most of the biological treatments, which means, the effluent must be biodegradable by selected and adapted micro-organisms.

The following figure presents the variation in the concentration of BOD_5 at the exit of the plant, during the period under analysis. It is clear that the highest amounts are recorded during the summer months.

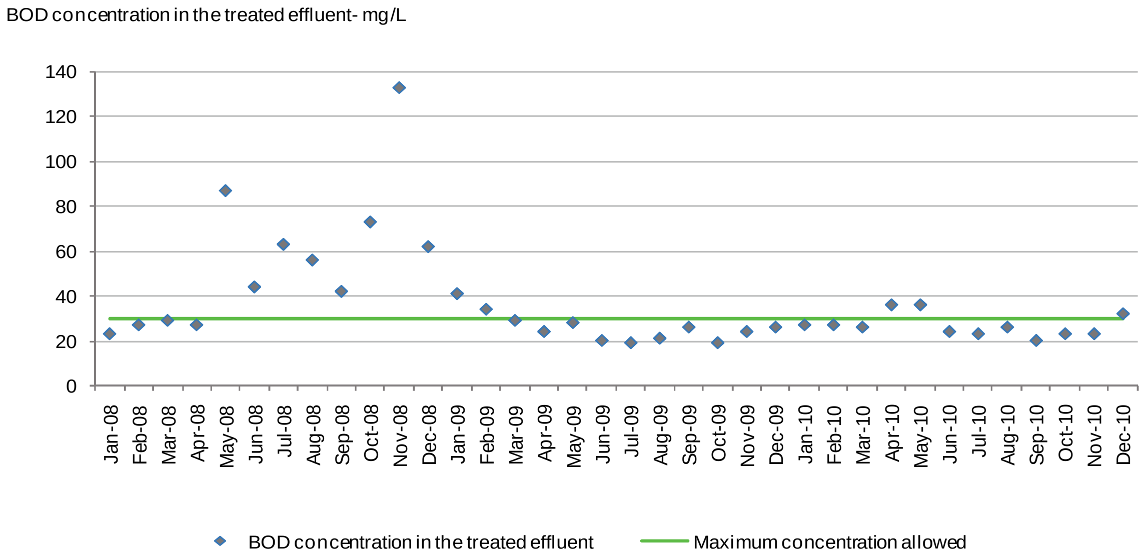


Figure 3.7-6: Variation of the concentration of BOD_5 in the treated wastewater between 2008 and 2010, and discharge limit value

During the visit paid to the WwTP of Siliana, some information was collected and it was possible to identify certain irregularities on the operation of the installation, which must be resolved in the short term:

- There is major flow of grit into the wastewater treatment plant, which causes accumulation of grit in the aeration tanks;
- During winter, the capacity of the drying beds is not sufficient for the dewatering of sludge;
- According to the technician responsible for the WwTP, the purified wastewater have very high concentrations of solids;
- According to the technician responsible for the WwTP, the submersible agitators in the channels of oxidation are necessary to ensure the flow of water;
- According to the technician responsible for the WwTP, the pumps that proportion the aluminum sulfate do not have the capacity necessary to ensure the required proportioning, and therefore they are currently out of service;
- Since the treated effluent is provided for irrigation, there is the need to have a tertiary treatment be carried out at the outlet.

Concerning the energy consumption of the plant, the values of the annual operation reports indicate a specific average consumption of 0.29 kWh/m^3 of treated effluent, in 2008, 0.53 kWh/m^3, in 2009, and 0.49 kWh/m^3 in 2010. The following table summarizes the values of energy consumption in the WwTP of Siliana.

Table 3.7-5: Energy consumption

Year	Value	Energy consumption (kWh)	Energy consumption indicator (kWh/m^3)
2008	Minimum	11,530	
	Average	20,146	0.29
	Maximum	32,905	
2009	Minimum	24,246	
	Average	32,778	0.53
	Maximum	37,533	
2010	Minimum	21,709	
	Average	32,094	0.49
	Maximum	36,228	

The following figure presents the variation of the energy consumption for the period being analyzed.

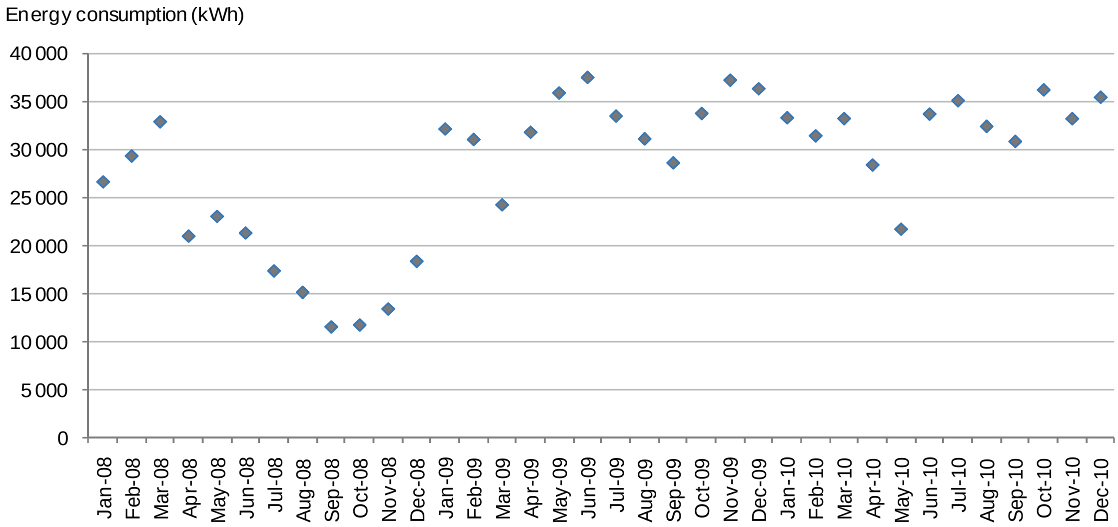


Figure 3.7-7: Variation of the energy consumption, between 2008 and 2010

3.7.1.4 Greatest limitations found and the necessary actions

The greatest limitations found in the WwTP of Siliana concern basically issues such as the accumulation of grit in the treatment tanks, the oxidation ditch agitation, the treated effluent quality and the sludge dewatering during winter.

Accumulation of grit

The wastewater presents a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber, thus building up sediment in the aeration tanks. In order to resolve this problem, we propose the construction of a grit retention chamber upstream of the headworks, which will work as a complement to the aerated grit and grease chamber.

Oxidation ditch agitation

The oxidation ditches flow will be ensured by submersible agitators, positioned to ensure the correct flow direction.

Sludge dewatering

For the sludge dewatering, for a matter of uniformity, it is planned to carry out the replacement of the drying beds by a mechanical system, as described in paragraph 3.3.1.4.

Disinfection

In order to ensure the conformity to the standard in force, NT 106.02 (1989), and since the treated effluent is reused for irrigation, it is planned to implement a disinfection system via ultraviolet radiation, being served upstream by an operation of filtration in order to guarantee the water necessary transmittance so that assures an efficient radiation distribution.

Condition and operation of electromechanical equipment

Generally, the equipment presents a good level of maintenance in accordance with its working conditions.

In general, the electromechanical equipment has a reasonable level of maintenance in accordance with its working conditions. It was visible on the wall (in the control room) a board with the preventive maintenance plan which includes lubricating frequency and lubricating level verification for different equipment, among other information.

Automation could be increased specially focusing on integration between measurement probes (example of oxygen probe in biological reactor) and actuation of mechanical equipment (example of working hours of the surface aerators).

The grease pump was out of service. It was mentioned to clog easily. The exploitation team prefers to suck up the grease directly from the retainer to the transportation wagon.

As maintenance working procedure, it was mentioned it is maintained a small stock of spare parts and no major difficulties in parts acquisition on the market. Some equipment has to be ordered and the time to deliver is approximately one month, however it was stated that this never puts at risk the plant functioning. In fact, the existence of a treatment line out of service was sometimes used to provide parts in a sudden need of devices reparation. For instance, since one oxidation ditch was out of service, its oxygen probe was used to replace the oxygen probe of the oxidation ditch in service.

To complement this information, it is presented in Annex III (Annex III.6) a table with the main comments on the WwTP electromechanical equipment.

3.7.2 Design data

3.7.2.1 Planning year of the project

The planning year of this study is 2029, assuming 2016 as the investment year and 2019 as the first year of operation.

3.7.2.2. Quantitative and qualitative characteristics of the foreseen effluent

The following table summarizes the estimated quantitative and qualitative characteristics for the raw wastewater to be treated in the Siliana WwTP, in conformity with the basic data described in paragraph 3.2.

Table 3.7-6: Estimate of the characteristics of the raw wastewater

Parameter	Unit	2011	2029
Population			
Domestic	inhabitants	25,322	31,855
Industrial	e.p.	2,079	5,796
Tourism	beds	0	0
Total	e.p.	27,402	37,650
Flows			
Average daily flow	m^3/d	2,321	4,084
	L/s	26.9	47.3
Infiltration flow	m^3/d	1,461	2,403
	L/s	16.9	27.8
Average daily flow + infiltration	m^3/d	3,782	6,487
	L/s	43.8	75.1
Peak flow	m^3/h	215.6	375.1
	L/s	59.9	104.2
Maximum design flow	m^3/h	504.0	562.0
	L/s	140.0	156.0
Pollutant loads			
TSS	kg/d	2,373	3,128
BOD_5	kg/d	1,233	1,694
COD	kg/d	3,273	4,475
TN	kg/d	231	335
TP	kg/d	40	54
Fecal coliforms (FC)	NMP/d	2.53×10^{15}	3.19×10^{15}
Concentrations (without infiltration flow)			
TSS	mg/L	1,022	766
BOD_5	mg/L	531	415
COD	mg/L	1,410	1,096
TN	mg/L	100	82
TP	mg/L	17	13
Fecal coliforms (FC)	NMP/100mL	1.09×10^{8}	7.80×10^{7}

These amounts have been estimated taking into consideration the junction of the new industrial zones planned by the AFI, described in Table 3.2-3, because the pre-design carried out made it possible to conclude that the capacity of the existing structures is sufficient.

In order to estimate the quantitative and qualitative characteristics of the industrial effluent, it was considered that the industrial users will have access to preliminary treatment of the effluents, thus making it possible to respect the discharge limits into the public sewerage network stipulated in prevailing legislation. In other words, the concentration of BOD_5 of the industrial effluents to be treated in the Jendouba WwTP will be 400 mg/L. The estimate of the equivalent industrial population was carried out presuming a specific wastewater production of 40 m^3/ha/d and specific production of BOD_5 of 45 g/cap/d.

3.7.2.3 Legislative framework relating to the quality of the receiving water and required quality for the treated effluent

In general, it is necessary to observe wastewater discharge standards established in the applicable legislation, especially standard NT 106.02; however, this standard is under revision, having been supplied to the consultant team a draft of the new decree. In spite of this new decree which is not yet in force, it should be noted that discharge standards will become differentiated in sensitive receiving water and other receiving water.

As mentioned, the treated effluent is discharged into the Wadi Siliana (flowing to the Siliana dam), and one part of this treated water is reused for complementary irrigation of 70 ha of agricultural land, therefore we consider that, in the future, this receiving water could be deemed a sensitive receiving water, to be particularly sensitive to the water pollution caused by microbiological substances and justifying the inclusion of a stage of disinfection.

Nonetheless, while the new decree is not implemented, the treated wastewater in the WwTP of Siliana must observe the quality framework presented in Table 1.3-4 of Chapter I.

3.7.2.4 Legislative framework concerning the final destination of sludge

According to the strategy defined by ONAS, the final destination of the dewatered sludge should observe the following priorities:

1. Green sector – agricultural re-use;
2. Red sector – incineration;
3. Black sector – controlled discharge.

The wastewater flowing into the Siliana WwTP is essentially urban and although the qualitative characteristics of the wastewater produced in the new industrial zone to be connected to the WwTP, it is admitted that the sludge sourced from the treatment will respect all the provisions stipulated in prevailing legislation (see chapter I, 1.3.3.3.3) and may be re-used for agriculture.

3.7.3 Eligible solutions of rehabilitation and extension

3.7.3.1 General considerations

For the rehabilitation of Siliana treatment plant are identified three alternative solutions, which have been already described in paragraph 3.4.3.1.

For all the three solutions, there will be the construction of a grit retention tank, the installation of the submersible agitators, the construction of a new stage for thickened sludge mechanical dewatering and the installation of a system of pathogenic microorganisms' removal (final disinfection) via ultraviolet radiation.

At the request of ONAS, odor treatment of the treatment structures and buildings associated with the emission of the odors will be included.

The description of the treatment lines, the advantages and disadvantages for each of these biological treatment systems are presented in the following chapters. The design criteria, the design results and the operational conditions are presented in Annex III (Annex III.6).

The treatment schemes of each solution being studied are presented in the Annex III (Annex III.7).

3.7.3.2 Solution 1

3.7.3.2.1 Detailed description of the treatment sequence – design and criteria

For Solution 1, it will be studied the rehabilitation of the WwTP according to the same existing treatment process, i.e., activated sludge in extended aeration regime.

The advantages and disadvantages of this solution are described in paragraph 3.3.3.2.1.

According to the design data described in paragraph 3.7.2.2, it was estimated that, in the year 2029, the WwTP of Siliana must have the capacity to treat wastewater corresponding to 37,650 population equivalent. Therefore, the average daily flow to treat in the year 2029 will be 4,084 m^3/day (the installed capacity is 4,530 m^3/day) and the average organic load will be 1,694 kg/day (the installed capacity is 2,450 kg/day). The design that has been carried out within the framework of this project allowed concluding that the existing processing capacity would be sufficient for the project target year.

The estimated maximum inflow in this study (375 m^3/h) is always lower than the maximum capacity of the main pumping station upstream the WwTP (504 m^3/h, in 2011, and 562 m^3/h, in 2016), and therefore the maximum capacity taken into account for designing will be 562 m^3/h.

Given the high level of grit flowing into the WwTP, a grit retention tank is foreseen, to be built upstream of the preliminary treatment stage.

According to the PD of Siliana, the existing preliminary treatment facilities were designed for the maximum capacity of the pumping station in the year 2011 (504 m^3/h). However, the checking of the operating conditions with a flow of 562 m^3/h resulted in acceptable values. Thus, it is considered that all the preliminary treatment facilities have sufficient capacity until the project target year.

The design that has been carried out revealed that half the biological total volume available is sufficient for the biological treatment of wastewater affluent in the planning year, in extended aeration mode, with the operation mass loading rate of 0.064 kg BOD/kg MLSS/day, within the recommended theoretical range (0.05 – 0.15 kg BOD/kg MLSS/day). In year zero, the operating team may operate solely with one treatment line (3 900 m^3), thus improving the operating conditions of the biological treatment.

According to the PD of Siliana, the secondary clarifier has been designed for the network pumping station flow in the year 2011 (504 m^3/h). However, the checking of the operating conditions with a flow of 562 m^3/h resulted in acceptable values, and therefore there is no intention to enlarge it. Furthermore, as mentioned for the biological reactor, given the conditions of wastewater flowing into the plant in year zero, the operating team may operate with a single sedimentation tank.

Downstream the secondary clarifier, it is planned to undertake a tertiary treatment stage, aiming at the reduction of the bacteriological load in order to fulfill the requirements of the standard NT 106.02, by means of a filtration followed through disinfection by UV.

As for the stage of thickening, the existing thickener operation was evaluated for the estimated excess sludge flow considering the year zero and the planning year. This evaluation showed that the existing thickener does have sufficient capacity, as the solids loading and the hydraulic loading rate, with the inflow characteristics of the planning year, do not exceed the admissible values.

The design that has been carried out revealed that the drying beds are sufficient for the dewatering of sludge either for year zero, or for the project target year. However the capacity is not sufficient for the rainy period. This problem can be solved using the sludge mechanical dewatering by means of the decanter centrifuge machine. It is recommended that, prior to dewatering it would be possible of storing sludge, with capacity for three days of production, with the aim to cope with a possible situation of equipment failure. It is planned to add on line a polyelectrolyte solution to the sludge to be dewatered. On the other hand, the dewatered sludge will be stored in containers that will be a driving regularization for sending it to their final destination.

The treatment line of Solution 1 for the rehabilitation of the WwTP of Siliana shows the following stages:

- Preliminary treatment
    - Grit retention tank (new);
    - Screening consisting of 1 mechanical bar screen, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
    - Manual bar screen, with bars spacing of 10 mm, installed in the recourse channel (existing);
    - Rotating sieve for micro filtering the grease from the grit and grease removal operation and from the secondary clarifier scum (existing);
    - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing).
    - Flow measurement in a Venturi channel using an ultrasonic level meter (existing).

- Biological or secondary treatment
  - Oxidation of the organic matter in the 2 existing treatment lines, with a volume of approximately 7,800 m^3 (existing);
  - Settling of sludge in the two secondary circular clarifiers, equipped with a scraper bridge (existing);
  - Transport of biological sludge for a pumping station (existing);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (existing);
  - Elevation of excess sludge into the thickener and flow measurement using an electromagnetic flow meter (existing);
  - Scum extraction from the secondary clarifiers via a sludge pump (installed on the rotating scraper bridge) to the rotating sieve (existing);
- Tertiary treatment
  - Nitrogen biological removal, materialized in the oxidation ditch (existing);
  - Chemical precipitation of phosphorus with aluminum sulfate dosing (existing);
  - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
  - Excess activated sludge thickening in a thickener, equipped with a scraper bridge (existing);
  - Temporary storage of the thickened sludge in a tank upstream the dewatering (new);
  - Dewatering of the thickened sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
  - Storage of dewatered sludge in containers (new);
  - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are returned through a pumping station to the biological treatment facility (new);
- Treatment of odors
  - Treatment of the contaminated air, extracted from the grit retention tank, preliminary treatment building, thickener, thickened sludge storage tank and dewatering building, by biofilter (new).

3.7.3.2.2 Energy report

The average electricity consumption (solution 1, planning year) is attached hereof (see Annex III, Annex III.6 at the end)

3.7.3.2.3 Consumption of chemical reagents

The chemical reagents consumed in the wastewater treatment process are aluminium sulfate and polyelectrolyte. The quantities of chemical reagents consumed in year zero and in the planning year are presented in Annex III.6 (at the end).

3.7.3.2.4 Management of by-products

The quantities of by-products resulting from the wastewater treatment process, in particular solid screenings, grit, grease and sludge, are presented in Annex III.6 (at the end).

3.7.3.2.5 Equipment

In general, the electromechanical equipment is in good working order and at good state of conservation.

The following table summarizes the solutions proposed in terms of replacement of the existing equipment items in the Siliana WwTP, in the framework of solution 1. For a fuller understanding of the following comments, it is necessary to view the treatment scheme of the solution attached to the report.

Table 3.7-7: Electro-mechanical equipment, instruments and electrical installations

Designation	Diagnosis	Proposed solution	Characteristics
Preliminary treatment			
Grit extraction system by "air-lift"	The wastewater includes a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber.	We propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber. Grit extraction will be achieved via an "air-lift" system.	Estimated extraction flow rate = 18 m^3/h
Mechanical step screen	The mechanical step screen is in service but needs an overhaul.	Replacement is not judged to be necessary	
Rotary screen	The rotary screen presents a certain level of corrosion in its motorization. Motorization of the rotary screen should be renovated through application of a new coating treatment in order to prevent further corrosion.	Replacement is not judged to be necessary	
Measurement of the difference in water level (screening)	The demonstrated state of degradation justifies replacement.	Automation should be improved, in particular in terms of integration between measurement of the level and operation of the mechanical screen.	
Belt conveyor	The paintwork is a bit degraded and altered in certain places.	Replacement is not judged to be necessary	Estimated volumetric flow rate of screenings = 0.5 m^3/d

Designation	Diagnosis	Proposed solution	Characteristics
Scraper bridge (grit and grease extraction in a double aerated channel)	The equipment is in good working order and a good state of conservation.	Replacement is not judged to be necessary	
Grit pumps (grit and grease extraction in a double aerated channel)	The pumps are in a reasonable state of conservation given their working conditions.	Replacement is not judged to be necessary	
Grit classifier (grit and grease extraction in a double aerated channel)	The equipment is in good working order and a good state of conservation	Replacement is not judged to be necessary	Estimated total capacity = 20 m^3/h.
Compressors (grit and grease extraction in a double aerated channel)	The compressors present a certain level of degradation, they are dirty and covered in dust.	We recommend the replacement of the equipment items. There are two compressors for the double channel: 1+1.	Estimated volumetric flow rate of air for each compressor = 129 m^3/h
Grease removal via a screw conveyor (grit and grease extraction in a double aerated channel)	The grease pumping circuit is out of service. The consulting team was informed that the circuit was immediately blocked after the start-up of the installation and was then abandoned.	Grease removal will be implemented via a screw conveyor installed in the grease tank.	Estimated volumetric flow rate of grease = 30 m^3/d
Measurement of effluent flow	Measurement is made by an ultrasonic level meter.	Replacement is not judged to be necessary	

Designation	Diagnosis	Proposed solution	Characteristics
Secondary or biological treatment			
Aeration	In general, the brushes are in a good state of conservation given their working conditions. The construction supporting the brushes has presented a high level of deterioration caused by the impact of the wastewater.	Replacement is not judged to be necessary but the construction supporting the brushes needs to be renovated and appropriate treatment is urgently required in order to prevent the corrosive impact of the wastewater. There are four brushes; two brushes per channel.	Estimated mass flow rate of oxygen for each brush = 100 kg/h.
Oxygen measurement (aeration tank)	The consulting team was informed of the need to replace the oxygen probes. The operation of the brushes is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor.	We recommend installation of a programmable automation controller that permits integration between the oxygen measurements and operation of the aeration equipment.	
Mixing	There is no submersible mixer in order to guarantee good flow conditions in the oxidation channels.	It is necessary to install the submersible mixers in order to guarantee suitable flow conditions in the oxidation channels. There will be four mixers; two mixers per channel.	The mixers will be of the slowly rotating “banana” blade type.
Scraper bridges (secondary clarifiers)	The scraper bridges are in a good state of conservation given their working conditions.	Replacement is not judged to be necessary. An overhaul is nonetheless required, in particular in relation to motorization.	
Sludge recirculation pump	The equipment is in good working order and a good state of conservation	Replacement is not judged to be necessary	Estimated flow for each pump = 504 m^3/h.
Measurement of the flow of sludge recirculation	The equipment is in good working order and a good state of conservation	Measurement is made via an electro-magnetic flow-meter. Replacement is not judged to be necessary.	

Designation	Diagnosis	Proposed solution	Characteristics
Excess sludge extraction pump	The equipment is in good working order and a good state of conservation	Replacement is not judged to be necessary	Estimated flow for each pump = 43 m^3/h.
Measurement of the flow of excess sludge	The equipment is in good working order and a good state of conservation	Measurement is made via an electro-magnetic flow-meter. Replacement is not judged to be necessary	
Tertiary treatment			
Dosing pump of aluminium sulfate and dosing circuit	Chemical precipitation of phosphorus with dosing of aluminium sulfate	We recommend a dosing circuit with dosing tank, retention chamber, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Estimated flow for each pump = 94 L/h.
Disinfection	The Tunisian norm NT 106.02 obliges observance of 2000/100 ml of fecal coliforms and 1000/100 ml of fecal streptococci in order to guarantee the microbiological quality of the public water supply.	Disinfection by ultraviolet radiation implemented upstream by the filtration operation via vertical multicellular pumps, self-cleaning pressure filters, and ultraviolet radiation system in the open channel.	Maximum flow = 562 m^3/h
Treatment of the sludge			
Scraper bridge (thickener)	The scraper and its motorization are in good working order and a good state of conservation	Replacement is not judged to be necessary	

Designation	Diagnosis	Proposed solution	Characteristics
Thickened sludge pumps	The thickened sludge pump is in good working order and a good state of conservation. In the framework of renovation of the WwTP it will be necessary to replace this pump in order to lift thickened sludge to the thickened sludge storage tank or to the sludge drying beds.	We recommend an excentric screw pump.	Estimated flow per pump = 36 m^3/h.
Submersible mixer (thickened sludge storage tank)	In the framework of renovation of the WwTP, we propose temporary storage of the thickened sludge in a tank upstream of the dewatering stage.	It is necessary to install a submersible mixer in order to avoid sedimentation of the sludge.	-
Lift pump to raise the thickened sludge to the centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend an excentric screw pump.	Estimated flow per pump = 16 m^3/h.
Centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of an equipment item.	Capacity estimated = 16 m^3/h.
Polymer preparation equipment	In the framework of renovation of the WwTP, we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of fully automatic continuous polymer solution preparation equipment. Dosing tank, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Capacity 1,000 L/h.
Polymer dosing pump	-	Membrane dosing pumps	Estimated flow per pump = 0.6 m^3/h.
Lifting the dewatered sludge	-	The dewatered sludge will be lifted via a screw conveyor.	Estimated volumetric flow rate of the dewatered sludge = 13 m^3/d

Designation	Diagnosis	Proposed solution	Characteristics
Treatment of odors			
Contaminated air treatment system	We propose to extract the contaminated air from the grit retention tank, preliminary treatment building, thickener, thickened sludge storage tank and dewatering building	The contaminated air will be deodorized via a bio filter and a piping circuit and fan	
Electrical installations			
MV-LV transformation station	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	
Low voltage cupboard	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	
Command station with master control panel	In the framework of the intervention proposed for the WwTP, these equipment items should be renovated.	We recommend installation of a programmable automation controller that permits integration between the measurement instruments and operation of the mechanical equipment.	

3.7.3.3 Solution 2

3.7.3.3.1 Detailed description of the treatment sequence – design and criteria

Solution 2 integrates the biological treatment by activated sludge in conventional aeration, with sludge anaerobic digestion and biogas energy recovery. The treatment line integrates new facilities, the primary treatment equipment and the sludge mesophilic anaerobic stabilization, namely anaerobic digester, gasholder, flare, equipment for biogas treatment, motor generators, boiler and heat exchanger. This solution integrates a high number of operations, so the complexity of operating and maintenance is remarkable. In order to overcome this difficulty, the operators must be trained in for exploiting the new equipment and its operations. Moreover, this is an advantageous solution as for the energy matter, considering the lowest power consumption relating to the extended aeration systems and the possibility to recover energy from the produced biogas.

The considerations carried out in Solution 1, on the preliminary treatment structures and secondary clarification, are also valid for Solution 2.

According to the topographic survey carried out, it was verified that the Siliana WwTP has a sufficient hydraulic profile in order to add a new primary sedimentation tank without the obligation to intervene in relation to the preliminary treatment structures.

The design carried out revealed that in a conventional aeration regime, the volume necessary for biological treatment for the planning year is 1 900 m^3. It will be necessary, therefore, to adapt one of the existing channels, filling the bottom of the channel, until attaining the desired volume (height of around 1.7 m).

Downstream of the secondary sedimentation stage, a new tertiary treatment stage in the form of filtration followed by UV disinfection is foreseen, aimed to reduce the bacteriological aeration in order to respond to the requirements of norm NT 106.02.

In relation to the thickening, and taking into account the higher production of sludge for this solution 2, it was concluded that the existing thickener is not sufficient, because the solid load and the hydraulic load exceed the permitted values for the planning year. It is therefore necessary to construct a new thickener, as has already been foreseen in the Concept Design of the Siliana WwTP. Nonetheless, it is foreseen that one thickener is sufficient for the year zero conditions.

It was also verified that the sludge drying beds are not sufficient in order to dewater the amount of digested sludge that is estimated at the planning year. Furthermore, even at present, on rainy days, the capacity of the sludge drying beds is clearly insufficient. This problem may be resolved through installation of mechanical dewatering of the sludge via a centrifuge.

Thus, the treatment line of Solution 2 for the rehabilitation of the WwTP of Siliana includes the following stages:

- Preliminary treatment
    - Grit retention tank (new);
    - Screening consisting of 1 mechanical bar screen, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
    - Manual bar screen, with bars spacing of 10 mm, installed in the recourse channel (existing);

  - Rotating sieve for micro filtering the grease from the grit and grease removal operation and from the secondary clarifier scum (existing);
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing).
  - Flow measurement in a Venturi channel using an ultrasonic level meter (existing).

- Primary treatment
  - Primary settling in 1 clarifier, of circular plant, with bottom and surface scrapers bridge (new);
  - Rise of floats towards the thickeners (new);
  - Extraction of primary sludge for the thickeners (new);
- Biological or secondary treatment
  - Oxidation of the organic matter in 1 treatment line, with a volume of approximately 1,900 m^3 (existing);
  - Settling of sludge in the two secondary circular clarifiers, equipped with bottom and surface scraper bridge (existing);
  - Sludge directing for a pumping station (existing);
  - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (existing);
  - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (existing);
  - Scum extraction from the secondary clarifier via a sludge pump (installed on the rotating scraper bridge) to the rotating sieve (existing);
- Tertiary treatment
  - Nitrogen biological removal materialized in the aeration tank;
  - Chemical precipitation of phosphorus with aluminum sulfate dosing (existing);
  - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
  - Thickening of the primary sludge, excess sludge and physicochemical sludge in two thickeners, of circular plant, provided with a scraping bridge (one existing and one new);
  - Mesophilic anaerobic stabilization of thickened sludge (new);
  - Storage of biogas in a gasholder (new);
  - Biogas energy recovery by a motor generator with production of thermal and electrical energy (new);

  - Heating of sludge in digestion with heat produced by cogeneration (new);
  - Burning the biogas in excess and the bad quality biogas in the flare (new);
  - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
  - Storage of dewatered sludge in containers (new);
  - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility (new);

- Treatment of odors :
  - treatment of the contaminated air, extracted from the grit retention tank, from the preliminary treatment building, thickeners and dewatering building, by biofilter (new).

3.7.3.3.2 Energy report

The average electricity consumption (solution 2, planning year) is attached hereof (see Annex III, Annex III.6 at the end). The energy report of solution 2 includes electricity produced by cogeneration.

3.7.3.3.3 Consumption of chemical reagents

The chemical reagents consumed in the wastewater treatment process are aluminium sulfate, hydrated lime and polyelectrolyte. The quantities of chemical reagents consumed in year zero and at the planning year are presented in Annex III.6 (at the end).

3.7.3.3.4 Management of by-products

The quantities of by-products resulting from the wastewater treatment process, in particular solid screenings, grit, grease and sludge, are presented in Annex III.6 (at the end).

3.7.3.3.5 Equipment

The following table summarizes the solutions proposed for the replacement of the existing equipment items in the Siliana WWTP, in the framework of solution 2. For a fuller understanding of the following comments, it is necessary to view the treatment scheme of the solution attached to the report.

Table 3.7-8: Electro-mechanical equipment, instruments and electrical installations

Designation	Diagnosis	Proposed solution	Characteristics
Preliminary treatment			
Grit extraction system by “air-lift”	The wastewater includes a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber.	We propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber. Grit extraction will be achieved via an “air-lift” system.	Estimated extraction flow rate = 18 m^3/h
Mechanical step screen	The mechanical step screen is in service but needs an overhaul.	Replacement is not judged to be necessary	
Rotary screen	The rotary screen presents a certain level of corrosion in its motorization. Motorization of the rotary screen should be renovated through application of a new coating treatment in order to prevent further corrosion	Replacement is not judged to be necessary	
Measurement of the difference in water level (screening)	The demonstrated state of degradation justifies replacement. Diagnosis of state of conservation of equipment is detailed in Annex III (Table III.2.1.1.1).	Automation should be improved, in particular in terms of integration between measurement of the level and operation of the mechanical screen.	
Belt conveyor	The paintwork is a bit degraded and altered in certain places.	Replacement is not judged to be necessary	Estimated volumetric flow rate of screenings = 0.5 m^3/d
Scraper bridge (grit and grease extraction in a double aerated channel)	The equipment is in good working order and a good state of conservation.	Replacement is not judged to be necessary	

Designation	Diagnosis	Proposed solution	Characteristics
Grit pumps (grit and grease extraction in a double aerated channel)	The pumps are in a reasonable state of conservation given their working conditions.	Replacement is not judged to be necessary	
Grit classifier (grit and grease extraction in a double aerated channel)	The equipment is in good working order and a good state of conservation	Replacement is not judged to be necessary	Estimated total capacity = 20 m^3/h.
Compressors (grit and grease extraction in a double aerated channel)	The compressors present a certain level of degradation; they are dirty and covered in dust.	We recommend the replacement of the equipment items. There are two compressors for the double channel: 1+1.	Estimated volumetric flow rate of air for each compressor = 129 m^3/h
Grease removal via a screw conveyor (grit and grease extraction in a double aerated channel)	The grease pumping circuit is out of service. The consulting team was informed that the circuit was immediately blocked after the start-up of the installation and was then abandoned.	Grease removal will be implemented via a screw conveyor installed in the grease tank.	Estimated volumetric flow rate of grease = 30 m^3/d
Measurement of effluent flow	Measurement is made by an ultrasonic level meter.	Replacement is not judged to be necessary	

Designation	Diagnosis	Proposed solution	Characteristics
Primary treatment			
Scraper bridges (primary sedimentation tanks)	In the framework of this solution for renovation of the WwTP, we propose the existence of primary treatment.	The scraper bridge is constituted by a mobile transversal beam that serves as a walkway, two lateral guides, an articulated system for collecting the sludge and discharging the scum, a motor reduction unit for activating the two lateral guides, a control unit of the articulated system of bottom scraper/scum blade and a command and control panel.	
Primary sludge lift pumps (primary sedimentation tanks)		It is necessary to install submersible pumps. There is one pump per scraper bridge.	Estimated flow for each pump = 18 m^3/h.
Secondary or biological treatment			
Aeration	In general, the brushes are in a good state of conservation given their working conditions. The construction supporting the brushes has presented a high level of deterioration caused by the impact of the wastewater.	Replacement is not judged to be necessary, but the construction supporting the brushes requires renovation and appropriate treatment is urgently required in order to prevent the corrosive impact of the wastewater. There will be two brushes in service; two brushes for each channel.	Estimated volumetric flow rate of air for each brush = 1,521 m^3/h.
Oxygen measurement (aeration tank)	The consulting team was informed of the need to replace the oxygen probes. The operation of the brushes is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor.	We recommend installation of a programmable automation controller that permits integration between the oxygen measurements and operation of the aeration equipment.	
Mixing	There is no submersible mixer in order to guarantee good flow conditions in the oxidation channels.	It is necessary to install the submersible mixers in order to guarantee suitable flow conditions in the oxidation channels. There will be four mixers; two mixers per channel	The mixers will be of the slowly rotating “banana” blade type.

Designation	Diagnosis	Proposed solution	Characteristics
Scraper bridges (secondary clarifiers)	The scraper bridges are in a good state of conservation given their working conditions.	Replacement is not judged to be necessary. An inspection is nonetheless required, in particular in relation to motorization.	
Sludge recirculation pump	The equipment is in good working order and a good state of conservation.	Replacement is not judged to be necessary	Estimated flow for each pump = 504 m^3/h.
Measurement of the flow of sludge recirculation	The equipment is in good working order and a good state of conservation	Measurement is made via an electro-magnetic flow-meter. Replacement is not judged to be necessary	
Excess sludge extraction pump	The equipment is in good working order and a good state of conservation.	Replacement is not judged to be necessary.	Estimated flow for each pump = 43 m^3/h.
Measurement of the flow of excess sludge	The equipment is in good working order and a good state of conservation	Measurement is made via an electro-magnetic flow-meter. Replacement is not judged to be necessary	
Tertiary treatment			
Dosing pump of aluminium sulfate and dosing circuit	Chemical precipitation of phosphorus with dosing of aluminium sulfate	We recommend a dosing circuit with dosing tank, retention chamber, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Estimated flow for each pump = 90 L/h.
Disinfection	The Tunisian norm NT 106.02 obliges observance of 2000/100 ml of fecal coliforms and 1000/100 ml of fecal streptococci in order to guarantee the microbiological quality of the public water supply.	Disinfection by ultraviolet radiation implemented upstream by the filtration operation via vertical multicellular pumps, self-cleaning pressure filters, and ultraviolet radiation system in the open channel.	Maximum flow = 562 m^3/h

Designation	Diagnosis	Proposed solution	Characteristics
Treatment of the sludge			
Scraper bridge (existing thickener)	The scraper and its motorization are in good working order and a good state of conservation. In the framework of this solution for renovation of the WwTP, we propose construction of another thickener.	Replacement of the existing scraper is not judged to be necessary.	The new thickener will be circular-shaped like the existing one.
Thickened sludge pumps	In the framework of this solution, the sludge pump which lifts the sludge towards the digesters (or to the sludge drying beds) will be new.	In the framework of renovation of the WwTP it will be necessary to replace this pump and to add another because of the new thickener. We recommend an excentric screw pump. There is one pump for each thickener.	Estimated flow per pump = 36 m^3/h.
Anaerobic digestion of the sludge	In the framework of this solution for renovation of the WwTP, we propose mesophilic anaerobic stabilization of the thickened sludge.	The anaerobic digestion of the sludge will be implemented using the digesters, agitation of the digesters via the sludge recirculation pumps, pumps for the sludge heating circuit during digestion, gasholder and torch.	
Sludge heating system during digestion	For mesophilic anaerobic stabilization of the thickened sludge, it is necessary to foresee a sludge heating system during digestion.	We always recommend the use of a boiler and a hot water tank with recirculation pumps for these circuits.	The boiler must work with natural gas and biogas
Cogeneration	The cogeneration system enables energy use of the biogas produced and also heating of the sludge during digestion with the heat produced by the motor-generator.	In addition to the sludge heating system during digestion using the boiler, we propose a cogeneration system constituted by elements such as the biogas-driven motor-generator.	
Lift pump of the digested sludge to the centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer.	We recommend an excentric screw pump.	Estimated flow per pump = 21 m^3/h.
Centrifugal clarifier	In the framework of renovation of the WwTP we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	-	Capacity 21 m^3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Polymer preparation equipment	In the framework of renovation of the WwTP we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of fully automatic continuous polymer solution preparation equipment. Dosing tank, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump	Capacity 1,000 L/h.
Polymer dosing pump	-	Membrane dosing pumps	Estimated flow per pump = 0.7 m^3/h.
Lifting the dewatered sludge		The dewatered sludge will be lifted via a screw conveyor.	Estimated volumetric flow rate of the dewatered sludge = 16 m^3/d
Treatment of odors			
Contaminated air treatment system	We propose to extract the contaminated air from the grit retention tank, preliminary treatment building, thickener and dewatering building	The contaminated air will be deodorized via a bio filter and a piping circuit and fan	-
Electrical installations			
MV-LV transformation station	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Low voltage cupboard	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Command station with master control panel	In the framework of the intervention proposed for the WwTP, these equipment items should be renovated.	We recommend installation of a programmable automation controller that permits integration between the measurement instruments and operation of the mechanical equipment.	-

3.7.3.4 Solution 3

3.7.3.4.1 Detailed description of the treatment sequence – design and criteria

Solution 3 integrates the biological treatment by activated sludge in conventional aeration, with mesophilic anaerobic digestion of sludge. Biogas is frequently used as combustible for the boiler which provides the necessary power to the reheating of sludge. Biogas in excess will be incinerated in the flare.

The treatment line integrates the new facilities, the primary treatment equipment and the sludge mesophilic anaerobic stabilization, namely anaerobic digester, gasholder, flare, equipment for biogas treatment, boiler and heat exchanger.

In general, all the considerations made in relation to solution 2, concerning the capacity of the existing structures and the extension needed, are also valid for solution 3.

The treatment line of Solution 3 for the rehabilitation of the WwTP of Siliana includes the following stages:

- Preliminary treatment
  - Grit retention in tank (new);
  - Screening consisting of 1 mechanical bar screen, with bars spacing of 6 mm, a conveyor belt and a trailer (existing);
  - Manual bar screen, with bars spacing of 10 mm, installed in the recourse channel (existing);
  - Rotating sieve for micro filtering the grease from the grit and grease removal operation and from the secondary clarifier scum (existing);
  - Grit and grease removal in a dual-channel aerated chamber, with a scraper bridge (existing).
  - Flow measurement in a Venturi channel using an ultrasonic level meter (existing).
- Primary treatment
  - Primary settling in 1 clarifier, of circular plant, with bottom and surface scrapers bridge (new);
  - Rise of floats towards the thickeners (new);
  - Extraction of primary sludge for the thickeners (new);
- Biological or secondary treatment
  - Oxidation of the organic matter in 1 treatment line, with a volume of approximately 1 900 m^3 (existing);
  - Settling of sludge in the two secondary circular clarifiers, equipped with a bottom and surface scraper bridge (existing);
  - Sludge directing for a pumping station (existing);

    - Sludge recycling at the beginning of the aeration tanks and flow measurement using an electromagnetic flow meter (existing);
    - Feeding of excess sludge into the thickeners and flow measurement using an electromagnetic flow meter (existing);
    - Scum extraction from the secondary clarifier via a sludge pump (installed on the rotating scraper bridge) to the rotating sieve (existing);
- Tertiary treatment
    - Nitrogen biological removal, materialized in the new aeration tank;
    - Chemical precipitation of phosphorus with aluminum sulfate dosing (existing);
    - Disinfection by ultraviolet radiation served upstream by a filtration (new);
- Sludge treatment
    - Thickening of the primary sludge, excess sludge and physicochemical sludge in two thickeners, of circular plant, provided with a scraping bridge (one existing and one new);
    - Mesophilic anaerobic stabilization of thickened sludge (new)
    - Storage of biogas in a gasholder (new);
    - Heating of sludge in digestion with heat produced by the boiler (new);
    - Burning the biogas in excess and the bad quality biogas in the flare (new);
    - Dewatering of digested sludge in the decanter centrifuge machine with addition of polymer (new); in case of emergency, dewatering of the thickened sludge in drying beds (existing);
    - Storage of dewatered sludge in containers (new);
    - The supernatant coming from the thickeners, the filtrate of the drying beds and the centrifuge, the cleaning water of the pressure filter, as well as the internal wastewater are flowing backwards through a pumping station to the biological treatment facility (new).
- Treatment of odors :
    - treatment of the contaminated air, extracted from the grit retention tank, from the preliminary treatment building, thickeners and dewatering building, by biofilter (new);

3.7.3.4.2 Energy report

The average electricity consumption (solution 3, planning year) is attached hereof (see Annex III, Annex III.6 at the end).

3.7.3.4.3 Consumption of chemical reagents

The chemical reagents consumed in the wastewater treatment process are aluminium sulfate, hydrated lime and polyelectrolyte. The quantities of chemical reagents consumed in year zero and in the planning year are presented in Annex III.6 (at the end).

3.7.3.4.4 Management of by-products

The quantities of by-products resulting from the wastewater treatment process, in particular solid screenings, grit, grease and sludge, are presented in Annex III.6 (at the end).

3.7.3.4.5 Equipment

The solution 3 includes the same treatment line as solution 2, except for cogeneration. As a result, all the considerations made for solution 2 concerning the existing equipment items and replacement needs, are also valid for this solution. For a fuller understanding of the comments, it is necessary to view the treatment scheme of the solution attached to the report.

Table 3.7-9: Electro-mechanical equipment, instruments and electrical installations

Designation	Diagnosis	Proposed solution	Characteristics
Preliminary treatment			
Grit extraction system by "air-lift"	The wastewater includes a high quantity of grit, which is not eliminated by the existing aerated grit and grease chamber.	We propose the construction of a grit retention chamber upstream of the headworks that will work as a complement to the aerated grit and grease chamber. Grit extraction will be achieved via an "air-lift" system.	Estimated extraction flow rate = 18 m^3/h
Mechanical step screen	The mechanical step screen is in service but needs an overhaul.	Replacement is not judged to be necessary	
Rotary screen	The rotary screen presents a certain level of corrosion in its motorization. Motorization of the rotary screen should be renovated through application of a new coating treatment in order to prevent further corrosion	Replacement is not judged to be necessary	
Measurement of the difference in water level (screening)	The demonstrated state of degradation justifies replacement. Diagnosis of state of conservation of equipment is detailed in Annex III (Table III.2.1.1.1).	Automation should be improved, in particular in terms of integration between measurement of the level and operation of the mechanical screen.	
Belt conveyor	The paintwork is a bit degraded and altered in certain places.	Replacement is not judged to be necessary	Estimated volumetric flow rate of screenings = 0.5 m^3/d
Scraper bridge (grit and grease extraction in a double aerated channel)	The equipment is in good working order and a good state of conservation.	Replacement is not judged to be necessary	

Designation	Diagnosis	Proposed solution	Characteristics
Grit pumps (grit and grease extraction in a double aerated channel)	The pumps are in a reasonable state of conservation given their working conditions.	Replacement is not judged to be necessary	
Grit classifier (grit and grease extraction in a double aerated channel)	The equipment is in good working order and a good state of conservation	Replacement is not judged to be necessary	Estimated total capacity = 20 m^3/h.
Compressors (grit and grease extraction in a double aerated channel)	The compressors present a certain level of degradation; they are dirty and covered in dust.	We recommend the replacement of the equipment items. There are two compressors for the double channel: 1+1.	Estimated volumetric flow rate of air for each compressor = 129 m^3/h
Grease removal via a screw conveyor (grit and grease extraction in a double aerated channel)	The grease pumping circuit is out of service. The consulting team was informed that the circuit was immediately blocked after the start-up of the installation and was then abandoned.	Grease removal will be implemented via a screw conveyor installed in the grease tank.	Estimated volumetric flow rate of grease = 30 m^3/d
Measurement of effluent flow	Measurement is made by an ultrasonic level meter.	Replacement is not judged to be necessary	
Primary treatment			
Scraper bridges (primary sedimentation tanks)	In the framework of this solution for renovation of the WwTP, we propose the existence of primary treatment.	The scraper bridge is constituted by a mobile transversal beam that serves as a walkway, two lateral guides, an articulated system for collecting the sludge and discharging the scum, a motor reduction unit for activating the two lateral guides, a control unit of the articulated system of bottom scraper/scum blade and a command and control panel.	

Designation	Diagnosis	Proposed solution	Characteristics
Primary sludge lift pumps (primary sedimentation tanks)		It is necessary to install submersible pumps. There is one pump per scraper bridge.	Estimated flow for each pump = 18 m^3/h.
Secondary or biological treatment			
Aeration	In general, the brushes are in a good state of conservation given their working conditions. The construction supporting the brushes has presented a high level of deterioration caused by the impact of the wastewater.	Replacement is not judged to be necessary, but the construction supporting the brushes requires renovation and appropriate treatment is urgently required in order to prevent the corrosive impact of the wastewater. There will be two brushes in service; two brushes for each channel.	Estimated volumetric flow rate of air for each brush = 1,521 m^3/h.
Oxygen measurement (aeration tank)	The consulting team was informed of the need to replace the oxygen probes. The operation of the brushes is not automated, as it would be in an automated system that includes measurement of the oxygen broken down in the biological reactor.	We recommend installation of a programmable automation controller that permits integration between the oxygen measurements and operation of the aeration equipment.	
Mixing	There is no submersible mixer in order to guarantee good flow conditions in the oxidation channels.	It is necessary to install the submersible mixers in order to guarantee suitable flow conditions in the oxidation channels. There will be four mixers; two mixers per channel	The mixers will be of the slowly rotating “banana” blade type.
Scraper bridges (secondary clarifiers)	The scraper bridges are in a good state of conservation given their working conditions.	Replacement is not judged to be necessary. An inspection is nonetheless required, in particular in relation to motorization.	
Sludge recirculation pump	The equipment is in good working order and a good state of conservation.	Replacement is not judged to be necessary	Estimated flow for each pump = 504 m^3/h.
Measurement of the flow of sludge recirculation	The equipment is in good working order and a good state of conservation	Measurement is made via an electro-magnetic flow-meter. Replacement is not judged to be necessary	

Designation	Diagnosis	Proposed solution	Characteristics
Excess sludge extraction pump	The equipment is in good working order and a good state of conservation.	Replacement is not judged to be necessary.	Estimated flow for each pump = 43 m^3/h.
Measurement of the flow of excess sludge	The equipment is in good working order and a good state of conservation	Measurement is made via an electro-magnetic flow-meter. Replacement is not judged to be necessary	
Tertiary treatment			
Dosing pump of aluminium sulfate and dosing circuit	Chemical precipitation of phosphorus with dosing of aluminium sulfate	We recommend a dosing circuit with dosing tank, retention chamber, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump.	Estimated flow for each pump = 90 L/h.
Disinfection	The Tunisian norm NT 106.02 obliges observance of 2000/100 ml of fecal coliforms and 1000/100 ml of fecal streptococci in order to guarantee the microbiological quality of the public water supply.	Disinfection by ultraviolet radiation implemented upstream by the filtration operation via vertical multicellular pumps, self-cleaning pressure filters, and ultraviolet radiation system in the open channel.	Maximum flow = 562 m^3/h
Treatment of the sludge			
Scraper bridge (existing thickener)	The scraper and its motorization are in good working order and a good state of conservation. In the framework of this solution for renovation of the WwTP, we propose construction of another thickener.	Replacement of the existing scraper is not judged to be necessary.	The new thickener will be circular-shaped like the existing one.
Thickened sludge pumps	In the framework of this solution, the sludge pump which lifts the sludge towards the digesters (or to the sludge drying beds) will be new.	In the framework of renovation of the WwTP it will be necessary to replace this pump and to add another because of the new thickener. We recommend an excentric screw pump. There is one pump for each thickener.	Estimated flow per pump = 36 m^3/h.

Designation	Diagnosis	Proposed solution	Characteristics
Anaerobic digestion of the sludge	In the framework of this solution for renovation of the WwTP, we propose mesophilic anaerobic stabilization of the thickened sludge.	The anaerobic digestion of the sludge will be implemented using the digesters, agitation of the digesters via the sludge recirculation pumps, pumps for the sludge heating circuit during digestion, gasholder and torch.	
Sludge heating system during digestion	For mesophilic anaerobic stabilization of the thickened sludge, it is necessary to foresee a sludge heating system during digestion.	We always recommend the use of a boiler and a hot water tank with recirculation pumps for these circuits.	The boiler must work with natural gas and biogas
Lift pump of the digested sludge to the centrifugal clarifier	In the framework of renovation of the WwTP, we propose dewatering of the digested sludge in a centrifugal clarifier with the addition of polymer.	We recommend an excentric screw pump.	Estimated flow per pump = 21 m^3/h.
Centrifugal clarifier	In the framework of renovation of the WwTP we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	-	Capacity 21 m^3/h.
Polymer preparation equipment	In the framework of renovation of the WwTP we propose dewatering of the thickened sludge in a centrifugal clarifier with the addition of polymer.	We recommend installation of fully automatic continuous polymer solution preparation equipment. Dosing tank, mixer, emptying armatures, measurement and dosing equipment and a membrane dosing pump	Capacity 1,000 L/h.
Polymer dosing pump	-	Membrane dosing pumps	Estimated flow per pump = 0.7 m^3/h.
Lifting the dewatered sludge		The dewatered sludge will be lifted via a screw conveyor.	Estimated volumetric flow rate of the dewatered sludge = 16 m^3/d

Designation	Diagnosis	Proposed solution	Characteristics
Treatment of odors			
Contaminated air treatment system	We propose to extract the contaminated air from the grit retention tank, preliminary treatment building, thickener and dewatering building	The contaminated air will be deodorized via a bio filter and a piping circuit and fan	-
Electrical installations			
MV-LV transformation station	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Low voltage cupboard	In the framework of the intervention proposed for the WwTP, this equipment item should be renovated.	We recommend the replacement of this equipment item.	-
Command station with master control panel	In the framework of the intervention proposed for the WwTP, these equipment items should be renovated.	We recommend installation of a programmable automation controller that permits integration between the measurement instruments and operation of the mechanical equipment.	-

3.7.4 Economic assessment

3.7.4.1 Investment costs

The estimate of the fixed capital investment costs associated with the civil engineering and equipment items is based on market consultations and information supplied by ONAS.

The following table presents a summary of the fixed capital investment costs associated with each treatment solution studied. Annex III.8 presents systematization of the partial values used for the values presented in the following table. The breaking down of prices for the proposed solution is given in Annex III.9.

Table 3.7-10: Estimate of the initial investment costs

Treatment solutions	Civil engineering (TND)	Equipment items and IE (TND)	Total (TND)
1	1,058,431	2,105,601	3,164,032
2	1,773,057	4,444,947	6,218,004
3	1,760,280	3,086,948	4,847,228

In conformity with the project implementation timetable described in chapter V, it is admitted that the initial investment will be made in 2016, which corresponds to the start of the construction works.

3.7.4.2 Operating and maintenance costs

In order to estimate the operating and maintenance costs, the unit costs supplied by ONAS have been used, in relation to:

- maintenance;
- consumption of chemical reagents;
- electricity consumption;
- transport and final deposit of the by-products and sludge.

The operating costs associated with analytic control of operation of the WwTP have not been calculated, since they depend upon the planning defined by ONAS and are common to all the treatment solutions studied.

The maintenance costs resulting from addition of the two parts corresponding to the civil engineering and maintenance of the electromechanical equipment. They have been estimated through application of a rate of 2.5% and 1.0% on the budgetary forecasts of the investment for the electromechanical equipment items and civil engineering, respectively.

In relation to the chemical reagents, the following unit prices are admitted:

- aluminium sulfate – 400 TND ;
- cationic polyelectrolyte – 6,500 TND;

- lime – 150 TND.

The electricity consumption has been estimated on the basis of the energy reports presented in Annex III.6, and a unit electricity cost of 0.13 TND/kWh was admitted.

In order to estimate the costs of transport and final deposit of the by-products and of the sludge, a unit cost of 40 TND/t has been taken into consideration.

In conformity with the project implementation timetable, the start date of operation of the plant after renovation will be 2019.

3.7.4.3 Updated total costs

Annex III.8 presents the updated total costs for the year 2016, through application of an updating rate of 3%. A summary of the results obtained is presented in the following table.

Table 3.7-11: Estimate of the fixed capital investment costs (FCIC), operating costs (OC) and updated total costs (UTC) for each solution studied

Treatment solutions	FCIC (TND)	OC (TND)	UTC (TND)
1	3,164,032	10,011,308	11,063,800
2	6,218,004	9,976,016	14,095,507
3	4,847,228	10,406,096	13,103,063

For each solution studied the ratio TND/m^3 is respectively, 0.77, 0.98 and 0.91.

3.7.5 Technical and economic comparison of the solutions

From the previous table, it is noted that although Solution 2 has lower operating costs, its total discounted costs are the highest due to the high initial capital investment costs. From a strictly economic perspective, the solution 1 is the most advantageous one, with the investment costs and total discounted costs the lowest.

During the missions in Tunisia, the consultant team tried to find examples of WwTP using the process of conventional aeration activated sludge, with mesophilic anaerobic digestion of sludge and energy recovery from biogas. Although it may not be a representative sample of such plants, the team visited Choutrana WwTP near Tunis. At the time of the visit the anaerobic digestion of sludge with energy recovery of biogas was out of service. The team notes that based on the training plans provided by ONAS, a major effort would be needed to implement Solution 2, for the integration of training of the operation team.

In contrast, Solution 1 uses an existing treatment process, which is much simpler and well controlled by the operation team.

Solution 3 is an intermediate option, between 1 and 2. However, it would involve operational difficulties almost as great as Solution 2.

The consultant team considers that the size of the Siliana WwTP does not justify a change in its process, and so recommends that the rehabilitation of the WwTP be carried out according to Solution 1.

3.7.6 Conclusion and recommendations

As the conclusion through discussion with ONAS during the present Survey, Solution 1 is selected as the best solution for the Siliana WwTP to be proceeded for d**e**tailed design.

3.7.6.1 Summary of key interventions for the selected solution

With regard to the solution adopted key interventions recommended include:

- Preliminary treatment
  - construction of a new grit retention tank including the grit extraction system by "air-lift";
  - replacement of the compressors;
  - installation of a screw conveyor for grit removal;
- Secondary or biological treatment
  - installation of submersible mixers;
- Tertiary treatment
  - construction of an ultraviolet radiation disinfection system in the open channel implemented upstream by the filtration operation via multicellular vertical feeding pumps linked to the filters, self-cleaning pressure filters;
- Sludge treatment
  - construction and installation of all equipment concerning sludge mechanical dewatering
  - construction and installation of all the civil works and equipment associated with the contaminated air treatment system including the extraction Of the contaminated air from the grit retention tank, preliminary treatment building, thickener, thickened sludge storage tank and dewatering building.

3.7.6.2 Recommendation regarding continuation of normal activity during works

As it is necessary to maintain the operation of the WWTP it becomes essential to perform all work in a progressive manner. In this sense, it is recommended:

- interventions should be made as much as possible during the dry season, so that the affluent flow is smaller ;
- construction of the sand retention tank sand should be a priority and be completed before interventions in the pre-treatment ;
- interventions in the aeration tanks must be done line by line to allow the rest to maintain in operation ;
- interventions concerning the pre-treatment of wastewater from the yeast production,

disinfection, sludge treatment and odor treatment, are not directly involved in the operation of STEP, so can be done sequentially.

3.7.6.3 Remarks on further studies

The results for the STEP of Siliana helped to find a solution for setting the budget of the operation of rehabilitation and extension.

However, the further studies, especially the Detailed Design, will have to validate in detail the technical choices proposed or to propose some technical amendments in the budget of the operation.

CHAPTER IV

CLEAN DEVELOPMENT MECHANISM (CDM) PROJECT ASSESSMENT

CHAPTER IV: CLEAN DEVELOPMENT MECHANISM (CDM) PROJECT ASSESSMENT

4.1 CDM PROJECT

4.1.1 Project description and configuration

This project consists of the rehabilitation and of upgrading the capacity of five WwTPs located in Tunisia.

The current treatment system of the five WwTPs, already described in the preceding chapter, consists of an activated sludge system on minimum load (extended aeration mode). From the view-point of the implicit greenhouse gas (GHG) emissions, the sludge is stabilized aerobically due to the high sludge age with which the process is operated. Therefore, the respective methane production and emissions are very low. The necessary electric power for the operation of the WwTP is provided by the public electrical supply network.

4.1.2 Identification and analysis of alternative solutions

Three alternatives of intervention are identified to be analyzed in this study: one where there are no significant changes in process and two others corresponding to a modification of the existing activated sludge treatment system, introducing a medium load activated sludge process (except for Béja WwTP).

- The first alternative corresponds to the existing treatment lines, by performing the resizing of the WwTPs to increase their capacity if needed. This alternative for the treatment system does not allow its eligibility as a Clean Development Mechanism (CDM) project, because there is not a specific reduction of GHG emissions, with respect to the reference situation, reason why it does not meet the criteria required for a CDM project;

- The second alternative corresponds to the modification of the activated sludge treatment system into a medium load activated sludge process. The primary sludge and excess biological sludge will be stabilized in an anaerobic digester operating in mesophilic temperature. The biogas produced during the digestion will be recovered and used in a cogeneration system.

  The thermal energy produced will be used for sludge heating, in order to maintain mesophilic temperature in the anaerobic digester, and the electric power produced is used in the operation of WwTP electric components. This solution prevents the GHG emission, so it is eligible as a CDM project according to the criteria of additionality. The emissions resulting from the modification of the treatment process must be practically non-existent, since the production of methane is marginal in the reference situation and in the project situation there is a production of methane that is recovered for the production of biogas, through which the balance is practically nil.

  The reduction of GHG emissions associated with this alternative is mainly due to the substitution of the public network electric power consumption by the electric power locally produced with recourse to biogas (methane), which replaces the energy mix of the electro-producer system of the country in the generation of power for the WwTP;

- The third alternative also corresponds to the modification of existing activated sludge system by an activated sludge system on medium load (except for Béja WwTP). The primary and excess biological sludge will be stabilized in an anaerobic digester at mesophilic temperature. The biogas produced during the digestion process will be confined and led to a boiler to produce heat for heating sludge to digestion. Power generation is not considered in this solution. The implementation of this alternative for the project does not allow for its eligibility as a CDM project, since there is no reduction of GHG emissions with regard to the reference situation. The methane is produced in the project situation, but it will be used internally in order to produce thermal power. Since there is no electric power generation, there is no reduction of GHG emissions in this way. Thus, the balance of GHG emissions results only from the modification of the treatment system and should be practically nil.

- The third alternative of the Béja WwTP is to introduce a pre-treatment of industrial water. The rest of the process is identical to the first alternative. There is neither biogas recovery nor cogeneration and, as for the first alternative, the third one is not eligible as CDM project.

4.1.3 Selection of a methodology for baseline scenario and monitoring

Further to the analysis performed in the previous paragraph, only the second option sets up a potential CDM project. Even at this early stage of the study, it is possible to understand that it will be a small-scale project (criteria: capacity of unit power generation below 15 MW and annual reduction of emissions below 60,000 t CO_2e), which fits in the sectors of power generation and waste management.

In this case, after an analysis of the methodologies approved by the CDM Executive Board and the choices made for a set of similar projects, it is now possible to indicate the most appropriate methodologies for the eventual registration of this project:

- Reference Methodology AMS-I.D – “Grid connected renewable electricity generation” – Sectorial Scope 1 – Energy production (renewable/non-renewable sources); and

- Reference Methodology AMS-III.H – “Methane recovery in Wastewater Treatment” - Sectorial Scope 13 – Waste Management.

The choice of these methodologies is based on the characteristics of the project, on the components of methane recovery and power generation in a cogeneration system, and is, in particular, recommended by the use of the same methodology in two projects similar to the project in study: The project `Sludge Digestion of 23 WwTPs with the use of biogas for cogeneration´, which PIN (Project Idea Note) was approved by the Designated National Authority (DNA) of Tunisia on 20/11/2009, and the project `Makati South Sewage Treatment WwTP upgrade With on-site power ', implemented in the Philippines and registered on 24/06/2008.

4.2 LEGAL FRAMEWORK

4.2.1 Relevant environmental standards and legislation in Tunisia

The national legislation concerning the wastewater treatment systems in Tunisia does not include either the sludge treatment systems or the recovery of the biogas for cogeneration systems. The main laws and important regulations for the wastewater treatment sector in Tunisia are as follows (Source: ANPE – National Agency for Environmental Protection and ONAS – National Sanitation Utility):

- Law No. 75-16 dated March 31, 1975 concerning the Code of the Water, amended by Law No. 87-35 of July 6, 1987, Law No. 88-94, of August 2, 1988, Decree No. 2001-2606 of November 9, 2001 and Law No. 2001-116 of November 26, 2001;
- Decree No. 79-768 dated September 8, 1979, which regulates the conditions of connection and discharge of effluents into the public sewage network;
- Official Statement of the Minister for the Economy, dated July 20, 1989, which announces the approval of the Tunisian Standard NT 106.002 (1989), which regulates the discharge of effluents into the receiving environment;
- Decree No. 89-1047 dated July 28, 1989, which establishes the conditions for the reuse of treated wastewater in agriculture;
- Law No. 95-70 dated July 17, 1995, relating to the conservation of water and soils.

This way, there is no legal obligation on the type of wastewater treatment and sludge treatment to be adopted in a WwTP, since the existing legislation only relates to conditions of discharge of wastewater. Therefore, it is not established legal obligation to include, into the project, a specific system to treat the sludge produced in the 5 WwTP, nor there is a legal obligation to recover and to use the biogas collected for power generation.

Under these conditions, the project satisfies this eligibility criterion as a CDM project.

It must also be referred that, if solution 2 is chosen to be implemented, the 5 WwTP projects will be submitted to an Environmental Impact Assessment, in accordance with the Tunisian legislation – Decree No. 2005-1991 dated July 11, 2005, which specifies the categories of projects to be submitted to Environmental Impact Assessment.

Also in this case, projects under study are in compliance with the CDM procedures as regards environmental assessment.

4.2.2 Institutional Framework - Designated National Authority

Designated National Authority in Tunisia, designated as "National Office of the Clean Development Mechanism", and established at the beginning of 2005, is an interdepartmental organization, composed of representatives of nine ministries and six other institutions, which include public companies, the banking sector, non-governmental organizations and the private sector. The composition of the DNA is as follows:

- The Presidency: Minister of Environment;

- The Permanent Secretariat;
- The appointed members of the following ministries/organizations: Ministry of Environment; Ministry of Foreign Affairs; Ministry of Planning and International Cooperation; Ministry of Finance; Ministry of Industry, Energy and Small and Medium-sized Companies; Ministry of Agriculture and Hydraulic Resources; Ministry of Transport; Ministry of Commerce and Handicrafts; Ministry of Interior and Local Development; Tunisian Union of Industry, Commerce and Handicrafts; Tunisian Union of Agriculture and Fishing; Central Bank of Tunisia; National Agency for Energy Management; Tunisian Company of Electricity and Gas; Tunisian Chemical Group.

The functions of DNA include the process of review and approval of CDM projects, the issuance of Letters of Approval, the annual reports of CDM activities in Tunisia and the definition of criteria for determining the contribution of a project for the sustainable development of the country. DNA is also assigned to promote the investment in such projects, in Tunisia.

The permanent secretariat of the DNA, located at the headquarters of the Directorate General for Environment and Quality of Life (Ministry of Environment), essentially performs the function of spokesman for the DNA. In this way, he is responsible for establishing contacts with the Executive Committee of the Clean Development Mechanism and being the interface between the project promoter and the DNA, through the submission of projects to the DNA and communication of the results of the approval process, to the project promoters. He is also responsible for trying to contact organizations interested in buying carbon credits as well as organizations that assist the economic operators of the projects. The Secretariat is also responsible for developing the national organization concerning CDM, preparing the project portfolio, promoting the potential of CDM projects in Tunisia and ensuring the monitoring of projects throughout their lifecycle.

In what concerns the procedure of evaluation and approval of the CDM projects in Tunisia, the process can be divided in two phases, namely the reception and approval of PIN (DNA of Tunisia has established this initial phase to be compulsory), and the reception and approval of the Project Design Document (PDD) by the DNA. The maximum time of response from the DNA, for each phase, is respectively 15 and 45 days. The Letter of Approval is issued to the project promoter as soon as the project is in accordance with the required conditions.

The Clean Development Mechanism, as a system that allows the countries that have assumed quantified targets for reducing emissions to comply with the legal obligations under the Kyoto Protocol, has also the objective to contribute to the sustainable development in the countries/parties where this type of projects are being undertaken. It lays in the responsibility of the host country to determine whether a CDM project contributes to sustainable development. This is one of the criteria for eligibility of a CDM project.

To assess the contribution of a project for the sustainable development of the country, Tunisia has adopted a quantitative and transparent system, based on the weight of economic, social, environmental and strategic criteria. Each type of criteria consists of several indicators, to which a weight is also allotted. The members of the DNA must assign a score from 0 to 10 to each indicator, since the contribution of the project to sustainable development, or the index of sustainable development, results from the weighting of the various criteria according to the assigned scores. It is assumed that the project would contribute to sustainable development, if the index of sustainable development is equal or greater than 1.5.

4.2.3 Current situation of CDM development in Tunisia

Tunisia meets the conditions required to participate in the Clean Development Mechanism, having ratified the Kyoto Protocol in June 2002 and established a Designated National Authority for CDM projects in December of 2004 (and its notification to the secretariat of United Nations Framework on Climate Change – UNFCCC, in January 2005). Tunisia is actively engaged in promoting the development of CDM projects in the country, having developed in 2005 a National Strategy for the promotion and acceleration of CDM processes, with the purpose of preparing the country to compete within the international carbon market.

The national strategy for promoting CDM includes actions at several levels with the objective to find the investment for CDM projects in Tunisia: promotion and communication at national and international level, reinforcement of national capacity and monitoring of projects to their implementation. The promotion of this type of projects, at the national level, comprehends the organization of an annual conference on the CDM process, the disclosure of periodical publications, the provision of a dynamic website and the follow-up of international negotiations regarding the CDM.

Communication at the international level aims to ensure a good image of the CDM product in the country and to promote Tunisia as a privileged destination for these projects. For this purpose, a portfolio of Tunisian projects was created for international disclosure. Simultaneously, contacts are established with the buyers of carbon credits, CDM forums are organized in Tunisia, being also assured the participation in other CDM forum worldwide. To strengthen national capabilities, training programs for the institutions involved in the CDM are organized. Monitoring of CDM projects shall be taken as essential and is intended to provide technical assistance to operators who have started their CDM projects and thus to ensure their implementation.

Within the context of this strategy, studies of potential reduction of GHG emissions in Tunisia were undertaken, having been obtained a potential result greater than 3 million tons of CO_2 e/year for year 2011. During the period of 2012-2016, a volume of about 17 million tons of CO_2 e/year has been estimated. The sectors with the higher potential for reduction of emissions and the development of CDM projects are the energy sector (energy efficiency, renewable energy, alternative energy) and the waste management sector, representing respectively 42% and 46% of reduction potential at short term (for year 2011), and 50% and 35% at the medium term (for the period of 2012-2016).

The portfolio of projects submitted for approval in Tunisia, as well as their state of progress in the process, is important for understanding the level of development of CDM in the country. In Tunisia, until September 2010, only two projects had completed the CDM process, both in the recovery and burning of landfill gas. Within the global international framework, they are currently registered 1,824 projects in the Asia / Pacific, 478 projects in Latin America and the Caribbean, 46 projects in Africa and 13 in Eastern Europe.

The following table shows, for each sector, the number of projects submitted for the approval of the DNA, as well as their corresponding state in the CDM process.

Table 4.2-1 : Number of CDM projects in Tunisia and corresponding state of approval of the process, per sector (end of March 2010)

Sector	Number of projects	State of the process				
		PIN approved by the DNA	PDD in preparation phase	PDD in study/approved by the DNA	Project in validation phase	Registered project
Energy	74	25	8	2	1	
Wastes	15	1				2
Industrial processes	2					
Transport	9	1				
Sanitation	19	5				
Agriculture/Forest	20	2				
TOTAL	139	34	8	2	1	2

For the projects in sanitation sector, the approved 5 PIN shown in the table are from November 2009, and the process probably continues. Already mentioned above, one of these projects, «Sludge Digestion in 23 WwTP using the Biogas for Cogeneration», is similar nature to this project.

4.3 FEASIBILITY ANALYSIS FOR A CDM PROJECT

4.3.1 Introduction

The Clean Development Mechanism is a compliance instrument of the Kyoto Protocol, within the United Nations Framework Convention on Climate Change. The Kyoto agreement has a compliance period between 2008 and 2012, and the Protocol itself will end on 31, December, 2012[(1)]. Because the United Nations have not yet agreed on the follow-up of the Kyoto agreement, this date has become a crucial date. If the countries do not agree on a follow-up, the market link with carbon credits will drastically change.

The European Union, especially through its Emissions Trading Scheme (ETS), has unilaterally indicated that it will continue to accept Certified Emission Reductions (CERs) as compliance units, at least until 2020. As EU Emissions Trading System (EU-ETS) is the largest compliance market in the world, the price of the carbon credits is very dependent on the demand

1 As a result of the COP 17 held at Durban in December 2011, the Kyoto Protocol has been extended by a given number of Parties. This means that CDM credits will be eligible for Parties as compliance tools for the attainment of their new reduction commitment objectives. However, there is a lot of uncertainty at the moment, namely on how many parties will sign the "New Kyoto Protocol", knowing that there are doubts about the willingness of critical Parties, like the USA, Russia, Japan, Canada or Australia, to commit with new quantitative objectives.
In fact, the crucial question is what will be the real effectiveness of the New Kyoto Protocol, as a means to create a strong international market demand for CERs.
Furthermore, it is not clear how this COP decision will influence the present rules of the European Union Emission Trading Scheme, namely if CERs from projects registered after 2013, and taking place in Parties other than the Least Developed Countries (LDC), will be valid for compliance.

coming from ETS installations. Therefore, through 2020, CERs coming from projects that are registered by 31 December 2012 will continue to be valid. Registration of a project after this date has a probability that CERs will have very limited demand.

Knowing that in 2010 the average CDM project took over 600 days to progress from validation to registration, this effectively means that the validation of a given CDM project documentation should start by the summer 2011. This in turn means that the preparation of the Project Design Document (PDD) would have been started in early 2011, in order to be ready for validation in due time.

Given that the interventions in the WwTP will only start in 2016 and that the first year of operation will be 2019, we can conclude that, even if the project could be registered in time, which is very unlikely, it would only be possible to trade the CERs obtained in 2019 and 2020.

Despite this unfavorable scenario, emissions reduction was calculated in order to evaluate the viability of the project implementation assuming a start in 2011.

The Methodology AMS-III.H (Methane recovery in wastewater treatment) was used[2] as the fundamental tool to calculate emissions reduction for the following 5 wastewater treatment plants investment project in the Republic of Tunisia.

WwTP	Waste water annual flow
Béja	2 278,935
Medjez El-Bab	872,846
Tabarka	1 639,215
Jendouba	1 869,966
Siliana	847,142

Medjez El-Bab installation data was chosen to calculate emissions as a complete set of information for the energy balance of the baseline and project scenarios was available. This is one of the smallest installations and, therefore, calculations were also conducted for the Béja installation, the largest one, assuming in this case that a similar quantity of grid electricity is to be used in both baseline and project scenarios.

Even though the information provided by the two WwTPs was enough to draw general conclusions, the calculations were made for the 3 other WwTP.

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[2] The baseline and monitoring methodology AMS-I.D "Renewable Energy Projects" comprises energy generation units, such as renewable biomass, supplying electricity to a national or a regional grid or to an identified consumer facility via national/regional grid through a contractual arrangement.

The present project includes a component of methane emissions reduction which would not be accounted otherwise within the above mentioned methodology.

On the contrary, AMS.III.H "Methane recovery in wastewater treatment", for projects such as the substitution of aerobic wastewater or sludge treatment systems with anaerobic systems with biogas recovery and combustion, not only includes this methane reduction component, but also considers the direct thermal electrical energy generation resulting from the biogas combustion. In fact, AMS.III.H utilizes the same calculation tool as the AMS.I.D when it comes to calculate the baseline, project and/or leakage emissions from electricity consumption.

Further, looking at similar CDM projects in the registration pipeline, we can find AMS.III.H as the main methodology selected. That was the case, as an example, for the following projects: Methane Recovery in Waste Water Treatment at Kibbutz Lahav, PTT Green Energy Waste Water Treatment System Project, Eiamrungruang Waste Water Treatment and Biogas Utilization Project and Henan Xingtai Waste Water Treatment Project.

In Chapter 4.3.2, a calculation of the emissions of the baseline scenario was performed. In Chapter 4.3.3, the same calculation was carried out for the future project scenario. Both calculations were based on the AMS-III.H methodology.

In Chapter 4.3.4, reduction volume of annual emissions of both scenarios are assessed and calculated for the two WwTPs (Medjez El-Bab and Béja).

Chapter 4.3.5 refers to CDM registration and implementation costs, Chapter 4.3.6 to the theme of registration timing and the issue of 2012 as the deadline to register effective CDM projects and Chapter 4.3.7 lists a set of conclusions.

4.3.2 Estimation of annual emissions in the baseline scenario (Medjez El-Bab and Béja WwTP)

According to AMS-III.H methodology, for the case of introduction of anaerobic sludge treatment system with biogas recovery and combustion to a wastewater treatment WwTP without sludge treatment, the baseline emissions consist of the following list of different emission sources:

(i) Emissions on account of electricity used ($BE_{power,y}$);

(ii) Methane emissions from baseline sludge wastewater treatment systems ($BE_{ww,treatment,y}$);

(iii) Methane emissions from baseline sludge treatment systems ($BE_{s,treatment,y}$);

(iv) Methane emissions on account of inefficiencies in the baseline wastewater treatment systems and presence of degradable organic carbon in the treated wastewater discharged into river/lake/sea ($BE_{ww,discharge,y}$);

(v) Methane emissions from the decay of the final sludge generated by the baseline treatment systems ($BE_{s,final,y}$).

$$BE_y = \{BE_{power,y} + BE_{ww,treatment,y} + BE_{s,treatment,y} + BE_{ww,discharge,y} + BE_{s,final,y}\}$$

Where:

BE_y	Baseline emissions in year “y” (tCO2e)
$BE_{power,y}$	Baseline emissions from electricity consumption in year “y” (tCO2e)
$BE_{ww,treatment,y}$	Baseline emissions of the wastewater treatment systems affected by the project activity in year “y” (tCO2e)
$BE_{s,treatment,y}$	Baseline emissions of the sludge treatment systems affected by the project activity in year “y” (tCO2e)
$BE_{ww,discharge,y}$	Baseline methane emissions from degradable organic carbon in treated wastewater discharged into sea/river/lake in year “y” (tCO2e)
$BE_{s,final,y}$	Baseline methane emissions from anaerobic decay of the final sludge produced in year “y” (tCO2e)

For each emissions type, connected with these above mentioned variables, a separated calculation was performed, in order to assess the complete baseline scenario.

4.3.2.1 Emissions on account of electricity used

The baseline emissions from electricity consumption ($BE_{power,y}$) are determined as per the procedures described in the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". This is an algorithm developed in the context of the CDM Executive Board, specifically to calculate emissions for the projects electricity consumption/production. This Tool is the main piece of the methodology AMS-I.D "Renewable Energy Projects".

In this case, the calculation uses to the following formula which represents the quantity of electricity consumed and the factor of emission equivalent to the CO_2 on the electric grid in Tunisia:

$$BE_{power,y} = EC_{BL,k,y} \; x \; EF_{EL,k,y}$$

Where:

Variables	Description	Value/Assumption	
		Medjez El-Bab	Béja
$EC_{BL,k,y}$	Quantity of electricity that would be consumed by the baseline electricity consumption source "k" in year "y" (Information from the Survey)	420 MWh/year	1,246 MWh/year
$EF_{EL,k,y}$	Emission factor for electricity generation for source "k" in year "y". This value is mentioned in the Tunisian "Nationally Appropriate Mitigation Action" published by the Ministry of Agriculture and Environment, 13 October 2010 (Table 2, pp 40) *http://www.jiko-bmu.de/files/basisinformationen/application/pdf/nama_proposals_tunisia.pdf*	0.627 t CO_2e/MWh	

The CO_2e emissions associated with electricity consumption are:

$\boldsymbol{BE_{power,y}}$ **=**

Medjez El-Bab: **264 t CO_2e/year**

Béja: **781 t CO_2e/year**

4.3.2.2 Methane emissions from baseline wastewater treatment systems

The methane emissions from the baseline wastewater treatment systems affected by the project ($BE_{ww,treatment,y}$) are determined using the COD removal efficiency of the baseline WwTP:

$$BE_{ww,treatment,y} = \sum_i (Q_{ww,i,y} * COD_{\inf low,i,y} * \eta_{COD,BL,i} * MCF_{ww,treatment,BL,i}) * B_{o,ww} * UF_{BL} * GWP_{CH4}$$

Where:

Variables	Description	Value/Assumption	
		Medjez El-Bab	Béja
$Q_{ww,treatment,y}$	Volume of wastewater treated in baseline wastewater treatment system "i" in year "y" (Information from the Survey)	839,413 m^3	2,187,483 m^3
$COD_{inf\ low,i,y}$	Chemical oxygen demand of the wastewater inflow to the baseline treatment system "i" in year "y" (Information from the Survey)	0.001177 t/m^3	0,001981 t/m3
$\eta_{COD,BL,i}$	COD removal efficiency of the baseline treatment system "i"(1) (Calculations made using Information from the Survey)	0.8219	0.85
$MCF_{ww,treatment,BL,i}$	Methane correction factor for baseline wastewater treatment systems "i"	0.1 (2)	
$B_{o,ww}$	Methane producing capacity of the wastewater (Default value proposed by the Inter-Governmental Panel on Climate Change)	0.25 kg CH_4/kg COD	
UF_{BL}	Model correction factor to account for model uncertainties (Default value)	0.89	
GWP_{CH4}	Global Warming Potential for methane	21	

(1) Multiplied by a 0.89 uncertainty factor
(2) Tabled values of 0.0 for "Aerobic treatment, well managed" and 0.3 for "Aerobic treatment, poorly managed or overloaded"

The total methane emissions coming from the baseline wastewater sludge treatment systems are:

BE $_{ww,treatment,y}$ =

Medjez El-Bab: **379 t CO_2e/year**

Béja: **1,720 t CO_2e/year**

4.3.2.3 Methane emissions from baseline sludge treatment systems

The methane emissions from the baseline sludge treatment systems affected by the project activity are determined using the methane generation potential of the sludge treatment systems:

$$BE_{treatment,s,y} = \sum_j S_{j,BL,y} * MCF_{s,treatment,BL,j} * DOC_s * UF_{BL} * DOC_F * F * 16/12 * GWP_{CH4}$$

Where:

Variables	Description	Value/Assumption	
		Medjez El-Bab	Béja
$S_{j,BL,y}$	Amount of dry matter in the sludge that would have been treated by the sludge treatment system "j" in the baseline scenario. In this case, the baseline wastewater treatment systems is different from the treatment system in the project scenario, so the monitored values of the amount of sludge generated during the crediting period will be used to estimate the amount of sludge generated in the baseline. (Calculations made from information coming from the Survey)	745.36 t	2,351.95 t
DOC_s	Degradable organic content of the untreated sludge generated in the year "y" (fraction, dry basis) (Default value for domestic sludge)	0.5	
$MCF_{s,treatment,BL,j}$	Methane correction factor for the baseline sludge treatment system "j". Tabled values of 0.0 for "Aerobic treatment, well managed" and 0.3 for "Aerobic treatment, poorly managed or overloaded" – a 0,1 value was assumed, reflecting a system managed in a satisfactory way.	0.1	0.1
UF_{BL}	Model correction factor to account for model uncertainties (Default value)	0.89	
DOC_F	Fraction of DOC dissimulated to biogas (Default value)	0.5	
F	Fraction of CH4 in biogas (Default value)	0.5	

The methane emissions from the baseline sludge treatment systems are:

$\boldsymbol{BE_{treatment,s,y}} =$

Medjez El-Bab: **232 t CO_2e/year**

Béja: **733 t CO_2e/year**

4.3.2.4 Methane emissions on account of inefficiencies in the baseline wastewater treatment systems and presence of degradable organic carbon in the treated wastewater discharged into rivers/lakes

The methane emissions from degradable organic carbon in treated wastewater discharged in the baseline situation, e.g. in a river, sea or lake, are determined as follows:

$$BE_{ww,discharge,y} = Q_{ww,y} * GWP_{CH4} * B_{o,ww} * UF_{BL} * COD_{ww,discharge,BL,y} * MCF_{ww,BL,discharge}$$

Where:

Variables	Description	Value/Assumption	
		Medjez El-Bab	Béja
$Q_{ww,y}$	Volume of treated wastewater discharged in year "y" (Information coming from the Survey)	839,413 m^3	2,187, 483 m^3
UF_{BL}	Model correction factor to account for model uncertainties (Default value)	0,89	
$COD_{ww,discharge,BL,y}$	Chemical oxygen demand of the treated wastewater discharged into sea, river or lake in the baseline situation in the year "y" (Information coming from the Survey)	0.00009 t/m^3	0.00009 t/m^3
$MCF_{ww,BL,discharge}$	Methane correction factor based on discharged pathway in the baseline situation (e.g. into sea, river or lake) of the wastewater (fraction) (Tabled value coming from the Inter-Governmental Panel on Climate Change)	0.1	

The emissions of methane related to the degradation of organic carbon in the natural water systems, after discharge is:

$\boldsymbol{BE_{ww,discharge,y}}$ =

Medjez El-Bab: 35 t CO_2e/year

Béja: 92 t CO_2e/year

4.3.2.5 Methane emissions from the decay of the final sludge generated by the baseline treatment systems

Methane emissions from anaerobic decay of the final sludge produced are determined as follows:

$$BE_{s,final,y} = S_{final,BL,y} * DOC_s * UF_{BL} * MCF_{s,BL,final} * DOC_F * F * 16/12 * GWP_{CH4}$$

Where:

Variables	Description	Value/Assumption	
		Medjez El-Bab	Béja
$S_{final,BL,y}$	Amount of dry matter in the final sludge generated by the baseline wastewater treatment systems in the year "y" (Information from the Survey)	745.36 t	2,351.95 t
$MCF_{s,BL,final}$	Methane correction factor of the disposal site that receives the final sludge in the baseline situation, estimated according to the procedures described in the manual "Tool to determine methane emissions avoided for the solid waste in a landfill solid waste" (Unmanaged-shallow solid waste disposal site)	0.4	0.4
UF_{BL}	Model correction factor to account for model uncertainties (Default value)	0.89	

The methane emissions associated with the decay of the final sludge generated by the baseline treatment system are:

$BE_{ww,discharge,y}$ =

Medjez El-Bab: 929 t CO_2e/year

Béja: 2,931 t CO_2e/year

4.3.2.6 Summary table of total emissions

The total baseline annual emissions of the Medjez El-Bab and Béja WwTP are the sum of the different components mentioned and calculated above:

Parameters	Description	Emissions (tCO_2e/year)	
		Medjez El-Bab	Béja
$BE_{power,y}$	Baseline emissions for the annual electricity consumption "y"	263.5	781.3
$BE_{ww,treatment,y}$	Baseline emissions from the wastewater treatment systems due to the project activity during the year "y"	379.4	1,720.2
$BE_{s,treatment,y}$	Baseline emissions from sludge treatment systems due to the annual activities of the project during the year "y"	232.2	732.6
$BE_{ww,discharge,y}$	Methane emissions from the baseline degradable organic carbon in treated wastewater discharged into the sea/river/lake during the year "y"	35.3	92.0
$BE_{s,final,y}$	Baseline emissions from anaerobic decomposition of produced final sludge during the year "y"	928.7	2,930.5
BE_y	**Total baseline emissions**	**1,839**	**6,257**

The baseline emissions of the project refer to a scenario where it is assumed that there is no new project and that the present infrastructure will continue to be used in the future in the same conditions. This means that in the year 0 of the project, the CO_2e emissions of the Medjez El-Bab WwTP would have been 1,839 tons and of Béja WwTP would have been 6,257 tons.

In the context of a CDM project, even a Small Scale Project one, this is quite a small amount of greenhouse gases.

These limited amounts of emissions are principally caused by the following two reasons:

(i) The present WwTPs are operated well and the COD is treated sufficiently not to emit methane gas;

(ii) Due to the low rate of emission factor in Tunisia, the amount of emission equivalent to the CO2 produced by fossil fuel for the electricity on national grid is quite limited, because it is determined by the predominance of natural gas as main fossil fuel.

4.3.3 Estimation of annual emissions in the project scenario (Medjez El-Bab and Béja WwTP)

According to AMS-III.H methodology, the emissions from the systems affected by project activity are:

(i) CO2 emissions from electricity used by the project facilities ($PE_{power,y}$);

(ii) Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery in the project scenario ($PE_{ww,treatment,y}$);

(iii) Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation ($PE_{s,treatment,y}$);

(iv) Methane emissions on account of inefficiency of the project activity wastewater treatment systems and presence of degradable organic carbon in treated wastewater ($PE_{ww,discharge,y}$);

(v) Methane emissions from the decay of the final sludge generated by the project activity treatment systems ($PE_{s,final,y}$);

(vi) Methane fugitive emissions due to inefficiencies in capture systems ($PE_{fugitive,y}$);

(vii) Methane emissions due to incomplete flaring ($PE_{flaring,y}$);

(viii) Methane emissions from biomass stored under anaerobic conditions which would not have occurred in the baseline situation ($PE_{biomass,y}$).

$$PE_y = \begin{Bmatrix} PE_{power,y} + PE_{ww,treatment,y} + PE_{s,treatment,y} + PE_{ww,discharge,y} + PE_{s,final,y} + \\ PE_{fugitive,y} + PE_{biomass,y} + PE_{flaring,y} \end{Bmatrix}$$

Where:

PE_y	Project activity emissions in the year "y" (tCO2e)
$PE_{power,y}$	Emissions from electricity consumption in the year "y" (tCO2e)
$PE_{ww,treatment,y}$	Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery, in year "y" (tCO2e)
$PE_{s,treatment,y}$	Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery, in year "y" (tCO2e)
$PE_{ww,discharge,y}$	Methane emissions from degradable organic carbon in treated wastewater in year "y" (tCO2e)
$PE_{s,final,y}$	Methane emissions from anaerobic decay of the final sludge produced in year "y" (tCO2e)
$PE_{fugitive,y}$	Methane emissions from biogas release in capture systems in year "y" (tCO2e)
$PE_{flaring,y}$	Methane emissions due to incomplete flaring in year "y" (tCO_2e)

$PE_{biomass,y}$	Methane emissions from biomass stored under anaerobic conditions (tCO_2e)

4.3.3.1 Emissions from electric consumption

The project activity emissions from electric consumption ($PE_{power,y}$) are determined as per the procedures described in the "Tool to calculate baseline, project and/or leakage emissions from electric consumption".

$$PE_{power,y} = EC_{PJ,j,y} \times EF_{EL,j,y}$$

Where:

Variables	Description	Value/Assumption	
		Medjez El-Bab	Béja
$EC_{PJ,j,y}$	Quantity of electricity consumed by the project electric consumption source "j" in year "y". This is the electric consumption from the grid, according to the information provided by the Survey. The electricity generated on site from the combustion of biogas was assumed to be CO_2e free.	1,471 MWh/year	1,246 MWh/year
$EF_{EL,j,y}$	Emission factor for electric generation for source "j" in year "y" (See chapter 4.3.2)	0.627 t CO_2e/MWh	

The CO2e emissions associated with electric consumption are:

***$PE_{power,y}$* =**

Medjez El-Bab: 922 t CO_2e/year

Béja: 781 t CO_2e/year

4.3.3.2 Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery

Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery ($PE_{ww,treatment,y}$) are determined using the same equation used to calculate the parameter $BE_{ww,treatment,y}$.

Variables	Description	Value/Assumption	
		Medjez El-Bab	Béja
$Q_{ww,treatment,y}$	Volume of wastewater treated in project wastewater treatment system "i" in year "y" (Information from the Survey)	1,924,872 m^3	4,610,019 m^3
$COD_{inf\ low,i,y}$	Chemical oxygen demand of the wastewater inflow to the project activity treatment system "i" in year "y" (Information from the Survey)	0.001177 t/m^3	0.001981 t/m^3

Variables	Description	Value/Assumption	
		Medjez El-Bab	Béja
$\eta_{COD,PJ,i}$	COD removal efficiency of the project activity treatment system "i", measured based on inflow COD and outflow COD in system "i"(1) (Calculations made using Information from the Survey)	0.8064	0.8299
$MCF_{ww,treatment,PJ,i}$	Methane correction factor for project wastewater treatment systems "i" (Aerobic treatment, well managed). A 0,0 value was assumed, reflecting a well-managed system in the future	0	0
$B_{o,ww}$	Methane producing capacity of the wastewater (Default value)	0.25 kg CH_4/kg COD	
UF_{PJ}	Model correction factor to account for model uncertainties (Default value)	1.12	
GWP_{CH4}	Global Warming Potential for methane (Default value)	21	

(1) Multiplied by a 0.89 uncertainty factor

The emissions from this activity are nil:

$\boldsymbol{PE_{ww,treatment,y}}$ =

Medjez El-Bab: **0 t CO_2e/year**

Béja: **0 t CO_2e/year**

4.3.3.3 Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation

Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery are determined using the same equation used to calculate the parameter $BE_{s,treatment,y}$:

Variables	Description	Value/Assumption	
		Medjez El-Bab	Béja
$S_{j,PJ,y}$	Amount of dry matter in the sludge treated by the sludge treatment system "j" in the project scenario in year "y" (Calculations made from information coming from the Survey)	1,543 t	4,800 t
DOC_s	Degradable organic content of the untreated sludge generated in the year "y" (fraction, dry basis) (Default value for domestic sludge)	0,5	
$MCF_{s,treatment,j}$	Methane correction factor for the project sludge treatment system "j". Tabled values of 0.0 for "Aerobic treatment, well managed" and 0.3 for "Aerobic treatment, poorly managed or overloaded" – a 0.0 value was assumed, reflecting a well-managed system.	0	0

Variables	Description	Value/Assumption	
		Medjez El-Bab	Béja
UF_{PJ}	Model correction factor to account for model uncertainties (Default value)	1.12	
DOC_F	Fraction of DOC dissimilated to biogas (Default value)	0.5	
F	Fraction of CH_4 in biogas (Default value)	0.5	

The methane emissions from the project sludge treatment systems are:

$PE_{treatment,s,y}$ =

Medjez El-Bab: **0 t CO_2e/year**

Béja: **0 t CO_2e/year**

4.3.3.4 Methane emissions on account of inefficiency of the project activity wastewater treatment systems and presence of degradable organic carbon in treated wastewater

Methane emissions from degradable organic carbon in treated wastewater in the project situation are determined using the same equation used to calculate the parameter $BE_{ww,discharge,y}$:

Variables	Description	Value/Assumption	
		Medjez El-Bab	Béja
$Q_{ww,y}$	Volume of treated wastewater discharged in year “y” (Information coming from the Survey)	839,413 m^3	2,187,483 m^3
UF_{PJ}	Model correction factor to account for model uncertainties (Default value)	1.12	
$COD_{ww,discharge,PJ,y}$	Chemical oxygen demand of the treated wastewater discharged into sea, river or lake in the project scenario in the year “y” (Information coming from the Survey)	0.00009 t/m^3	0.00009 t/m^3
$MCF_{ww,PJ,discharge}$	Methane correction factor based on discharged pathway of the wastewater in the project scenario (e.g. into sea, river or lake). Tabled value coming from the Inter-Governmental Panel on Climate Change	0.1	

The emissions of methane related to the degradation of organic carbon in the natural water systems, after discharge are:

$PE_{ww,discharge,y}$ =

Medjez El-Bab: **44 t CO_2e/year**

Béja: **116 t CO_2e/year**

4.3.3.5 Methane emissions from the decay of the final sludge generated by the project treatment systems

Methane emissions from anaerobic decay of the final sludge produced are determined using the same equation used to calculate the parameter $BE_{s,final,y}$:

Variables	Description	Value/Assumption	
		Medjez El-Bab	Béja
$S_{final,PJ,y}$	Amount of dry matter in the final sludge generated by the project wastewater treatment systems in the year "y" (Information from the Survey)	972 t	3,024 t
$MCF_{s,PJ,final}$	Methane correction factor of the disposal site that receives the final sludge in the project situation, estimated as per the procedures described in the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" (Unmanaged-shallow solid waste disposal site)	0.4	0.4
UF_{PJ}	Model correction factor to account for model uncertainties (Default value)	1.12	

The methane emissions associated with the final disposal of the treated sludge are:

$\boldsymbol{PE_{s,final,y}}$ **=**

Medjez El-Bab: **1,524 t CO_2e/year**

Béja: **4,741 t CO_2e/year**

4.3.3.6 Methane fugitive emissions due to inefficiencies in capture systems

Based on the methane emission potential of wastewater and sludge, the project activity emissions from methane release in capture systems are determined as follows:

$$PE_{fugitive,y} = PE_{fugitive,ww,y} + PE_{fugitive,s,y}$$

Where:

$PE_{fugitive,ww,y}$ Fugitive emissions through capture inefficiencies in the anaerobic wastewater treatment systems in the year "y" (tCO_2e). Considered zero because the Project only involves sludge treatment system.

$PE_{fugitive,s,y}$ Fugitive emissions through capture inefficiencies in the anaerobic sludge treatment systems in the year "y" (tCO_2e)

$$PE_{fugitive,s,y} = (1 - CFE_s) * MEP_{s,treatment,y} * GWP_{CH4}$$

Where:

CFE_s Capture efficiency of the biogas recovery equipment in the sludge treatment systems (a default value of 0.9 shall be used)

$PE_{fugitive,s,y}$ Methane emission potential of the sludge treatment systems equipped with a biogas recovery system in year "y"

$$MEP_{s,treatment,y} = \sum_l (S_{l,PJ,y} * MCF_{s,treatment,PJ,l}) * DOC_s * UF_{PJ} * DOC_F * F * 16/12$$

Where:

Variables	Description	Value/Assumption	
		Medjez El-Bab	Béja
$S_{l,PJ,y}$	Amount of sludge treated in the project sludge treatment system "l" equipped with a biogas recovery system (on a dry basis) in the year "y" (Information from the Survey)	1,543 t	4,800 t
$MCF_{s,treatment,PJ,l}$	Methane correction factor for the wastewater treatment system equipped with biogas recovery equipment. Values of 0.0 for "Aerobic treatment, well managed" and 0.3 for "Aerobic treatment, unmanaged or overloaded" – a 0.0 value was assumed, reflecting a well-managed system.	0.0	0.0
UF_{PJ}	Model correction factor to account for model uncertainties (Default value)	1.12	

The emissions of the project scenario due to fugitive emissions related to inefficiencies in capture systems are nil:

$PE_{fugitive,y}$ =

Medjez El-Bab: **0 t CO_2e/year**

Béja: **0 t CO_2e/year**

4.3.3.7 Methane emissions due to incomplete flaring

Not applicable to this project.

4.3.3.8 Methane emissions from biomass stored under anaerobic conditions which would not have occurred in the baseline situation

Not applicable to this project.

4.3.3.9 Summary table of total emissions

The total annual emissions from the project activity of the Medjez El-Bab and Béja WwTPs are the sum of the different components mentioned and calculated above. The emissions are as follows:

Parameters	Description	Emissions (tCO_2e/year)	
		Medjez El-Bab	Béja
$PE_{power,y}$	Emissions from electricity consumption in year "y"	922.1	781.3
$PE_{ww,treatment,y}$	Emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery, in year "y"	0	0
$PE_{s,treatment,y}$	Emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery, in year "y"	0	0
$PE_{ww,discharge,y}$	Emissions from degradable organic carbon in treated wastewater in year "y"	44.4	115.8
$PE_{s,final,y}$	Emissions from anaerobic decay of the final sludge produced in year "y"	1,524.1	4,741.6
$PE_{fugitive,y}$	Emissions from biogas release in capture systems in year "y"	0	0
$PE_{flaring,y}$	Emissions due to incomplete flaring in year "y"	0	0
$PE_{biomass,y}$	Emissions from biomass stored under anaerobic conditions	0	0
PE_y	**Total project activity emissions**	**2,491**	**5,638.7**

Leakage

As per AMS-III.H methodology, since the used technology/equipment is not transferred to/from another activity, leakage effects are not to be considered.

The project emissions refer to a scenario where it is assumed the realization of the new project. This means that in the year y, after conclusion of the project, the CO2e emissions of the Medjez El-Bab WwTP will be approximately 2,491 tons and 5,639 tons for the Béja WwTP.

In case of Medjez El-Bab, the project emissions will be larger than those of the baseline scenario, and no absolute reduction would be produced. However the new project will treat an effluent volume more than double of the present one (2.3 times). Taking in account this fact, we can consider an emission of 1,083 tCO_2e/year and, consequently, a small reduction of less than 1,000 tons of CO_2e.

In case of Béja, the project emissions are 618 tons smaller than the emissions of the reference scenario.

4.3.4 Assessment of annual reduction of emissions

After an independent evaluation, the verified annual reduction of emissions, in tons of CO_2e, can be used to generate an equivalent number of carbon credits (CER - Certified Emission Reduction). The crediting period for a CDM project activity is selected by the project participants, and may be either:

i) A maximum of seven years which may be renewed at most two times, provided that, for each renewal, a designated operational entity determines and informs the Executive Board that the original project baseline is still valid or has been updated taking account of new data where applicable; or

ii) A maximum of 10 years with no option of renewal.

In this exercise, we have chosen the first alternative, and all the calculations will refer to a 7 years crediting period. In a conservative assessment, 7 years is considered as the minimum period of time used for determining the economic value of a CDM Project.

4.3.4.1 Medjez El-Bab WwTP

The reduction of emissions achieved by the project activity will be the difference between the baseline emissions and the sum of the project emission and leakage:

$$ER_y = BE_y - (PE_y + Leakage)$$

Table 4.3-1: Reduction of Emissions (Medjez El-Bab WwTP)

Year	Baseline Emissions[1] ($tCO_2e/year$)	Project Emissions ($tCO_2e/year$)	Leakage ($tCO_2e/year$)	Reduction of Emissions ($tCO_2e/year$)
2012	1,839	1,889	0	-50
2013	1,839	1,989	0	-150
2014	1,839	2,089	0	-250
2015	1,839	2,190	0	-351
2016	1,839	2,290	0	-451
2017	1,839	2,390	0	-551
2018	1,839	2,491	0	-652
Total	**12,873**	**15,328**	**0**	**-2,455**

(1) Average values for the period 2012-2018.

In the Medjez El-Bab installation, a net reduction of emissions is not anticipated. The fact that methane emissions in the baseline scenario are very small compared to those of the project scenario and that electricity grid consumption will significantly increase, determines very similar CO_2e emissions in both cases.

4.3.4.2 Béja WwTP

In case of Béja, expected electric consumption is similar to the volume to be imported from the national grid in the baseline scenario.

Results presented in the following table gives 0 reductions of CO_2e emissions of the electricity between the baseline scenario and the Project. All the assumptions and calculations presented for the Medjez El-Bab WwTP has been assumed as the one for the Béja WwTP.

Table 4.3-2: Reduction of Emissions (Béja WwTP)

Year	Baseline(1) Emissions(2) (tCO_2e/year)	Project Emissions(2) (tCO_2e/year)	Leakage (tCO_2e/year)	Reduction of Emissions (tCO_2e/year)
2012	6,257	4,434	0	1,823
2013	6,257	4,635	0	1,622
2014	6,257	4,836	0	1,421
2015	6,257	5,036	0	1,221
2016	6,257	5,237	0	1,020
2017	6,257	6,257	0	819
2018	6,257	6,257	0	619
Total	**43,700**	**35,254**	**0**	**8,545**

(1) Average values for the period 2012-2018.
(2) Except emissions from electric consumption, assumed as nil.

In the Béja installation, it is estimated a very small net emission reduction between 600 and 1,800 t CO_2e/year. Opposite to the Medjez El-Bab case, there is no increase between the grid electricity consumption on both scenarios.

Considering a CER price of 5.5 € (closing price December, 20th, 2011), this emission reduction would represent an average amount of circa 6,700 €/year.

4.3.5 Estimated costs for CDM registration

The Table below represents the average costs related to the registration process of a Small Scale CDM Project.

Summary of transaction costs for small-scale CDM projects (in 10^3 €)

Summary of Transaction Costs	Average	Low	High
Project Preparation Costs	27	17	37
Project Implementation Costs	8	4	13
Relative Transaction Costs	12%	7%	17%

Sources: UNEP CD4CDM/Ecosecurities, Guidebook to Financing CDM Projects, May 2007;
The Clean Development Mechanism (CDM) Capacity Building Project, Transaction Costs of CDM Projects, September 2004;
Norsk Energi, CDM Project Development Manual, Macedonia, December 2008;
Danish Energy Authority, CDM Project Manual, May 2003.

For a 5,000 CERs/year CDM project, a registration average cost of 33,000 €/64,500 TND is estimated. Yearly, monitoring and verification costs are estimated at 8,000 €/15,630TND.

These numbers may differ significantly from project to project and only offer an order of magnitude of the costs involved.

4.3.6 Case of CDM project in 2012

The Clean Development Mechanism is a compliance instrument of the Kyoto Protocol, within the United Nations Framework Convention on Climate Change. The Kyoto agreement has a compliance period between 2008 and 2012, and the Protocol itself will end on 31, December, 2012. Because the United Nations have not yet agreed on the follow-up of the Kyoto agreement, this date has become a crucial date. If the countries do not agree on a follow-up, the market link with carbon credits will drastically change.

The European Union, however, through its Emissions Trading Scheme has unilaterally indicated that will continue to accept CERs as compliance units, at least until 2020. As EU-ETS is the largest compliance market in the world, the price of the carbon credits is very dependent on the demand coming from ETS installations. Therefore, through 2020, CERs coming from projects that are registered by 31 December 2012 will continue to be valid. Registration of a project after this date has a probability that CERs will have very limited demand.

Knowing that in 2010 the average CDM project took over 600 days to progress from validation to registration, this effectively means that the validation of a given CDM project documentation should start by the summer 2011. This in turn means that the preparation of the Project Design Document (PDD) would have been started in early 2011, in order to be ready for validation in due time.

4.3.7 Conclusions

Considering that:

- The estimated emission reduction of the project (alternative 2) is very small and uncertain;
- The average costs of a CDM project registration process;
- The average timeline to prepare and register a CDM project;
- The deadline of 31, December, 2012 for the registration of a CDM project that would be eligible for the EU-ETS through 2020 (assuming there is no international agreement to succeed to the Kyoto Protocol);

It is reasonable to consider that:

- The emission reductions involved in this project are very small, mainly due to the fact that the present methane emissions (the baseline scenario) are very limited;
- The costs involved in a) producing the information needed for the registration process, namely the Project Design Document, b) contracting a DOE (Designated Operational Entity) to the verification phase, and c) registering the project in the CDM Executive

Board are estimated to be in the same order of magnitude of the value of the CERs to be generated and placed in the market;

- There is an important risk that there is no time left to prepare a successful CDM registration process for this project and that the deadline of December 2012 could not be met;
- The Project for rehabilitation and upgrade of five wastewater treatment WwTPs located in Tunisia will not stand for an interesting CDM project, from a cost-benefit analysis perspective.

4.3.8 Results for other WwTP (Tabarka, Jendouba and Siliana WwTP)

The calculations for the estimation of annual emissions in the baseline scenario and in the project scenario for the other 3 WwTPs: Tabarka, Jendouba and Siliana, are presented in this part.

All the criteria, definitions and conclusions are as same as the cases of Medjez El-Bab and Béja WwTPs presented in chapters 4.3.2, 4.3.3 and 4.3.4. Only the specific variables and results are presented.

4.3.8.1 Estimation of annual emissions in the baseline scenario

4.3.8.1.1 Emissions on account of electricity used

Variables	Description	Value/Assumption		
		Tabarka	Jendouba	Siliana
$EC_{BL,k,y}$	Quantity of electricity that would be consumed by the baseline electricity consumption source “k” in year “y” (Information from the Survey)	399.35 MWh/year	611.05 MWh/year	399.31 MWh/year
$EF_{EL,k,y}$	Emission factor for electricity generation for source “k” in year “y”. This value is mentioned in the Tunisian “Nationally Appropriate Mitigation Action” published by the Ministry of Agriculture and Environment, 13 October 2010 (Table 2, pp 40) - *http://www.jiko-bmu.de/files/basisinformationen/application/pdf/nama_proposals_tunisia.pdf*	0.627 t CO_2e/MWh		

The CO2e emissions associated with electricity consumption are:

$\boldsymbol{BE_{power,y}}$ **=**

Tabarka:	**250 t CO_2e/year**
Jendouba:	**383 t CO_2e/year**
Siliana:	**250 t CO_2e/year**

4.3.8.1.2 Methane emissions from baseline waste water treatment systems

Variables	Description	Value/Assumption		
		Tabarka	Jendouba	Siliana
$Q_{ww,treatment,y}$	Volume of wastewater treated in baseline wastewater treatment system "i" in year "y" (Information from the Survey)	1,639,215 m^3	1,869,895 m^3	847,165 m^3
$COD_{inf low,i,y}$	Chemical oxygen demand of the wastewater inflow to the baseline treatment system "i" in year "y" (Information from the Survey)	0.000479 t/m^3	0.00131 t/m^3	0.00141 t/m^3
$\eta_{COD,BL,i}$	COD removal efficiency of the baseline treatment system "i"(1) (Calculations made using Information from the Survey)	0.72278	0.82885	0.83319
$MCF_{ww,treatment,BL,i}$	Methane correction factor for baseline wastewater treatment systems "i"	0.1 (2)		
$B_{o,ww}$	Methane producing capacity of the wastewater (Default value proposed by the Inter-Governmental Panel on Climate Change)	0.25 kg CH_4/kg COD		
UF_{BL}	Model correction factor to account for model uncertainties (Default value)	0.89		
GWP_{CH4}	Global Warming Potential for methane	21		

(1) Multiplied by a 0.89 uncertainty factor

(2) Tabled values of 0.0 for "Aerobic treatment, well managed" and 0.3 for "Aerobic treatment, unmanaged or overloaded" – a 0.1 value was assumed in accordance with the Survey, reflecting a system managed in a satisfactory way.

The total methane emissions coming from the baseline waste water sludge treatment system are:

$\boldsymbol{BE_{ww,treatment,y}}$ =

Tabarka: **265 t CO_2e/year**

Jendouba: **949 t CO_2e/year**

Siliana: **465 t CO_2e/year**

4.3.8.1.3 Methane emissions from baseline systems for sludge treatment

Variables	Description	Value/Assumption		
		Tabarka	Jendouba	Siliana
$S_{j,BL,y}$	Amount of dry matter in the sludge that would have been treated by the sludge treatment system "j" in the baseline scenario. In this case, the baseline wastewater treatment systems is different from the treatment system in the project scenario, so the monitored values of the amount of sludge generated during the crediting period will be used to estimate the amount of sludge generated in the baseline. (Calculations made from information coming from the Survey)	1,521.7 t	1,489.0 t	762.6 t
DOC_s	Degradable organic content of the untreated sludge generated in the year "y" (fraction, dry basis) (Default value for domestic sludge)	0.5		
$MCF_{s,treatment,BL,j}$	Methane correction factor for the baseline sludge treatment system "j". Tabled values of 0.0 for "Aerobic treatment, well managed" and 0.3 for "Aerobic treatment, poorly managed or overloaded" - a 0.1 value was assumed, reflecting a system managed in a satisfactory way.	0.1	0.1	0.1
UF_{BL}	Model correction factor to account for model uncertainties (Default value)	0.89		
DOC_F	Fraction of DOC dissimulated to biogas (Default value)	0.5		
F	Fraction of CH_4 in biogas (Default value)	0.5		

The methane emissions from the baseline sludge treatment systems are:

$\boldsymbol{BE_{treatment,s,y}}$ =

Tabarka:	**474 t CO_2e/year**
Jendouba:	**464 t CO_2e/year**
Siliana:	**238 t CO_2e/year**

4.3.8.1.4 Methane emissions on account of inefficiencies in the baseline wastewater treatment systems and presence of degradable organic carbon in the treated wastewater discharged into rivers/lakes

Variables	Description	Value/Assumption		
		Tabarka	Jendouba	Siliana
$Q_{ww,y}$	Volume of treated wastewater discharged in year "y" (Information coming from the Survey)	1,639,215 m^3	1,869,895 m^3	847,165 m^3
UF_{BL}	Model correction factor to account for model uncertainties (Default value)	0,89		
$COD_{ww,discharge,BL,y}$	Chemical oxygen demand of the treated wastewater discharged into sea, river or lake in the baseline situation in the year "y" (Information coming from the Survey)	0.00009 t/m^3	0.00009 t/m^3	0.00009 t/m^3
$MCF_{ww,BL,discharge}$	Methane correction factor based on discharged pathway in the baseline situation (e.g. into sea, river or lake) of the wastewater (fraction). Tabled value coming from the Inter-Governmental Panel on Climate Change	0.1		

The methane emissions related to the degradation of organic carbon in the rivers/lakes after discharge of treated water are:

$\boldsymbol{BE_{ww,discharge,y}}$ =

Tabarka: **68.9 t CO_2e/year**

Jendouba: **78.6 t CO_2e/year**

Siliana: **35.6 t CO_2e/year**

4.3.8.1.5 Methane emissions from the decay of the final sludge generated by the baseline treatment systems

Variables	Description	Value/Assumption		
		Tabarka	Jendouba	Siliana
$S_{final,BL,y}$	Amount of dry matter in the final sludge generated by the baseline wastewater treatment systems in the year "y" (Information from the Survey)	1,521.7 t	1,489.0 t	762.6 t
$MCF_{s,BL,final}$	Methane correction factor of the disposal site that receives the final sludge in the baseline situation . Value determined as per the procedures described in the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site", according to information coming from the Survey.	0.4	0.4	0.4

Variables	Description	Value/Assumption		
		Tabarka	Jendouba	Siliana
UF_{BL}	Model correction factor to account for model uncertainties (Default value)	0.89		

The methane emissions associated with the decay of the final sludge generated by the baseline treatment systems are:

$\boldsymbol{BE_{ww,discharge,y}}$ =

Tabarka: **1,896 t CO_2e/year**

Jendouba: **1,855 t CO_2e/year**

Siliana: **950 t CO_2e/year**

4.3.8.1.6 Total baseline annual emissions

The total baseline annual emissions of the Tabarka, Jendouba and Siliana WwTP are the sum of the different components mentioned and calculated above:

Parameters	Description	Emissions (tCO_2e/year)		
		Tabarka	Jendouba	Siliana
$BE_{power,y}$	Baseline emissions for the annual electricity consumption "y"	250	383	250
$BE_{ww,treatment,y}$	Baseline emissions from the wastewater treatment systems due to the project activity during the year "y"	265	949	465
$BE_{s,treatment,y}$	Baseline emissions from sludge treatment systems due to the annual activities of the project during the year "y"	474	464	238
$BE_{ww,discharge,y}$	Methane emissions from the baseline degradable organic carbon in treated wastewater discharged into the sea/river/lake during the year "y"	69	79	36
$BE_{s,final,y}$	Baseline emissions from anaerobic decomposition of produced final sludge during the year "y"	1,896	1,855	950
BE_y	**Total baseline emissions**	**2,955**	**3,730**	**1,939**

4.3.8.2 Estimation of annual emissions in the project scenario (Tabarka, Jendouba and Siliana WwTP)

4.3.8.2.1 Emissions from electric consumption

Variables	Description	Value/Assumption		
		Tabarka	Jendouba	Siliana
$EC_{PJ,j,y}$	Quantity of electricity consumed by the project electric consumption source “j” in year “y”. This is the electric consumption from the grid, according to the information sent by the Survey. The electricity generated on site from the combustion of biogas was assumed to be CO_2e free,	1,566 MWh/year	2,230 MWh/year	1,099 MWh/year
$EF_{EL,j,y}$	Emission factor for electric generation for source “j” in year “y” (See chapter 4.3.2)	0.627 t CO_2e/MWh		

The CO2e emissions associated with electric consumption are:

$PE_{power,y}$ =

Tabarka: **982 t CO_2e/year**

Jendouba: **1,398 t CO_2e/year**

Siliana: **689 t CO_2e/year**

4.3.8.2.2 Methane emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery

Variables	Description	Value/Assumption		
		Tabarka	Jendouba	Siliana
$Q_{ww,treatment,y}$	Volume of wastewater treated in project wastewater treatment system “i” in year “y” (Information from the Survey)	3,106,150 m^3	4,271,595 m^3	1,490,660 m^3
$COD_{inf low,i,y}$	Chemical oxygen demand of the wastewater inflow to the project activity treatment system “i” in year “y” (Information from the Survey)	0.000479 t/m^3	0.001310 t/m^3	0.001410 t/m^3
$\eta_{COD,PJ,i}$	COD removal efficiency of the project activity treatment system “i”, measured based on inflow COD and outflow COD in system “i”(1) (Calculations made using Information from the Survey)	0.765	0.811	0.817
$MCF_{ww,treatment,PJ,i}$	Methane correction factor for project wastewater treatment systems “i” (Aerobic treatment, well managed) - ” – a 0,0 value was assumed, reflecting a well-managed system in the future	0	0	0

Variables	Description	Value/Assumption		
		Tabarka	Jendouba	Siliana
$B_{o,ww}$	Methane producing capacity of the wastewater (Default value)	0.25 kg CH_4/kg COD		
UF_{PJ}	Model correction factor to account for model uncertainties (Default value)	1.12		
GWP_{CH4}	Global Warming Potential for methane (Default value)	21		

(1) Multiplied by a 0.89 uncertainty factor

The emissions from this activity are nil:

***PE**$_{ww,treatment,y}$* =

Tabarka: **0 t CO_2e/year**

Jendouba: **0 t CO_2e/year**

Siliana: **0 t CO_2e/year**

4.3.8.2.3 Methane emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery in the project situation

Variables	Description	Value/Assumption		
		Tabarka	Jendouba	Siliana
$S_{j,PJ,y}$	Amount of dry matter in the sludge treated by the sludge treatment system "j" in the project scenario in year "y" (Calculations made from information coming from the project team)	1,698 t	3,231 t	1,266 t
DOC_s	Degradable organic content of the untreated sludge generated in the year "y" (fraction, dry basis) (Default value for domestic sludge)	0.5		
$MCF_{s,treatment,j}$	Methane correction factor for the project sludge treatment system "j". Tabled values of 0.0 for "Aerobic treatment, well managed" and 0.3 for "Aerobic treatment, poorly managed or overloaded" – a 0.0 value was assumed, reflecting a well-managed system.	0	0	0
UF_{PJ}	Model correction factor to account for model uncertainties (Default value)	1.12		
DOC_F	Fraction of DOC dissimilated to biogas (Default value)	0.5		
F	Fraction of CH_4 in biogas (Default value)	0.5		

The methane emissions from the project sludge treatment systems are:

$PE_{treatment,s,y}$ =

Tabarka: **0 t CO_2e/year**

Jendouba: **0 t CO_2e/year**

Siliana: **0 t CO_2e/year**

4.3.8.2.4 Methane emissions on account of inefficiency of the project activity wastewater treatment systems and presence of degradable organic carbon in treated wastewater

Variables	Description	Value/Assumption		
		Tabarka	Jendouba	Siliana
$Q_{ww,y}$	Volume of treated wastewater discharged in year "y" (Information coming from the Survey)	1,604,361 m^3	1,794,471 m^3	812,344 m^3
UF_{PJ}	Model correction factor to account for model uncertainties (Default value)	1.12		
$COD_{ww,discharge,PJ,y}$	Chemical oxygen demand of the treated wastewater discharged into sea, river or lake in the project scenario in the year "y" (Information coming from the Survey)	0.00009 t/m^3	0.00009 t/m^3	0.00009 t/m^3
$MCF_{ww,PJ,discharge}$	Methane correction factor based on discharged pathway of the wastewater in the project scenario (e.g. into sea, river or lake). Tabled value coming from the Inter-Governmental Panel on Climate Change	0.1		

The emissions of methane related to the degradation of organic carbon in the natural water systems, after discharge are:

$PE_{ww,discharge,y}$ =

Tabarka: **85 t CO_2e/year**

Jendouba: **95 t CO_2e/year**

Siliana: **43 t CO_2e/year**

4.3.8.2.5 Methane emissions from the decay of the final sludge generated by the project treatment systems

Variables	Description	Value/Assumption		
		Tabarka	Jendouba	Siliana
$S_{final,PJ,y}$	Amount of dry matter in the final sludge generated by the project wastewater treatment systems in the year "y" (Information from the Survey)	1,070 t	2,036 t	840 t
$MCF_{s,PJ,final}$	Methane correction factor of the disposal site that receives the final sludge in the project situation, estimated as per the procedures described in the "Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site" (Unmanaged-shallow solid waste disposal site) *	0.4	0.4	0.4
UF_{PJ}	Model correction factor to account for model uncertainties (Default value)	1.12		

The methane emissions associated with the final disposal of the treated sludge are:

$PE_{s,final,y}$ =

Tabarka: **1,678 t CO_2e/year**

Jendouba: **3,192 t CO_2e/year**

Siliana: **1,317 t CO_2e/year**

4.3.8.2.6 Methane fugitive emissions due to inefficiencies in capture systems

Variables	Description	Value/Assumption		
		Tabarka	Jendouba	Siliana
$S_{l,PJ,y}$	Amount of sludge treated in the project sludge treatment system "l" equipped with a biogas recovery system (on a dry basis) in the year "y" (Information from the Survey)	1,698 t	3,231 t	1,266 t
$MCF_{s,treatment,PJ,l}$	Methane correction factor for the wastewater treatment system equipped with biogas recovery equipment. Tabled values of 0.0 for "Aerobic treatment, well managed" and 0.3 for "Aerobic treatment, poorly managed or overloaded" – a 0.0 value was assumed, reflecting a well-managed system.	0.0	0.0	0.0
UF_{PJ}	Model correction factor to account for model uncertainties (Default value)	1.12		

The emissions of the project scenario due to fugitive emissions related to inefficiencies in capture systems are nil :

***PE**$_{fugitive,y}$* =

Tabarka: **0 t CO_2e/year**

Jendouba: **0 t CO_2e/year**

Siliana: **0 t CO_2e/year**

4.3.8.2.7 Methane emissions due to incomplete flaring

Not applicable to this project.

4.3.8.2.8 Methane emissions from biomass stored under anaerobic conditions which would not have occurred in the baseline situation

Not applicable to this project.

4.3.8.2.9 Summary table of total emissions

The total annual emissions from the project activity of the Tabarka, Jendouba and Siliana WwTP are the sum of the different components mentioned and calculated above. The emissions are the following:

Parameters	Description	Emissions (tCO_2e/year)		
		Tabarka	Jendouba	Siliana
$PE_{power,y}$	Emissions from electricity consumption in year "y"	982	1,398	689
$PE_{ww,treatment,y}$	Emissions from wastewater treatment systems affected by the project activity, and not equipped with biogas recovery, in year "y"	0	0	0
$PE_{s,treatment,y}$	Emissions from sludge treatment systems affected by the project activity, and not equipped with biogas recovery, in year "y"	0	0	0
$PE_{ww,discharge,y}$	Emissions from degradable organic carbon in treated wastewater in year "y"	85	95	43
$PE_{s,final,y}$	Emissions from anaerobic decay of the final sludge produced in year "y"	1,678	3,192	1,317
$PE_{fugitive,y}$	Emissions from biogas release in capture systems in year "y"	0	0	0
$PE_{flaring,y}$	Emissions due to incomplete flaring in year "y"	0	0	0
$PE_{biomass,y}$	Emissions from biomass stored under anaerobic conditions	0	0	0
PE_y	**Total project activity emissions**	**2,744**	**4,686**	**2,049**

4.3.8.3 Assessment of annual reduction of emissions

4.3.8.3.1 Tabarka WwTP

Table 4.3-3: Reduction of Emissions (Tabarka WwTP)

Year	Baseline Emissions (tCO_2e/year)	Project Emissions (tCO_2e/year)	Leakage (tCO_2e/year)	Reduction of Emissions (tCO_2e/year)
2012	2,955	2,128	0	827
2013	2,955	2,232	0	723
2014	2,955	2,334	0	621
2015	2,955	2,437	0	518
2016	2,955	2,539	0	416
2017	2,955	2,642	0	313
2018	2,955	2,744	0	211
Total	**20,685**	**17,056**	**0**	**3,629**

4.3.8.3.2 Jendouba WwTP

Table 4.3-4: Reduction of Emissions (Jendouba WwTP)

Year	Baseline Emissions (tCO_2e/year)	Project Emissions (tCO_2e/year)	Leakage (tCO_2e/year)	Reduction of Emissions (tCO_2e/year)
2012	3,730	3,449	0	281
2013	3,730	3,656	0	74
2014	3,730	3,861	0	-131
2015	3,730	4,068	0	-338
2016	3,730	4,273	0	-543
2017	3,730	4,480	0	-750
2018	3,730	4,686	0	-956
Total	**26.110**	**28.473**	**0**	**-2,363**

4.3.8.3.3 Siliana WwTP

Table 4.3-5: Reduction of Emissions (Siliana WwTP)

Year	Baseline Emissions (tCO_2e/year)	Project Emissions (tCO_2e/year)	Leakage (tCO_2e/year)	Reduction of Emissions (tCO_2e/year)
2012	1,939	1,721	0	218
2013	1,939	1,776	0	163
2014	1,939	1,831	0	108
2015	1,939	1,886	0	53
2016	1,939	1,939	0	0
2017	1,939	1,994	0	-55
2018	1,939	2,049	0	-110
Total	**13,573**	**13,196**	**0**	**377**

CHAPTER V

PROJECT IMPLEMENTATION

CHAPTER V. PROJECT IMPLEMENTATION

5.1 COST ESTIMATION

5.1.1 General considerations

The project cost is based on the price as of June 2011. Base costs are estimated in the range of precision of a Feasibility Study (F/S) or a Preliminary Design.

The exchange rates applied are:

- 1 EUR = 1.96 TND
- 1 TND = 58.9 JPY
- 1 EUR = 115.4 JPY

Quantity estimates for various items were made during the planning stage. A survey of the unit price for various items was also undertaken. The quantities and unit prices were then used to determine the construction and O&M costs.

The source of the data for the various cost categories is listed below:

- Personnel expenditure : Tunisian data provided by ONAS
- Mechanical and electrical equipment : European market price
- Piping materials and other materials : Tunisian data provided by ONAS
- Electric power and chemical : Tunisian data provided by ONAS

5.1.2 Eligible Portion for Japanese ODA Loan

5.1.2.1 Cost Estimation for WwTP

For this study, following methodology is applied and the cost estimation of Waste Water Treatment Plant (WwTP) is generally conducted by using:

- Main equipment (F/C basis) : Equipment list basis
- Other material (F/C basis) : Flow Sheet and layout basis
- Civil work (L/C basis) : ONAS construction data basis with equipment list, Flow Sheet and layout
- Instrumentation (F/C basis) : Similar facility ratio basis of I/O numbers
- Electrical work (F/C basis) : Single line diagram, motor numbers and layout basis

(F/C: Foreign currency, L/C: Local currency)

5.1.2.1.1 Items included in the Base Cost for WwTP

The base cost includes design, procurement and construction of WwTPs with initial loading adsorbents/chemicals and 2 years of spare parts.

The base cost covers the following tasks:

- Equipment, materials and construction works
- Instrument and control system
- Electrical facility including main-sub station
- Civil work and foundations
- Building
- Shipment of equipment and transportation of materials

5.1.2.1.2 Base Cost of WwTP for each Solution

Table 5.1-1 shows the base cost of each Solution for WwTP (2011 values):

Table 5.1-1: Base Cost of each Solution (WwTP)

Béja		Solution 1	Solution 2	Solution 3
Civil Works(TND)		2,326,879	3,422,392	2,307,241
Equipment and Electrical(TND)		5,883,472	9,811,845	5,540,939
Total	**(TND)**	**8,231,851**	**13,234,237**	**7,848,180**
	(Million JPY)	**485**	**779**	**462**
Jendouba		Solution 1	Solution 2	Solution 3
Civil Works(TND)		1,918,721	2,973,907	2,943,992
Equipment and Electrical(TND)		4,685,661	8,055,684	5,795,291
Total	**(TND)**	**6,604,382**	**11,029,592**	**8,739,283**
	(Million JPY)	**389**	**650**	**514**
Medjez el Bab		Solution 1	Solution 2	Solution 3
Civil Works(TND)		1,031,921	1,634,061	1,613,223
Equipment and Electrical(TND)		3,089,487	5,457,232	4,010,507
Total	**(TND)**	**4,121,408**	**7,091,293**	**5,623,729**
	(Million JPY)	**243**	**418**	**331**
Tabarka		Solution 1	Solution 2	Solution 3
Civil Works(TND)		1,708,172	2,185,946	2,171,621
Equipment and Electrical(TND)		3,199,741	5,685,285	4,158,181
Total	**(TND)**	**4,907,913**	**7,871,231**	**6,329,802**
	(Million JPY)	**289**	**464**	**373**
Siliana		Solution 1	Solution 2	Solution 3
Civil Works(TND)		1,058,431	1,773,057	1,760,280
Equipment and Electrical(TND)		2,105,601	4,444,947	3,086,948
Total	**(TND)**	**3,164,032**	**6,218,004**	**4,847,228**
	(Million JPY)	**186**	**366**	**286**

5.1.2.1.3 Base cost for each WwTP (Selected Solution)

As a result of the survey, ONAS and the Survey team agreed to select following solution for each WwTP. The Table 5.1-2 shows the base cost for each WwTP (2011 values):

Table 5.1-2: Base cost for each WwTP (Selected Solution)

Béja (Solution3)		
Civil Works(TND)		2,307,241
Equipment and Electrical(TND)		5,540,939
Total	**(TND)**	**7,848,180**
	(Million JPY)	**462**
Jendouba (Solution 1)		
Civil Works(TND)		1,918,721
Equipment and Electrical(TND)		4,685,661
Total	**(TND)**	**6,604,382**
	(Million JPY)	**389**
Medjez el Bab (Solution 1)		
Civil Works(TND)		1,031,921
Equipment and Electrical(TND)		3,089,487
Total	**(TND)**	**4,121,408**
	(Million JPY)	**243**
Tabarka (Solution 1)		
Civil Works(TND)		1,708,172
Equipment and Electrical(TND)		3,199,741
Total	**(TND)**	**4,907,913**
	(Million JPY)	**289**
Siliana (Solution 1)		
Civil Works(TND)		1,058,431
Equipment and Electrical(TND)		2,105,601
Total	**(TND)**	**3,164,032**
	(Million JPY)	**186**

5.1.2.2 Cost Estimation for Sewage Networks and Pumping stations

For the Survey, following methodology is applied and the cost estimation of Sewage Networks and Pumping station is generally conducted by using:

- Pipe works (L/C basis) : Size, length, material and under geological conditions
- Equipment (F/C basis) : Pump size , head and kW basis
- Civil work (L/C basis) : Capacity , Pump number , Capacity of access to electricity
- Type of Intervention : Rehabilitation or Extension

5.1.2.2.1 Items included in the Base cost for Sewage Networks

The base cost includes design, procurement and construction of Sewage Networks with 2 years of spare parts.

The base cost covers the following items:

- Materials (Trunk, Main and Branch) and construction works
- Civil work and foundations
- Temporary works
- Transportation of materials
- Insulation and painting

5.1.2.2.2 Items included in the Base cost for Pumping Station

The base cost includes design, procurement and construction of Pumping Station with 2 years of spare parts.

The base cost covers the following items:

- Equipment, materials and construction works
- Instrument and control system
- Electrical facility including main-substation
- Civil work and foundations
- Building, fence, gate and lighting for pumping station
- Temporary works
- Shipment of equipment and transportation of materials

5.1.2.3 Selection of Interventions (Networks and Pumping stations) for the Project

5.1.2.3.1 General considerations for Establishment of Shortlist

Prior to the establishment of shortlist of interventions, following conditions are considered:

- Basically, the criteria and Types of intervention (A, B and C) established in the Chapter II shall be applied in order to identify the priority of each intervention;
- Three (3) sets (cases) of interventions are simulated considering the Type of operation and annual amount of past Japanese ODA financing to Tunisia;
- All interventions are grouped commune by commune and the shortlist is established at commune basis, because interventions in the same commune are associated each other and they function as an unique system;
- Several communes, which interventions on sewage network are already financed, were excluded;
- In addition to above, the interventions classified as Type C which cost exceeds 1,000 TND/capita are re-classified individually considering economic efficiency;
- In the end, the interventions of the five (5) communes in the Sfax governorate connected to the WwTP Sfax Sud (Sfax Ville, Sfax Sud, Gremda, El Ain and Tyna) are excluded from the shortlist by JICA. JICA considered the fact that Sfax Sud WwTP has already been rehabilitated in 2006 under finance by JICA and that it has problematic issues on its operation since short term after the rehabilitation. Thus JICA considered that the solution for the WwTP shall be studied prior to the decision for financing to the interventions connected to the WwTP.

5.1.2.3.2 Simulations for 3 Cases

The shortlist is established by simulating the following 3 cases:

a) Case 1

The case includes the communes which networks are connected to the 5 WwTP of the project (Béja, Medjez el Bab, Jendouba, Tabarka and Siliana) and the communes which consist of the Type A interventions, with serious environmental problems to be improved. Selected communes also include some Type B interventions (rehabilitation) and Type C interventions (extensions).

b) Case 2

The case includes the communes which consist of the Type B interventions (rehabilitation). Each commune will be classified according to economic efficiency with prioritization of cost per capita. Selected communes also include some Type C interventions (extensions).

c) Case 3

The case includes the communes which consist of only Type C interventions (extensions).

Table 5.1-3: Number of selected communes per governorate in each case

Governorate	Case 1	Case 2	Case 3
Béja	4	6	6
Bizerte	1	2	2
Jendouba	3	4	5
Kasserine	0	2	2
Kébili	2	3	7
Kef	1	2	2
Sfax	0	4	7
Sidi Bouzid	1	1	1
Siliana	2	3	3
Zaghouan	2	3	3
TOTAL	**14**	**28**	**35**

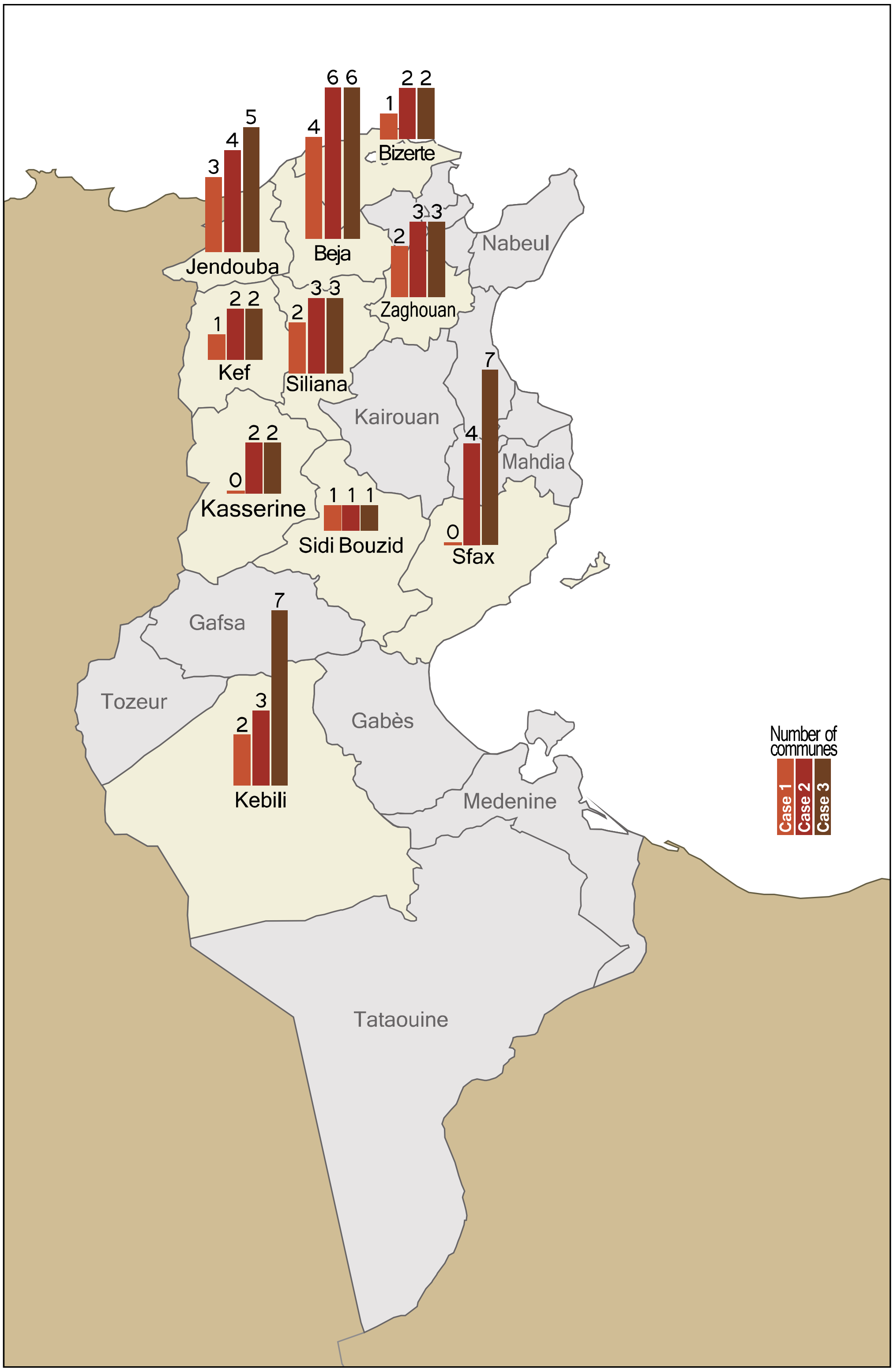


Figure 5.1-1: Number of selected communes per governorate in each case

<u>Table 5.1-4: List of subprojects for each case</u>

Case	Type	Governo-rate	Commune	Commune code	A Investment cost (Type A) (TND)	B Investment cost (Type B) (TND)	C Investment cost (Type C) (TND)	A Population served (Type A) (hab)	B Population served (Type B) (hab)	C Population served (Type C) (hab)	A Cost par capita (Type A) (TND/hab)	B Cost par capita (Type B) (TND/hab)	C Cost par capita (Type C) (TND/hab)	Civil works costs (TND)	Equipment cost (TND)	Total cost (TND)	Total population served (hab)	Average cost par capita (TND)	Total length of intervention on network (m)	Number of Pumping Station (Rh)	Number of Pumping Station (Ex)	Total Number of Pumping Station (Rh +Ex)	Necessary Land Acquisition L/A (m2)	Remarks
1	STEP	Beja	Medjez el Bab	Med	0	873,148	0	0	7,450	0	0	117	0	844,398	28,750	873,148	7,450	117	3,713	1	0	1	0	
		Jendouba	Tabarka	Tab	0	1,434,428	654,896	0	6,110	821	0	235	798	2,060,575	28,750	2,089,325	6,931	301	12,718	1	0	1	0	w/o Cité Malloula, JEN-Tab-RS-Ex-2, JEN-Tab-SP-EX-1, JEN-Tab-SP-EX-2
		Beja	Beja	Bej	170,304	3,957,440	0	560	12,319	0	304	321	0	4,127,743	0	4,127,743	12,879	321	17,008	0	0	0	0	
		Jendouba	Jendouba	Jen	0	7,274,190	594,941	0	28,923	1,077	0	252	552	7,310,011	559,119	7,869,131	30,000	262	26,539	4	1	5	100	including transfer pipe
		Siliana	Siliana	Sil	0	1,139,213	0	0	2,773	0	0	411	0	1,139,213	0	1,139,213	2,773	411	5,159	0	0	0	0	
	A+B+C	Sidi Bouzid	Sidi Bouzid	Sid	1,448,692	2,336,173	870,115	8,460	24,310	2,030	171	96	429	4,597,480	57,500	4,654,980	34,800	134	26,243	0	1	1	100	
		Siliana	Krib	Kri	2,484,544	0	0	8,000	0	0	311	0	0	2,484,544	0	2,484,544	8,000	311	12,171	0	0	0	0	
		Kebili	Kebili	Keb	443,092	1,681,944	476,928	4,000	4,000	1,000	111	420	477	2,345,156	256,807	2,601,964	9,000	289	10,375	2	1	3	100	
		Bizerte	Raf Raf	Raf	1,774,199	0	0	5,000	0	0	355	0	0	1,548,754	225,445	1,774,199	5,000	355	6,750	0	2	2	800	
		Kef	Tajerouine	Taj	216,775	2,059,604	159,965	225	5,600	400	963	368	400	2,378,844	57,500	2,436,344	6,225	391	10,990	1	1	2	100	
		Zaghouan	Hammam Zriba	Ham	925,631	5,900,018	0	1	10,700	0	925,631	551	0	6,377,711	447,938	6,825,649	10,701	638	24,500	0	1	1	400	special for spa
		Beja	Nefza	Nef	225,130	28,118	84,157	260	125	215	866	225	391	291,404	46,000	337,404	600	562	1,572	0	1	1	100	w/o Cité Erriadh, Cité Saada, Cité Ezzouhour, BEJ-Nef-RS-Ex-2, BEJ-Nef-RS-Ex-3, BEJ-Nef-RS-Ex-5, BEJ-Nef-RS-Ex-6, BEJ-Nef-RS-Ex-8, BEJ-Nef-RS-Ex-9, BEJ-Nef-SP-Ex-2
		Zaghouan	Zaghouan	Zag	117,760	5,367,678	0	50	12,225	0	2,355	439	0	5,393,280	92,158	5,485,438	12,275	447	23,745	0	2	2	500	w/o Cité Hanaya, ZAG-Zag-RS-EX-2, ZAG-Zag-SP-EX-3
		Jendouba	Ghardimaou	Gha	246,977	965,200	517,041	548	1,466	458	451	658	1,129	1,671,718	57,500	1,729,218	2,472	700	8,695	0	1	1	100	
		Beja	Testour	Tes	227,861	640,734	395,871	240	1,072	462	949	598	857	1,218,466	46,000	1,264,466	1,774	713	5,320	0	1	1	100	
		Kebili	Jemna	Jem	3,345,872	0	0	4,000	0	0	836	0	0	3,291,946	53,926	3,345,872	4,000	836	22,850	0	1	1	400	
2	B+C	Kef	Kef	Kef	0	2,210,947	579,025	0	44,191	1,000	0	50	579	2,582,889	207,082	2,789,972	45,191	62	10,600	2	1	3	100	
		Kebili	Douz	Dou	0	793,908	1,082,685	0	25,000	2,000	0	32	541	1,819,093	57,500	1,876,593	27,000	70	8,274	0	1	1	100	
		Bizerte	Alia	Ali	0	450,743	0	0	3,500	0	0	129	0	450,743	0	450,743	3,500	129	1,950	0	0	0	0	
		Kasserine	Kasserine	Kas	0	7,088,039	1,756,298	0	59,760	4,900	0	119	358	8,844,337	0	8,844,337	64,660	137	39,176	0	0	0	0	including transfer pipe
		Sfax	Mahres	Mah	0	2,086,774	1,824,245	0	18,325	2,750	0	114	663	3,819,019	92,000	3,911,019	21,075	186	21,541	1	1	2	100	
		Zaghouan	El Fahs	Fah	0	4,842,535	0	0	17,700	0	0	274	0	4,842,535	0	4,842,535	17,700	274	18,450	0	0	0	0	
		Sfax	Sakiet Ezzit	Sae	0	874,506	3,338,965	0	7,795	6,024	0	112	554	4,213,471	0	4,213,471	13,819	305	27,575	0	0	0	0	
		Sfax	Chihia	Chi	0	988,625	2,577,811	0	6,529	3,963	0	151	651	3,566,436	0	3,566,436	10,491	340	23,153	0	0	0	0	
		Beja	Maagoula	Maa	0	125,051	0	0	300	0	0	417	0	67,551	57,500	125,051	300	417	30	0	1	1	100	
		Kasserine	Sbeitla	Sbe	0	1,012,299	315,215	0	2,950	1,025	0	343	308	1,327,514	0	1,327,514	3,975	334	6,725	0	0	0	0	
		Siliana	Bouarada	Bou	0	1,068,523	0	0	2,569	0	0	416	0	1,022,523	46,000	1,068,523	2,569	416	5,860	0	1	1	100	
		Sfax	Sakiet Eddaier	Sak	0	2,664,276	17,152,112	0	13,340	29,565	0	200	580	19,816,388	0	19,816,388	42,905	462	129,367	0	0	0	0	
		Beja	Teboursouk	Teb	0	3,968,560	261,476	0	5,688	300	0	698	872	4,184,036	46,000	4,230,036	5,988	706	16,032	0	1	1	100	
		Jendouba	Fernana	Fer	0	687,651	527,204	0	1,142	425	0	602	1,240	1,157,354	57,500	1,214,854	1,567	775	6,295	0	1	1	100	
3	C	Kebili	El Golaa	Gol	0	0	387,109	0	0	750	0	0	516	387,109	0	387,109	750	516	3,065	0	0	0	0	
		Sfax	Agareb	Aga	0	0	1,381,400	0	0	3,000	0	0	460	1,323,900	57,500	1,381,400	3,000	460	8,095	0	1	1	100	
		Kebili	Kebili Nord	Ken	0	0	6,814,930	0	0	14,080	0	0	484	6,564,239	250,691	6,814,930	14,080	484	39,368	0	4	4	700	
		Kebili	Kebili Sud	Kes	0	0	3,633,540	0	0	7,500	0	0	484	3,501,948	131,592	3,633,540	7,500	484	22,945	0	2	2	200	
		Jendouba	Bousselem	Bss	0	0	629,375	0	0	724	0	0	869	571,875	57,500	629,375	724	869	4,033	0	1	1	100	
		Sfax	Jebeniana	Jeb	0	0	1,785,950	0	0	2,350	0	0	760	1,785,950	0	1,785,950	2,350	760	10,000	0	0	0	0	
		Kebili	Douz Sud	Dos	0	0	2,230,196	0	0	3,000	0	0	743	2,172,696	57,500	2,230,196	3,000	743	17,319	0	1	1	100	
		Sfax	Hencha	Hen	0	0	1,938,900	0	0	2,850	0	0	680	1,938,900	0	1,938,900	2,850	680	12,000	0	0	0	0	
		Beja	Nefza	Nef	0	0	223,112	0	0	90	0	0	2,479	177,112	46,000	223,112	90	2,479	1,211	0	1	1	100	Cité Erriadh, Cité Saada, Cité Ezzouhour, BEJ-Nef-RS-Ex-2, BEJ-Nef-RS-Ex-3, BEJ-Nef-RS-Ex-9, BEJ-Nef-SP-Ex-2
		Zaghouan	Zaghouan	Zag	0	0	375,820	0	0	200	0	0	1,879	318,320	57,500	375,820	200	1,879	1,630	0	1	1	100	Cité Hanaya, ZAG-Zag-RS-EX-2, ZAG-Zag-SP-EX-3
		Jendouba	Tabarka	Tab	0	0	1,567,266	0	0	314	0	0	4,991	1,452,266	115,000	1,567,266	314	4,991	9,413	0	2	2	200	Cité Malloula, JEN-Tab-RS-Ex-2, JEN-Tab-SP-EX-1, JEN-Tab-SP-EX-2
Communes connected to the WwTP Sfax Sud	B+C	Sfax	Sfax Ville	Sfv	0	21,220,910	3,624,869	0	217,990	6,700	0	97	541	24,487,251	358,528	24,845,779	224,690	111	102,332	2	1	3	100	including transfer pipe
		Sfax	Sfax Sud	Sfs	0	4,061,923	4,992,539	0	10,915	4,655	0	372	1,073	8,996,962	57,500	9,054,462	15,570	582	50,551	0	1	1	100	
	C	Sfax	Gremda	Gre	0	0	12,570,236	0	0	20,705	0	0	607	12,570,236	0	12,570,236	20,705	607	86,272	0	0	0	0	
		Sfax	El Ain	Ain	0	0	6,538,526	0	0	10,680	0	0	612	6,538,526	0	6,538,526	10,680	612	44,890	0	0	0	0	
		Sfax	Tyna	Tyn	0	0	3,138,770	0	0	4,220	0	0	744	3,081,270	57,500	3,138,770	4,220	744	19,427	0	1	1	100	
Communes excluded from the Project (Financed by other donors)	A+B+C	Bizerte	Tinja	Tin	458,274	1,287,031	733,795	2,000	9,900	2,100	229	130	349	2,161,197	317,903	2,479,100	14,000	177	10,740	1	2	3	800	
	B+C	Bizerte	Zarzouna	Zar	0	3,006,958	0	0	21,300	0	0	141	0	2,114,097	892,861	3,006,958	21,300	141	7,890	3	0	3	0	comprenant conduite de transfert
		Bizerte	Mateur	Mat	0	924,389	0	0	15,000	0	0	62	0	661,989	262,400	924,389	15,000	62	2,800	2	0	2	0	
		Bizerte	Menzel Jamil	Jam	0	2,288,172	0	0	30,000	0	0	76	0	1,888,886	399,286	2,288,172	30,000	76	6,830	1	1	2	0	
		Bizerte	Menzel Abderahmen	Abd	0	1,464,951	0	0	18,700	0	0	78	0	1,170,252	294,699	1,464,951	18,700	78	4,410	1	0	1	0	
		Bizerte	Bizerte	Biz	0	5,919,763	1,164,375	0	34,500	2,500	0	172	466	7,026,638	57,500	7,084,138	37,000	191	29,420	0	1	1	100	>2,500 TND/Log (>500 TND/hab)
		Bizerte	Menzel Bourguiba	Men	0	5,691,293	496,680	0	28,500	400	0	200	1,242	6,141,815	46,158	6,187,973	28,900	214	24,250	0	1	1	400	>2,500 TND/Log (>500 TND/hab)
		Kef	Dahmani	Dah	0	1,283,782	43,108	0	4,515	125	0	284	345	1,312,515	14,375	1,326,890	4,640	286	5,524	1	0	1	0	
	C	Kebili	Souk Lahad	Sou	0	0	7,081,368	0	0	15,000	0	0	472	6,751,219	330,149	7,081,368	15,000	472	34,990	0	5	5	800	
		Kasserine	Thala	Tel	0	0	2,858,613	0	0	5,950	0	0	480	2,743,613	115,000	2,858,613	5,950	480	12,665	0	2	2	200	
		Kasserine	Feriana	Fei	0	0	3,490,627	0	0	4,950	0	0	705	3,375,627	115,000	3,490,627	4,950	705	22,962	0	2	2	200	
Unnecessary Interventions	D	Beja	Nefza	Nef	0	0	0	0	0	0	0	0	0	293,825	0	293,825	675	435	1,612	0	0	0	0	BEJ-Nef-RS-Ex-5, BEJ-Nef-RS-Ex-6, BEJ-Nef-RS-Ex-8
Total (ONAS F/S)					0	0	0	0	0	0	0	0	0	216,305,365	6,613,118	222,918,483	922,458	242	1,130,021	23	50	73	7,900	

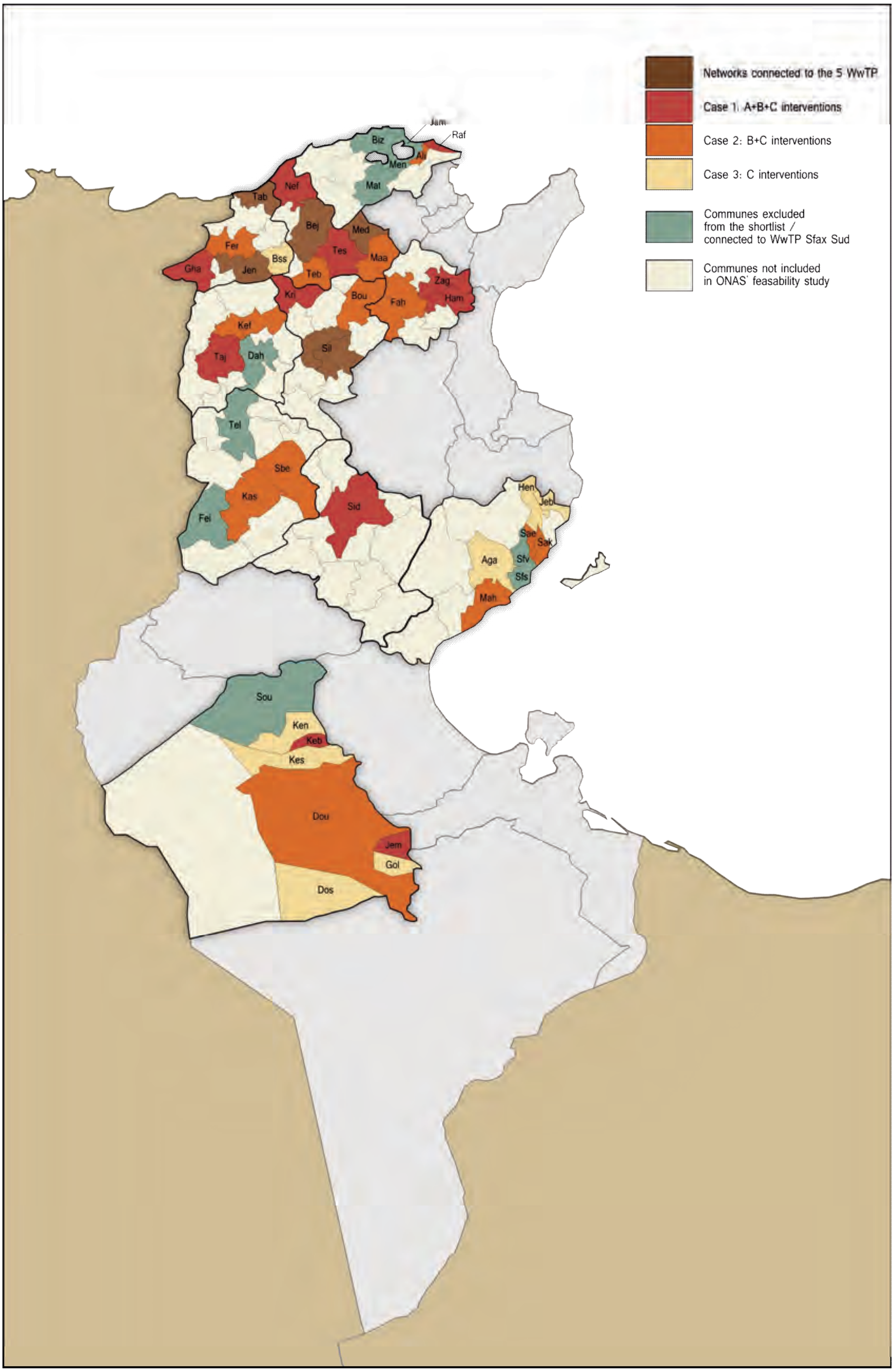


Figure 5.1-2: Geographical distribution of shortlisted communes

5.1.2.3.3 Project Summary for Networks and Pumping Stations in each Case

Following table presents a project summary including all interventions on networks and pumping stations, their length and the number of pumping stations in each case.

Table 5.1-5: Project Summary in each Case

Case	Total Length of Network (m)	Number of Pumping Stations	Total cost for Civil works (TND)	Total cost for Equipment (TND)	Total Cost (TND)	Total Cost (M JPY)
Case 1	218, 349	22	47,081,244	1,957,394	49,038,638	2,888
Case 2	533,377	32	104,795,134	2,520,976	107,316,110	6,321
Case 3	662,456	45	124,989,448	3,294,260	128,283,708	7,556

5.1.2.4 Cost Estimation for Consulting Service

5.1.2.4.1 General Condition for Consulting Services

Some consulting services during execution period will be required for executing both WwTPs and Networks.

For WwTPs, considering advanced facilities which will be installed into each WwTP, experienced international consultants and local consultants will be both required. Thus, in order to ensure the required performance, the consultants shall be selected through shortlist process.

5.1.2.4.2 General Terms of References for Consulting Services

The general terms of references for consulting services related to each component is summarized as follows:

- WwTP
  - To Prepare the Detailed Design (DD), tender documents for bidding of contractors and Environmental Impact Assessments (EIA) for 5 WwTPs;
  - To supervise the execution plan prepared by contractor and construction work, and to check the performance of the WwTP;
  - To provide quality inspection after completion of construction;
  - To assist the start-up of each WwTP.
- Networks and Pumping Stations
  - To Prepare the Detailed Design (DD) and tender documents for bidding of contractors.

5.1.2.5 Men-Month required for the consulting services

The number of Men-Month required for the consulting services of Detailed Design, preparation of Tender Documents and EIA is calculated considering a fixed number of 110 M/M for the WwTP and 21 M/M/Lot for the Networks basically.

5.1.2.5.1 WwTP

The distribution of Men-Months for experts on WWTP is as follows.

Table 5.1-6: Consulting services for Detail Design of WwTP

Detail Design: International Consultant		
Title	Initial Scope of Works	M/M
Project Manager (WwTP Engineer)	Planning of WwTP, Estimation, Construction Planning	3.0×5WwTP = 15
Process Engineer	Examination and design of treatment process	3.0×5WwTP = 15
Civil Engineer	Examination and design of civil works	3.0×5WwTP = 15
Equipment/ Instrumentation Expert	Examination and design of mechanical and electric equipment	3.0×5WwTP = 15

Table 5.1-7: Consulting services for EIA of WwTP

EIA: International Consultant		
Title	Initial Scope of Works	M/M
Environmental Considerations Specialist	Assessment of environmental impacts and preparation of EIA report	3.0×5WwTP = 15
Social Considerations Specialist	Assessment of social impacts and preparation of EIA report	2.0×5WwTP = 10

Table 5.1-8: Consulting services for Tender Document of WwTP

Tender Documents: International Consultant		
Title	Initial Scope of Works	M/M
Project Manager (WwTP Engineer)	Preparation of general and administrative clause for the tender	1.0×5WwTP = 5
Civil Engineer	Preparation of technical clause for civil works	2.0×5WwTP = 10
Equipment/ Instrumentation Expert	Preparation of technical clause for equipment	2.0×5WwTP = 10

Table 5.1-9: Consulting services of Supervision (International) of works of WwTP

Supervision: International Consultant		
Title	Initial Scope of Works	M/M
Project Manager (WwTP Engineer)	Technical supervision of general construction works	8.0
Equipment/ Instrumentation Expert	Technical supervision of installation of machineries	8.0
Electrical Engineer	Technical supervision of electric works	2.0

Table 5.1-10: Consulting services of Supervision (Local) of works of WwTP

Supervision: Local Consultant		
Title	Initial Scope of Works	M/M
Civil Engineer	Technical supervision of civil works	4.0
Environment and Social Considerations	Monitoring of the environmental management plan (EMP)	3.0

5.1.2.5.2 Networks and Pumping Station

The lots shall be divided governorate by governorate as detailed in the Table 5.1-12 and a consultant shall be procured for each lot. The distribution of Men-Months for experts on Networks and Pumping Stations is as follows.

Table 5.1-11: Consulting services of Detail Design and Tender Document of Networks and Pumping Stations

Detailed Design and Tender Documents: Local Consultant		
Title	Initial Scope of Works	M/M
Project Manager (Sewage Planning)	Planning of sewage system and preparation of general and administrative clause for the tender	12.0/Lot
Civil Engineer (Sewage)	Examination , design and preparation of technical clause for pipe and civil works	6.0/Lot
Equipment/ Instrumentation Expert	Examination, design and preparation of technical clause for equipment of pumping station, etc.	2.0/Lot
Cost Estimation	Estimation of construction cost and preparation of bill of quantities	1.0/Lot

Regarding the estimation of consulting services M/M for networks and pumping stations, although 21.0 M/M is applied on per lot basically, total length of network shall be also considered as an indicator of variation.

The distribution of Men-Months for each case in all the governorates is presented in the following table.

Table 5.1-12: Consulting services M/M for each Case (Networks and Pumping Stations)

Governorate	Consulting services M/M for each Case			ONAS responsible department
	Case 1	Case 2	Case 3	
	M/M	M/M	M/M	
BEJA	14	21	21	Projects Department (North Regional Department) Project Department (Béja Regional Department)
BIZERTE	3	3	3	Projects Department (North Regional Department) Project Department (Bizerte Regional Department)
JENDOUBA	21	21	21	Projects Department (North Regional Department) Project Department (Jendouba Regional Department)
KASSERINE / SIDI BOUZID	14	21	21	Projects Department (Central Regional Department) Project Department (Kasserine & Sidi Bouzid Regional Departments)
KEBILI	14	21	42	Projects Department (South Regional Department) Project Department (Kébili Regional Department)
KEF / SILIANA	14	21	21	Projects Department (North Regional Department) Project Department (Kef & Siliana Regional Departments)
SFAX	0	36	36	Projects Department (South Regional Department) Project Department (Sfax Regional Department)
ZAGHOUAN	21	21	21	Projects Department (North Regional Department) Project Department (Zaghouan Regional Department)
Total	**101**	**165**	**186**	

5.1.2.6 Base Cost for Consulting Services (WwTP + Network)

5.1.2.6.1 Cost for international and local consultants

Consulting services cost for each case is detailed in the Table 5.1-13, 5.1-14 and 5.1-15.

Table 5.1-13: Consulting Services Cost (Case1)

Category	Monthly Cost (M JPY)	Total (Month)	Total Cost (M JPY)
International Consultants Staff	2.591	128	331.6
Local Consultants Staff	1.80	108	194.4
	Total	**236**	**526.0**

Table 5.1-14: Consulting services Cost (Case 2)

Category	Monthly Cost (M JPY)	Total (Month)	Total Cost (M JPY)
International Consultants Staff	2.591	128	331.6
Local Consultants Staff	1.80	172	309.6
	Total	**300**	**641.2**

Table 5.1-15: Consulting services Cost (Case 3)

Category	Monthly Cost (M JPY)	Total (Month)	Total Cost (M JPY)
International Consultants Staff	2.591	128	331.6
Local Consultants Staff	1.80	193	347.4
	Total	**321**	**679.0**

5.1.2.6.2 Topographic and Geotechnical Survey Cost

Topographic and Geotechnical Survey cost for each case is detailed in the Table 5.1-16, 5.1-17 and 5.1-18.

Table 5.1-16: Topographic and Geotechnical Survey (Case1)

Category	Unit	Unit Price (TND)	Quantity	Total Cost (TND)
Topographic Survey (WwTP)[1]	Ha	650	10	6,500
Geotechnical Survey (WwTP)[2]	Unit	10,000	5	50,000
Topographic Survey (Networks)[3]	Km	300	218	65,400
Topographic Survey (New Pumping Station)[1]	Unit	500	13	6,500
Geotechnical Survey (New Pumping Station)[2]	Unit	2,000	13	26,000
			Total	**154,400**

[1] Topographic surveys used to measure the perimeter and the ground levels
[2] Geotechnical studies allowing the characterization and the bearing capacity of soils
[3] Topographic surveys used to measure the longitudinal profile and cross section of sewage pipes

Table 5.1-17: Topographic and Geotechnical Survey (Case2)

Category	Unit	Unit Price (TND)	Quantity	Total Cost (TND)
Topographic Survey (WwTP)	Ha	650	10	6,500
Geotechnical Survey (WwTP)	Unit	10,000	5	50,000
Topographic Survey (Networks)	Km	300	533	159,900
Topographic Survey (Pumping Station)	Unit	500	20	10,000
Geotechnical Survey (Pumping Station)	Unit	2,000	20	40,000
			Total	**266,400**

Table 5.1-18: Topographic and Geotechnical Survey (Case3)

Category	Unit	Unit Price (TND)	Quantity	Total Cost (TND)
Topographic Survey (WwTP)	Ha	650	10	6,500
Geotechnical Survey (WwTP)	Unit	10,000	5	50,000
Topographic Survey (Networks)	Km	300	662	198,600
Topographic Survey (Pumping Station)	Unit	500	33	16,500
Geotechnical Survey (Pumping Station)	Unit	2,000	33	66,000
			Total	**337,600**

5.1.2.7 Price Escalation

Annual price escalation is considered to cover a rise in prices of the construction materials, equipment and labor. Annual price escalation rates are estimated both for foreign currency portion and local currency portion as summarized below:

- Foreign currency potion : 1.6 %
- Local currency potion : 0.9 %

5.1.2.8 Physical Contingency

Under the present conditions for the planning of the projects, there exist many unknown factors. For example, the route of Networks, which occupy the biggest portion of the construction cost, will be determined precisely by topographic survey and engineering consideration in the Detail Design and therefore length of Networks as well as construction cost of Networks will change to a certain extent. Prospective beneficiary population will determine locations and number of service points through the sensitization program. Therefore, 5.0 % for the physical contingency is provided for estimating the project cost.

5.1.3 Non-eligible Portion for Japanese ODA Loan

5.1.3.1 Land Acquisition and Compensation cost

The cost for land acquisition and compensation may not be considered for WwTP. On the other hand, for new pumping stations, the cost of land acquisition and compensation shall be considered.

Land Acquisition and Compensation Cost is estimated, on a tentative base cost of $1m^2$=100 TND, as shown in Table 5.1-19.

Table 5.1-19: Land Acquisition and Compensation Cost

	Area (m^2)	Total Cost (TND)	Total Cost (M JPY)
Case 1	2,800	280,000	16.5
Case 2	3,500	350,000	20.6
Case 3	5,100	510,000	30.0

5.1.3.2 Administration Expenses by Executing Agency

Administration expenses for the executing agency; ONAS, required for the Project implementation is estimated at 3.0 % of the base cost.

5.1.3.3 Tax

To all the goods and labor costs in project except imported equipment, 18 % of VAT (Value Added Tax) is applied. In case of imported equipment, 12 % of import tax is charged before 18 %VAT.

5.1.4 Total Investment Cost

The cost estimated is shown in Table 5.1-20, 5.1-21, 5.1-22.

Table 5.1-20: Investment Cost (Case1)

	Cost		
	F/C (TND)	L/C (TND)	Total (M JPY)
A. Eligible potion Construction Cost			
Civil Works	0.0	55,105,730.0	3,245.7
Equipment	20,578,823.0	0.0	1,212.1
Price Escalation	2,338,327.0	3,286,422.7	331.3
subtotal	**22,917,150.0**	**58,392,152.7**	**4,789.1**
Physical Contingency	**1,145,857.5**	**2,919,607.6**	**239.5**
Consulting Services			
Personnel Cost	5,630,696.1	3,300,509.3	526.0
Topo&Geo	0.0	154,400.0	9.1
Price Escalation	310,551.1	124,255.7	25.6
Physical Contingency	297,062.4	178,958.3	28.0
subtotal	**6,238,309.5**	**3,758,123.3**	**588.8**
Subtotal A	**30,301,317.1**	**65,069,883.7**	**5,617.4**
B. Non-Eligible potion			
Land Acquisition	0.0	280,000.0	16.5
Administration Cost	909,039.5	1,952,096.5	168.5
Subtotal B	**909,039.5**	**2,232,096.5**	**185.0**
Total before Tax (A+B)	31,210,356.6	67,301,980.2	5,802.4
Tax and Duty	6,292,007.9	12,114,356.4	1,084.1
Interest during construction	1,702,420.6	3,423,058.9	301.9
Total	**39,204,785.1**	**82,839,395.5**	**7,188.4**

Table 5.1-21: Investment Cost (Case2)

	Cost		
	F/C (TND)	L/C (TND)	Total (M JPY)
A. Eligible potion Construction Cost			
Civil Works	0.0	112,819,620.0	6,645.0
Equipment	21,142,405.0	0.0	1,245.3
Price Escalation	2,399,758.4	6,752,909.8	539.1
subtotal	**23,542,163.4**	**119,572,529.8**	**8,429.5**
Physical Contingency	**1,177,108.2**	**5,978,626.5**	**421.5**
Consulting Services			
Personnel Cost	5,630,696.1	5,256,366.7	641.2
Topo&Geo	0.0	266,400.0	15.7
Price Escalation	310,551.1	193,339.2	29.7
Physical Contingency	297,062.4	285,805.3	34.3
subtotal	**6,238,309.5**	**6,001,911.2**	**720.9**
Subtotal A	**30,957,581.1**	**131,553,067.4**	**9,571.9**
B. Non-Eligible potion			
Land Acquisition	0.0	350,000.0	20.6
Administration Cost	928,727.4	3,946,592.0	287.2
Subtotal B	**928,727.4**	**4,296,592.0**	**307.8**
Total before Tax (A+B)	31,886,308.5	135,849,659.5	9,879.6
Tax and Duty	6,428,279.8	24,452,938.7	1,818.9
Interest during construction	1,734,952.0	6,828,614.1	504.4
Total	**40,049,540.3**	**167,131,212.3**	**12,202.9**

Table 5.1-22: Investment Cost (Case3)

	Cost		
	F/C (TND)	L/C (TND)	Total (M JPY)
A. Eligible potion **Construction Cost**			
Civil Works	0.0	133,013,934.0	7,834.5
Equipment	21,915,689.0	0.0	1,290.8
Price Escalation	2,484,047.7	7,965,847.0	615.5
subtotal	**24,399,736.7**	**140,979,781.0**	**9,740.9**
Physical Contingency	**1,219,986.8**	**7,048,989.1**	**487.0**
Consulting Services I			
Personnel Cost	5,630,696.1	5,898,132.4	679.0
Topo&Geo	0.0	337,600.0	19.9
Price Escalation	310,551.1	218,502.9	31.2
Physical Contingency	297,062.4	322,711.8	36.5
subtotal	**6,238,309.5**	**6,776,947.1**	**766.6**
Subtotal A	**31,858,033.0**	**154,805,717.1**	**10,994.5**
B. Non-Eligible potion			
Land Acquisition	0.0	510,000.0	30.0
Administration Cost	955,741.0	4,644,171.5	329.8
Subtotal B	**955,741.0**	**5,154,171.5**	**359.9**
Total before Tax (A+B)	32,813,774.0	159,959,888.6	11,354.4
Tax and Duty	6,615,256.8	28,792,780.0	2,085.5
Interest during construction	1,779,587.9	8,016,925.7	577.0
Total	**41,208,618.7**	**196,769,594.3**	**14,016.9**

Table 5.1-23: Annual Fund Requirement for each case

Case 1

	Total			2013			2014			2015			2016			2017			2018			2019			2020			2021		
	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)
A. Eligible potion																														
Construction Cost																														
Civil Works	0.0	55,105,730.0	3,245.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,708,124.4	277.3	0.0	11,021,146.0	649.1	0.0	12,626,043.2	743.7	0.0	12,626,043.2	743.7	0.0	9,416,248.8	554.6	0.0	4,708,124.4	277.3	0.0	0.0	0.0
Equipments	20,578,823.0	0.0	1,212.1	0.0	0.0	0.0	0.0	0.0	0.0	195,739.4	0.0	11.5	2,253,621.7	0.0	132.7	5,977,907.5	0.0	352.1	5,977,907.5	0.0	352.1	5,977,907.5	0.0	352.1	195,739.4	0.0	11.5	0.0	0.0	0.0
Price Escalation	2,338,327.0	3,286,422.7	331.3	0.0	0.0	0.0	0.0	0.0	0.0	12,831.2	171,794.4	10.9	186,152.1	504,959.4	40.7	597,329.9	697,332.3	76.3	702,533.7	817,242.7	89.5	809,420.8	699,714.7	88.9	30,059.4	395,379.2	25.1	0.0	0.0	0.0
Subtotal	**22,917,150.0**	**58,392,152.7**	**4,789.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**208,570.6**	**4,879,918.8**	**299.7**	**2,439,773.8**	**11,526,105.4**	**822.6**	**6,575,237.4**	**13,323,375.5**	**1,172.0**	**6,680,441.2**	**13,443,285.9**	**1,185.3**	**6,787,328.3**	**10,115,963.5**	**995.6**	**225,798.8**	**5,103,503.6**	**313.9**	**0.0**	**0.0**	**0.0**
Physical Contingency	**1,145,857.5**	**2,919,607.6**	**239.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**10,428.5**	**243,995.9**	**15.0**	**121,988.7**	**576,305.3**	**41.1**	**328,761.9**	**666,168.8**	**58.6**	**334,022.1**	**672,164.3**	**59.3**	**339,366.4**	**505,798.2**	**49.8**	**11,289.9**	**255,175.2**	**15.7**	**0.0**	**0.0**	**0.0**
Consulting Services																														
Personnel Cost	5,630,696.1	3,300,509.3	526.0	0.0	305,602.7	18.0	4,838,879.5	1,008,489.0	344.4	0.0	1,252,971.1	73.8	263,938.9	458,404.1	42.5	527,877.8	213,921.9	43.7	0.0	30,560.3	1.8	0.0	30,560.3	1.8	0.0	0.0	0.0	0.0	0.0	0.0
Topo&Geo	0.0	154,400.0	9.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9,790.0	0.6	0.0	76,080.0	4.5	0.0	19,580.0	1.2	0.0	19,580.0	1.2	0.0	19,580.0	1.2	0.0	9,790.0	0.6	0.0	0.0	0.0
Price Escalation	310,551.1	124,255.7	25.6	0.0	5,525.6	0.3	236,002.3	27,475.0	15.5	0.0	46,076.8	2.7	21,801.7	24,488.6	2.7	52,747.1	12,896.2	3.9	0.0	3,245.4	0.2	0.0	3,725.9	0.2	0.0	822.1	0.0	0.0	0.0	0.0
Physical Contingency	297,062.4	178,958.3	28.0	0.0	15,556.4	0.9	253,744.1	51,798.2	18.0	0.0	65,441.9	3.9	14,287.0	27,948.6	2.5	29,031.2	12,319.9	2.4	0.0	2,669.3	0.2	0.0	2,693.3	0.2	0.0	530.6	0.0	0.0	0.0	0.0
Subtotal	**6,238,309.5**	**3,758,123.3**	**588.8**	**0.0**	**326,684.7**	**19.2**	**5,328,625.8**	**1,087,762.2**	**377.9**	**0.0**	**1,374,279.8**	**80.9**	**300,027.6**	**586,921.3**	**52.2**	**609,656.1**	**258,718.0**	**51.1**	**0.0**	**56,055.0**	**3.3**	**0.0**	**56,559.5**	**3.3**	**0.0**	**11,142.8**	**0.7**	**0.0**	**0.0**	**0.0**
Subtotal A	**30,301,317.1**	**65,069,883.7**	**5,617.4**	**0.0**	**326,684.7**	**19.2**	**5,328,625.8**	**1,087,762.2**	**377.9**	**218,999.1**	**6,498,194.6**	**395.6**	**2,861,790.0**	**12,689,332.0**	**916.0**	**7,513,655.4**	**14,248,262.3**	**1,281.8**	**7,014,463.3**	**14,171,505.2**	**1,247.9**	**7,126,694.7**	**10,678,321.2**	**1,048.7**	**237,088.7**	**5,369,821.5**	**330.2**	**0.0**	**0.0**	**0.0**
B. Non-Eligible potion																														
Land Acquisition	0.0	280,000.0	16.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28,000.0	1.6	0.0	56,000.0	3.3	0.0	56,000.0	3.3	0.0	56,000.0	3.3	0.0	56,000.0	3.3	0.0	28,000.0	1.6	0.0	0.0	0.0
Administration Cost	909,039.5	1,952,096.5	168.5	0.0	9,800.5	0.6	159,858.8	32,632.9	11.3	6,570.0	194,945.8	11.9	85,853.7	380,680.0	27.5	225,409.7	427,447.9	38.5	210,433.9	425,145.2	37.4	213,800.8	320,349.6	31.5	7,112.7	161,094.6	9.9	0.0	0.0	0.0
Subtotal B	**909,039.5**	**2,232,096.5**	**185.0**	**0.0**	**9,800.5**	**0.6**	**159,858.8**	**32,632.9**	**11.3**	**6,570.0**	**222,945.8**	**13.5**	**85,853.7**	**436,680.0**	**30.8**	**225,409.7**	**483,447.9**	**41.8**	**210,433.9**	**481,145.2**	**40.7**	**213,800.8**	**376,349.6**	**34.8**	**7,112.7**	**189,094.6**	**11.6**	**0.0**	**0.0**	**0.0**
Total before Tax (A+B)	31,210,356.6	67,301,980.2	5,802.4	0.0	336,485.3	19.8	5,488,484.6	1,120,395.0	389.3	225,569.1	6,721,140.4	409.2	2,947,643.7	13,126,012.0	946.7	7,739,065.0	14,731,710.2	1,323.5	7,224,897.2	14,652,650.3	1,288.6	7,340,495.5	11,054,670.8	1,083.5	244,201.4	5,558,916.2	341.8	0.0	0.0	0.0
Tax and Duty	6,292,007.9	12,114,356.4	1,084.1	0.0	60,567.3	3.6	1,106,478.5	201,671.1	77.1	45,474.7	1,209,805.3	73.9	594,245.0	2,362,682.2	174.2	1,560,195.5	2,651,707.8	248.1	1,456,539.3	2,637,477.1	241.1	1,479,843.9	1,989,840.7	204.4	49,231.0	1,000,604.9	61.8	0.0	0.0	0.0
Interest during construction	1,702,420.6	3,423,058.9	301.9																											
Total	**39,204,785.1**	**82,839,395.5**	**7,188.4**	**0.0**	**397,052.6**	**23.4**	**6,594,963.1**	**1,322,066.1**	**466.3**	**271,043.8**	**7,930,945.7**	**483.1**	**3,541,888.7**	**15,488,694.1**	**1,120.9**	**9,299,260.5**	**17,383,418.0**	**1,571.6**	**8,681,436.4**	**17,290,127.4**	**1,529.7**	**8,820,339.4**	**13,044,511.6**	**1,287.8**	**293,432.4**	**6,559,521.1**	**403.6**	**0.0**	**0.0**	**0.0**

Case 2

	Total			2013			2014			2015			2016			2017			2018			2019			2020			2021		
	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)
A. Eligible potion																														
Construction Cost																														
Civil Works	0.0	112,819,620.0	6,645.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10,479,513.4	617.2	0.0	22,563,924.0	1,329.0	0.0	24,168,821.2	1,423.5	0.0	24,168,821.2	1,423.5	0.0	20,959,026.8	1,234.5	0.0	10,479,513.4	617.2	0.0	0.0	0.0
Equipments	21,142,405.0	0.0	1,245.3	0.0	0.0	0.0	0.0	0.0	0.0	252,097.6	0.0	14.8	2,366,338.1	0.0	139.4	6,090,623.9	0.0	358.7	6,090,623.9	0.0	358.7	6,090,623.9	0.0	358.7	252,097.6	0.0	14.8	0.0	0.0	0.0
Price Escalation	2,399,758.4	6,752,909.8	539.1	0.0	0.0	0.0	0.0	0.0	0.0	16,525.6	382,386.2	23.5	195,462.6	1,033,818.6	72.4	608,592.9	1,334,836.2	114.5	715,780.3	1,564,369.1	134.3	824,682.8	1,557,450.3	140.3	38,714.2	880,049.3	54.1	0.0	0.0	0.0
Subtotal	**23,542,163.4**	**119,572,529.8**	**8,429.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**268,623.2**	**10,861,899.6**	**655.6**	**2,561,800.7**	**23,597,742.6**	**1,540.8**	**6,699,216.8**	**25,503,657.4**	**1,896.7**	**6,806,404.2**	**25,733,190.3**	**1,916.6**	**6,915,306.7**	**22,516,477.1**	**1,733.5**	**290,811.8**	**11,359,562.7**	**686.2**	**0.0**	**0.0**	**0.0**
Physical Contingency	**1,177,108.2**	**5,978,626.5**	**421.5**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**13,431.2**	**543,095.0**	**32.8**	**128,090.0**	**1,179,887.1**	**77.0**	**334,960.8**	**1,275,182.9**	**94.8**	**340,320.2**	**1,286,659.5**	**95.8**	**345,765.3**	**1,125,823.9**	**86.7**	**14,540.6**	**567,978.1**	**34.3**	**0.0**	**0.0**	**0.0**
Consulting Services																														
Personnel Cost	5,630,696.1	5,256,366.7	641.2	0.0	488,964.3	28.8	4,838,879.5	1,803,056.0	391.2	0.0	2,047,538.2	120.6	263,938.9	641,765.7	53.3	527,877.8	213,921.9	43.7	0.0	30,560.3	1.8	0.0	30,560.3	1.8	0.0	0.0	0.0	0.0	0.0	0.0
Topo&Geo	0.0	266,400.0	15.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20,990.0	1.2	0.0	98,480.0	5.8	0.0	41,980.0	2.5	0.0	41,980.0	2.5	0.0	41,980.0	2.5	0.0	20,990.0	1.2	0.0	0.0	0.0
Price Escalation	310,551.1	193,339.2	29.7	0.0	8,841.0	0.5	236,002.3	49,122.0	16.8	0.0	75,478.4	4.4	21,801.7	33,916.1	3.3	52,747.1	14,133.4	3.9	0.0	4,695.3	0.3	0.0	5,390.4	0.3	0.0	1,762.7	0.1	0.0	0.0	0.0
Physical Contingency	297,062.4	285,805.3	34.3	0.0	24,890.3	1.5	253,744.1	92,608.9	20.4	0.0	107,200.3	6.3	14,287.0	38,708.1	3.1	29,031.2	13,501.8	2.5	0.0	3,861.8	0.2	0.0	3,896.5	0.2	0.0	1,137.6	0.1	0.0	0.0	0.0
Subtotal	**6,238,309.5**	**6,001,911.2**	**720.9**	**0.0**	**522,695.6**	**30.8**	**5,328,625.8**	**1,944,786.9**	**428.4**	**0.0**	**2,251,206.9**	**132.6**	**300,027.6**	**812,869.9**	**65.5**	**609,656.1**	**283,537.0**	**52.6**	**0.0**	**81,097.3**	**4.8**	**0.0**	**81,827.2**	**4.8**	**0.0**	**23,890.3**	**1.4**	**0.0**	**0.0**	**0.0**
Subtotal A	**30,957,581.1**	**131,553,067.4**	**9,571.9**	**0.0**	**522,695.6**	**30.8**	**5,328,625.8**	**1,944,786.9**	**428.4**	**282,054.4**	**13,656,201.4**	**821.0**	**2,989,918.3**	**25,590,499.6**	**1,683.4**	**7,643,833.7**	**27,062,377.3**	**2,044.2**	**7,146,724.4**	**27,100,947.2**	**2,017.2**	**7,261,072.0**	**23,724,128.2**	**1,825.0**	**305,352.4**	**11,951,431.2**	**721.9**	**0.0**	**0.0**	**0.0**
B. Non-Eligible potion																														
Land Acquisition	0.0	350,000.0	20.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35,000.0	2.1	0.0	70,000.0	4.1	0.0	70,000.0	4.1	0.0	70,000.0	4.1	0.0	70,000.0	4.1	0.0	35,000.0	2.1	0.0	0.0	0.0
Administration Cost	928,727.4	3,946,592.0	287.2	0.0	15,680.9	0.9	159,858.8	58,343.6	12.9	8,461.6	409,686.0	24.6	89,697.5	767,715.0	50.5	229,315.0	811,871.3	61.3	214,401.7	813,028.4	60.5	217,832.2	711,723.8	54.8	9,160.6	358,542.9	21.7	0.0	0.0	0.0
Subtotal B	**928,727.4**	**4,296,592.0**	**307.8**	**0.0**	**15,680.9**	**0.9**	**159,858.8**	**58,343.6**	**12.9**	**8,461.6**	**444,686.0**	**26.7**	**89,697.5**	**837,715.0**	**54.6**	**229,315.0**	**881,871.3**	**65.4**	**214,401.7**	**883,028.4**	**64.6**	**217,832.2**	**781,723.8**	**58.9**	**9,160.6**	**393,542.9**	**23.7**	**0.0**	**0.0**	**0.0**
Total before Tax (A+B)	31,886,308.5	135,849,659.5	9,879.6	0.0	538,376.4	31.7	5,488,484.6	2,003,130.5	441.3	290,516.0	14,100,887.5	847.7	3,079,615.9	26,428,214.6	1,738.0	7,873,148.7	27,944,248.7	2,109.6	7,361,126.2	27,983,975.6	2,081.8	7,478,904.2	24,505,852.1	1,883.9	314,513.0	12,344,974.1	745.6	0.0	0.0	0.0
Tax and Duty	6,428,279.8	24,452,938.7	1,818.9	0.0	96,907.8	5.7	1,106,478.5	360,563.5	86.4	58,568.0	2,538,159.7	152.9	620,850.6	4,757,078.6	316.8	1,587,226.8	5,029,964.8	389.8	1,484,003.0	5,037,115.6	384.1	1,507,747.1	4,411,053.4	348.6	63,405.8	2,222,095.3	134.6	0.0	0.0	0.0
Interest during construction	1,734,952.0	6,828,614.1	504.4																											
Total	**40,049,540.3**	**167,131,212.3**	**12,202.9**	**0.0**	**635,284.2**	**37.4**	**6,594,963.1**	**2,363,694.0**	**527.7**	**349,084.0**	**16,639,047.2**	**1,000.6**	**3,700,466.4**	**31,185,293.2**	**2,054.8**	**9,460,375.5**	**32,974,213.4**	**2,499.4**	**8,845,129.2**	**33,021,091.2**	**2,465.9**	**8,986,651.3**	**28,916,905.4**	**2,232.5**	**377,918.8**	**14,567,069.5**	**880.3**	**0.0**	**0.0**	**0.0**

Case 3

	Total			2013			2014			2015			2016			2017			2018			2019			2020			2021		
	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)	F/C(TND)	L/C(TND)	Total(M JPY)
A. Eligible potion																														
Construction Cost																														
Civil Works	0.0	133,013,934.0	7,834.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12,498,944.8	736.2	0.0	26,602,786.8	1,566.9	0.0	28,207,684.0	1,661.4	0.0	28,207,684.0	1,661.4	0.0	24,997,889.6	1,472.4	0.0	12,498,944.8	736.2	0.0	0.0	0.0
Equipments	21,915,689.0	0.0	1,290.8	0.0	0.0	0.0	0.0	0.0	0.0	329,426.0	0.0	19.4	2,520,994.9	0.0	148.5	6,245,280.7	0.0	367.8	6,245,280.7	0.0	367.8	6,245,280.7	0.0	367.8	329,426.0	0.0	19.4	0.0	0.0	0.0
Price Escalation	2,484,047.7	7,965,847.0	615.5	0.0	0.0	0.0	0.0	0.0	0.0	21,594.7	456,073.0	28.1	208,237.4	1,218,868.5	84.1	624,046.6	1,557,901.3	128.5	733,955.9	1,825,791.6	150.8	845,623.6	1,857,575.3	159.2	50,589.4	1,049,637.3	64.8	0.0	0.0	0.0
Subtotal	**24,399,736.7**	**140,979,781.0**	**9,740.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**351,020.7**	**12,955,017.8**	**783.7**	**2,729,232.3**	**27,821,655.3**	**1,799.4**	**6,869,327.3**	**29,765,585.3**	**2,157.8**	**6,979,236.6**	**30,033,475.6**	**2,180.0**	**7,090,904.3**	**26,855,464.9**	**1,999.4**	**380,015.4**	**13,548,582.1**	**820.4**	**0.0**	**0.0**	**0.0**
Physical Contingency	**1,219,986.8**	**7,048,989.1**	**487.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**17,551.0**	**647,750.9**	**39.2**	**136,461.6**	**1,391,082.8**	**90.0**	**343,466.4**	**1,488,279.3**	**107.9**	**348,961.8**	**1,501,673.8**	**109.0**	**354,545.2**	**1,342,773.2**	**100.0**	**19,000.8**	**677,429.1**	**41.0**	**0.0**	**0.0**	**0.0**
Consulting Services																														
Personnel Cost	5,630,696.1	5,898,132.4	679.0	0.0	550,084.9	32.4	4,838,879.5	2,047,538.2	405.6	0.0	2,292,020.4	135.0	263,938.9	733,446.5	58.7	527,877.8	213,921.9	43.7	0.0	30,560.3	1.8	0.0	30,560.3	1.8	0.0	0.0	0.0	0.0	0.0	0.0
Topo&Geo	0.0	337,600.0	19.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28,110.0	1.7	0.0	112,720.0	6.6	0.0	56,220.0	3.3	0.0	56,220.0	3.3	0.0	56,220.0	3.3	0.0	28,110.0	1.7	0.0	0.0	0.0
Price Escalation	310,551.1	218,502.9	31.2	0.0	9,946.1	0.6	236,002.3	55,782.6	17.2	0.0	84,659.1	5.0	21,801.7	38,769.1	3.6	52,747.1	14,919.9	4.0	0.0	5,617.0	0.3	0.0	6,448.6	0.4	0.0	2,360.6	0.1	0.0	0.0	0.0
Physical Contingency	297,062.4	322,711.8	36.5	0.0	28,001.5	1.6	253,744.1	105,166.0	21.1	0.0	120,239.5	7.1	14,287.0	44,246.8	3.4	29,031.2	14,253.1	2.5	0.0	4,619.9	0.3	0.0	4,661.4	0.3	0.0	1,523.5	0.1	0.0	0.0	0.0
Subtotal	**6,238,309.5**	**6,776,947.1**	**766.6**	**0.0**	**588,032.5**	**34.6**	**5,328,625.8**	**2,208,486.8**	**443.9**	**0.0**	**2,525,028.9**	**148.7**	**300,027.6**	**929,182.4**	**72.4**	**609,656.1**	**299,314.8**	**53.5**	**0.0**	**97,017.1**	**5.7**	**0.0**	**97,890.3**	**5.8**	**0.0**	**31,994.2**	**1.9**	**0.0**	**0.0**	**0.0**
Subtotal A	**31,858,033.0**	**154,805,717.1**	**10,994.5**	**0.0**	**588,032.5**	**34.6**	**5,328,625.8**	**2,208,486.8**	**443.9**	**368,571.7**	**16,127,797.6**	**971.6**	**3,165,721.5**	**30,141,920.4**	**1,961.8**	**7,822,449.8**	**31,553,179.4**	**2,319.2**	**7,328,198.4**	**31,632,166.5**	**2,294.8**	**7,445,449.6**	**28,296,128.5**	**2,105.2**	**399,016.2**	**14,258,005.3**	**863.3**	**0.0**	**0.0**	**0.0**
B. Non-Eligible potion																														
Land Acquisition	0.0	510,000.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51,000.0	3.0	0.0	102,000.0	6.0	0.0	102,000.0	6.0	0.0	102,000.0	6.0	0.0	102,000.0	6.0	0.0	51,000.0	3.0	0.0	0.0	0.0
Administration Cost	955,741.0	4,644,171.5	329.8	0.0	17,641.0	1.0	159,858.8	66,254.6	13.3	11,057.2	483,833.9	29.1	94,971.6	904,257.6	58.9	234,673.5	946,595.4	69.6	219,846.0	948,965.0	68.8	223,363.5	848,883.9	63.2	11,970.5	427,740.2	25.9	0.0	0.0	0.0
Subtotal B	**955,741.0**	**5,154,171.5**	**359.9**	**0.0**	**17,641.0**	**1.0**	**159,858.8**	**66,254.6**	**13.3**	**11,057.2**	**534,833.9**	**32.2**	**94,971.6**	**1,006,257.6**	**64.9**	**234,673.5**	**1,048,595.4**	**75.6**	**219,846.0**	**1,050,965.0**	**74.9**	**223,363.5**	**950,883.9**	**69.2**	**11,970.5**	**478,740.2**	**28.9**	**0.0**	**0.0**	**0.0**
Total before Tax (A+B)	32,813,774.0	159,959,888.6	11,354.4	0.0	605,673.5	35.7	5,488,484.6	2,274,741.4	457.3	379,628.9	16,662,631.6	1,003.8	3,260,693.2	31,148,178.0	2,026.7	8,057,123.3	32,601,774.8	2,394.8	7,548,044.3	32,683,131.5	2,369.6	7,668,813.0	29,247,012.3	2,174.3	410,986.7	14,736,745.5	892.2	0.0	0.0	0.0
Tax and Duty	6,615,256.8	28,792,780.0	2,085.5	0.0	109,021.2	6.4	1,106,478.5	409,453.5	89.3	76,533.2	2,999,273.7	181.2	657,355.7	5,606,672.0	369.0	1,624,316.0	5,868,319.5	441.3	1,521,685.7	5,882,963.7	436.1	1,546,032.7	5,264,462.2	401.1	82,854.9	2,652,614.2	161.1	0.0	0.0	0.0
Interest during construction	1,779,587.9	8,016,925.7	577.0																											
Total	**41,208,618.7**	**196,769,594.3**	**14,016.9**	**0.0**	**714,694.7**	**42.1**	**6,594,963.1**	**2,684,194.9**	**546.5**	**456,162.0**	**19,661,905.2**	**1,185.0**	**3,918,048.9**	**36,754,850.1**	**2,395.6**	**9,681,439.3**	**38,470,094.3**	**2,836.1**	**9,069,730.1**	**38,566,095.2**	**2,805.8**	**9,214,845.8**	**34,511,474.6**	**2,575.5**	**493,841.6**	**17,389,359.7**	**1,053.3**	**0.0**	**0.0**	**0.0**

5.2 ECONOMIC ANALYSIS

In this study, following three cases are studied.

Case 1 : 5 waste water treatment plants (Béja, Medjez El-Bab, Tabarka, Jendouba, Siliana) (hereinafter “5 WwTPs” in this section) and sewerage network and pumping stations network (hereinafter “Network”) in the communes including Type A sites and 5WwTPs up to **7,188.4 million JPY.**

Case 2 : Case 1 in addition to Networks in the communes including Type B sites up to **12,202 .9million JPY.**

Case 3 : All the planned facilities are constructed with total project cost (Eligible potion + Non-eligible potion) of **14,016.9 million JPY** (as described in chapter 5.1.4).

5.2.1 Pre-requisition

5.2.1.1 Operation Company

All the facilities planned in the project will be operated by ONAS.

5.2.1.2 Project schedule

The project schedule is detailed in the Chapter 5.3.

5.2.1.3 Project Life

20 years is set as project life for this study.

5.2.1.4 Currency

This study is calculated based on Tunisian Dinar (TND) and Japanese yen (JPY). The exchange rate between the TND and JPY is set in the chapter 5.1.1.

5.2.2 Project cost

5.2.2.1 Initial construction cost for existing 5 WwTP and related Networks (GoT)

The initial cost of construction covered by the Government of Tunisia (hereinafter "GoT" in this section) for the 5 WwTP are shown in Table 5.2-1 (cost already paid before the rehabilitation and extension planned by our project).

Table 5.2-1: Construction cost of existing 5 WwTPs and related Networks

Construction cost of 5 WwTPs and related Network by ONAS (Existing plant cost)

unit: TND

Five (5) STEPs construction cost, by ONAS			
WwTP	Civil	Equipment	Total
Beja	4,521,940	3,656,019	8,177,959
Medjez El-Bab	1,912,383	2,534,688	4,447,071
Tabarka	3,540,735	2,371,037	5,911,772
Jendouba	2,616,499	2,663,889	5,280,388
Siliana	2,862,670	2,299,163	5,161,833
Total	15,454,227	13,524,796	**28,979,023**

unit: TND

Pipe collection network cost, by ONAS	
Beja related	1,405,551
Medejez related	111,780
Tabarka related	170,000
Jendouba related	1,153,333
Siliana related	1,805,241
Total	**4,645,905**

Source: ONAS

5.2.2.2 Project cost for economic analysis

Project cost for economic analysis in each case is detailed in the Table 5.2-2. Price escalation and interest during construction (IDC) are excluded for calculating FIRR.

Table 5.2-2: Construction cost of 5 WwTPs and related Network by Project

Case	Fund	WwTP	Network	Total	WwTP	Network	Total
		million TND			million JPY		
1	Loan	34.2	54.8	**89.0**	2,012.9	3,229.7	**5,242.6**
	Equity	7.9	12.2	**20.1**	466.9	717.9	**1,184.8**
	Total	42.1	67.0	**109.1**	2,479.8	3,947.6	**6,427.4**
2	Loan	34.2	118.2	**152.4**	2,012.9	6,961.8	**8,974.7**
	Equity	7.9	25.9	**33.9**	466.9	1,527.4	**1,994.3**
	Total	42.1	144.1	**186.2**	2,479.8	8,489.2	**10,969.0**
3	Loan	34.2	141.0	**175.1**	2,012.9	8,302.6	**10,315.5**
	Equity	7.9	31.0	**39.0**	466.9	1,828.4	**2,295.3**
	Total	42.1	172.0	**214.1**	2,479.8	10,131.0	**12,610.8**

5.2.2.3 Investment cost in Economics study

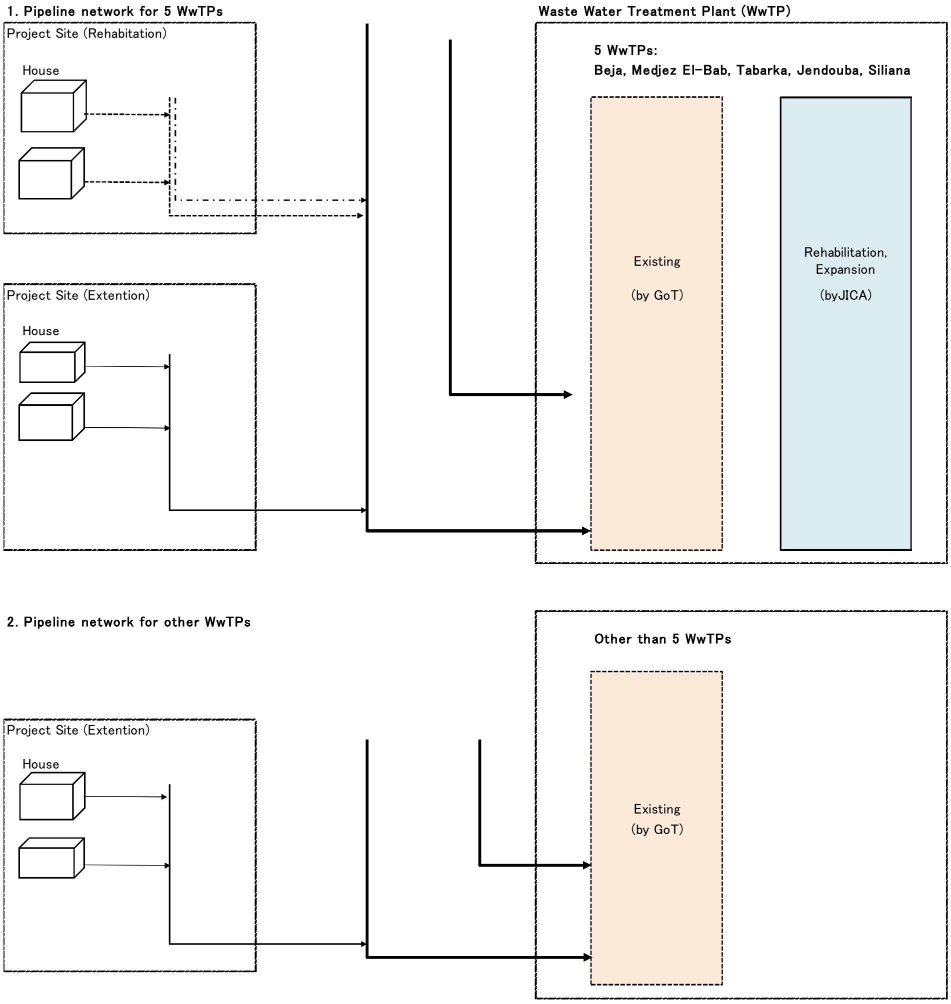
Further to above Table 5.2-2, individual collection network from each household to trunk Network line which were constructed by GoT should be added. But due that detail data collection on this part is difficult, and then this distribution network cost is considered from this Economics study.

The construction cost for existing networks in each case is estimated based on the data provided from ONAS as follows:

- Total capacity of existing networks related to the existing 5 WwTPs: 42,720 m^3/day;
- Total cost for existing networks related to the existing 5 WwTPs: 4.645 million TND
- Unit cost for existing network: 108.7 TND/m^3/day.

Therefore, total cost for existing networks for three cases are estimated 5.9 million TND (Case 1), 9.3 million TND (Case 2), and 9.7 million TND (Case 3), which correspond to the capacity of existing networks estimated in the Table 5.2-3 in the next chapter.

Relationship between existing infrastructures and new one are showed in figure 5.2-1.



Treated water capacity (m3/day): 54,102

Case 1 (unit : million TND) (note) Exchange rate: 58.9 JPY/TND

	Network	5 WwTPs (Existing)	5 STEPs (Rehabili, Extension)	Total
byJICA	*54.8*	--	*34.2*	*89.0*
by GoT	*12.2*	--	*7.9*	*20.1*
by GoT (Existing)	*5.9 (*)*	*29.0*	--	*34.9*
Total	***72.9***	***29.0***	***42.1***	***144.0***

JICA portion in billion JPY: *5.2*

Treated water capacity (m3/day): 85,391

Case 2 (unit : million TND)

	Network	5 WwTPs (Existing)	5 STEPs (Rehabili, Extension)	Total
byJICA	*118.2*	--	*34.2*	*152.4*
by GoT	*25.9*	--	*7.9*	*33.8*
by GoT (Existing)	*9.3 (*)*	*29.0*	--	*38.3*
Total	***153.4***	***29.0***	***42.1***	***224.5***

JICA portion in billion JPY: *9.0*

Treated water capacity (m3/day): 89,574

Case 3 (unit : million TND)

	Network	5 WwTPs (Existing)	5 STEPs (Rehabili, Extension)	Total
byJICA	*141.0*	--	*34.2*	*175.2*
by GoT	*31.0*	--	*7.9*	*38.9*
by GoT (Existing)	*9.7 (*)*	*29.0*	--	*38.7*
Total	***181.7***	***29.0***	***42.1***	***252.8***

JICA portion in billion JPY: *10.3*

(*): Network cost by GoT is estimated by proportion to treated waste water capacity.
ONAS data : 4.645 million TND for 42,720 m3/day capacity for 5 WwTPs.

Figure 5.2-1: Relationship of WwTP and Network (Case 1, Case 2 & Case 3)

5.2.3 Production and Sales plan

5.2.3.1 Production (Sewerage treatment) and Sales (Tariff collection) plan

Total capacity of 5 WwTPs is expected to be increased to 42,720 m^3/day in year 2029 from 20,570 m^3/day in 2011by this Project (Refer to the Table 5.2-3).

As a unit of average daily flow, 120 liter/person/day is applied, by estimation of which current capacity is 90 liter/person/day[4] and an increase ratio of 1.5%/year[5] is applied.

According to ONAS data, current tariff collection rate of sewerage service is 90 %, but in this study, 92 % is adopted as a target collection rate considering future improvement.

Based on the comparison between investment efficiency and geological conditions etc., propriety of projected commune was evaluated. And, basic capacity for this study is set as following Table 5.2-3.

Table 5.2-3: Sales Capacity of wastewater treatment of the 5 WwTP (unit: m^3/day)

Case	1		2		3	
Items	Treated waste water (m3/day)	Population (person)	Treated waste water (m3/day)	Population (person)	Treated waste water (m3/day)	Population (person)
5 WwTPs related	42,720	231,228	42,720	231,228	42,720	231,228
Additional Network related	11,382	94,846	42,671	355,586	46,854	390,444
Total	54,102	326,074	85,391	586,814	89,574	621,672
Collection ratio (%)	92 %		92 %		92 %	
Sales capacity (m3/day)	49,774		78,560		82,408	
(m3/year)	18,167,452		28,674,298		30,078,949	

[4] Source: SONEDE Annual Report 2009

[5] See the chapter 3.2.2.1

Table 5.2-3: Sales Capacity of wastewater treatment of the 5 WwTP (unit: m^3/day) (suite)

Detail of treated capacity in each WwTP & commune

1. WwTP

Case	Governorate	Commune	Total Population (person)	Total Treated water (m3/day)
Case 3 / Case 2 / Case 1: 5WwTP	Beja	Beja	78,419	12,994
	Beja	Medjez el Bab	24,644	5,429
	Jendouba	Tabarka	31,322	8,510
	Jendouba	Jendouba	64,988	11,703
	Siliana	Siliana	31,855	4,084
	5WwTP Total		**231,228**	**42,720**

2. Network — Treated capacity is estimated **120** litter/day/person

Case	Governorate	Commune	Total Population (person)	Total Treated water (m3/day)
Additional network (1)	Sidi Bouzid	Sidi Bouzid	34,800	4,176
	Siliana	Krib	8,000	960
	Kebili	Kebili	9,000	1,080
	Bizerte	Raf Raf	5,000	600
	Kef	Tajerouine	6,225	747
	Zaghouan	Hammam Zriba	10,700	1,284
	Beja	Nefza	600	72
	Zaghouan	Zaghouan	12,275	1,473
	Jendouba	Ghardimaou	2,472	297
	Beja	Testour	1,774	213
	Kebili	Jemna	4,000	480
	Additional Network (1) sub total		94,846	11,382
	Case 1		**326,074**	**54,102**
Additional network (2)	Kef	Kef	45,191	5,424
	Kebili	Douz	27,000	3,240
	Bizerte	Alia	3,500	420
	Kasserine	Kasserine	64,660	7,759
	Sfax	Mahres	21,075	2,529
	Zaghouan	El Fahs	17,700	2,124
	Sfax	Sakiet Ezzit	13,819	1,658
	Sfax	Chihia	10,491	1,259
	Beja	Maagoula	300	36
	Kasserine	Sbeitla	3,975	477
	Siliana	Bouarada	2,569	308
	Sfax	Sakiet Eddaier	42,905	5,149
	Beja	Teboursouk	5,988	719
	Jendouba	Fernana	1,567	188
	Additional Network（2）sub total		260,740	31,290
	Case 2		**586,814**	**85,391**
Additional network (3)	Kebili	El Golaa	750	90
	Sfax	Agareb	3,000	360
	Kebili	Kebili Nord	14,080	1,690
	Kebili	Kebili Sud	7,500	900
	Jendouba	Bousselem	724	87
	Sfax	Jebeniana	2,350	282
	Kebili	Douz Sud	3,000	360
	Sfax	Hencha	2,850	342
	Beja	Nefza	90	11
	Zaghouan	Zaghouan	200	24
	Jendouba	Tabarka	314	38
	Additional Network（3）sub total		34,858	4,183
	Case 3		**621,672**	**89,574**

5.2.3.2 Price for treated water

According to ONAS 2009 annual report, revenue by sewerage water treatment is 111 million TND, treated water capacity is 218 million m^3/year (refer to Table 5.2-4). With these data, overall average income by sewerage water treatment is 0.51 TND/m^3 (=111 million TND/218 million m^3/year).

Table 5.2-4: ONAS revenue by sewerage water treatment

Item	Year 2009
Revenue（million TND）	204
Sewerage water treatment (million TND）	111
Sewerage water treatment capacity (million m^3 /year）	218

Source: ONAS annual report 2009

In this study, by consideration of future revision of tariff structure, 0.7(*) TND/m^3 is set as base scenario.

(*) Increase ratio of water consumption is estimated to be 1.5% per annual by ONAS in this study. If same increasing ratio is adapted to Tariff from 2010 to 2029, 1.35 times of tariff is expected after 20 years (1.015^{20}). Then, 0.51 x 1.35 = 0.7 TND/m^3

5.2.4 OPEX related

5.2.4.1 Variable cost

Major items related to variable costs are utility, sludge treatment and water treatment chemicals. Based on ONAS' operating data, and they were analyzed by study team in following process, and relevant cost was estimated.

5.2.4.1.1 Sewerage water treatment capacity

According to ONAS' annual report in 2009, water of 218,000,000 m^3 was treated in a year.

Current treated capacity at 5WwTPs is surveyed by study team. In 2011, 7,508,050 m^3/year was treated, which is equivalent to 3.4 % of all ONAS' treated capacity in2011 and 15,592,800 m^3/year in year 2029 is estimated by study team. Refer to Table 5.2-5.

Table 5.2-5: Sewerage water treated capacity at 5 WwTPs

WwTP	Treatment capacity	
	2011 year	2029 year
Beja	6,244 m3/d	12,994 m3/d
Medjez El-Bab	2,391 m3/d	5,429 m3/d
Tabarka	4,491 m3/d	8,510 m3/d
Jendouba	5,123 m3/d	11,703 m3/d
Siliana	2,321 m3/d	4,084 m3/d
Total	**20,570** m3/d	**42,720** m3/d
	7,508,050 m3/year	**15,592,800** m3/year

Source: ONAS and Study Team

5.2.4.1.2 Electricity cost

According to ONAS' annual report in 2009, 104,500,000 kWh of electricity was consumed for 218,000,000 m^3/year sewerage treatment in all over the country. 74.5% of this consumption is for WwTP and 24 % is for Network.

From this information, necessary electricity for WwTP and Network are calculated to 0.36 kWh/m^3 and 0.12 kWh/m^3 respectively. Refer to Table 5.2-6.

Table 5.2-6: Electric power consumption

All ONAS	kWh/year	Treatment capacity (m3/year)	kWh/m3 (by calculation)
Total Electricity	**104,500,000**		
for STEP (74.5%)	77,852,500	**218,000,000**	0.36
for Network (24%)	25,080,000	**218,000,000**	0.12

Source: ONAS Annual Report 2009, and Study Team

Electricity Tariff is also reported as 0.132 TND/kWh. This study adopts same tariff. Table 5.2-7 shows estimated electric cost at 5WwTPs which treats 7,508,050 m^3/year of sewerage water.

Table 5.2-7: Estimated electric cost at WwTPs from ONAS report

Project sites, 2011	kWh/year (by Calc)	m3/year	kWh/m3
for 5 WwTPs	2,702,898	7,508,050	0.36
for Network for 5 WwTPs	900,966	7,508,050	0.12
TOTAL	3,603,864		

Electric Tariff	**0.132**	TND/kWh

Electric cost for Project sites 2009-2011 base

for 5 WwTPs	356,783	TND/year
for Network for 5 WwTPs	118,928	TND/year

5.2.4.1.3 Other cost

Related data is supplied from ONAS, which is shown in Table 5.2-8 column "a".

When above data in Table 5.2-7 is inputted to column "b" in Table 5.2-8, only 3.6 % is calculated at WwTPs and 2.6 % at Network (Column "c"). Therefore utilizing this ratio, personnel, sludge and maintenance cost are adjusted as per column "b", and considering total capacity of 7,508,050 m^3/year, unit cost is determined as per column "d" in Table 5.2-8.

Table5.2-8: Unit cost of each items

Analysis of ONAS data, using & caoparison with ONAS annual report data

	year 2010			
	ONAS' Answers "a"	Annual report base "b"	Data Ratio "c"	Unit ratio "d"
	TND/year	TND/year	"b"/ "c"	TND/m3 ,by calculation
1. 5 STEPs				7,508,050 m3/year
Electricity	9,810,388	356,783	0.036	0.048
Personnel	647,710	23,556		0.003
Chemical	1,491,521	54,243		0.007
Sludge	3,480,910	126,593		0.017
Maintenace	468,910	17,053		0.002
2. NETWORK				7,508,050 m3/year
Electricity	4,493,401	118,928	0.026	0.016
Personnel	30,940,134	818,897		0.109
Chemical	7,438,067	196,864		0.026
Sludge	0	0		0.000
Maintenace	3,626,278	95,977		0.013
3. TOTAL				
Electricity	14,303,789	475,710		0.063
Personnel	31,587,844	842,453		0.112
Chemical	8,929,588	251,108		0.033
Sludge	3,480,910	126,593		0.017
Maintenace	4,095,188	113,030		0.015
Total (TND/year) (TND/m3)	62,397,319	1,808,894		0.241
	WwTP	7,508,050	m3/year	
	Network	7,508,050	m3/year	

5.2.4.1.4 Estimated Operation Cost

Operation cost in year 2029 are estimated as per Table 5.2-9 column "f" (Case 1), "g"(Case 2) and "h"(Case 3) based on the data in year 2010 (Table 5.2-9, column "b"). Personnel and maintenance cost do not follow to the treated capacity. These costs estimated 1.5 (*) times of year 2010.

Note (*): JICA's in-house data shows that commodity increasing ratio in Tunisia is around 4% per year. After 20 years, this cost will be 2.2 times (= (1+4%) ˆ 20years). On the other hand, considering organization reform for rationalizing personnel cost, administration cost, etc. inside ONAS, 70 % of this figure (=1.5) is adopted.

Table 5.2-9: Estimated operation cost in year 2029

Analysis of ONAS data, using & caoparison with ONAS annual report data

	year 2010		year 2029			
	Annual report base "b"	Unit ratio "d"	Unit ratio "e"	case 1 "f"	Case 2 "g"	Case 3 "h"
	TND/year	TND/m3 ,by calculation	Adjusted by Study team	54,102 m3/day	85,391 m3/day	89,574 m3/day
1. 5 WwTPs		7,508,050 m3/year		(**19,747,230** m3/year)	(**31,167,715** m3/year)	(**32,694,510** m3/year)
Electricity	356,782	0.048	0.048 TND/m3	748,454 TND/year	748,454 TND/year	748,454 TND/year
Personnel	23,556	0.003	(*1) 1.5 times of year 2010	35,334 TND/year	35,334 TND/year	35,334 TND/year
Chemical	54,243	0.007	0.007 TND/m3	109,150 TND/year	109,150 TND/year	109,150 TND/year
Sludge	126,593	0.017	0.017 TND/m3	265,078 TND/year	265,078 TND/year	265,078 TND/year
Maintenace	17,053	0.002	(*1) 1.5 times of year 2010	25,580 TND/year	25,580 TND/year	25,580 TND/year
			WwTP Total Capacity	42,720 m3/day	42,720 m3/day	42,720 m3/day
2. NETWORK		7,508,050 m3/year		**19,747,230** m3/year	**31,167,715** m3/year	**32,694,510** m3/year
Electricity	118,928	0.016	0.015 TND/m3	296,208 TND/year	467,516 TND/year	490,418 TND/year
Personnel	818,897	0.109	(*1) 1.5 times of year 2010	(*2) 1,842,518 TND/year	(*2) 2,456,691 TND/year	(*2) 2,456,691 TND/year
Chemical	196,864	0.026	0 TND/m3	– TND/year	– TND/year	– TND/year
Sludge	0	0.000	0 TND/m3	– TND/year	– TND/year	– TND/year
Maintenace	95,977	0.013	(*1) 1.5 times of year 2010	(*2) 215,948 TND/year	(*2) 287,931 TND/year	(*2) 287,931 TND/year
3. TOTAL						
Electricity	475,710	0.063		1,044,663 TND/year	1,215,970 TND/year	1,238,872 TND/year
Personnel	842,453	0.112		1,877,852 TND/year	2,492,025 TND/year	2,492,025 TND/year
Chemical	251,108	0.033		109,150 TND/year	109,150 TND/year	109,150 TND/year
Sludge	126,593	0.017		265,078 TND/year	265,078 TND/year	265,078 TND/year
Maintenace	113,030	0.015		241,528 TND/year	313,511 TND/year	313,511 TND/year
Total (TND/year) (TND/m3)	1,808,894	0.241		3,538,270 TND/year	4,395,733 TND/year	4,418,635 TND/year

(*1) : (1+4%) ˆ 20years = 2.2times --> 2.2 x 70% = 1.5

(*2) : 1.5 times of current operator nubers is assumed for Case 1, and 2 times for case 2 & 3, from view point of treatment capacity.

Source: ONAS & Study Team

5.2.4.2 Fixed cost related

5.2.4.2.1 Personnel cost

Refer to the chapter 5.2.4.1 (4)

5.2.4.2.2 Maintenance cost

Refer to the chapter 5.2.4.1 (4).

5.2.4.2.3 Sales and administration cost

This project is different from ordinary business case in private companies. The entire tariff is collected from habitants, company, etc. and almost no special sales work is required for the sewerage water treatment business, but tariff collection work and ordinary administration cost is considered, from the data in similar project cases, 2 % of sales revenue is counted for this cost.

5.2.5 Taxation system

5.2.5.1 General taxes

All taxes and duties, including, but not limited to, corporate income tax are considered.

Business license tax and customs duties that might be added on to the EPC cost are not considered in this study.

5.2.5.2 Corporate income tax

The corporate income tax rate is set at 20 % after 11 years operation.

ONAS is not tax payer because of non-profit in present stage. In this study, this tax exemption is continued for more 10 years, and after 11 years, ONAS is expected to be tax payer.

5.2.5.3 Depreciation allowance

The plant construction costs shall be depreciated in the following manner:

1) Manner of depreciation : Straight-line method
2) Salvage value : Zero
3) Service life : Process plant 20 years, Utility and ancillary facilities 20 years

The construction costs incurred prior to the operation and interests during the construction shall be evenly depreciated over 20 years.

5.2.6 Fund arrangement

In this survey, we suppose the following arrangements:

5.2.6.1 Debt / Equity ratio

81.6 % in Case 1, 81.8 % in both Case 2 and 3 of required funds are prepared by a loan and the remaining cost is covered by the project owner's private fund.

5.2.6.2 Disbursement schedule

According to the construction schedule, disbursement schedule is studied. Detail data is described in the chapter 5.1 total of 8 years before WwTPs start-up and after then, from year 2021, total project will be stared.

The disbursement schedule for Economics study is as per Table 5.2-10.

Table 5.2-10: Estimated Disbursement Schedule

Case		Total	2013	2014	2015	2016	2017	2018	2019	2020	2021
			-8	-7	-6	-5	-4	-3	-2	-1	Start
1	Eligible portion (Million TND)	89.0	0.3	6.1	6.5	14.8	20.3	19.6	16.2	5.2	0.0
	Non-Eligible portion (Million TND)	20.1	0.1	1.4	1.4	3.3	4.6	4.4	3.7	1.1	0.0
	Total (Million TND)	109.1	0.4	7.6	7.9	18.1	24.9	24.0	19.9	6.3	0.0
		100%	0.4%	6.9%	7.2%	16.6%	22.9%	22.0%	18.3%	5.8%	0.0%

Case		Total	2013	2014	2015	2016	2017	2018	2019	2020	2021
2	Eligible portion (Million TND)	152.4	0.5	7.0	13.4	27.2	32.6	31.8	28.5	11.3	0.0
	Non-Eligible portion (Million TND)	33.9	0.1	1.6	2.9	6.0	7.3	7.1	6.4	2.5	0.0
	Total (Million TND)	186.2	0.6	8.6	16.4	33.2	39.9	38.9	34.8	13.8	0.0
		100%	0.3%	4.6%	8.8%	17.9%	21.4%	20.9%	18.7%	7.4%	0.0%

Case		Total	2013	2014	2015	2016	2017	2018	2019	2020	2021
3	Eligible portion (Million TND)	175.1	0.6	7.2	15.9	31.7	37.0	36.3	32.9	13.5	0.0
	Non-Eligible portion (Million TND)	39.0	0.1	1.7	3.5	7.0	8.3	8.1	7.4	3.0	0.0
	Total (Million TND)	214.1	0.7	8.9	19.4	38.8	45.3	44.3	40.2	16.5	0.0
		100%	0.3%	4.2%	9.1%	18.1%	21.1%	20.7%	18.8%	7.7%	0.0%

5.2.6.3 Long-term loan conditions

a) Interest : 1.4 % (JICA Terms and Conditions of ODA loans in February 2012)

b) Repayment : 25 years (initial 7 years exempt)

5.2.7 Analysis of Economics of the Project

5.2.7.1 Analysis method

Based on the above prerequisites, the economics of the project using the DCF (Discount Cash Flow) method-based Financial Internal Rate of Return (FIRR) have been analyzed.

5.2.7.2 Result of study

5.2.7.2.1 FIRR at Base scenario

FIRR is as per Table 5.2-11.

This figure is based on the treatment price at 0.7 TND/m^3, but in future, if this price is discussed among relevant bodies and a different price may be decided, this FIRR may change accordingly.

Tariff sensitivity is shown in Figure 5.2-2, in the chapter 5.2.7.2.3.

Table 5.2-11: FIRR at base scenario in each case

Project	Case 1	Case 2	Case 3
Treatment capacity (m^3/day)	54,102	85,391	89,574
Sales capacity (m^3/day)	49,774	78,560	82,408
Total capital requirement (million TND)	164.0	256.4	289.4
JICA Cost (million TND)	**89.0**	**152.4**	**175.1**
GoT Cost (million TND)	60.9	81.7	88.6
Revenue (million TND/year)	12.7	20.1	21.1
Profit (*) (million TND/year)	0.2	1.5	0.6
FIRR before Tax (%)	1.59	2.36	1.88
Benefit population (person)	326,074	586,814	621,672

(*) Profit before TAX, 1st year

5.2.7.2.2 Cash flow analysis at base case

Cash Flow is as per Table 5.2-12, 14 and 15.

Table 5.2-12: Cash Flow in Case 1

(Unit: Million TND)

Year		Cash from Operation	Financial Source			Source of Funds	Fixed Capital Cost	Debt Service		Uses of Funds	Cash Balance		
			Equity	L/T Loan	S/T Loan			on L/T Loan	on S/T Loan		Current Year	Beginning Year	Ending Year
2013	-8	0.00	0.10	0.36	0.00	0.46	0.46	0.00	0.00	0.46	0.00	0.00	0.00
2014	-7	0.00	1.79	6.14	0.00	7.94	7.94	0.00	0.00	7.94	0.00	0.00	0.00
2015	-6	0.00	1.87	6.41	0.00	8.28	8.28	0.00	0.00	8.28	0.00	0.00	0.00
2016	-5	0.00	4.32	14.78	0.00	19.09	19.09	0.00	0.00	19.09	0.00	0.00	0.00
2017	-4	0.00	5.93	20.29	0.00	26.22	26.22	0.00	0.00	26.22	0.00	0.00	0.00
2018	-3	0.00	5.75	19.67	0.00	25.42	25.42	0.00	0.00	25.42	0.00	0.00	0.00
2019	-2	0.00	4.73	16.20	0.00	20.93	20.93	0.00	0.00	20.93	0.00	0.00	0.00
2020	-1	0.00	1.51	5.16	0.00	6.67	6.67	0.00	0.00	6.67	0.00	0.00	0.00
2021	1	8.99	0.00	0.00	0.00	8.99	0.00	6.19	0.00	6.19	2.79	0.00	2.79
2022	2	8.99	0.00	0.00	0.00	8.99	0.00	6.12	0.00	6.12	2.86	2.79	5.66
2023	3	8.99	0.00	0.00	0.00	8.99	0.00	6.05	0.00	6.05	2.93	5.66	8.59
2024	4	8.99	0.00	0.00	0.00	8.99	0.00	5.98	0.00	5.98	3.00	8.59	11.59
2025	5	8.99	0.00	0.00	0.00	8.99	0.00	5.91	0.00	5.91	3.07	11.59	14.66
2026	6	8.99	0.00	0.00	0.00	8.99	0.00	5.85	0.00	5.85	3.14	14.66	17.81
2027	7	8.99	0.00	0.00	0.00	8.99	0.00	5.78	0.00	5.78	3.21	17.81	21.02
2028	8	8.99	0.00	0.00	0.00	8.99	0.00	5.71	0.00	5.71	3.28	21.02	24.29
2029	9	8.99	0.00	0.00	0.00	8.99	0.00	5.64	0.00	5.64	3.35	24.29	27.64
2030	10	8.99	0.00	0.00	0.00	8.99	0.00	5.57	0.00	5.57	3.42	27.64	31.06
2031	11	8.45	0.00	0.00	0.00	8.45	0.00	5.50	0.00	5.50	2.95	31.06	34.01
2032	12	8.44	0.00	0.00	0.00	8.44	0.00	5.43	0.00	5.43	3.01	34.01	37.02
2033	13	8.42	0.00	0.00	0.00	8.42	0.00	5.36	0.00	5.36	3.06	37.02	40.08
2034	14	8.41	0.00	0.00	0.00	8.41	0.00	5.29	0.00	5.29	3.12	40.08	43.20
2035	15	8.39	0.00	0.00	0.00	8.39	0.00	5.22	0.00	5.22	3.17	43.20	46.37
2036	16	8.38	0.00	0.00	0.00	8.38	0.00	5.15	0.00	5.15	3.23	46.37	49.60
2037	17	8.37	0.00	0.00	0.00	8.37	0.00	5.08	0.00	5.08	3.28	49.60	52.88
2038	18	8.35	0.00	0.00	0.00	8.35	0.00	5.01	0.00	5.01	3.34	52.88	56.22
2039	19	8.34	0.00	0.00	0.00	8.34	0.00	0.00	0.00	0.00	8.34	56.22	64.56
2040	20	8.34	0.00	0.00	0.00	8.34	0.00	0.00	0.00	0.00	8.34	64.56	72.89
Total		173.75	26.01	89.01	0.00	288.76	115.02	100.85	0.00	215.87	72.89		

(note) L/T : Long term Loan, S/T : Short term Loan

Table 5.2-13: Cash Flow in Case 2

(Unit: Million TND)

Year		Cash from Operation	Financial Source: Equity	Financial Source: L/T Loan	Financial Source: S/T Loan	Source of Funds	Fixed Capital Cost	Debt Service: on L/T Loan	Debt Service: on S/T Loan	Uses of Funds	Cash Balance: Current Year	Cash Balance: Beginning Year	Cash Balance: Ending Year
2013	-8	0.00	0.13	0.46	0.00	0.59	0.59	0.00	0.00	0.59	0.00	0.00	0.00
2014	-7	0.00	2.00	7.01	0.00	9.00	9.00	0.00	0.00	9.00	0.00	0.00	0.00
2015	-6	0.00	3.82	13.41	0.00	17.23	17.23	0.00	0.00	17.23	0.00	0.00	0.00
2016	-5	0.00	7.72	27.12	0.00	34.84	34.84	0.00	0.00	34.84	0.00	0.00	0.00
2017	-4	0.00	9.33	32.76	0.00	42.09	42.09	0.00	0.00	42.09	0.00	0.00	0.00
2018	-3	0.00	9.07	31.85	0.00	40.91	40.91	0.00	0.00	40.91	0.00	0.00	0.00
2019	-2	0.00	8.11	28.49	0.00	36.61	36.61	0.00	0.00	36.61	0.00	0.00	0.00
2020	-1	0.00	3.21	11.28	0.00	14.49	14.49	0.00	0.00	14.49	0.00	0.00	0.00
2021	1	15.34	0.00	0.00	0.00	15.34	0.00	10.60	0.00	10.60	4.74	0.00	4.74
2022	2	15.34	0.00	0.00	0.00	15.34	0.00	10.48	0.00	10.48	4.86	4.74	9.60
2023	3	15.34	0.00	0.00	0.00	15.34	0.00	10.36	0.00	10.36	4.98	9.60	14.58
2024	4	15.34	0.00	0.00	0.00	15.34	0.00	10.24	0.00	10.24	5.10	14.58	19.67
2025	5	15.34	0.00	0.00	0.00	15.34	0.00	10.12	0.00	10.12	5.21	19.67	24.89
2026	6	15.34	0.00	0.00	0.00	15.34	0.00	10.01	0.00	10.01	5.33	24.89	30.22
2027	7	15.34	0.00	0.00	0.00	15.34	0.00	9.89	0.00	9.89	5.45	30.22	35.67
2028	8	15.34	0.00	0.00	0.00	15.34	0.00	9.77	0.00	9.77	5.57	35.67	41.24
2029	9	15.34	0.00	0.00	0.00	15.34	0.00	9.65	0.00	9.65	5.69	41.24	46.93
2030	10	15.34	0.00	0.00	0.00	15.34	0.00	9.53	0.00	9.53	5.81	46.93	52.73
2031	11	14.42	0.00	0.00	0.00	14.42	0.00	9.41	0.00	9.41	5.00	52.73	57.74
2032	12	14.39	0.00	0.00	0.00	14.39	0.00	9.29	0.00	9.29	5.10	57.74	62.84
2033	13	14.37	0.00	0.00	0.00	14.37	0.00	9.18	0.00	9.18	5.19	62.84	68.03
2034	14	14.35	0.00	0.00	0.00	14.35	0.00	9.06	0.00	9.06	5.29	68.03	73.32
2035	15	14.32	0.00	0.00	0.00	14.32	0.00	8.94	0.00	8.94	5.38	73.32	78.71
2036	16	14.30	0.00	0.00	0.00	14.30	0.00	8.82	0.00	8.82	5.48	78.71	84.19
2037	17	14.28	0.00	0.00	0.00	14.28	0.00	8.70	0.00	8.70	5.57	84.19	89.76
2038	18	14.25	0.00	0.00	0.00	14.25	0.00	8.58	0.00	8.58	5.67	89.76	95.43
2039	19	14.23	0.00	0.00	0.00	14.23	0.00	0.00	0.00	0.00	14.23	95.43	109.66
2040	20	14.23	0.00	0.00	0.00	14.23	0.00	0.00	0.00	0.00	14.23	109.66	123.88
Total		296.52	43.38	152.37	0.00	492.28	195.76	172.64	0.00	368.40	123.88		

(note) L/T : Long term Loan, S/T : Short term Loan

Table 5.2-14: Cash Flow in Case 3

(Unit: Million TND)

Year		Cash from Operation	Financial Source: Equity	Financial Source: L/T Loan	Financial Source: S/T Loan	Source of Funds	Fixed Capital Cost	Debt Service: on L/T Loan	Debt Service: on S/T Loan	Uses of Funds	Cash Balance: Current Year	Cash Balance: Beginning Year	Cash Balance: Ending Year
2013	-8	0.00	0.15	0.53	0.00	0.67	0.67	0.00	0.00	0.67	0.00	0.00	0.00
2014	-7	0.00	2.09	7.36	0.00	9.45	9.45	0.00	0.00	9.45	0.00	0.00	0.00
2015	-6	0.00	4.54	15.94	0.00	20.47	20.47	0.00	0.00	20.47	0.00	0.00	0.00
2016	-5	0.00	9.02	31.70	0.00	40.72	40.72	0.00	0.00	40.72	0.00	0.00	0.00
2017	-4	0.00	10.52	36.95	0.00	47.47	47.47	0.00	0.00	47.47	0.00	0.00	0.00
2018	-3	0.00	10.32	36.25	0.00	46.57	46.57	0.00	0.00	46.57	0.00	0.00	0.00
2019	-2	0.00	9.37	32.93	0.00	42.30	42.30	0.00	0.00	42.30	0.00	0.00	0.00
2020	-1	0.00	3.84	13.49	0.00	17.32	17.32	0.00	0.00	17.32	0.00	0.00	0.00
2021	1	16.27	0.00	0.00	0.00	16.27	0.00	12.18	0.00	12.18	4.09	0.00	4.09
2022	2	16.27	0.00	0.00	0.00	16.27	0.00	12.05	0.00	12.05	4.22	4.09	8.31
2023	3	16.27	0.00	0.00	0.00	16.27	0.00	11.91	0.00	11.91	4.36	8.31	12.67
2024	4	16.27	0.00	0.00	0.00	16.27	0.00	11.77	0.00	11.77	4.49	12.67	17.16
2025	5	16.27	0.00	0.00	0.00	16.27	0.00	11.64	0.00	11.64	4.63	17.16	21.79
2026	6	16.27	0.00	0.00	0.00	16.27	0.00	11.50	0.00	11.50	4.77	21.79	26.56
2027	7	16.27	0.00	0.00	0.00	16.27	0.00	11.36	0.00	11.36	4.90	26.56	31.46
2028	8	16.27	0.00	0.00	0.00	16.27	0.00	11.23	0.00	11.23	5.04	31.46	36.50
2029	9	16.27	0.00	0.00	0.00	16.27	0.00	11.09	0.00	11.09	5.18	36.50	41.68
2030	10	16.27	0.00	0.00	0.00	16.27	0.00	10.96	0.00	10.96	5.31	41.68	46.99
2031	11	15.48	0.00	0.00	0.00	15.48	0.00	10.82	0.00	10.82	4.66	46.99	51.65
2032	12	15.46	0.00	0.00	0.00	15.46	0.00	10.68	0.00	10.68	4.77	51.65	56.43
2033	13	15.43	0.00	0.00	0.00	15.43	0.00	10.55	0.00	10.55	4.88	56.43	61.31
2034	14	15.40	0.00	0.00	0.00	15.40	0.00	10.41	0.00	10.41	4.99	61.31	66.30
2035	15	15.37	0.00	0.00	0.00	15.37	0.00	10.27	0.00	10.27	5.10	66.30	71.39
2036	16	15.35	0.00	0.00	0.00	15.35	0.00	10.14	0.00	10.14	5.21	71.39	76.60
2037	17	15.32	0.00	0.00	0.00	15.32	0.00	10.00	0.00	10.00	5.32	76.60	81.92
2038	18	15.29	0.00	0.00	0.00	15.29	0.00	9.87	0.00	9.87	5.43	81.92	87.34
2039	19	15.26	0.00	0.00	0.00	15.26	0.00	0.00	0.00	0.00	15.26	87.34	102.61
2040	20	15.26	0.00	0.00	0.00	15.26	0.00	0.00	0.00	0.00	15.26	102.61	117.87
Total		316.30	49.85	175.14	0.00	541.29	224.99	198.43	0.00	423.42	117.87		

(note) L/T : Long term Loan, S/T : Short term Loan

Also, DSCR (Debt Service Coverage Ratio), calculated from the following formula, is studied as then index for judging the long-term debt-paying ability

$$\text{DSCR=} \frac{\text{Profit after tax + Depreciation \& Amortization + Interest on long-term loan}}{\text{Repayment on long-term loan + Interest on long-term loan}}$$

When the ratio of debt is around 78.5 %, at the treatment tariff of 0.7 TND/m^3, DSCR is calculated as per Table 5.2-15.

From the table, these finance schemes are concluded to be mathematically healthy, because DSCR is always over one (1).

Table 5.2-15: DSCR (Unit: times)

Year	Case 1	Case 2	Case 3
1st year（2021）	1.44	1.44	1.33
2nd year (2022)	1.46	1.46	1.35
3rd year（2023）-	1.48	1.48	1.36

5.2.7.2.3 Sensitivity Analysis

The variation effect of F-IRR before tax on the treatment water tariff in 3 Cases is shown in Figure 5.2-2.

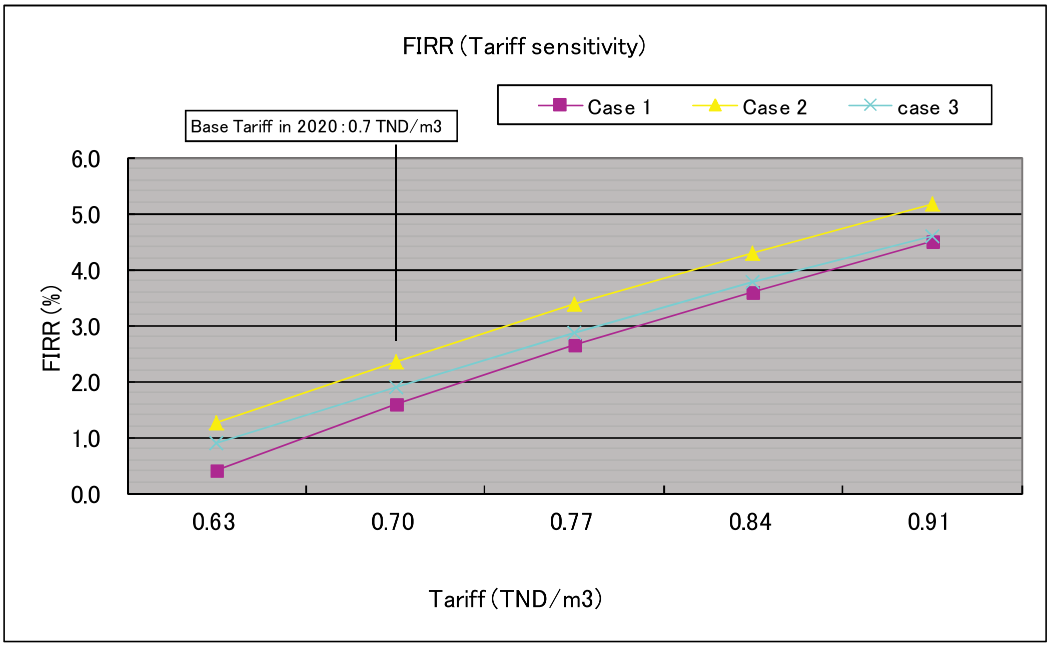


Figure5.2-2: Tariff Sensitivity

5.2.8 Economic analysis

In this section, from viewpoints of social development and infrastructure improvement, economic by this F/S Project to Tunisia is reviewed and studied. Following items are assumed to be benefit and expenditure in this study.

Expenditure:

- Total investment cost (refer to sect.5.2.2)
- Operation and Maintenance cost for the facility

Benefit:

- Activation of agriculture industries by reusing of treated water
- Reduction of medical expenditure and social cost of diarrhea by improving sanitary conditions

5.2.8.1 Reuse of treated water

Currently, re-utilization of treated water from WwTP to agriculture is not sufficient in Tunisia, but if water is treated suitably for those purposes, this water will contribute to augmentation of agricultural production through irrigation system. In this survey, water quality of treated waste water becomes to meet water quality standard in Tunisia, NT 106. 02.

In Tunisia, around 10 % of GDP (6,300 million TND (= 63,342 million TND x 10 %)) is agriculture production. Though northern area is not suffered from heavy shortage of water, but if treated water is used for the agriculture use, increase of agriculture production is expected. According to Ministry of Agriculture, the area around Medjez, Béja and Siliana area is expected. Detail data on the agriculture production in these area is not reported, but if treated water from these 3 WwTPs (8,215,055 m^3/year (= 22,507 m^3/day x 365), (refer to Table 5.2-5), and total water capacity for agriculture in all Tunisia (21,000,000,000 m^3/year, Ministry of Agriculture data), and total production in Tunisia (6,300 million TND) are used for estimation, following improvement is expected.

6,300 million TND x (8,215,055 m^3/year/21,000,000,000 m^3/year) = 2.5 million TND

In this study, 10 % of treated water is assumed to be used for this purpose, then 2.5 million TND x 10 % = 0.2 million TND is assumed to be additional benefit.

5.2.8.2 Reduction of medical expenditure and social cost of diarrhea by improving sanitary conditions

The lack of adequate drinking water supply and deficient sanitation, poor water quality and hygiene are the cause of water-related diseases which can be fatal for young children[6], especially in developing countries.

By improving the sanitation system, the quality of health would improve leading to an expected reduction in the diseases caused by bacteriological degradation of water. As a result, it is also expected that the costs linked to diarrhea, the most impactful water-related disease, would be reduced.

[6] "Effects of Improved Water Supply and Sanitation on Ascariasi, Diarrhea, Dracunculiasis, Hookworm Infection, Schistosomiasis, and Trachoma" Esrey, J., Potash B., Roberts L. and Schiff C, 1991, World Health Organization.

These costs not only include the direct costs for treatment and care of the different cases of diarrhea (a), but also indirect costs, linked to the social costs of mortality (b).

The following analysis is largely inspired by a World Bank report[7] and makes use of its general methodology and certain references or gathered data.

5.2.8.2.1 Direct costs of diarrhea – Treatment cost of children with diarrhea

The treatment and care costs which include both hospitalization costs and the use of medication or the doctor's wage are calculated for the children suffering from diarrhea.

Regarding children under age 5, the Directorate of Basic Healthcare (DSSB: Direction des Soins de Santé de Base) reported [8] 65,855 cases of diarrheic diseases in Public Healthcare Centers (CSP: Centre de Soins Publics) in 2004. According to a UNICEF survey[9], this number represents around 28% of all cases of diarrhea in Tunisia[10]. If this percentage is applied, there were a total number of 235,196 cases of diarrhea among children under the age of 5.

Regarding children over age 5, the DSSB reported 118,300 cases of diarrheic diseases identified in CSP in 2004, which represent, for UNICEF, around 30% of all cases of diarrhea in the whole country. If this percentage is applied, there were a total number of 394,000 cases of diarrhea among children over the age of 5.

Considering that 85% of cases of diarrhea are attributable to inadequate drinking water and sanitation as well as a lack of hygiene[11], the number of cases to be linked to the project is reduced to 199,917 for children under age 5 and 334,900 for children over age 5.

The interviews carried out by the World Bank by Tunisian doctors established that the average case of diarrhea lasts 3 days and that the costs vary widely depending on how serious the illness is: case of hospitalization (46-65 TND), case of dehydration (150-200 TND), case of bleeding diarrhea (500-700 TND) or uncomplicated cases (3 TND).

In light of these criteria, treatment costs are as follows: case of hospitalization (13,434,369 TND), case of dehydration (472,303 TND), case of bleeding diarrhea (1,031,570 TND) and uncomplicated cases (584,156 TND). Regarding the children over age 5, as the available data does not identify the costs for each situation, we considered all the cases as uncomplicated (1,004,700 TND). In addition to the cost for the time that doctor care for children suffering from dehydration and bleeding diarrhea (132,545 TND), the total direct costs of diarrhea in children under the age of 5 is amounts to 16,187,366 TND. Divided to the whole Tunisian population[12], we get an annual cost of 1,534 TND per capita.

Table 5.2-16 summarizes the data and the calculation method making it possible to estimate the annual direct cost of the impact of diarrhea on the children population.

[7] "Republic of Tunisia – Evaluation of the cost of water degradation", 2007, World Bank

[8] "Epidemiological report", 2004, DBH.

[9] "Multiple Indicator Cluster Survey", 2000, Tunisia, UNICEF.

[10] The rest (72%) being composed by cases identified in Caisse Nationale de Sécurité Sociale (2%), in private sector (20%) and by the people who does not seek the assistance of a doctor (50%). This last category includes those who simply seek advice of a pharmacist or of entourage, those who chose self-medication, and those who are not treated at all.

[11] "Evaluation of the Costs and Benefits of Water and Sanitation Improvements at the Global Level", Hutton, G. and Haller L. 2004. WHO. Geneva

[12] " Bulletin mensuel statistique N° 657" September 2011, INS

Table 5.2-16: Estimation of direct costs of diarrhea – Treatment cost of children with diarrhea

A. DIARRHEA DIRECT COST - Treatment cost of children with diarrhea			
A1. Hospitalization cost (under age 5)	Quantity	Unit	Source
Number of identified diarrhea cases in CSP (child under age 5)	65,855	case	DSSB, 2004
Total number of child under age 5 cases in Tunisia	235,196	case	WB
Proportion of cases due to the lack of appropriate water and sanitation	85	%	Hutton & Haller (2004)
Number of under age 5 cases in Tunisian population due to the lack of appropriate water and sanitation	199,917	case	
Rate of cases that need a hospitalization	0.35	%	DSSB, 2004
Number of cases that need a hospitalization	69,971	case	
Duration of disease by case	3	days/case	Itw. Doctors (WB)
Total duration of hospitalization	209,912	days	
Daily hospitalization cost (between 45 and 65 TND/case/day)	53	TND/day	Itw. Doctors (WB)
Medicine cost per day	1	TND/day	Itw. Doctors (WB)
Doctor cost per day	10	TND/day	Itw. Doctors (WB)
A1. Total hospitalization cost (under age 5)	13,434,396	TND	
A2. Cases of dehydration (under age 5)			
Rate of cases with dehydration	1.35	%	DSSB, 2004
Number of cases with dehydration	2,699	case	
Treatment cost (between 150 and 200 TND)	175	TND/case	Itw. Doctors (WB)
A2. Total cost of dehydration cases (under age 5)	472,303	TND	
A3. Cases of bloody diarrhea (under age 5)			
Rate of case with bloody diarrhea	0.86	%	DSSB, 2004
Number of case with bloody diarrhea	1,719	case	
Treatment cost (between 500 and 700 TND)	600	TND/case	Itw. Doctors (WB)
A3. Total cost of bloody diarrhea cases (under age 5)	1,031,570	TND	
A4. Uncomplicated cases (under age 5)			
Rate of uncomplicated cases	97.4	%	DSSB, 2004
Number of uncomplicated cases	194,719	case	
Treatment cost (3 days of medicine by case, w/o hospitalization)	3	TND/case	Itw. Doctors (WB)
A4. Total cost of uncomplicated cases (under age 5)	584,156	TND	
A5. Uncomplicated cases (over age 5)			
Number of identified diarrhea cases in CSP (child over age 5)	118,300	case	DSSB, 2004
Total number of child over age 5 cases in Tunisia	394,000	case	WB
Proportion of cases due to the lack of appropriate water and sanitation	85	%	Hutton & Haller (2004)
Number of over age 5 children cases in Tunisian population due to the lack of appropriate water and sanitation	334,900	case	
Treatment cost (3 days of medicine by case, w/o hospitalization)	3	TND/case	Itw. Doctors (WB)
A5. Total cost of uncomplicated cases (over age 5)	1,004,700	TND	
A6. Cost of time spent to care about children with dewatering and bloody diarrhea			
Number of cases with dewatering and bloody diarrhea	4,418	case	
Value of one lost day of work	10	TND/days	
Treatment duration	3	days/case	Itw. Doctors (WB)
A6. Total cost of time spent to care about children	132,545	TND/year	
A. DIARRHEA TOTAL DIRECT COSTS	16,187,366	TND/year	
Total population of Tunisia (2010)	10,549,300	hab	INS (2010)
DIARRHEA DIRECT COST PER CAPITA	1.534	TND/hab/year	

Then using population rate (Population in the Project area in each Cases), total medical expenditure in the Project area could be estimated to be around 0.5 million TND for Case 1 (= 326.1 thousand person x 1.534 TND/person), around 0.9 million TND (Case 2: 586.8 thousand person x 1.534 TND/person) and around 1.0 million TND (Case 3: 621.7 thousand person x 1.534 TND/person). Refer to Table 5.2-17.

Table 5.2-17: Decrease of medical expenditure (Unit: million TND)

	Case 1	Case 2	Case 3
Revenue (million TND)	0.5	0.9	1.0

5.2.8.2.1 Indirect costs of diarrhea – Social cost of diarrheic infant mortality

It is important to note that in Tunisia, even if the rate of mortality due to diarrhea has fallen considerably in recent years, this disease continues to be very dangerous for young children. If we assumed the hypothesis that all patients over 5 years are treated and survive, we obtain a loss equal to zero, and that is why the mortality of this age group will not be treated.

According to the Ministry for Public Health, diarrhea is the fourth most common cause of death among children under the age of 5, an age group representing 10% of the total population. The specific rate of death due to diarrhea is estimated at 0.57‰[13].

By taking the total population of the country as a base, the number of children under age 5 who die from diarrhea caused by poor water environment increases to 511 per year.

The social costs of child diarrheic mortality are estimated using the Disability Adjustment Life Years method (DALY)[14]. This method attempts to allocate a common value to diseases and to premature deaths caused by environmental degradation in terms of life years corrected by the invalidity factor. A year lost due to a premature death represents one DALY; future lost years are calculated at a fixed discount rate. A more or less severe disease corresponds to more or less important portion of one DALY.

Since the death of a child under the age of 5 years old represents a loss of 33 DALY[15], the 511 identified deaths represent an annual loss of around 16,863 DALY.

The monetary evaluation of the DALY is based on the Human Capital Approach method which considers the economic value of a lost year, caused by a disease or a premature death, to be the equivalent of the productive value of that year, in other words of the GDP per capita.

Assuming a GDP per capita of 6,004, it appears that the indirect cost, the damage to society due to diarrhea among children under the age of 5 because of a poor water environment amounting to 101,274,357 TND. Divided to the whole Tunisian population, we get an annual cost of 9,600 TND per capita.

Table 5.2-18 summarizes the data and the calculation method making it possible to estimate the annual cost of the indirect impact of diarrhea on the population of children under the age of 5.

[13] "Water, Environment and Human Health" Nedhif, M, Directorate of Environmental Hygiene and Environment Protection, 2008, Ministry of Public Health.

[14] "Global Burden of Disease in 2002: data sources, methods and results. Revised in February 2004. Global Programme on Evidence 51 for Health Policy Discussion Paper No 54." Mathers, C., Bernard, C., Iburg, K., Inoue, M., Ma Fat, D., Shibuya, K., Stein, C., Tomijima, N., Xu, H., 2004, WHO.

[15] "Health statistics and health information systems. Disability Adjustment Life Years (DALY)," 2006, WHO.

Table 5.2-18: Estimation of indirect costs of diarrhea – Social cost of diarrheic infant mortality

B. DIARRHEA INDIRECT COST - Social cost of diarrheic infant mortality (under age 5)	Quantity	Unit	Source
Proportion of children under age 5 in Tunisian population (2010)	10	%	Min. Public Health
Total population of Tunisia (2010)	10,549,300	hab	INS (2010)
Number of children under age 5 in Tunisian population (2010)	1,054,930	hab	
Specific mortality rate due to diarrhea	0.57	‰	Min. Public Health
Death of children under age 5 due to diarrhea in Tunisian population (2010)	601	deaths/year	
Proportion of cases due to the lack of appropriate water and sanitation	85	%	Hutton & Haller (2004)
Deaths of children under age 5 in Tunisian population due to the lack of appropriate water and sanitation	511	deaths/year	
DALY per death of child	33	DALY	WHO, 2006
Total DALYs - Diarrheic infant mortality (under age 5)	16,863	DALYs/an	
Gross Domestic Product of Tunisia (2010)	63,342,000,000	TND	INS (2010)
Total population of Tunisia (2010)	10,549,300	hab	INS (2010)
GDP per capita	6,004	TND/hab	
B. DIARRHEA INDIRECT COST - Social cost of diarrheic infant mortality (under age 5)	101,245,452	TND	
Total population of Tunisia (2010)	10,549,300	hab	INS (2010)
DIARRHEA INDIRECT COST PER CAPITA	9.600	TND/hab/year	

Further, by improving sanitation, death of Children will be decreased and by those people, social production will be improved. Related data is coming from INS data and UN data etc., and is estimated as per Table 5.2-19.

Table 5.2-19: Decrease of social cost

	Case 1	Case 2	Case 3
Population 2011	326,074	586,814	621,672
Number of Children	33,000	59,000	62,000
Number of Children dead under 5 years (hab/ year)	19	34	35
Death of Children by water originated disease (hab / year)	16	29	30
DALYs/ Child dead under 5 years, (hab /year)	33	33	33
DALLYs / year (TND/ hab)	6,005	6,005	6,005
Total social cost of Children mortality year (million TND / year)	3.2	5.8	5.9

Total benefit is summarized as per Table 5.2-20.

Table 5.2-20: Total benefit by the project

Unit: Million TND

Items	Case 1	Case 2	Case 3
Revenue by WwTP operation	12.7	20.1	21.1
Benefit from Agriculture	0.2	0.2	0.2
Decrease of medical expenditure	0.5	0.9	1.0
Decrease of Children mortality cost	3.2	5.8	5.9
Total	16.6	27.0	28.2

5.2.8.3 EIRR

Considering above benefits, total economic impact and EIRR in base scenario, with 20 years project life for each case is calculated as Table 5.2-21:

Table 5.2-21: EIRR

	Case 1	Case 2	Case 3
Revenue (million TND)	16.6	27.0	28.2
EIRR (%)	5.7	6.8	6.2

5.2.9 Project index

5.2.9.1 Quantitative impact

Quantitative impact by the project is as per Table 5.2-22.

Table 5.2-22: Quantitative Impact

a) WwTP

Indicator	WwTP	Design Capacity (Existing WwTP)	Actual (2011)	Completion Year (2020)	Project Target Year (2029)
Number of beneficiaries served by the Project (hab)	Béja	–	65,560	71,990	78,419
	Medjez el Bab	–	20,113	22,379	24,644
	Tabarka	–	21,239	26,281	31,322
	Jendouba	–	50,088	57,538	64,988
	Siliana	–	25,322	28,589	31,855
BOD5 processing of the 5 WwTP (kg/ day)	Béja	7,800	6,484	7,550	8,615
	Medjez el Bab	2,000	1,368	1,872	2,376
	Tabarka	1,825	1,664	2,168	2,671
	Jendouba	3,400	2,251	3,226	4,200
	Siliana	2,450	1,233	1,464	1,694
Average daily flow of 5 WwTP for wastewater treatment (m^3/ day)	Béja	14,000	6,244	9,619	12,994
	Medjez el Bab	4,500	2,391	3,910	5,429
	Tabarka	5,500	4,491	6,501	8,510
	Jendouba	8,000	5,123	8,413	11,703
	Siliana	4,530	2,321	3,203	4,084
BOD5 concentration of the 5 WwTP on discharge water (mg/l)	Béja	30	20-31 (*1)	≦30 (NT 106.002)	
	Medjez el Bab	30	25 (*1)		
	Tabarka	30	21-25 (*1)		
	Jendouba	30	22-24 (*1)		
	Siliana	30	27-56 (*1)		

(*1) ONAS: Annual Report (2008-2010)

b) Network (3 Cases)

Indicator	Case	Actual (2011)	Completion Year (2020)	Project Target Year (2029)
Length of new networks (Extension) (km)	Case 1	–	71.1	
	Case 2	–	287.1	
	Case 3	–	416.1	
Number of beneficiaries of networks (hab)	Case 1	119,082	136,981	154,880
	Case 2	327,631	371,626	415,620
	Case 3	327,631	389,055	450,478

c) Network (Each commune)

Governorate	Commune	Length of new networks (Extension) (km)	Number of beneficiaries (hab)		
		Completion Year (2020)/ Project target Year (2029)	Actual (2011)	Completion Year (2020)	Project target Year (2029)
Béja	Medjez el Bab	0.7	7,450	7,450	7,450
	Béja	1.0	12,319	12,599	12,879
	Nefza	4.3	385	538	690
	Testour	0.7	1,312	1,543	1,774
	Maagoula	0.0	300	300	300
	Teboursouk	1.3	5,448	5,718	5,988
Bizerte	Raf Raf	0.3	0	2,500	5,000
	Alia	0.0	3,500	3,500	3,500
Jendouba	Tabarka	18.8	6,110	6,678	7,245
	Jendouba	5.1	28,923	29,462	30,000
	Ghardimaou	4.6	2,014	2,243	2,472
	Fernana	5.0	1,142	1,355	1,567
	Boussalem	4.0	0	362	724
Kasserine	Kasserine	13.2	59,760	62,210	64,660
	Sbeitla	2.3	2,950	3,463	3,975
Kébili	Kébili	2.5	8,000	8,500	9,000
	Jemna	22.9	500	2,250	4,000
	Douz	5.8	25,000	26,000	27,000
	El Golaa	3.1	0	375	750
	Kébili Nord	39.4	0	7,040	14,080
	Kébili Sud	22.9	0	3,750	7,500
	Douz Sud	17.3	0	1,500	3,000
Kef	Tajerouine	2.0	5,825	6,025	6,225
	Kef	3.6	44,191	44,691	45,191
Sfax	Mahres	18.7	18,325	19,700	21,075
	Sakiet Ezzit	122.8	7,795	10,807	13,819
	Chihia	19.2	6,529	8,510	10,491
	Sakiet Eddaier	24.1	13,340	28,123	42,905
	Agareb	8.1	0	1,500	3,000
	Jebeniana	10.0	0	1,175	2,350
	Hencha	12.0	0	1,425	2,850
Sidi Bouzid	Sidi Bouzid	10.3	32,770	33,785	34,800
Siliana	Siliana	0.0	2,773	2,773	2,773
	Krib	3.2	0	4,000	8,000
	Bou Arada	0.0	2,569	2,569	2,569
Zaghouan	Hammam Zriba	2.3	10,701	10,701	10,701
	El Fahs	0.0	17,700	17,700	17,700
	Zaghouan	4.6	0	6,238	12,475
Total		**416.1**	**327,631**	**389,055**	**450,478**

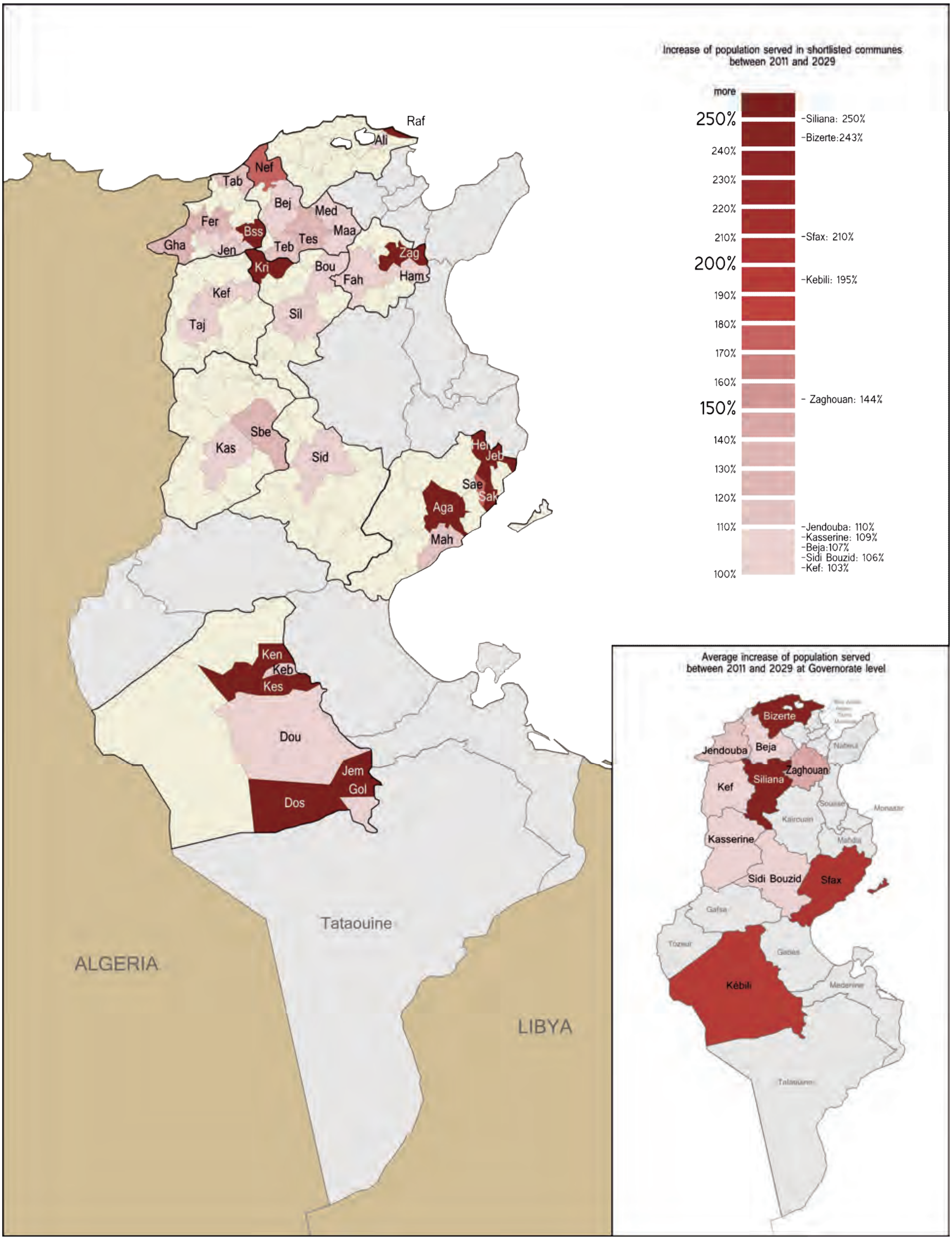


Figure5.2-3: Increase of served population between 2011 and 2029

5.2.9.2 Project benefit

As per 5.2.8, following benefit are expected by this F/S project.

a) Increase of agriculture production by increasing usage of underground water (For EIRR calculation, 0.2 million TND of benefit is estimated)

b) Decrease of medical expenditure, and decrease of Children mortality cost by improving water quality (For EIRR calculation, 3.7 million TND for Case 1, 6.7 million TND for Case 2 and 6.9 million TND for Case 3 of benefit is estimated.

5.2.10 Assessments of financial feasibility

Based on the previous analysis, following conclusions could be assessed.

5.2.10.1 Project Profitability

From general view point of investment study, this FIRR is very low. This comes from public project which is difficult to charge its cost to users.

But based on the above study, Case 2 shows the highest financial result, with a total capital requirement of 234.1 million TND, and achieves an FIRR of 2.36 % at a base tariff of 0.7 TND/m^3; if current tariff of 0.5 TND/m^3 is applied; FIRR is less than zero, in which FIRR is not calculated. Further DSCR (Debt Service Coverage Ratio) for the 1st year of repayments and years afterward shows more than one (1), which is theoretically healthy cash flow.

5.2.10.2 Sewage Tariff

The sales price is assumed to be increased. In this study, all cases show healthy financial economics when the base scenario is applied, but if people cannot accept this base scenario tariff, the idea of a subsidy is recommended to be applied by the GoT.

5.2.10.3 Economic Efficiency

EIRR of the project is estimated to be 5.7 % in the Case 1, 6.8% in the Case 2, and 6.2 % in the Case 3, which are not high, but it might be conducted that the investment will be positive from the viewpoint of development of the project.

5.3 IMPLEMENTATION SCHEDULE

5.3.1 Progress rate of construction

Progress rate of construction will be each year from 2015 to 2020 shown in Figure 5.3-1.

Table 5.3-1: Progress rate of construction

Case	2015	2016	2017	2018	2019	2020
1	7%	17%	24%	24%	21%	7%
2	8%	18%	22%	23%	21%	8%
3	8%	19%	22%	22%	21%	8%

5.3.2 Implementation Schedule for WwTP

The facilities will be implemented according to the implementation Schedule shown in Figure 5.3-2 the first task would be selected the International Consultants (see the Figure 5.3-1). Next task would be selected the Contractor on 2016 at lot by lot in total 4lots. WwTP construction will be built from 2016 to 2019. While the civil and electrical works are carried out, the mechanical and electrical equipment would be procured and installed. The construction works would be completed and WwTP would begin operation by 2020.

5.3.3 Implementation Schedule for Pumping station and Networks.

The facilities will be implemented according to the implementation Schedule shown in Figure 5.3-3 Local Contractor selection will be held each year from 2014 to 2017 in total three times.

NO	Task	Start	End
1	JICA Procedure, E/N, L/A of ODA Loan,etc	2012/01/01	2012/09/30
2	Loan period	2012/10/01	2021/12/31
3	Preparation of shortlist	2012/07/01	2012/09/30
4	Tender for shortlisted consultants	2012/10/01	2013/03/31
4-1	Evaluation and selection of consultants	2013/04/01	2013/09/30
4-2	Approval of Contract (Japan and Tunisia)	2013/10/01	2013/12/31
5	Detail design, EIA, Preparation of Tender Document	2014/01/01	2014/12/31
6	Construction Supervision	2016/04/01	2019/12/31

Figure 5.3-1: Project Implementation Schedule for consulting services

NO	Task	Start	End
1	JICA Procedure, E/N, L/A of ODA Loan,etc	2012/01/01	2012/09/30
2	Loan period	2012/10/01	2021/12/31
3	Tender for contractors Lot 1 - Lot 4 (ICB)	2015/01/01	2016/12/31
3-1	Evaluation and selection of contractors by ONAS	2015/07/01	2017/06/30
3-2	Approval of Contract	2016/01/01	2017/09/30
4	Construction period: Lot 1 (Beja)	2016/10/01	2018/06/30
4-1	Topo and geotechnic survey	2016/04/01	2016/09/30
4-2	Civil works	2016/10/01	2017/09/30
4-3	Equipement and electric works	2017/07/01	2018/03/31
5	Construction period: Lot 2 (Medjez el Bab)	2017/04/01	2018/12/31
5-1	Topo and geotechnic survey	2016/10/01	2017/03/31
5-2	Civil works	2017/04/01	2018/03/31
5-3	Equipement and electric works	2018/01/01	2018/09/30
6	Construction period: Lot 3 (Tabarka,Jendouba)	2017/10/01	2019/06/30
6-1	Topo and Geotechnic Survey	2017/04/01	2017/09/30
6-2	Civil works	2017/10/01	2018/09/30
6-3	Equipement and electric works	2018/07/01	2019/03/31
7	Construction period: Lot 4 (Siliana)	2018/04/01	2019/12/31
7-1	Topo and geotechnic survey	2017/10/01	2018/03/31
7-2	Civil works	2018/04/01	2019/03/31
7-3	Equipement and electric works	2019/01/01	2019/09/30
8	Guarantee period	2018/07/01	2021/12/31

Figure 5.3-2: Project Implementation Schedule for WwTP

NO	Task	Start	End
1	JICA Procedure, E/N, L/A of ODA Loan, etc	2012/1/1	2012/9/30
2	Loan Period	2012/10/1	2021/12/31
3	Tender for Consultants (LCB)	2012/7/1	2013/12/31
3-1	Tender evaluetion and approval of contract	2012/10/1	2014/3/31
4	Detail design, Preparation of Tender Document	2013/7/1	2016/6/30
5	Land acquisition and compensation for new pumping stations	2013/10/1	2016/8/31
6	1st Tender for Contractors (LCB)	2014/4/1	2015/3/31
6-1	Tender evaluetion and approval of contract	2014/10/1	2015/3/31
6-2	Topo and geotechnic survey	2015/4/1	2015/9/30
6-3	Civil works	2015/10/1	2017/6/30
6-4	Equipement and electric works	2017/10/1	2018/6/30
7	2nd Tender for Contractors (LCB)	2015/4/1	2016/3/31
7-1	Tender evaluetion and approval of contract	2015/10/1	2016/3/31
7-2	Topo and geotechnic survey	2015/4/1	2016/9/30
7-3	Civil works	2016/10/1	2018/6/30
7-4	Equipement and electric works	2018/1/1	2019/6/30
8	3rd Tender for Contractors (LCB)	2016/4/1	2017/3/31
8-1	Tender evaluetion and approval of contract	2016/10/1	2017/3/31
8-2	Topo and geotechnic survey	2017/4/1	2017/9/30
8-3	Civil works	2017/10/1	2019/6/30
8-4	Equipement and electric works	2019/1/1	2020/6/30
9	Tender for material supplyers	2014/4/1	2017/3/31
9-1	Tender evaluetion and approval of contract	2014/10/1	2017/6/30
10	Construction period	2015/4/1	2020/9/30
11	Guarantee period	2020/10/1	2021/12/31

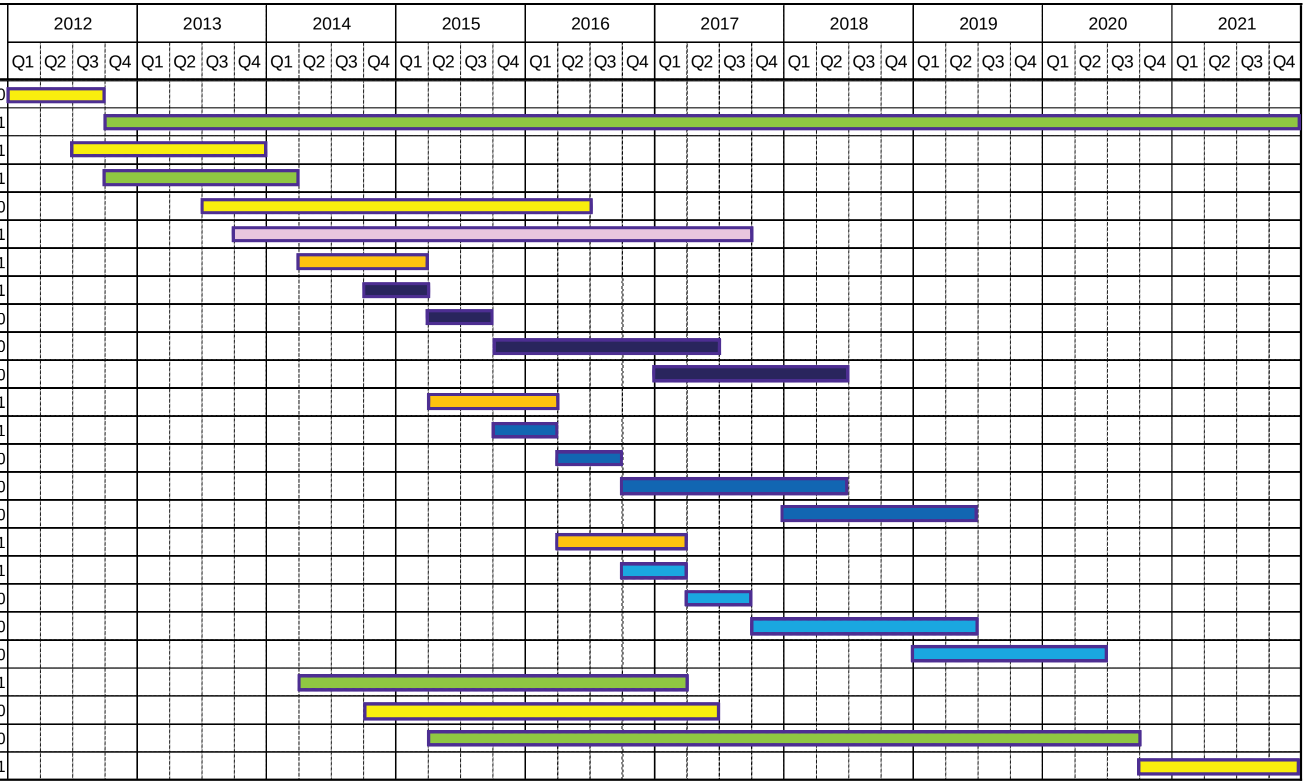


Figure 5.3-3: Project Implementation Schedule for Pumping station and Networks

5.4 IMPLEMENTATION FRAMEWORK

The Project will be mainly implemented under the supervision of ONAS and project consultants after the JICA study.

5.4.1 Organizational structure for implementation

Regarding the organizational structure for implementation of the Project, according to the services required by the various Project stages for this structure, ONAS will appropriately use the departments concerned in its office, in the regional department and in the ONAS regional office.

5.4.1.1 Organizational structure of the ONAS headquarters

5.4.1.1.1 Organization of the ONAS headquarters

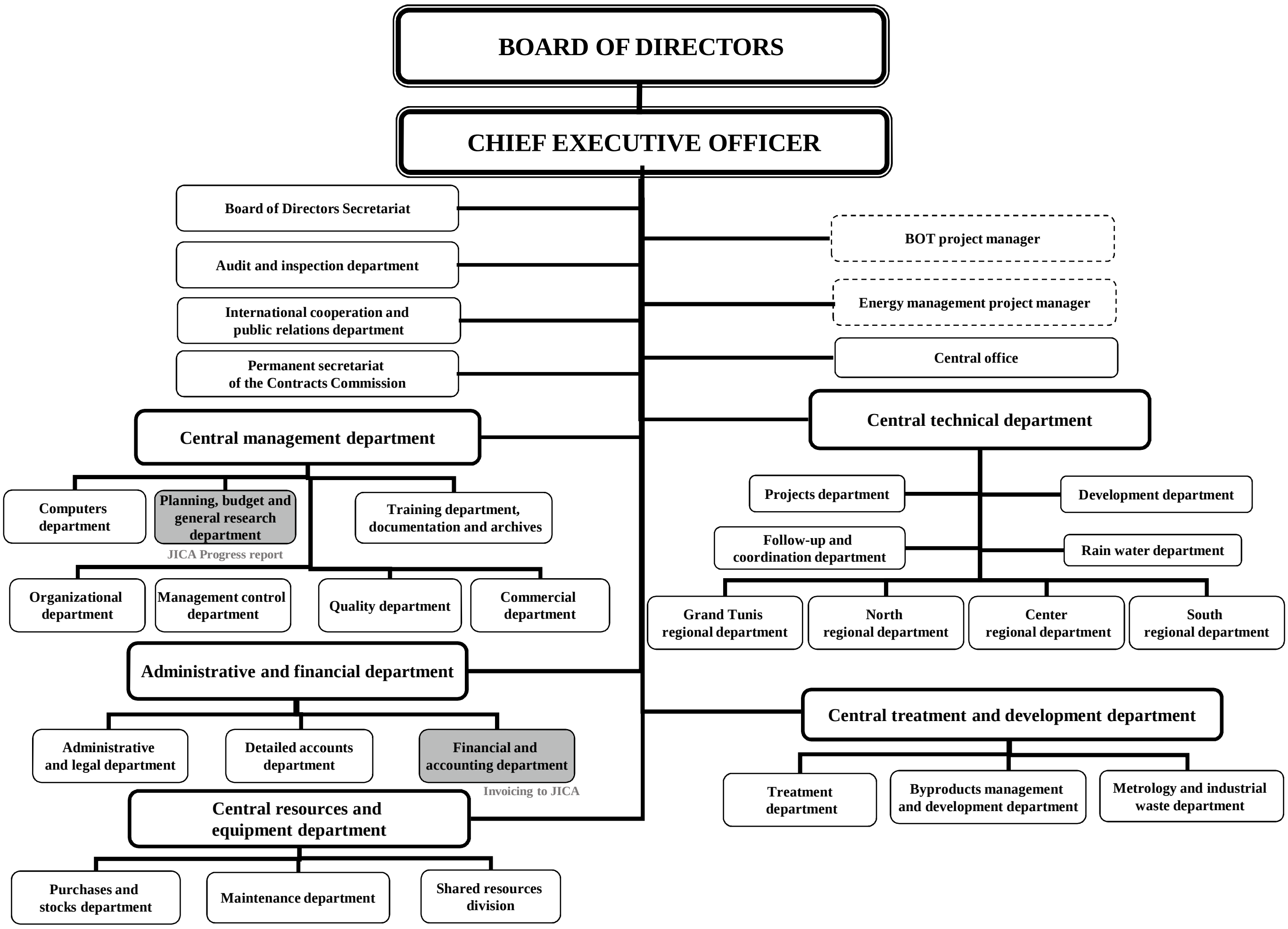


Figure 5.4-1: Organizational diagram of the ONAS headquarters

5.4.1.1.2 Staff at ONAS headquarters

Table 5.4-1 below presents the staff employed at the ONAS headquarters, using the following job classification criteria:

- The “Executive” classification corresponds to employees with authority and decision-making functions, assuming training with a specialized general higher education second cycle diploma (for example, director or assistant director of a department) ;
- The “Implementation” classification corresponds to implementation employees, that is, those with responsibility functions requiring technical, editorial, administrative or commercial specialization (for example, office employees, foremen, workers, mechanics) ;
- The “Supervision” classification corresponds to supervisors, that is to say employees in charge of the direct or indirect management of other employees (training, consultation, follow-up and work inspection).

Table 5.4-1: Staff at ONAS headquarters

	Executive	Implementation	Supervision	**Total Staff**
ONAS headquarters	251	432	180	**863**
General Management Department	14	13	13	**40**
Board of Directors Secretariat	1	2	0	**3**
Department of Audit and Inspection	15	10	3	**28**
Permanent Secretariat of the Contracts Commission	13	5	7	**25**
Department of International Cooperation and Public Relations	5	2	1	**8**
Central Management Department	22	4	3	**29**
Planning, Budget and Research Department	11	2	2	**15**
Computer Department	10	4	9	**23**
Training, Documentation and Archives Department	8	7	5	**20**
Central Administrative and Financial Department	5	5	2	**12**
Administrative and Legal Department	24	73	31	**128**
Financial and Accounting Department	25	15	20	**60**
Central Resources and Equipment Department	5	32	11	**48**
Purchases and Stocks Department	11	27	8	**46**
Maintenance Department	13	90	24	**127**

	Executive	Implementation	Supervision	**Total Staff**
Central Treatment and Development Department	1	2	0	**3**
Treatment Department	20	116	27	**163**
Byproducts Management and Development Department	3	1	1	**5**
Metrology and Industrial Waste Department	8	2	4	**14**
Central Technical Department	3	3	0	**6**
Development Department	14	4	2	**20**
Projects Department	10	3	6	**19**
Follow-up and Coordination Department	8	7	1	**16**
Rain Water Department	2	3	0	**5**

5.4.1.1.3 Processing capacity of contracts by the ONAS headquarters

Documents provided by ONAS concerning contracts signed by certain Departments in the ONAS headquarters during the year 2010, may have an overview of the contract processing capacity of the agency.

Table 5.4-2 below summarizes the contract processing capacity by showing the number and price of contracts in parallel signed by each Department in 2010.

Tableau 5.4-2: Processing of Contracts by the ONAS headquarters in 2010

	Annual processing of contracts (2010)		
Central ONAS Department	Number of contracts signed	Total price (TND)	Average contract price (TND)
Purchases and Supplies Department	35	69,263,593	1,978,960
Development Department	3	477,132	159,044
Maintenance Department	8	2,088,611	261,076
Administrative and Legal Department	1	1,126,152	1,126,152

5.4.1.2 Organizational Structure of the ONAS Regional Departments

5.4.1.2.1 Organization of the ONAS Regional Departments

ONAS includes the 4 Regional Departments given in Figure 5.4-2.

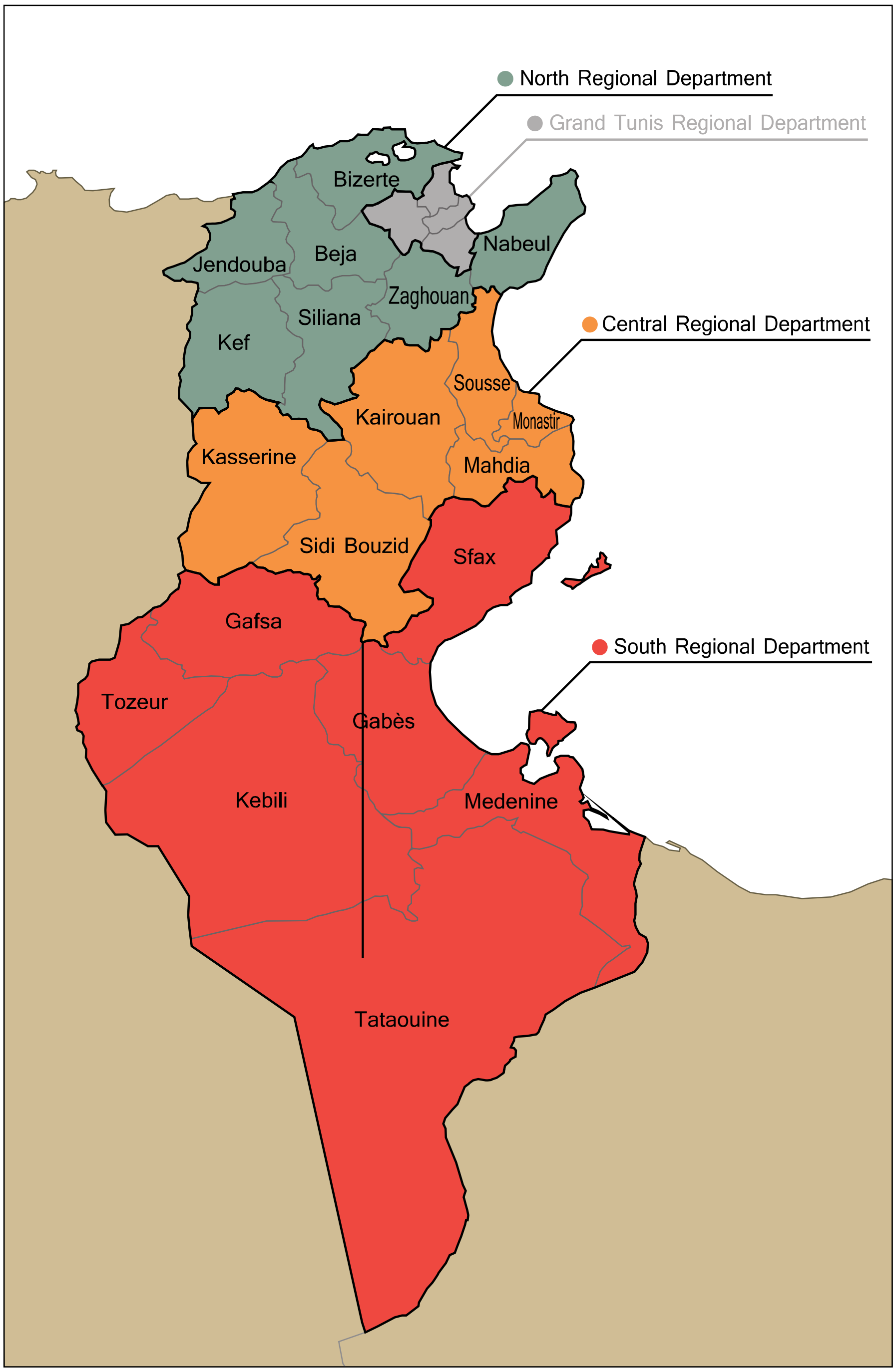


Figure 5.4-2: Areas of jurisdiction of ONAS Regional Departments

The following scheme shows the organization of one ONAS Regional Department (Example of North Regional Department). Other Regional Departments are the Grand Tunis Regional Department (not concerned by the project), Central Regional Department and South Regional Department, and have all the same organizational structure.

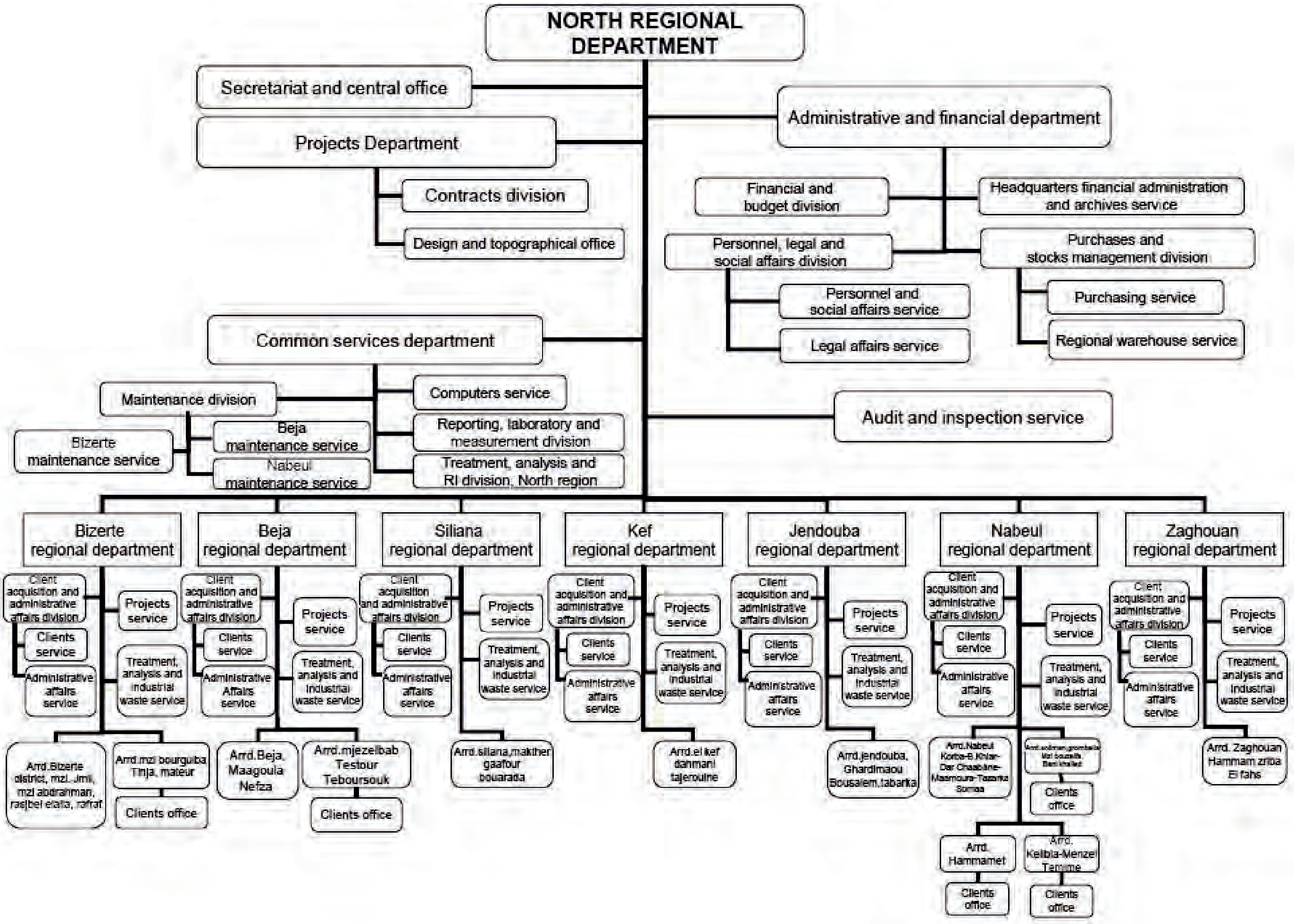


Figure 5.4-3: Organizational diagram of ONAS Regional Department

5.4.1.2.2 Staff at ONAS Regional Departments

Table 5.5-3 below shows the staff at ONAS Regional Departments using job classification criteria indicated above (5.5.1.1 b).

Table 5.4-3: Staff at ONAS Regional Departments

ONAS Regional Departments	Executive	Implementation	Management	**Total Staff**
North Regional Department	65	730	192	**987**
North Regional Department	2	4	3	**9**
Administrative and Financial Department	6	15	6	**27**
Projects Department	8	5	13	**26**
Common Services Department	5	18	9	**32**
Zaghouan Regional Department	4	40	7	**51**
Nabeul* Regional Department	7	183	40	**230**
Jendouba Regional Department	5	106	25	**136**
Kef Regional Department	4	41	11	**56**
Siliana Regional Department	1	71	12	**84**
Béja Regional Department	11	121	35	**167**
Bizerte Regional Department	12	126	31	**169**
Central Regional Department	90	627	202	919
Central Regional Department	7	8	3	**18**
Administrative and Financial Department	9	19	6	**34**
Projects Department	16	15	29	**60**
Common Services Department	10	33	12	**55**
Sousse* Regional Department	12	186	45	**243**
Monastir* Regional Department	17	176	55	**248**
Mahdia* Regional Department	6	55	13	**74**
Kasserine Regional Department	4	54	10	**68**
Kairouan* Regional Department	7	59	19	**85**
Sidi Bouzid Regional Department	2	22	10	**34**
South Regional Department	55	412	145	612
South Regional Department	1	3	3	**7**
Central Regional Department	5	20	8	**33**
Administrative and Financial Department	10	6	19	**35**
Projects Department	8	23	15	**46**
Sfax Regional Department	7	107	34	**148**
Gabes* Regional Department	5	51	16	**72**
Medine* Regional Department	7	64	15	**86**
Tatouine* Regional Department	2	20	3	**25**
Gafsa* Regional Department	5	61	13	**79**
Tozeur* Regional Department	2	47	12	**61**
Kébili Regional Department	3	10	7	**20**

(*) Governorates not covered by the project, Source: ONAS

5.4.1.2.3 Contract processing capacity for ONAS Regional Departments

Table 5.4-4 below summarizes the contract processing capacity by placing the number and price of contracts in parallel signed by each Regional Department in 2010.

Table 5.4-4: Processing of contracts by the ONAS Regional Departments in 2010

	Annual Processing of Contracts (2010)		
ONAS Regional Departments	Number of contracts signed	Total price (TND)	Average amount of the contract (TND)
North Regional Department	34	29,011,073	853,267
Central Regional Department	41	23,804,316	580,593
South Regional Department	36	22,950,227	637,506

5.4.2 Organization of subsequent project stages

5.4.2.1 Wastewater Treatment Plant (WwTP)

For the provision of consultants for the project and contractors for elements related to WwTP, the International Competitive Bidding (ICB) is the best way of complying with technical requirements and services required for the Projects.

Under the responsibility of ONAS, project consultants will provide their technical consulting services, particularly for elements related to WwTP in order to guarantee the quality of Detailed Design (DD) / Avant-Projet Détaillé (APD) and execution, since some state of the art equipment, such as the anaerobic digestion system, etc. for which ONAS does not have sufficient experience, will be installed for the Project.

5.4.2.1.1 Preparation of execution studies

The Development Department and the Central Technical Department under the Projects Department, in cooperation with the Projects Division of the Regional Departments concerned, with the advice of the Project Sections of the Regional Departments concerned, is responsible for drawing up the execution studies or Detailed Design (DD), Tender Documents (TD) and Environmental Impact Assessment (EIA).

For the EIA, the National Environmental Protection Agency (ANPE) under the Ministry of Agriculture and the Environment (MAE) is the agency responsible for the EIA procedure.

ANPE will provide TDR for EIA and has the authority to examine and approve EIA reports. ANPE will also verify the monitoring reports prepared by ONAS, in accordance with the conditions defined in the Environmental Management Plan (PGE) for the Project.

5.4.2.1.2 Construction Phase

The Development Department and the Projects Department under the Central Technical Department, in cooperation with the Projects Division under the Regional Departments concerned, is responsible for drawing up the Tender Documents (TD), the launching of the Tender and the preparation of contracts for the selection of the work contractor.

The evaluation and approval of the execution project will be carried out by the Projects Department and of the Central Technical Department, in cooperation with the Projects Division of the Regional Departments concerned. The same Departments will be in charge of monitoring and construction, even if safety management of the work site is conducted by the contractor.

The periodic project progress report for JICA will be drawn up by the Planning, Budget and General Research Department of the Central Management Department. Accounting and invoicing to JICA will be carried out by the Financial and Accounting Department of the Central Administrative and Financial Department.

5.4.2.1.3 Operation and Maintenance (O&M)

The operation of WwTP will be conducted by the Treatment Service of the Regional Department concerned, all services under Common Services Department (Maintenance, etc.) of the Regional Department concerned, as well as the Central Treatment and Development Department.

A supervisor appointed in each WwTP will take charge of daily operations and the preparation of monthly and annual operational reports.

He will also be responsible for the monitoring and control of the oxidation of sludge in the aeration tank, the quality of flow water, solid wastes, etc.

In order to monitor water quality according to parameters provided by Tunisian standards, water samples are analyzed in the laboratory provided in each regional maintenance service center.

5.4.2.2 Pumping Stations and network

For elements related to pumping stations and networks, ONAS has sufficient experience to implement projects with a similar scale with the local contractor. As such, project consultants will not be required in principle.

For interventions in the networks and pumping stations, the input of contractors may be requested through a Local Competitive Bidding (LCB) among Tunisian companies.

5.4.2.2.1 Preparation of execution studies

First of all, the ONAS regional department will conduct a topographic study and will prepare the tender plans and documents to obtain contractors.

The Project Divisions of each Regional Department, in collaboration with the Project Sections of the Regional Departments concerned are responsible for drawing up the execution studies or the Detailed Design (DD) and the Tender Documents (TD).

5.4.2.2.2 Construction

The Projects Divisions of the Regional Department concerned, without the intervention of the ONAS headquarters, is in charge of all administrative procedures regarding construction, which includes the drawing up of the Tender Documents (TD), the launching of the invitation to tender and the preparation of contracts for the selection of the work contractor.

The evaluation and approval of the execution project will be under this same Projects Division of the Regional Departments concerned. It will also be in charge of monitoring of construction, even if the safety management of the work site is conducted by the contractor.

The periodic project progress report to JICA will be drawn up by the Planning, Budget and General Research Department of the Central Management Department. Accounting and invoicing to JICA will be carried out by the Financial and Accounting Department of the Central Administrative and Financial Department.

5.4.2.2.3 Operation and Follow-up

Operation is carried out at the district level by the Regional Departments in collaboration with all services (maintenance, etc.) of the Common Services Division of the Regional Department concerned.

Follow-up is carried out at the district level by the Regional Departments in collaboration with all services (maintenance, etc.) of the Common Services Division of the Regional Department concerned, with evaluation by the Follow-up and Coordination Department under the central ONAS Central Technical Department.

5.4.2.3 CDM Registration

In ONAS, the Purification Department under the Central Purification and Upgrading Department is responsible for all administrative work for the CDM registration, including the preparation of a Project Design Document (PDD).

In Tunisia, the Ministry of Agriculture and the Environment is assigned as the Designated National Authority Director (AND), with the following as the principal AND members:

- Ministry of Agriculture and the Environment
- Ministry of Foreign Affairs
- Ministry of International Cooperation and Planning
- Ministry of Finance
- Tunisian Industry, Commercial and Trade Union
- Tunisian Agriculture and Fisheries Union
- Central Bank of Tunisia, etc.

The DNA is responsible for the examination and approval of CDM (Clean Development Mechanism) projects, the issuance of approval letters, annual reports of CDM activities in Tunisia, and the definition of criteria to determine the contribution of the project for the sustainable development of the country.

5.4.3 Capacity assessment for Implementation and Recommendation for Procurement

Distribution of lot concerning consulting services and contractors shall be arranged based on ONAS implementation structure and its capacity as follows:

- Considering current organization of ONAS that responsible body for execution is decentralized to regional level, distribution of lot shall be initially divided to three (3) regional departments or ten (10) regional directions in each governorate considering each type of contract;
- Amount of each lot shall be also carefully examined by considering ONAS's annual capacity for payment (Table 5.5-4);
- If a contract amount will be more than 17 million TND (1 billion JPY), pre-qualification procedure shall be applied on the bidding procedure for the procurement of contractor.

Considering above conditions and in order to optimize construction period to avoid pre-qualification procedure, each lot shall be adjusted to 10 - 15 million TND and two (2) lots per year may be the maximum volume of contract which each ONAS regional department can deal with.

In addition to above, mutual coordination between ONAS central and regional office is one of the key factor in order to ensure the smooth implementation of the Project.

5.4.4 Allotment of the contract

5.4.4.1 Wastewater Treatment Plant (WwTP)

5.4.4.1.1 Preparation of execution studies

The preparation of execution studies or the Detailed Design (DD), the Tender Documents (TD) and Environmental Impact Assessment (EIA) for all the WwTP is regrouped into a single contract.

Table 5.4-5: Allotment for WwTP execution studies (1 lot)

Designation of lot	Number of lots	ONAS Department in charge
WwTP of Béja, Medjez el Bab, Jendouba, Tabarka and Siliana	1 lot	Development Dept. and Projects Dept. (Central Technical Dept.) Projects Dept. (Regional Dept. concerned) Project Section (Regional Dept. concerned)

5.4.4.1.2 Construction

Rehabilitation and extension work for the WwTP are divided into 4 lots.

The allotment process leads to one lot for each WwTP. However, the Tabarka and Jendouba WwTP, due to their geographical proximity (same Jendouba governorate) and the institutional correspondence (same Regional Department in charge) are regrouped into a single lot. The Béja and Medjez el Bab WwTP could have been regrouped according to the same process, but due to the high technical complexity of the work for the Béja WwTP (pre-treatment, etc.); these will be covered by a specific allotment.

Table 5.4-6: Allotment for WwTP work (4 lots)

Designation of lot	Number of lots	ONAS Department in charge
Béja WwTP	1 lot	Development Dept. and Projects Dept. (Central Technical Dept.) Projects Dept. (North Regional Dept.)
Medjez el Bab WwTP	1 lot	Development Dept. and Projects Dept. (Central Technical Dept.) Projects Dept. (North Regional Dept.)
Tabarka WwTP	1 lot	Development Dept. and Projects Dept. (Central Technical Dept.) Projects Dept. (North Regional Dept.)
Jendouba WwTP		
Siliana WwTP	1 lot	Development Dept. and Projects Dept. (Central Technical Dept.) Projects Dept. (North Regional Dept.)

5.4.4.2 Networks and Pumping Stations

5.4.4.2.1 Preparation of execution studies

The Detailed Design (DD) and the Tender Documents (TD) for the pumping stations and networks are divided into 10 lots.

The allotment process leads to one lot in each Regional Department covered by the project, since it is the competent ONAS level for each project stage.

For reasons of geographical proximity and the small number of interventions planned, we will only have a single lot for the two governorates of Kasserine and Sidi Bouzid, and a single lot for Kef and Siliana governorates.

The table 5.4-8 shows the allotment for preparation of execution studies for Networks and Pumping Stations.

Table 5.4-7: Allotment for execution studies for Networks and Pumping Stations (10 lots)

Governorate	Nbr of lots	Length of network and number of pumping stations						ONAS department in charge
		Case 1		Case 2		Case 3		
		L (km)	Nbr SP	L (km)	Nbr SP	L (km)	Nbr SP	
BEJA	1 lot	27.6	3	43.7	5	44.8	6	Projects Dept. (North Regional Dept.) Project Section (Regional Dept. Béja)
BIZERTE	1 lot	6.7	2	8.7	2	8.7	2	Projects Dept. (North Regional Dept.) Project Section (Regional Dept. Bizerte)
JENDOUBA	1 lot	47.9	7	54.2	8	67.7	11	Projects Dept. (North Regional Dept.) Project Section (Regional Dept. Jendouba)
KASSERINE / SIDI BOUZID	1 lot	26.2	1	72.1	1	72.1	1	Projects Dept. (Central Regional Dept.) Project Section (Regional Dept. Kasserine / Sidi Bouzid)
KEBILI	1 lot	33.2	4	41.5	5	124.2	12	Projects Dept. (South Regional Dept.) Project Section (Regional Dept. Kébili)
KEF / SILIANA	1 lot	28.3	2	44.8	6	44.8	6	Projects Dept. (North Regional Dept.) Project Section (Regional Dept. Kef / Siliana)
SFAX	3 lots	0	0	201.6	0	231.7	1	Projects Dept. (South Regional Dept.) Project Section (Regional Dept. Sfax)
ZAGHOUAN	1 lot	48.2	3	66.7	3	68.3	4	Projects Dept. (North Regional Dept.) Project Section (Regional Dept. Zaghouan)
Total	**10 lots**	218.3	**22**	533.4	**30**	662.4	**43**	

5.4.4.2.2 Construction

Rehabilitation and extension work for pumping stations and networks are divided into 23 lots.

Due to the scope of the contract, allotment is divided into a fourfold process to facilitate implementation:

- Facilitation of processing by ONAS through the maximum reduction of the number of contracts ;
- Stimulation of competition between Tunisian companies through the maximum reduction of the amount of contracts;
- Facilitation of the operational implementation of work by contractors through a linear limit of the network to be rehabilitated/extended for lots of less than 50 km and thought the separation of rehabilitation et extension lots ;
- Facilitation and shortening of the procedure through a limit in the cost of construction of the lots to at least 17,000,000 TND (1,000,000,000 JPY) and non-application of the pre-qualification procedure provided by JICA.

The table 5.4-8 shows the allotment for works on Networks and Pumping Stations.

Table 5.4-8: Allotment for work on Networks and Pumping Stations (23 lots)

Governorate	Lot designation	Lot number	Total length of network (km)	Average length of network per lot (km)	Nbr of Pumping Stations	Total amount (TND)	Average amount per lot (TND)	ONAS department in charge
BEJA*	Rehabilitation	1-1-1	35.3	35.3	1	8,985,597	8,985,597	Projects Dept. (North Reg. Dept.)
	Extension	1-2-1	9.6	9.6	5	2,195,363	2,195,363	
	Total	**2 lots**	**44.8**		**6**	**11,180,960**		
BIZERTE*	Rehabilitation	2-1-1	8.7	8.7	2 (Ex)	2,224,942	2,224,942	Projects Dept. (North Reg. Dept.)
	Total	**1 lot**	**8.7**		**2**	**2,224,942**		
JENDOUBA*	Rehabilitation	3-1-1	32.9	32.9	5	9,541,140	9,541,140	Projects Dept. (North Reg. Dept.)
	Extension	3-2-1	34.8	34.8	6	5,558,028	5,558,028	
	Total	**2 lots**	**67.7**		**11**	**15,099,168**		
KASSERINE / SIDI BOUZID*	Rehabilitation	4-1-1	48.2	24.1	0	11,619,018	5,809,509	Projects Dept. (Central Reg. Dept.)
		4-1-2		24.1			5,809,509	
	Extension	4-2-1	24.0	24.0	1	3,207,813	3,207,813	
	Total	**3 lots**	**72.1**		**1**	**14,826,831**		
KEBILI	Rehabilitation	5-1-1	10.3	10.3	2	2,918,944	2,918,944	Projects Dept. (South Reg. Dept.)
	Extension	5-2-1	113.9	38.0	10	17,971,261	5 990 420	
		5-2-2		38.0			5 990 420	
		5-2-3		38.0			5 990 420	
	Total	**4 lots**	**124.2**		**12**	**20,890,205**		
KEF / SILIANA*	Rehabilitation	6-1-2	26.7	26.7	3	6,240,559	6 240 559	Projects Dept. (North Reg. Dept.)
	Extension	6-2-1	18.1	18.1	4	3,678,037	3 678 037	
	Total	**2 lots**	**44.8**		**6**	**9,918,596**		
SFAX*	Rehabilitation	7-1-1	15.1	15.1	0	4,757,600	4 757 600	Projects Dept. (South Reg. Dept.)
	Extension	7-2-1	216.6	43.3	1	31,855,964	6 371 193	
		7-2-2		43.3			6 371 193	
		7-2-3		43.3			6 371 193	
		7-2-4		43.3			6 371 193	
		7-2-5		43.3			6 371 193	
	Total	**6 lots**	**231.7**		**1**	**36,613,564**		
ZAGHOUAN	Rehabilitation	8-1-1	62.0	31.0	0	15,649,833	7 824 916	Projects Dept. (North Reg. Dept.)
		8-1-2		31.0			7 824 917	
	Extension	8-2-1	6.3	6.3	4	1,879,609	1 879 609	
	Total	**3 lots**	**68.3**		**4**	**17,529,442**		
	Total	**23 lots**	**662.4**		**43**	**128,283,708**		

* In those governorates, the interventions listed below include both Rehabilitations (Rh) and Extensions (Ex), but since they are bond as a group we have considered each group of interventions to have a single classification: Rh or Ex.

The choice between Rh and Ex classification is based on the proportion of Rh/Ex investment cost: if the majority of the investment is Rehabilitations then all the investment is considered Rh, otherwise it is Ex.

Codes of groups of interventions	Adopted classification
BIZ-Raf-RS-Rh-1, BIZ-Raf-SP-Ex-1, BIZ-Raf-SP-Ex-2	Rh
BEJ-Maa-RS-Rh-1, BEJ-Maa-SP-Ex-1	Rh
SIL-Bou-RS-Rh-1, SIL-Bou-SP-Ex-1	Rh
JEN-Tab-RS-Ex-1, JEN-Tab-SP-Rh-1	Ex
SFA-Sfv-RS-Ex-5, SFA-Sfv-RS-Rh-6, SFA-Sfv-SP-Ex-1	Ex
SID-Sid-RS-Rh-7, SID-Sid-RS-Ex-5, SID-Sid-RS-Ex-6	Rh

5.4.4.2.3 Suppliers

Supply for the pumping stations and networks is separated into 3 contracts, each divided into 3 lots, or a total of 9 lots.

The supply contracts division corresponds to the normal strategy adopted by ONAS for all projects, which is one contract for the supply of pipes, one contract for the supply of cast parts (plates for manholes) and one contract for the supply and mounting of equipment for the pumping stations.

The allotment system leads to one lot per Regional Department since this is the class responsible for purchases and supplies.

The following tables shows the details of allotment for the supply of pipes (Table 5.4-9), of casts parts for manholes (Table 5.4-10) and of equipment for pumping stations (Table 5.4-11).

<u>Table 5.4-9: Allotment of the market for the supply of sewage pipes (3 lots)</u>

Regional Dpt. in charge	Governo-rate	Pipe type			Average purchase cost (TND)	Length (km)	Cost (TND)	Total Cost and Length
North Reg. Dpt. 1 lot	Béja	Gravity Sewer	PVC	250	24	41.5	995,208	1,122,983 TND 44.8 km
				315	38.2	1.5	57,071	
				400	61.2	0.8	60,404	
		Rising Main	HDPE	125	10	0.8	8,380	
				160	16	0.1	1,920	
	Bizerte	Gravity Sewer	PVC	250	24	8.5	202,800	207,700 TND 8.7 km
		Rising Main	HDPE	160	16	0.1	2,400	
				200	25	0.1	2,500	
	Jendouba	Gravity Sewer	PVC	250	24	48.8	1,171,200	2,812,963 TND 67.7 km
				315	38.2	6.8	260,677	
				400	61.2	1.7	101,592	
				500	95.3	1.8	170,396	
			PVC/HDPE	1000	400	2.6	1,036,000	
		Rising Main	HDPE	125	10	5.5	54,980	
				160	16	0.1	2,288	
				250	40	0.4	15,200	
				315	63	0.0	630	
	Kef	Gravity Sewer	PVC	250	24	17.0	408,240	623,878 TND 21.6 km
				500	95.3	2.0	186,788	
		Rising Main	HDPE	125	10	2.3	22,600	
				200	25	0.3	6,250	
	Siliana	Gravity Sewer	PVC	250	24	23.2	556,452	556,502 TND 23.2 km
		Rising Main	HDPE	125	10	0.0	50	
	Zaghouan	Gravity Sewer	PVC	250	24	48.0	1,150,560	1,942,618 TND 68.3 km
				315	38.2	15.0	571,090	
				400	61.2	2.0	122,400	
				630	206.5	0.2	36,138	
		Rising Main	HDPE	125	10	1.0	9,930	
				200	25	2.1	52,500	
					TOTAL	234.3	-	7,266,643

Table 5.4-9: Allotment of the market for the supply of sewage pipes (3 lots) (following)

Regional Dpt. in charge	Governo-rate	Pipe type			Average purchase cost (TND)	Length (km)	Cost (TND)	Total Cost and Length
Central Reg. Dpt. 1 lot	Kasserine	Gravity Sewer	PVC	250	24	37.3	895,104	2,193,735 TND 45.9 km
				315	38.2	1.1	43,395	
				400	61.2	3.5	217,811	
				630	206.5	1.5	299,425	
			PVC/HDPE	800	400	2.5	738,000	
	Sidi Bouzid	Gravity Sewer	PVC	250	24	21.7	520,061	696,176 TND 26.2 km
				315	38.2	2.4	91,661	
				400	61.2	0.2	15,055	
				500	95.3	0.6	55,989	
		Rising Main	HDPE	125	10	1.3	13,410	
					TOTAL	72,1	-	2,889,911

South Reg. Dpt. 1 lot	Kébili	Gravity Sewer	PVC	250	24	89.6	2,149,680	2,866,680 TND 124.2 km
				315	38.2	6.0	230,919	
				400	61.2	0.4	23,868	
				500	95.3	2.1	196,413	
		Rising Main	HDPE	125	10	25.4	253,800	
				160	16	0.7	12,000	
	Sfax	Gravity Sewer	PVC	250	24	212.2	5,091,768	6,817,855 TND 231.7 km
				315	38.2	8.2	313,125	
				400	61.2	4.9	297,922	
				500	95.3	2.6	247,780	
			PVC/HDPE	800	300	2.8	854,400	
		Rising Main	HDPE	125	10	0.9	9,110	
				200	25	0.1	3,750	
					TOTAL	356.0	-	9,684,535

Table 5.4-10: Allotment of the market for the supply of cast parts / plates for manholes (3 lots)

ONAS Regional Dpt. In charge	Type of manhole cover	Average purchase cost (TND)	Length of associated network (km)	Distance from manhole to manhole	Approx. number of manholes	Approx. amount of purchase to supplier (TND)
North Regional Department (1 lot) (governorates of Béja, Bizerte, Jendouba, Kef, Siliana and Zaghouan,)	Ductile cast iron cover DN800	160	234.3	u /40 ml	5,858	937,200
Central Regional Department (1 lot) (governorates of Kasserine and Sidi Bouzid)	Ductile cast iron cover DN800	160	72.1	u /40 ml	1,803	288,400
South Regional Department (1 lot) (governorates of Kébili and Sfax)	Ductile cast iron cover DN800	160	356.0	u /40 ml	8,900	1,424,000

Table 5.4-11: Allotment of the market for the supply of pumping stations equipment (3 lots)

ONAS Regional Dpt. In charge	Governorate	Equipment cost for interventions of extension of SP (TND)	Equipment cost for interventions of rehabilitation of SP (TND)	Approx. amount of purchase to supplier (TND)
North Regional Department **1 lot**	Béja	241,500	28,750	270,250
	Bizerte	225,445	421,719	647,164
	Jendouba	345,000	530,369	875,369
	Kef	115,000	149,582	264,582
	Siliana	46,000	-	46,000
	Zaghouan	115,000	-	115,000
			TOTAL	**2,218,365**
Central Regional Dpt. **1 lot**	Kasserine	-	-	-
	Sidi Bouzid	57,500	-	57,500
			TOTAL	**57,500**
South Regional Department **1 lot**	Kébili	608,710	199,307	808,017
	Sfax	597,596	34,500	632,096
			TOTAL	**1,440,113**

5.4.5 Institutional Arrangement for Implementation

For the Institutional Provision for the implementation of the Project under a Japanese ODA loan from the financial structure viewpoint, ONAS will be the borrower of the Japanese ODA loan for the Project and the Ministry of Finance will be the guarantor for this loan.

Disbursement method of the Japanese ODA loan

For the disbursement method of the Japanese ODA loan, the Financial and Accounting Service under the Central Administrative and Financial Department is responsible for controlling the entire financial process in ONAS, such as payments, accounting, audits, etc. This department is considered as the key section for the organization of financial administration work between ONAS and JICA.

ONAS will be the borrower of the Japanese ODA loan for the Project and the Ministry of Finance will be the guarantor for this loan.

For the JICA disbursement method under the Project, based on the method cited above, the cash flow for the Japanese ODA loan is summarized in the following table:

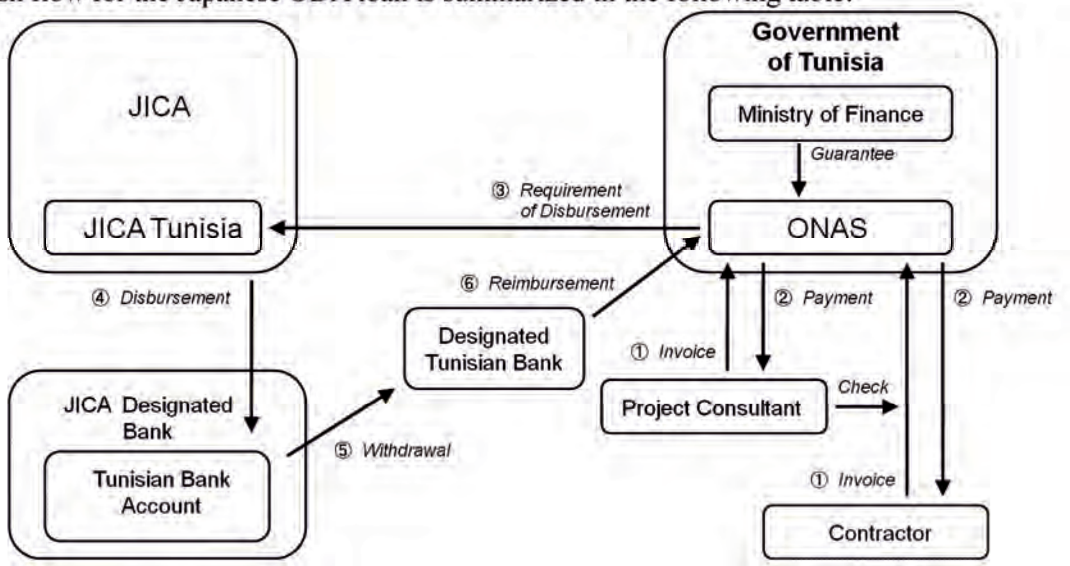


Figure 5.4-4: Cash flow of Japanese ODA loan (Reimbursement method)

① Project consultants and the companies will issue an invoice to ONAS at the time when work progress satisfies the conditions indicated in the contract.

② ONAS will verify the invoice and proceed with payments to the project consultants and companies in accordance with the applicable laws in Tunisia.

③ ONAS will submit a disbursement request to JICA for the amount which ONAS paid to the project consultants and companies.

④ JICA will confirm the request for disbursement from ONAS and will make payment in Japanese yen to an account created in a Japanese bank designated by JICA, based on the amount paid by ONAS.

⑤ A Tunisian bank designated by ONAS will withdraw the amount from its account created in a Japanese bank designated by JICA when JICA disburses the amount, and

⑥ The Tunisian bank will reimburse the amount to ONAS based on authorization from ONAS.

5.5 RECOMMENDATIONS FOR ENSURING PROJECT SUSTAINABILITY

5.5.1 Short Term

5.5.1.1 Sludge Management

In 5 WwTPs of the project, sludge has been stocked at drying bed and temporary dump inside the WwTP without any protection against pollution since several years.

To ensure the project sustainability, it is an urgent matter that ONAS find a controlled dumping station and it seems to be a serious risk and will be a bottleneck for the approval of EIA report by ANPE.

ONAS has already tackled this issue by taking various approaches, such as pilot projects for reutilization of sludge for agriculture, creation of ONAS's own dumping station, etc., especially in the greater Tunis areas.

It should be stressed that ONAS shall develop necessary institutional and legal arrangement concerning sludge management in national level and enhance them to regional level as soon as possible.

5.5.2 Mid Term

5.5.2.1 Operation and Maintenance for WwTP.

The WwTP of the Project shall be operated adequate manner in compliance with Tunisian standards. Main equipment, such as inlet pumps, scrapers used in primary sedimentation tanks and thickeners, scrapers used in secondary sedimentation tanks and thickeners and mechanical dewatering devices, shall be maintained periodically by checking its performance through monitoring the quality of treated water, odor, sludge, etc.

5.5.2.2 Operation and Maintenance for Sewage Networks

Sewage Networks are important to the community to improve living conditions by removing sewage from dwellings and commercial premises. Sewage shall be treated and discharged into public water areas in compliance with Tunisian standard.

The task for operation and maintenance of sewage networks include the following items:

- Inspection : Inlet chambers and manholes are visually checked. Detailed inspection of the inside of manholes and connection pipes is undertaken;
- Cleaning : Networks and Manholes are cleaned using high-pressure jet cleaners, mud suction vehicles and water tankers. Deposits in Networks are collected at manhole locations and are sucked up by mud suction vehicles and disposed;
- Repair : The Packer method is used (cement milk injection) is applied to decayed parts of Networks. The number of annual repairs is estimated by the Survey Team.

5.5.2.3 Others

Considering daily operation and maintenance of WwTP and networks, some amount of following materials shall be reserved in ONAS regional direction level for daily operations and maintenances:

- Chemical products : Chemicals are required for disinfection, coagulation treatment, and dewatering and water quality analysis;
- Spare parts : Lubricant and spare parts are required for daily maintenance of the mechanical and electrical equipment;
- Inspection & cleaning : Inspection devices and cleaning equipment such as CCD cameras, vehicles for jet cleaning, vehicles for the suction of deposits, and equipment and materials may be necessary for daily maintenance of network.

5.5.3 Long Term

5.5.3.1 Financial Sustainability

As described in the Chapter I, financial deficit of ONAS increased an average of 18% per year between 2005 and 2009. On the other hand, thanks to increasing state subsidies from 41 M TND in 2005 to 76 M TND in 2009, ONAS is able every year to break even. These subsidies increased by an average of 16.5% per year in the same period.

Although service cost has increased annually, the tariff has been freeze since 2003 and it caused high deficit.

The state subsidies compensate financial deficit of ONAS, however it is not obvious how much the state has disbursed for covering the deficit. ONAS's financial sustainability now highly depends on the state subsidies not only for periodic investment and rehabilitations but also daily operation and maintenance. Although, when tariff are not sufficient to recover the service cost, state subsidies should be disbursed, it is always the risk for ONAS to secure required interventions, such as maintenance, rehabilitation and replacement.

Thus, the GoT shall address the consequences of the tariff freeze for ONAS and take some actions to ensure the ONAS's financial sustainability by modifying the tariff system.

CHAPTER VI

INITIAL ENVIRONMENTAL EXAMINATION (IEE)

CHAPTER VI INITIAL ENVIRONMENTAL EXAMINATION (IEE)

6.1 INTRODUCTION

6.1.1 Objectives of the IEE

The Initial Environmental Examination (IEE) of the "Rural Cities Sewage and Water Environment Improvement Project" in the Republic of Tunisia was carried out in accordance with the JBIC Guidelines for Confirmation of Environmental and Social Considerations (hereinafter referred to as "the JBIC Guidelines") dated April 2002 and relevant law of the GoT. The IEE includes the findings, recommendations and conclusions based on the JICA Survey. The objectives of the IEE are:

1) To identify the items of negative impact on environmental and social conditions through the Project implementation,
2) To suggest mitigation measures to be adopted, and
3) To prepare the recommendations for Environmental Impact Assessment (EIA) and public consultation for preparing land acquisition plan to be conducted by the GoT after the JICA Survey, including necessary items to be surveyed, methodology and implementation schedule required based on the Guidelines.

6.1.2 Environmental Policy of the JBIC Guidelines

<u>Screening</u>

JICA classifies the project into one of the following four (4) categories before environmental review. The subsequent environmental review will then be conducted in accordance with the required procedures of its category. During the screening process, JICA will classify the project in terms of its potential environmental impact, taking into account certain factors: 1) the sector and scale of the project, 2) the substance, 3) degree and uncertainty of its potential environmental impact and 4) the environmental and social context of the project site.

<u>Category A:</u>

Projects likely to have a significant impact on the environment, projects with complicated impacts or unprecedented impacts which are difficult to assess are classified as Category A. Projects in sensitive sectors, with sensitive characteristics and projects located in or near sensitive areas are also classified as Category A.

EIA reports, which borrowers and relevant agencies are responsible for preparing, shall be required for Category A projects. If large-scale involuntary resettlement will not be avoidable due to the projects, Resettlement Action Plans (RAP) also must be submitted to JICA. JICA will proceed with its environmental review based on the EIA reports (and RAP, if necessary).

<u>Category B:</u>

Projects with limited impact on the environment which is site-specific, irreversible and attenuated by introducing normal mitigation measures are classified as Category B.

The environmental reviews for Category B are similar to that of category A, including evaluation of negative and positive impact, counter-measures for negative impact and measures to promote positive impact, but submission of an EIA report is not a mandatory requirement. JICA will proceed with its environmental review based on the relevant laws of the borrowers' side, and if an EIA report has been prepared, JICA may refer to it.

<u>Category C:</u>

Projects likely to have a minimal or no adverse impact are classified as Category C. For those projects, a screening procedure shall be accomplished but an environmental review is not required.

<u>Category FI:</u>

Projects composed of some sub-projects are classified as Category FI, those sub-projects will be selected after JICA's approval of funding (or assessment of the project), cannot be specified prior to approval and have a potential impact on the environment. JICA will monitor the project implementation whether appropriate environmental and social considerations are undertaken based on the JBIC Guidelines.

Considering the Project components, although some land acquisition is unavoidable for construction of new pumping stations, involuntary resettlement will not be previewed. Neither natural habitat, historic, archaeological nor cultural assets will not be suffered any negative impacts. Furthermore, the Project will have no influence on protected areas. The Project can therefore be classified as Category B in accordance with the above criteria.

6.2 ENVIRONMENTAL MANAGEMENT IN TUNISIA

6.2.1 Political Framework for Environmental Management (National Policies, Development Plans, etc.)

At the national level, the objective of the environmental management in Tunisia is to ensure the people a good quality of life and sustainable socio-economic development.

6.2.1.1 Agenda 21

The GoT has developed an action program on the environmental management and sustainable development entitled national "Agenda 21" since 1996. This agenda constitutes as a fundamental guide line for making policies and is referred in order to establish the socio-economic development plans.

In Rio de Janeiro in 1992, the Conference of the United Nations on Environment and Development (UNCED) declared the principles and objectives of "Agenda 21" and participating nations have pledged to cooperate and create conditions to ensure a sustainable future based on the agenda. In 1993, based on the principles of the Rio Declaration, the GoT created the National Commission for sustainable development to ensure its environmental resources for present and future generations.

The program of national "Agenda 21" in Tunisia provides a basis for intervention in certain priority areas and sets a number of actions relating to sustainable development, planning to be carried out by public and private sectors in Tunisia or in cooperation with international assistance. This program will have to consider the use of natural resources related to the socio-economic development, including agricultural, industrial, touristic, urban development, etc.

The actions proposed by the program were implemented through the framework of the 9th National Economic and Social Development Plan (1997-2001). The 10th Plan (2002-2006) also included items for sustainable development aimed at:

i) Better cohesion between the needs of development and urban planning,

ii) Effective protection of natural resources and an effective fight against desertification,

iii) Fight targeted against pollution to improve the quality of life, and

iv) Better participation in the field of the environment at national and local level.

At local level, "Programmes d'actions régionaux de l'environnement pour le développement durable (PRE)" have been established. These programs were reviewed and adopted by the regional development councils. 100 cities are already voluntarily involved in the process of local "Agenda 21" and all regions of the country (24 governorates) finalized their regional environmental management program for sustainable development. These actions and proposals have been included in actual 11th Plan (2007-2011) as the priorities.

6.2.1.2 National Economic and Social Development Plan

In the 11th National Economic and Social Development Plan (2007-2011), protection of environmental resources and enhancing the citizen's quality of life are stressed as the top priority of the plan.

The total investments (state budget, grants and loans) outlaid in the field of protection of environmental resources, during the 10th Plan, amounted to about 1,507.451 million TND, exclusive of the investments related to flood control projects and sanitation projects outside of ONAS service zone.

Following activities are mainly included in 11th Plan regarding the environmental and sustainable development to be taken during its period:

- To establish a data base in the fields of environment protection and sustainable development to assist decision-making,
- To conduct strategic and prospective studies on the protection of natural resources and ecosystems from a perspective of sustainable development,
- To protect natural sites and ecosystems against the risks of pollution and destruction, as well as preserving their ecological balance, in order to ensure the sustainability of their developmental, social and environmental functions,
- To enhance environmental services, especially in the fields of sanitation and wastes management,
- To dedicate greater care to urban and rural environment for better quality of life,
- To reduce air pollution.

In order to implement above actions, some projects are listed in the 11th Plan according to the budgets allocated, which are estimated as 1,800 million TND, exclusive of the volume of environmental investment in the sectors of industry, energy, small and medium-sized enterprises

(SMEs) and agriculture. The investments distributed to the sector of sanitation amount to 914 million TND.

Sanitation Sector

In order to raise the rate of connection to the sanitation network to 91.0 % in ONAS service zone, it has been provided to:

- To increase the number of the population serviced by sanitation from 5.1 million inhabitants in 2006 to 5.9 million inhabitants by 2011;
- To construct 28 new wastewater treatment plants (WwTPs), and starting the construction of 6 further WwTPs, thus bringing the total WWTPs to 123, of which 41 are operated by the private sector;
- To lay an additional 2,800 km of pipes and build 160,000 connection boxes to the sewerage network;
- To step up the volume of treated wastewater by an additional 47 million m3, thus reaching a total volume of 264 million m3.

The 12th National Economic and Social Development Plan (2012-2016) have been elaborated in September 2011 as revision for the 11th plan.

The policy of 12th National Economic and Social Development Plan has been taken over by the provisional government after the political event in January 2011. Total investment planned during the 12th plan is amounted to 815 million TND and the Project has been included in the plan.

6.2.1.3 PISEAU II: Projet d’Investissement dans le Secteur de l’Eau II

PISEAU II is a national program of the GoT in the water sector, including the activities for conservation and protection of water resources. It follows a first phase of the PISEAU I (2001-2007) financed by the World Bank, AFD and KfW. The components of the PISEAU II regarding conservation and protection of water resources include:

- To implement monitoring system for soil quality and water pollution ;
- To implement pilot activities regarding rural sewage treatment equipment to improve the quality of treated wastewater, etc.

6.2.1.4 PRONAGDES: Programme National de Gestion des Déchets Solides

Since 1993, the Ministry of Agriculture, Environment and Water resources has established a National Program for Solid Waste Management (PRONAGDES) to deal with nuisance caused by waste and improve their management. The PRONAGDES address environmental protection and sustainable development based on the following principles:

Objectives:

- To prevent and reduce waste production and inadequate management;
- To increase the value of waste through recycling any reusable materials;

- To store and process waste in appropriate facilities;
- To implement management plans for each type of waste.

Main components:

- Management of house garbage and similar productions,
- Management of industrial waste and dangerous waste,
- Management of specific waste from hospitals, sludge from WwTPs, etc.

6.2.2 Institutional Framework for Environmental Management

General environmental management in Tunisia is the responsibility of the Ministry of Agriculture and Environment (MAE). Main stakeholders to be involved in environmental issues through formulating a project in sewage sector are National Agency for Environmental Protection (ANPE) and National Agency for Waste Management (ANGed).

6.2.2.1 Ministry of Agriculture and Environment (MAE)

Based on the Decree N° 898-2006 of 27 March 2006 related to the organization of the Ministry of Agriculture and Environment (MAE), which defined various services of the ministry and the missions entrusted to them, MAE is responsible for promoting legislation for the protection of the environment and nature conservation and to work for the integration of the concept of sustainable development in the policies and plans by general or particular measures in fields related to the environment and sustainable development. MAE also shall take responsibility to propose standards for discharge of waste from urban, industrial, tourism, health, agricultural activities to ensure environmental sustainability.

Under political reform in Tunisia, Ministry of Agriculture and Environment has been established by combining MAE and Ministry of Agriculture, Hydraulic Resources and Fisheries since January 2011.

6.2.2.2 National Agency for Environmental Protection (ANPE)

National Agency for Environmental Protection (ANPE), under the Ministry of Environment and Sustainable Development (MAE) is the agency responsible for ensuring the integrity of the preparation process, review and approval of EIA in Tunisia.

ANPE's responsibilities include the enforcement of regulations relating to environmental protection including those relating to EIA, prepare terms of reference (TOR) for the preparation of EIA and to review and approve the EIA reports. ANPE is also the focal point for environmental monitoring activities of PISEAU II and PRONAGDES.

6.2.2.3 National Agency for Waste Management (ANGed)

National Agency for Waste Management "ANGed" has been established under the Decree No. 2005-2317 of 22 August 2005. The Agency has following missions:

- To participate in national programs and implement the policy on waste management;
- To establish the mechanisms and economic incentives to achieve the goals set under the national strategy for waste management;
- To establish legislation and regulations on waste management;
- To make and execute plans and procedures included in national waste management, etc.

6.2.3 Legal Framework for Environmental Management

6.2.3.1 Main regulations background

Law No. 88-91 of 2nd August, 1988 (modified by Law No. 92-115 of 30th November, 1992)

National Agency for Environmental Protection (ANPE) has been created by this law. This is the first law to require an EIA before execution of any industrial, agricultural or commercial activity which has the risks of pollution or environmental degradation.

Decree No. 362-91 of 31st March, 1991

This decree specifies the contents of the EIA report and defines it as a tool to assess, evaluate and measure the direct and indirect effects at short, medium and long term of projects on the environment. Annexes I and II are attached to this decree listing the projects and activities subject to EIA.

Decree No. 1991-2005 of 11st July, 2005

This decree amends the Decree No. 362-91 of 31st March, 1991 and defines the categories of units (A/B) subject to the impact on the environment and the types of units subject to the specifications loads. For category A project, EIA report shall be evaluated by ANPE in a period not exceeding 21 working days and Category B project is evaluated in a period not exceeding three (3) months.

The projects in important sector shall be required EIA based on the Terms of Reference (TOR) provided by ANPE and Environmental Management Plans (EMP) are required, following the previous TOR. EIAs must be prepared by experts in the affected area.

The projects in sector listed in Annex II do not need a full EIA because of the nature of their activity and limited impact.

The environmental impact assessment regulations in force in Tunisia do not define a public inquiry, nor is a public consultation required in the procedure.

Tunisian Standards No. 106.02, 1989

This standard regulate the water quality of discharge water from WwTP to receiving environment, which sets the physicochemical parameters that each WwTP effluents must meet threshold values in following table:

This standard is under the process of amendment by GoT.

Table 6.2-1: Standards for Discharge water from WwTP

Parameters	Values	Unit
BOD	< 30	mg/l
COD	< 90	mg/l
SS (Suspended Solids)	< 30	mg/l
Ammonia nitrogen	< 15	mg/l
Total nitrogen	< 50	mg/l
Nitrites	< 5	mg/l
Nitrates	< 30	mg/l
Total Phosphorus	3-5	mg/l
Fecal Coliform	5-20 10^{4}	ppm/100 ml
Fecal Streptococci	1 -20 10^{4}	ppm/100 ml

Source: Approved Tunisian Standard NT 106.02 (1989)

6.2.3.2 Environmental Impacts Assessment (EIA) in Tunisia

Since the National Agency for Environment Protection (ANPE) has been established in 1988, the legal framework governing EIA has been strengthened so as to adapt it to the developments on national level and align it with international standards in terms of environmental management.

Among the major developments, in this regard, it is worth mentioning the Decree No. 1991-2005 of 11th July, 2005, related to EIA studies, and specifying the types of project for which such studies are required and those which are governed by a “Terms of References” documents.

Detailed procedure of EIA in Tunisia is described in the guideline provided by ANPE.

6.2.3.2.1 Objectives of the EIA

Generally, EIA is a tool for supporting the decision in different stages of the project. It integrates economic, social and environmental activities towards the solution for mitigating the negative impacts and providing the administrative managements needed to ensure that the project shall not threaten the environmental resources. The EIA is a valuable tool for the prevention of pollution and environmental degradation. It is also a planning tool that defines the actions to be implemented and the parameters, timelines, costs and responsibilities of different stakeholders to be monitored. The EIA in Tunisia examines both environmental and socio-economic aspects to minimize environmental impacts.

6.2.3.2.2 Procedure of the EIA

a) Necessary Contents for EIA Report

According to what was stated in article 6 of the Decree No. 1991-2005, the contents of the EIA should reflect the foreseeable impact on the environment and must contain at least the following items:

- Detailed description of the project facility,
- Description of the project site, especially the elements concerning environment and natural resources affected by the project,
- An analysis of the direct and indirect impact on the environment, in particular, natural resources, endangered species and sensitive areas, including primeval forests, natural and historical landscapes, protected areas, national parks, etc.,
- Measures envisaged by the project owner or the petitioner to eliminate or mitigate and, if possible, offset the damaging consequences on the environment,
- A detailed Environment Management Plan (EMP) / Plan de Gestion Environnementale (PGE).

b) Evaluation of EIA report

In case the project is categorized into Category A of Annex I of the Decree No. 1991-2005, ANPE shall evaluate EIA report and notify his decision to the project owner within 21 business days from the date of reception of EIA report. In case the project is categorized into Category B, ANPE shall evaluate it within 3 months relatively.

If the Category A project has impacts on sensitive area, above duration shall be extended from 21 days to 3 months.

c) Project Components to be required EIA

Article 12 of decree No. 1991-2005 of 11th July 2005 defines that the EIA is obligatory for three categories of intervention on “industrial, agricultural or commercial projects or equipment”: creation, extension of the existing one, transformation or change in the treatment process.

Furthermore, annex I of the same decree gives the list of interventions regrouped into two categories of impact assessments. For the JICA project, the interventions indicated in STEP correspond to “urban wastewater treatment units” and “collective industrial wastewater treatment units” and must be classified in Category B insofar as the following. This means that as defined in article 9 of the same decree, the National Agency for Environmental Protection has a period of three months to indicate its decision to oppose the building of the unit. Upon the expiry of this period, the agreement is considered tacit for the unit building.

Therefore, based on the legal requirements and in connection to the interventions planned in the present study, we may draw up the list of EIA obligations to be carried out.

Table 6.2-2: List of EIA obligations

Types of interventions included in the Project	Environmental Impact Assessment	
	Required	Not required
Installation of final disinfection by UV radiation;	✓	
Mechanical dewatering of sludge	✓	
Replacement of surface aerators by diffused aeration system	✓	
Installation of an internal nitrate recirculation;	✓	
Construction of pumping stations, regarding sludge recirculation and sludge purge	✓	

Based on the selected solutions described in the Chapter 3, each one of the 5 WwTP in the Project will be required separate EIA.

EIA for each WwTP must include the assessment of environmental impacts in the catchment area containing each WwTP. For municipalities, only the works of rehabilitation and extension of sewage network don't require an EIA. The work of networks must meet the specifications according to the environmental measures included in the "Cahier des Charges" provided by the ANPE.

d) EIA Approval

The GoT may issue the approval of EIA for realization of the project listed in:

- Annex I of the Decree No. 1991-2005 only after having verified that the ANPE shall not preclude the achievement of these,
- Annex II of the Decree No. 1991-2005 after the reception of the contract signed and legal documents according to the model approved by the Minister of the Environment.

The approval is issued to each project based on the submitted EIA report or the "Cahier des Charges". Construction work must be implemented in respect to its visa and to the measures mentioned in the EIA. If the measures mentioned in the EIA or in the "Cahier des Charges" have not been applied, approval shall be withdrawn by the GoT.

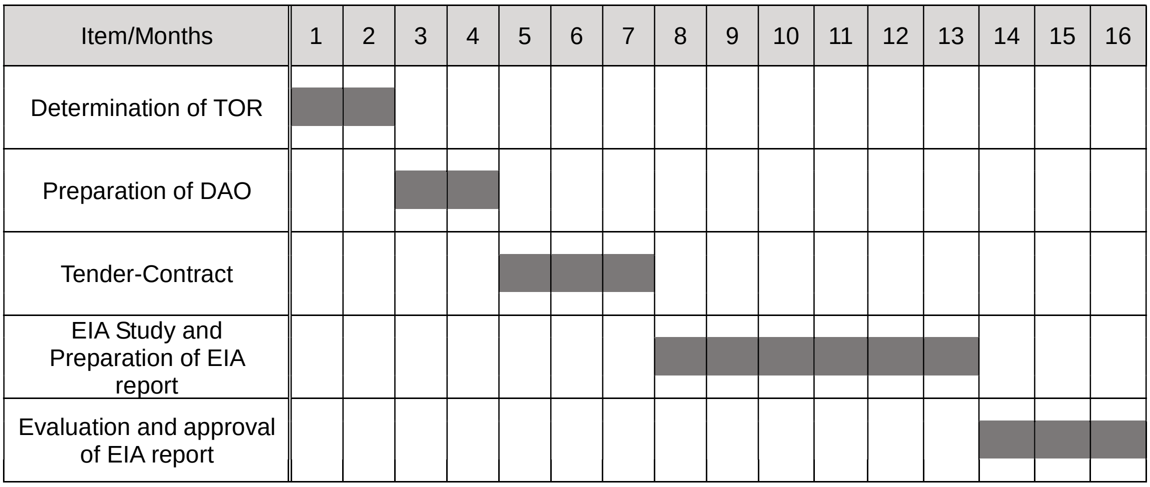
e) EIA Schedule

As described above, one EIA will be required for each WwTP. On the other hand, the project consists mainly in rehabilitation and it will be executed within existing site, thus, any necessary permission for installing WwTP has been already obtained.

To establish an EIA report for the project classified to Category B by ANPE, necessary procedure and necessary period corresponding to each procedure is as follows:

1) ONAS will consult ANPE detailed TORs for EIA, based on the project components: 1-2 months;
2) ONAS will prepare a tender document (DAO) for a procurement of EIA consultants: 1-2 months;
3) Evaluation, negotiations and contract works of the tender: 2-3 months;
4) EIA study and preparation of an EIA report: 6 months;
5) Evaluation and approval of EIA report by ANPE: within 3 months;
6) If ANPE requests additional work, the same procedure 5) shall be carried out until its approval.

Table 6.2-3: EIA schedule



6.2.3.3 Environmental Monitoring

A very important aspect of environmental management is environmental monitoring. Monitoring has two aspects.

The first and simplest is monitoring of compliance, which basically ensures that mitigation measures are properly implemented. This is part of the supervisory activities discussed above and is generally the one that most monitoring programs focus on.

The second aspect of environmental monitoring is impact monitoring. The main objective of impact monitoring is to determine whether the environmental mitigation measures implemented prove to be effective in reducing anticipated impacts. This monitoring allows the mitigation measures to be modified if the original measures prove to be ineffective.

6.2.3.3.1 Monitoring Policy under the JBIC Guidelines

For category A and B projects, JICA will monitor certain parameters due to environmental and social impact during construction and operation in order to confirm whether the Project could be implemented under the JBIC Guidelines or not. The necessary information for monitoring shall be provided by the relevant parties, such as GoT, executing agency, etc., to JICA by the appropriate means.

When third parties point out in concrete terms that environmental and social considerations are not being fully undertaken, if necessary, JICA will request the relevant parties to take appropriate action or to conduct their own investigations to confirm the state of undertaking of environmental and social considerations. JICA may also conduct its own investigations if required.

The implementation of environmental monitoring should involve ONAS as the responsible agency of the project, operator of the facilities and EIA study, and ANPE as the regulator. The operator needs to know that the services being delivered are in compliance with the procedures and regulations set out by the regulating institution. The operator will need to monitor their own production. The regulator on the other hand must be able to check that all procedures and regulations are adhered to. The regulator must be able to follow closely developments on a local as well as a national level and prepare new regulations if required.

6.2.3.3.2 Environmental Monitoring Plan (PGE) under Tunisian Law

Based on regulations, the Environmental Monitoring Plan (PGE) must be part of the EIA. It will be drawn up during the engineering study and planning phase of the project in order to:

- Define the EIA application conditions;
- Plan the implementation of attenuation measures and follow up the effects of the project during and after its implementation;
- Identify the necessary institutional arrangements (responsibility, coordination, training…).

These different components must be taken into consideration in the project design and integrated in the operation manual for construction and operation.

Under an EIA of WwTP, the PGE may be presented in order to provide:

- An impact attenuation program, with measures relative to the work phase (handling of chemical products, wastes, reduction of noise disturbances, etc.) and during the operation period (compliance with waste disposal standards in terms of quality of treated water, reduction of bad odors, insects, etc.);
- A follow-up program, particularly regarding quality at the WwTP level (sludge, raw and treated wastewater) and for both surface and underground water.

For the institutional portion, ONAS, which is the Project Manager, will be responsible for the measures indicated in the PGE and must promise to finance and estimate the corresponding costs (works, commissioning, maintenance, control of the follow up of the measure efficiency). The ANPE is the regulator since it may object to the implementation of the project or provide favorable opinions with or without reservations or conditions.

6.3 LAND ACQUISITION IN TUNISIA

One of the issues to be considered from the viewpoint of the social considerations is that some land acquisitions are required for construction of new pumping stations in the Project.

More than 50 new pumping stations will be installed according to the program planned by ONAS and a land of 150 - 400 m^2 is required for each station.

Based on the result of the site survey conducted by the Team in May and July 2011, some of the stations require land acquisition (expropriation of private properties).

6.3.1 Institutional Framework for Land Acquisition

6.3.1.1 Ministry of State Properties and Land Affairs (MDEAF)

Ministry of State Properties and Land Affairs (Ministère des Domaines de l'Etat et des Affaires Foncières (MDEAF)) is the agency responsible for the expropriation of property for the benefit of the state and public administrative institutions at their request, in collaboration with concerned agencies.

6.3.1.2 Commission of Recognition and Conciliation (CRC)

The expropriation procedure will be coordinated by a "Commission of Recognition and Conciliation (CRC)" established in each governorate based on the Law of 26th April, 2003. Its basic role will consist of working for the signing of an agreement between the parties concerned by the expropriation, on the value of the real estate to be expropriated (article 10 of Law No. 2003/26 of 14th April, 2003). Its composition, powers and operational procedures are set by decree No. 2003-1551 of 2nd July, 2003. The CRC is therefore composed of:

- A magistrate: chairman,
- A representative of the governor: member,
- The regional director of the State properties and land affairs or its representative: member
- The regional director of the topography and cartography office or its representative: member,
- A representative of the ministry or of the enterprise beneficiary of the expropriation: member,
- The expert for State properties: member,
- A representative for land property conservation: member,
- A representative of the municipality or municipalities in the location of the expropriated real estate: member.

Members of the commission will be appointed through a decree of the ministry of State properties and land affairs based on a proposal of the ministers, governors, chairmen of municipalities and heads of the companies concerned.

Concretely, the CRC is in charge of preparing the evaluation of the legal status and properties which must be expropriated in accordance with the documents drawn up by the project owner who asked for the expropriation (including the project documents), the inventory study of the properties which must be expropriated, holders of rights and other holders of existing rights on the real estate, as well as contracts between the parties concerned, among others.

The CRC will also arbitrate to reach an agreement on the price of the property which must be expropriated, in case doubts are expressed by one of the parties. The value of the good is therefore evaluated in two reports, one drawn up by a government expert and the other prepared by a specialist certified as a legal expert. Administrative consultation will be based on the value estimated by the CRC. The holders of rights must inform the CRC of their agreement or rejection of the said value.

6.3.2 Legal Framework for Land Acquisition

6.3.2.1 Type of land

The procedure to be followed for land acquisition will differ according to the type of land. The Tunisian legal land property system includes three categories of land, as indicated in the table 6.3-1.

Table 6.3-1: Categories of land

Type of land	Example	Acquisition procedure
State Public Domain	Hydraulic Public Domain Maritime Public Domain Road Public Domain Railway Public Domain Forest Public Domain Archeological Public Domain	Transfer or Temporary occupation (carried out by the concerned ministry)
State Private Domain	Land managed by state or communal organizations (Parks, dams etc.)	Affectation
Private Property	Private lands (for residential, agricultural purposes, etc.)	Amicable acquisition
		Expropriation

In the case of a land belonging to the State Public Domain, two procedures can be applied. First, the procedure of downgrading the State Public Domain, which is complex and almost not applied in practice, except for large scale tourism or industrial projects. Second, a procedure of Temporary Occupation which consists in a simple agreement between ONAS and the responsible of the State Public Domain concerned.

In the case of a land belonging to the State Private Domain, it will consist of a simple administrative procedure for a change of land assignment.

In the case of a private land, two solutions are possible: if there is a consensus between the parties, a sales contract will be signed for the amicable acquisition procedure. If there is refusal by the owners, the recourse to expropriation will be decided with the court referral of the Commission of Recognition and Conciliation (CRC) and the eventual legal settlement for land acquisition.

6.3.2.2 Procedure of assignment of State Private Domain

Land titles for properties belonging to the State Private Domain are covered by a procedure of land assignment (or change of purpose). ONAS will ask MDEAF for a change in the use of the land or lands concerned, based on a technical file.

With the authorization of land assignment, the land of the State Private Domain will then belong to the State Public Domain, more precisely to the Public Hydraulic Domain, which ONAS manages.

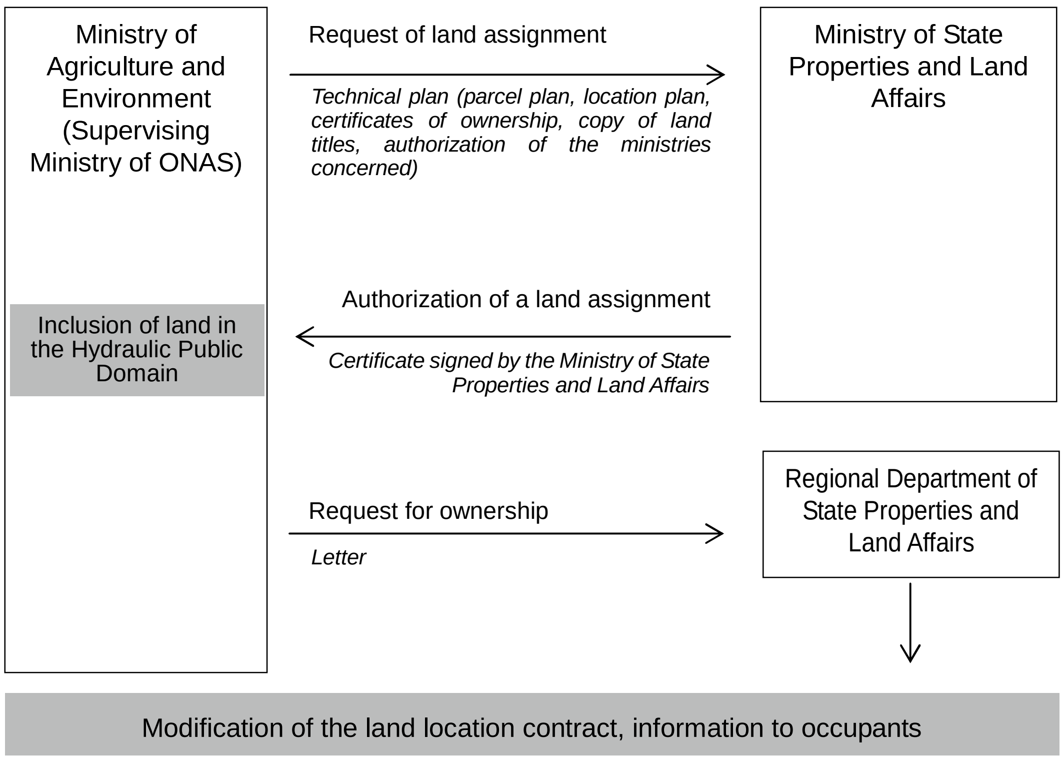


Figure 6.3-1: Procedure of assignment of the State Private Domain

6.3.2.3 Procedure for the acquisition of private land

Ownership of property is a fundamental right guaranteed by the constitution of the Republic of Tunisia of 1959 in its article 14 ("Ownership of property is guaranteed. It is exercised within the limits defined by the law."), but also by legislation (Code of Real Rights and Code of Obligations and Contracts).

In the case of acquisition of private land for integration into the ONAS property, an initial consultation is held with the owners in order to try acquiring the property amicably, that is to say, based on the mutual consent of the parties on the price of the land to be acquired. If this is rejected by the owners, the land will be acquired according to an expropriation procedure.

6.3.2.3.1 Amicable acquisition

The acquisition of private land is carried out according to an administrative procedure established by the MDEAF and common to all the Public Institutions in Tunisia. First, ONAS will contact the concerned populations through a local municipality who will duly inform them. A site visit and negotiations on the land value will constitute the initial public consultation stages with the land owners.

At this stage of the project, the projected position of the infrastructure is only vaguely defined (within a radius of around 100m). This will allow the planning of its installation on different lands and to obtain certain flexibility in negotiations with the owners.

Based on its experience, ONAS affirms that around 90% of private land acquisitions are carried out through the signing of an amicable sales contract.

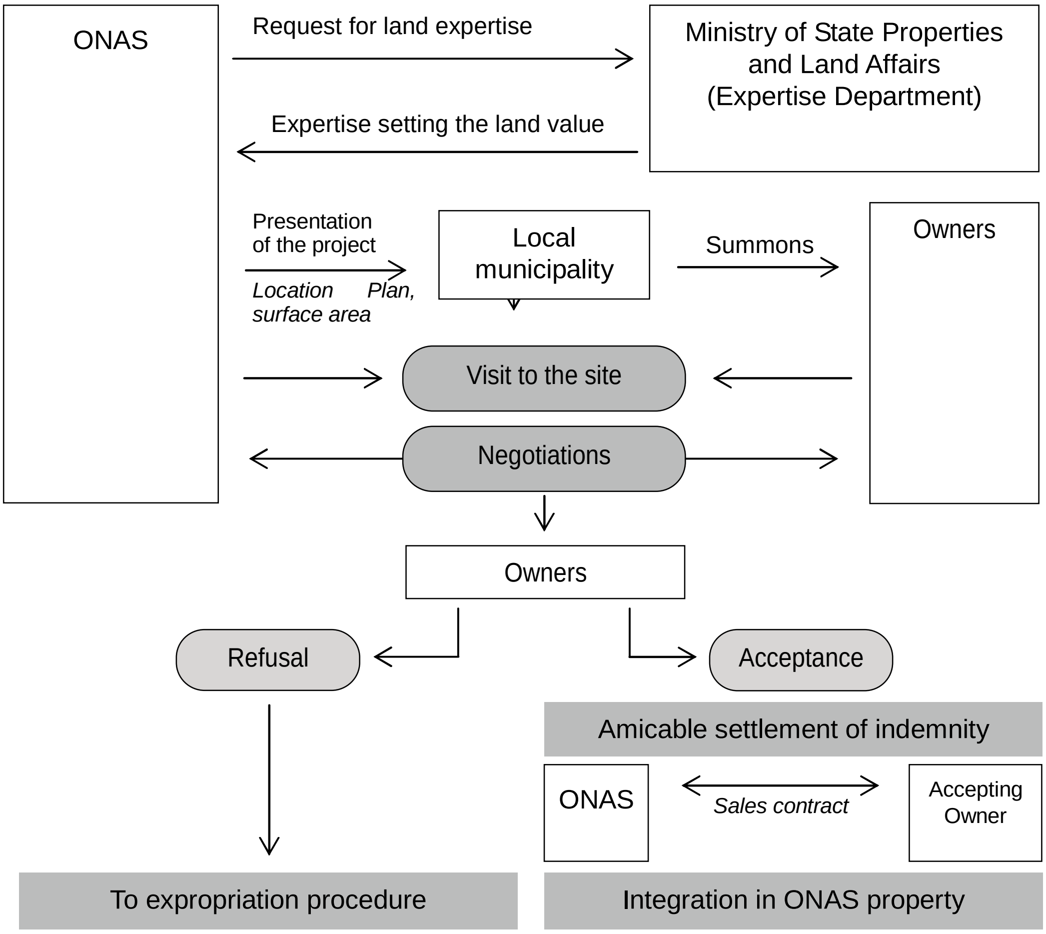


Figure 6.3-2: Amicable acquisition procedure

6.3.2.3.2 Expropriation

In case initial negotiations with the owners fail, due to non-agreement with the proposed value of the land to be acquired, the amicable acquisition procedure will be abandoned and replaced by an expropriation procedure.

According to article 20 of the Code of Real Rights, which indicates that “No one may be constrained to transfer his properties except in the cases defined by the law and with a fair indemnity”, expropriation will only be considered as the ultimate resort and should be appropriately compensated financially.

The expropriation procedure is set by Law No. 2003-26 of 14th April 2003, which amends the preceding Law No. 76-85 of 11th August, 1976, and revising the legislation on expropriations for public objectives.

The expropriation procedure is carried out by submission of the file to the Ministry of State Properties and Land Affairs (MDEAF), which is the organization responsible for the acquisition and expropriation of real estate for the benefit of the State and public administrative establishments upon their request, in collaboration with the agencies concerned.

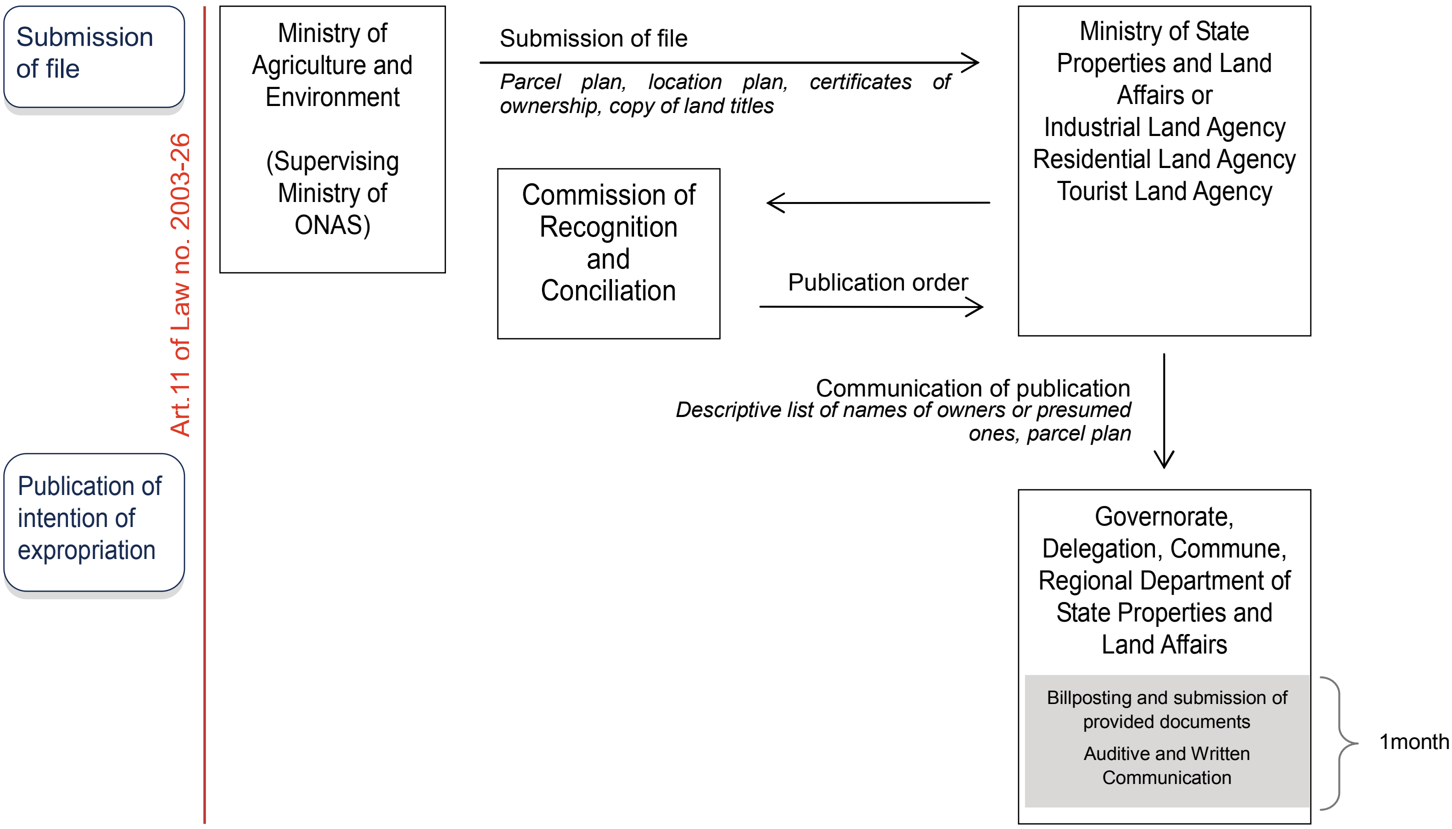


Figure 6.3-3: Expropriation procedure (1/3)

Following the submission of the file to MDEAF, the Commission of Recognition and Conciliation is consulted. According to article 11 of Law No. 2003-26 of 14th April, 2003, this commission will order the administrative institution concerned to publicize the plan to expropriate. The publication will be made through the billposting of the descriptive list indicating the names of the owners or presumed as such and the parcel plan for the land to be expropriated. This list will be posted in offices of the governorate, the delegation, the commune and the regional department of State properties and land affairs at the site of the land to be expropriated, for a period of one month. In addition, the same content will be published in the press, through local newspapers, and through information broadcasted by local radios.

The notice indicates the objective of the expropriation, its public utility, the registration numbers, surface areas and names of the land owners of the property to be expropriated. Furthermore, the notice announces the possibility for all rightful claimants to object to the expropriation by establishing a justified objection (see example Figure 6.3-4).

Original (in Arabic language)

وزارة أملاك الدولة والشؤون العقارية

الإدارة الجهوية لأملاك الدولة والشؤون العقارية بولاية نابل

إشهار مشروع نية الانتزاع لقطعتي أرض لازمتين لتمرير قناة تصريف المياه المستعملة بسيدي الظاهر من معتمدية بوعرقوب بولاية نابل

عملا بمقتضيات القانون عدد 85 لسنة 1976 المؤرخ في 11 أوت 1976 المتعلق بمراجعة التشريع المتعلق بالانتزاع للمصلحة العمومية والمنقح بالقانون عدد 26 لسنة 2003 المؤرخ في 14 أفريل 2003، وبناء على محضر جلسة اللجنة الجهوية للاستقصاء والمصالحة بولاية نابل المنعقدة بمركز الولاية بتاريخ 25 جانفي 2010.

تعلن وزارة أملاك الدولة والشؤون العقارية (الإدارة الجهوية لأملاك الدولة والشؤون العقارية بولاية نابل) أنها تعتزم إشهار نية الانتزاع لقطعتي أرض لازمتين لتمرير قناة تصريف المياه المستعملة بسيدي الظاهر من معتمدية بوعرقوب بولاية نابل، وذلك لفائدة المصلحة العمومية، وزارة البيئة والتنمية المستديمة (الديوان الوطني للتطهير)، وفقا للمعطيات المبينة بالجدول التالي:

Translation (in English language)

News

●●/●●/2010

Ministry of State Property and Real Estate Affairs

Regional administration of state property and real estate affair at Nabeul Governorate

Publicity of the project of exaction of two adjoining land titles that are needed to pass the wastewater discharge pipe at Sidi Daher commissioner of Bou Argoub at Nabeul Governorate

Pursuant to the requirements of the law number 85 /1976 Dated in 11 August1976 related to the revision of legislation that is about the expropriation for public interest, the previous law is revised by the law number 26/2003 dated in 14 April 2003, based on the session record of the minutes of the meeting of the committee of the regional survey and reconciliation at Nabeul governorate held at the statu s of the governorate in 25 January 2010.

Ministry of state property and real estate affairs announces (Regional administration of state property and real estate affairs of Nabeul governorate) the plan of the expropriation of two pieces of land required to pass the wastewater discharge pipe at Sidi Daher of Bou Argoub at Nabeul Governorate, and thus for public interest, Ministry of Environment and Sustainable Development (National Office for Sanitation), according to the data shown in the following table.

Number	Registered land number	Size of land to be expropriated	Names of owners or assumed	Notes
1	●●●●/●●●● ●●	Part of the land number ●●, area is $823m^2$	1- Mr ●● and Mr ●● and Mr ●● and Mr ●●, children of Mr ●● 2- Mr ●● 3- Ms ●●the wife of Mr ●● 4- Mr ●●	-Owners on specific proportions. -This property Endure the following; 1) Annual salary 44,128 Francs 2) An annual salary 192, 52 Franc for the interest of Mr ●● 3) Optional guarantee 9,500,000 Dinar -The named property as previous located in the area of Agricultural Estate Agency which is subjected to the provisions of Chapter2 from the law number 17 dated in 16 March 1977, revised by the law number 29 dated in 6 March 2000 related to authorization agricultural real estate agency.
2	●● Tunis ●●	Part of the land number ●●, area is $515m^2$.	1- Ms ●●	The named property as previous located in the area of Agricultural Estate Agency which is subjected to the provisions of Chapter 2 from the law n umber 17 dated in 16 March 1977, revised by the law number 29 dated in 6 March 2000 related to authorization agricultural real estate agency.

On each of who claims his right to acquire the property that is to be expropriated must submit a reasoned objection and to indicate of his identity, living place, subject of objection and the supporting document for that to the Investigation and reconciliation commission at Nabeul governorate located at the center of Nabeul Governorate in time limit not later than one month from the date of this

Figure 6.3-4: Example of publication of an expropriation notice

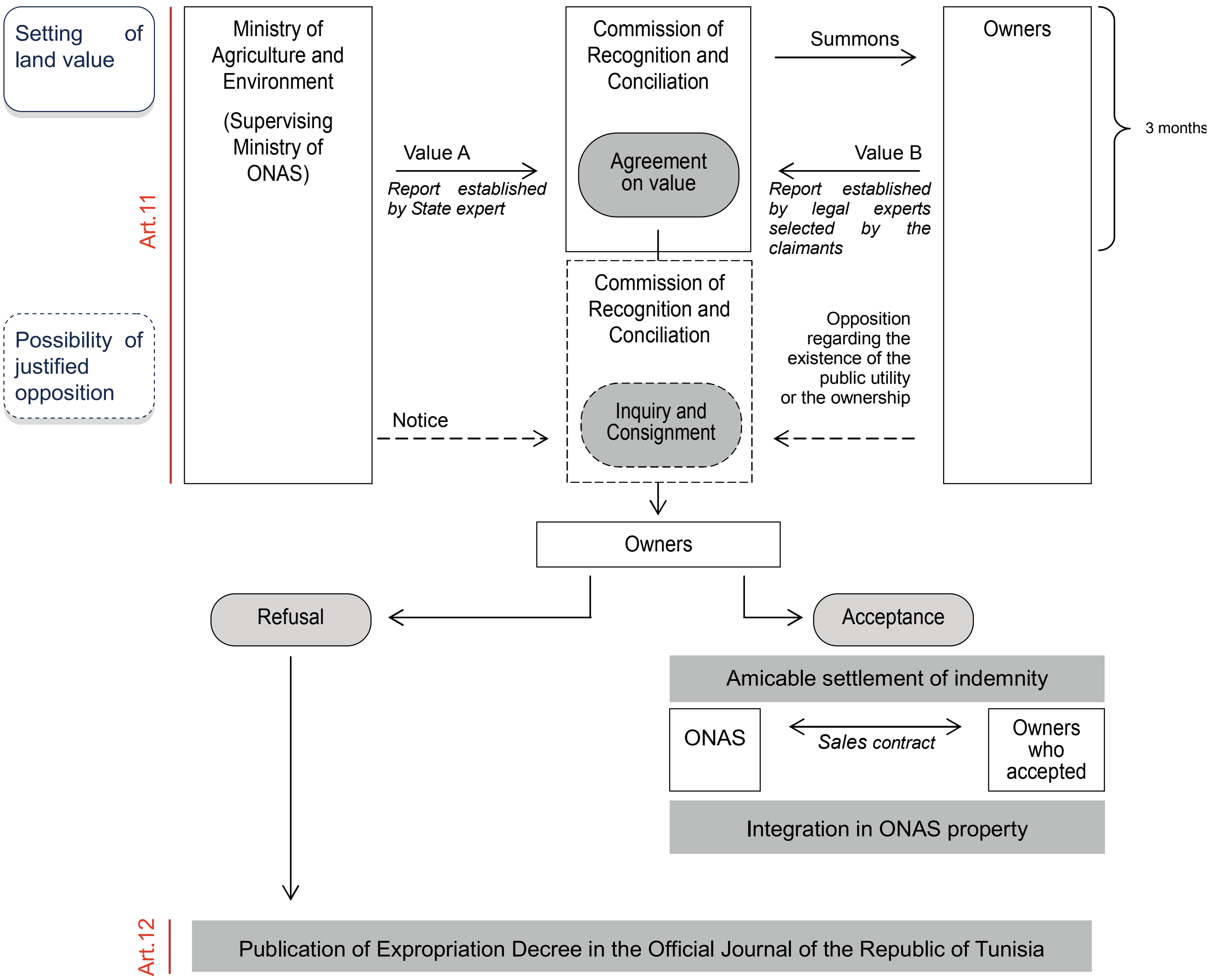


Figure 6.3-5: Expropriation procedure (2/3)

The Ministry of State Properties and Land Affairs publishes, following the report of the Commission of Recognition and Conciliation, an expropriation decree for lawsuits, particularly if the owners have refused the price proposal. The refusal is often based on the land value considered insufficient by the owner. The owner may oppose the MDEAF decision by lodging an appeal to the magistrate's court.

The court shall issue a decision on the expropriation indemnity within 3 months after the first hearing. In case of a new appeal of the owner, the court of appeals will issue a decision within 3 months after the first hearing. Finally, the Final court of appeals must give its decision within 3 months after the court referral date.

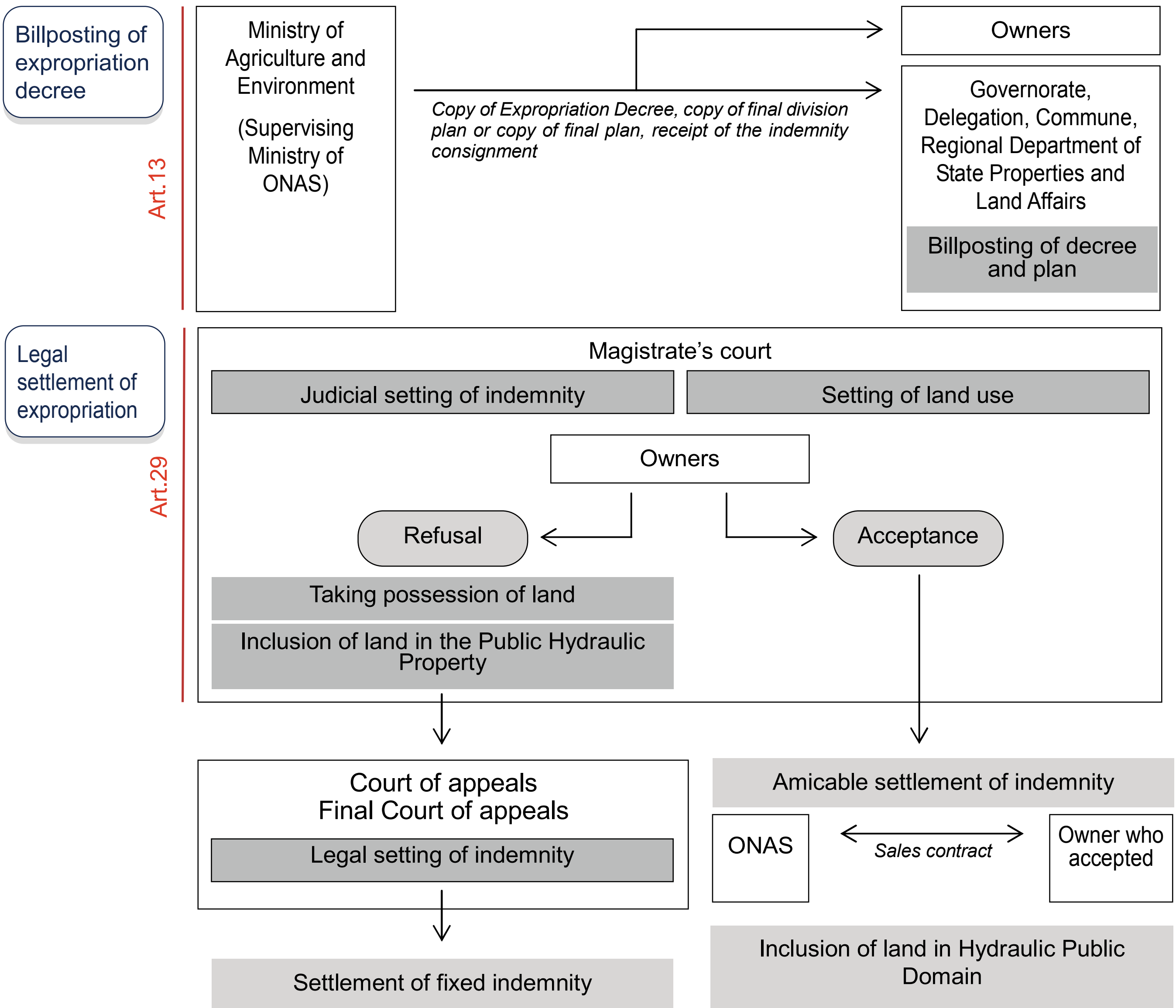


Figure 6.3-6: Legal framework of expropriation procedure (3/3)

6.3.2.4 Estimate of the land value and indemnity

The value of properties of owners or occupants inside the land area of the projected infrastructure is estimated through the preliminary expertise of the Ministry of State Properties and Land Affairs expert.

Upon the request of ONAS, the expertise department of the Ministry of State Properties and Land Affairs will draw up the land expertise, that is to say, it will set the value of the properties considering at that date the market price for comparable lands located in the same area, the productive value of agricultural lands, and other aspects which may influence the value of the properties. The estimate of the compensation indemnity will consider the loss of subsistence means caused by land purchase for the project.

Under the expropriation procedure coordinated by CRC, and according to article 11 of Law No. 2003/26 of 14th April, 2003, the indemnity amount is reevaluated and fixed based on two reports, one drawn up by the State properties expert, and the other by an expert selected by the owners (or some of them) from a the list of legal experts.

In the case of public works, the procedure requires almost 18 months from the first public consultation until the final compensation.

In order to estimate land acquisition costs, it is very difficult to establish average financial compensation values. The value of land may be changed considerably according to geographical location but also and mainly to the outcome of acquisition procedure. The indemnity value of the same land title may change from a simple value, in the case of an amicable outcome, to ten times the price, in the case of a court decision of the expropriation outcome. We may mention the example of a property estimated at 1,800 TND during the preliminary expertise of the Ministry of State Properties and Land Affairs expert, which was then re-evaluated at 18,200 TND based on the court expropriation decision. This is why the estimate of land acquisition costs cannot be carried out objectively.

6.3.2.5 Opposition to Expropriation

Article 11 of Law No. 2003/26 of 14th April, 2003, defines that any person with a property right is authorized to formulate an objection addressed to the Commission of Recognition and Conciliation. The opposition must be justified and must either object to the existence of a public utility, or to the ownership (a claim on the land property).

In case of opposition, the CRC must conduct the necessary investigations. It will summon the concerned owners at least 8 days in advance, for an inquiry during which they can express their observations and claims that will be noted in the report drawn up by the commission. The CRC will examine the objections after hearing opinions from the expropriating party (ONAS).

6.4 VALIDITY OF TUNISIAN PROCEDURE

Considering the Project components and its characteristics and as neither serious impact to the environment nor any large scale involuntary resettlements are expected, the Project shall be classified to Category B in JBIC Guideline through the environmental screening by JICA.

In this context, validity of Tunisian procedure for EIA and land acquisition of which the Project should take account is summarized in following table according to the comparison of relevant articles provided in the Guideline. World Bank Operational Policies (OPs)[1] shall be also referred as a world standard, in order to justify the necessary procedures to be applied on.

[1] World Bank Operational Policies (OPs): OP 4.01 - Environmental Assessment (1999), OP 4.12 - Involuntary Resettlement (2001)

Table 6.4-1: Validity of Tunisian Procedure

Basic Requirement of JBIC Guideline and/or OPs	Tunisian Procedure	References of Tunisian Law	Analysis and Comments
A. Environmental Impact Assessment (EIA)			
A-1. Legal Framework: The process of EIA is provided and ensured in some laws or decrees.	The projects in important sector shall be required EIA.	Decree No. 362-91 of 31st March, 1991 Decree No. 1991-2005 of 11th July, 2005	An appropriate legal framework has been established. User friendly tool kits and guidelines summarizing its procedure are also provided in the web site.
A-2. Institutional Framework: An organization responsible for EIA has been established.	National Agency for Environmental Protection (ANPE) has been created as the responsible body for EIA.	Law No. 88-91 of 2nd August, 1988 Law No. 92-115 of 30th November, 1992	An appropriate institutional framework has been established. ONAS has a department "Département Central Technique" responsible for environmental issues, including management of EIA. An officer who is responsible for the projects on sanitation sector is also nominated inside ANPE.
A-3. Domain of EIA: EIA takes into account the natural environment (air, water, and land); human health and safety; social aspects (involuntary resettlement, indigenous peoples, and physical cultural resources); and trans-boundary and global environmental aspects. EA considers natural and social aspects in an integrated way.	National Agency for Environmental Protection (ANPE) provides TOR for EIA.	Law No. 88-91 of 2nd August, 1988 Law No. 92-115 of 30th November, 1992	TOR provided by ANPE initially takes care of environmental aspects, then of socio-economic aspects.

Basic Requirement of JBIC Guideline and/or OPs	Tunisian Procedure	References of Tunisian Law	Analysis and Comments
A-4. Public Consultation: During the EIA process, some public consultations will be conducted including project affected groups and local non-governmental organizations (NGOs) about the project's environmental aspects and takes their views into account. Such consultations shall be provided as early as possible.	Not required during EIA process.	—	In case of the World banks' projects, ONAS conducted public consultation according to an article provided in OP4.01. In order to avoid any problems between stakeholders, such consultations shall be also applied on the Japanese ODA loan projects.
A-5. Disclosure: Any separate reports for the project are made available to project affected groups and local NGOs.	Not required during EIA process.	—	In case of the Category B projects, disclosure of EIA reports is not mandatory required to Tunisian side according to the JBIC Guideline. On the other hand, in case of World Bank projects, if a project classified to Category A or B, disclosure of EIA reports is mandatory required according to an article provided in OP4.01.
A-6. Monitoring: During project implementation, the reports on compliance with measures on the basis of the findings and results of the EIA will be prepared.	Preparation of Environmental Management Plans (EMP) is required. Method and frequency of monitoring will be determined in the plan.	Decree No. 362-91 of 31st March, 1991 Decree No. 1991-2005 of 11th July, 2005	ONAS has a department "Département Central Epuration" responsible for environmental issues, including management of EIA.

Basic Requirement of JBIC Guideline and/or OPs	Tunisian Procedure	References of Tunisian Law	Analysis and Comments
B. Land Acquisition			
B-1. Legal Framework: The process of land acquisition is provided and ensured in some laws or decrees.	Land acquisition is ensured by an administrative procedure. Expropriation procedure is ensured by a law.	Law No. 2003-26 of 14th April, 2003, amending previous Law No. 76-85 of 11th August, 1976	An appropriate legal framework is established. As soon as the expropriation decree is published, the expropriator has the right to take possession of the land, but in fact, court procedure may retard the project implementation.
B-2. Institutional Framework: An organization responsible for land acquisition has been established.	The Ministry of State Properties and Land Affairs (MDEAF) is the responsible body for Land Acquisition. A Commission of Recognition and Conciliation (CRC) is established in every governorate to manage the whole land acquisition process.	Law No. 2003-26 of 14th April, 2003, amending previous Law No. 76-85 of 11th August, 1976 Decree No 2003-1551 of 2nd July, 2003	An appropriate institutional framework is established. The creation of the CRC gives the opportunities to project affected people to defend their interests by nominating an expert for estimation of compensation.
B-3. Public Participation: Project affected people should be meaningfully consulted and should have opportunities to participate in planning and implementing land acquisition.	During Land Acquisition procedure, project affected people are invited to participate in a first consultation stage. During Expropriation process, project affected people are invited to participate in CRC sessions.	Law No. 2003-26 of 14th April, 2003, amending previous Law No. 76-85 of 11th August, 1976	Although it's more like negotiation, first contact consultation is quite open to any issue as it takes place upstream to the choice of a land to install the infrastructure. During CRC sessions, project affected people can prepare a reasoned objection in order to voice their demands.
B-4. Considerations of Vulnerable Group: Appropriate consideration must be given to vulnerable social groups.	Not required in Land Acquisition process.	—	—

Basic Requirement of JBIC Guideline and/or OPs	Tunisian Procedure	References of Tunisian Law	Analysis and Comments
B-5. Replacement Cost and Restoration of Livelihoods: Affected persons are provided prompt and effective compensation at full replacement cost for losses of assets attributable directly to the project. Affected persons should be assisted in their efforts to improve their livelihoods and standards of living or at least to restore them pre-project level.	The loss of livelihoods is estimated in the expertise and included in the indemnity compensation.	Law No. 2003-26 of 14th April, 2003, amending previous Law No. 76-85 of 11th August, 1976 Article 5 of Law No. 95-21 of 13th February 1995	The amount of compensation is reviewed and determined on the basis of two reports, one prepared by the expert nominated by the state, the other an expert on the list of legal experts that affected persons or some of them may choose. The loss of livelihoods is compensated by financial indemnity only, where a more consequential follow-up assistance (providing agricultural inputs, developing value chains) may be advisable. An agricultural public land can be allocated to the owner in exchange of his land of origin in order to facilitate resettlement.
B-6. Land Acquisition Plan (LAP): A land acquisition plan or a land acquisition policy framework will be prepared (if more than 200 people are displaced).	Not required in Land Acquisition process.	—	In case of JICA project, LAP is only required to the projects classified to Category A.
B-7. Abbreviated Resettlement Plan: Where impacts on the entire displaced population are minor or fewer than 200 people are displaced, an abbreviated resettlement plan may be agreed.	Not required in Land Acquisition process.	—	Required in case of World Bank projects as stated in OP 4.12. The JBIC Guideline does not have any article concerned about Abbreviated Resettlement Plan.
B-8. Monitoring: The borrower is responsible for adequate monitoring and evaluation of the activities set forth in the resettlement instrument.	Not required in Land Acquisition process.	—	Required in case of World Bank projects as stated in OP 4.12.

6.4.1 Validity of EIA Procedure in Tunisia

Regarding EIA procedure, appropriate legal and institutional framework has been established in Tunisia.

Before any conclusions, it should be re-confirmed that the Project will be classified as Category B in accordance with the criteria provided in the JBIC Guideline, because the Project will not have any significant impacts on environment. For category B project, EIA report is not an item mandatory required by JICA through their environmental reviews and JICA may refer the EIA report, if an EIA process has been conducted. To mention only about the Project, it is sufficient that separate EIA for each WwTP will be conducted basically in compliance with the conditions provided in the Tunisian procedure.

However, in order to avoid the problem between neighborhoods, JBIC guideline recommends that projects must be adequately coordinated so that they are accepted in a manner that is socially appropriate to the country and locality in which the project is planned.

Thus, by providing project information to the public at project design phase, some process of coordination and/or participation between public will be officially ensured during EIA process.

6.4.2 Validity of Land Acquisition Procedure in Tunisia

Though public consultations is not required in the JBIC guideline except for Category A projects, according to the Tunisian procedure relating to land acquisition, the executing agency will start a negotiation with local authorities and residents in the project target area during the topographic survey conducted prior to the detail design. Since the start of negotiations regarding the land acquisition, Tunisian procedure has a mechanism to ensure an opportunity that residents can participate and their opinions may be reflected to certain decisions of the project site in the project design stage. It may be said that appropriate procedures have been secured according to the JBIC guidelines. For compensation, Tunisian procedure has an adequate mechanism to verify the validity of the compensation price by comparing the prices proposed by the expropriator with the prices of a lawyer hired by the land owner. Assuming the Project will be classified to the category B, it can be said that land acquisition procedure in Tunisia has a proper mechanism in compliance with the requirements provided in the JBIC Guideline.

On the other hand, where a new pump station is planned, in order to avoid any expropriations and to mitigate impacts related to land acquisition, some alternative sites should be offered to stakeholders based on the detail information provided by topographic survey conducted after the JICA Study.

6.5 PROTECTED AREAS

In the north part of Tunisia, *Ichkeul National Park* located 50 km in Tunis in the governorate of Bizerte is classified as a RAMSAR biosphere reserve and was registered as world heritage site of UNESCO in 1980.

Due to particular lagoon system, the lake is fed by six freshwater rivers in winter and sea water enters through the Tinja River in summer, the park owes its originality. This dual alternating seasonal condition breeds the special aquatic vegetation and thousands of migratory water birds.

However, in 1996 the Park was inscribed on the list of world heritage in danger. In June 1998 the International Union for Conservation of Nature (IUCN) noted that the salinity of the lake may have exceeded any chance of recovering the World Heritage values of the site and was concerned at the slow pace and lack of effectiveness of the rehabilitation program.

The emergency was mitigated by ample rainfall during winters between 2003 and 2005 and the site taken out of danger list in 2006.

Figure 6.5-1: Location of Ichkeul National Park (Google)

Considering the conservation of biodiversity, the park especially provides habitat for passage and wintering water birds from the northern Palearctic region and breeding habitat for many southern Palearctic species listed in following table. Some of them are globally threatened or biome-restricted.

Table 6.5-1: List of Water Bird

Scientific name	Season	Population	IUCN Category
Barbary Partridge Alectoris barbara	Resident	–	Least Concern
Greylag Goose Anser anser	Winter	300-25,000 individuals	Least Concern
Eurasian Wigeon Anas penelope	Winter	10,000-50,000 individuals	Least Concern
Northern Shoveler Anas clypeata	Breeding	–	Least Concern
Northern Shoveler Anas clypeata	Winter	5,000-10,000 individuals	Least Concern
Marbled Teal Marmaronetta angustirostris	Breeding	50-200 breeding pairs	Vulnerable
Common Pochard Aythya ferina	Winter	10,000-90,000 individuals	Least Concern
Ferruginous Duck Aythya nyroca	Winter	20-90 individuals	Near Threatened
White-headed Duck Oxyura leucocephala	Winter	12-600 individuals	Endangered
Greater Flamingo Phoenicopterus roseus	Winter	500-4,500 individuals	Least Concern
Eleonora's Falcon Falco eleonorae	Breeding	–	Least Concern
Common Coot Fulica atra	Winter	2,000-45,000 individuals	Least Concern
Black-tailed Godwit Limosa limosa	Passage	3,000-6,000 individuals	Near Threatened
Collared Pratincole Glareola pratincola	Breeding	200-600 breeding pairs	Least Concern
Sardinian Warbler Sylvia melanocephala	Resident	–	Least Concern
Spotless Starling Sturnus unicolor	Resident	–	Least Concern
Moussier's Redstart Phoenicurus moussieri	Resident	–	Least Concern
Black Wheatear Oenanthe leucura	Resident	–	Least Concern
Black-eared Wheatear Oenanthe hispanica	Breeding	–	Least Concern

Source: Birdlife International

To protect this sensitive area against the conflict between environment and development, Program for Economic and Social Development (PDES) is prepared at regional level which identifies the main directions of development in the region of Bizerte by the year 2015 to satisfy both its socio-economic development and conservation of natural environments of the park.

The orientations of the PDES are being taken into account in rural development in upstream watershed areas and the wastewater of cities.

Regarding the Project components to be installed near the park area, rehabilitation and extension of networks and pumping stations is planned in the commune Menzel Bourguiba situated between the lake Bizerte and the lake Ichkeul. As the project aims at improving the situation of wastewater collection, it could provide positive impacts to the environment.

6.6 DESCRIPTION OF THE PROJECT

Based on the feasibility study prepared by ONAS, the project initially includes two components, the rehabilitation and extension of 5 Wastewater Treatment Plants (WwTP) in 3 governorates, and the rehabilitation and extension of sewerage networks and pumping stations in 10 governorates. The sub-projects in each governorate are summarized in the following figure:

Table 6.6-1: Project Summary for Network and Pumping Station (ONAS F/S)

Governorate	Network (2029)		Pumping Station (2029)	
	Rehabilitation (Km)	Extension (Km)	Rehabilitation (No.)	Extension (New) (No.)
Béja	38.4	8	1	5
Bizerte	77.5	17.5	8	7
Jendouba	30.1	37.6	5	6
Kasserine	30.4	51.1	0	4
Kébili	10.4	148.9	2	15
Kef	21.4	5.8	4	2
Sfax	75.4	459.9	3	5
Sidi Bouzid	16	10.2	0	1
Siliana	20	3.2	0	1
Zaghouan	61.5	6.9	0	4
Total	**380.9**	**749.1**	**23**	**50**

Table 6.6-2: Project Summary (WwTP)

	Specification (2029)						Proposed Solution	
	Total Population Equivalents (hab)	Average Daily Flow (m^3/day)	Pollutant Load DBO_5 (kg/day)	Activated Sludge Volume Requested (m^3)	Discharge Water Volume (m^3/day)	Sludge Volume (t/day)	Modification of Process and/or Additional Process	Extension of Civil Works
Medjez el Bab	39,592	5,429	2,376	6,546	5,323	18	✓	
Béja	143,586	12,994	8,615	19,880	12,862	61	✓	
Tabarka	44,509	8,510	2,671	7,762	8,391	19	✓	✓
Jendouba	104,988	11,703	4,200	11,928	11,590	33	✓	
Siliana	37,650	4,084	1,694	7,800	4,044	13	✓	

6.7 GENERAL DESCRIPTION OF ENVIRONMENTAL SITUATION

6.7.1 Networks and Pumping Stations

In general, regarding construction of sewerage networks, environmental and social impacts of the project are very limited, because the main sewer pipes to be rehabilitated are located under the existing roads and the new pipes for extension will be also installed along the roads.

Photo: Main Sewer, Bizerte

Sewerage networks will be built within the Right of Way (RoW), thus no involuntary resettlement will be expected in the Project at this moment.

As for the limited influence of the Project to the neighborhood during the construction phase, following temporary discomfort shall be assessed:

- Noise and vibrations due to the earthworks;
- Dust from earthworks and transportation of construction materials;
- Diversion of traffic circulation;
- Risk of safety for construction site and traffic circulation;
- Diversion of house access, etc.

On the other hand, one of the issues to be considered from the viewpoint of the social considerations is that some land acquisitions are required for construction of new pumping stations in the Project.

More than 50 new pumping stations are planned by ONAS and a land of 150 - 400 m^2 is required for each station.

Based on the result of the site survey conducted by the Team, some of the stations require some private land acquisition.

Photo: Pumping Station, Bizerte

Considering the operation phase, if a pumping station is planned in a residential area, specification of equipment in the stations should be determined in compliance with the limit value of noise.

Odor shall also be controlled and specification of equipment in pumping stations should be determined in order to avoid nuisance toward neighbors.

6.7.2 Wastewater Treatment Plants (WwTP)

The description regarding general situation and environmental considerations for the 5 wastewater treatment plants are summarized as follows:

WwTP: Medjez el Bab

Current Layout	Sludge Dump inside the WwTP area
	

Distance from the City Center: 1 km

Receiving Environment of Discharge Water: Wadi Medjerda

Disposal of Sludge and Solid Waste: Sludge has been stocked at drying bed and temporary dump inside the WwTP without any protection since 2007.

General Description of Environmental Situation: The WwTP is located in an agriculture area, 1 km distant from the city center, and direct influence to the neighborhood, such as odor and noise, will not be identified. The WwTP has enough space for extension, if required, and land acquisition will not be necessary. On the other hand, sludge stocked at temporary dump will be a cause of groundwater pollution and it‘s an urgent matter that ONAS find a controlled dump.

WwTP: Béja

Current Layout	Discharge water after treatment
	

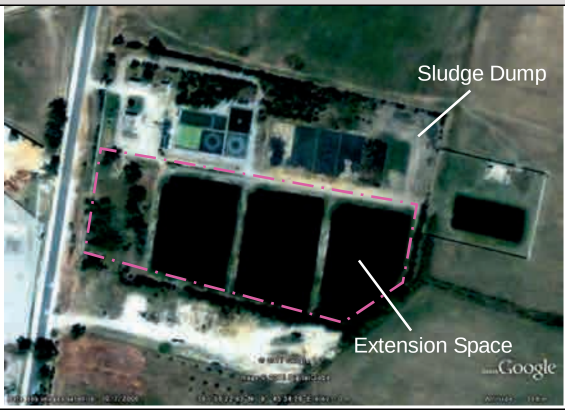
Distance from the City Center: 2 km

Receiving Environment of Discharge Water: Wadi Béja

Disposal of Sludge and Solid Waste: Sludge has been stocked at drying bed and temporary dump inside the WwTP without any protection.

General Description of Environmental Situation: The WwTP is located 2 km distant from the city center. The WwTP has enough space for extension, if required, and land acquisition will not be necessary. On the other hand, sludge stocked at temporary dump will be a cause of groundwater pollution. Treated water is colored due to the wastewater from a yeast factory and it's discharged to the Wadi Béja flowing into the Sidi Salem Dum that is one of the resources of drinking water for neighboring areas.

WwTP: Tabarka

Current Layout	Solid Waste Dump (7km from WwTP)
	

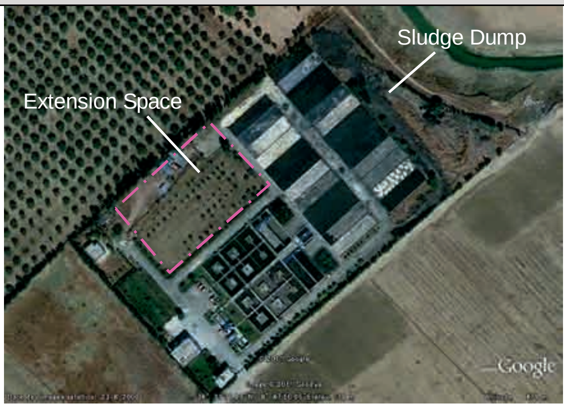
Distance from the City Center: 1 km

Receiving Environment of Discharge Water: Wadi el Kébir

Disposal of Sludge and Solid Waste: Sludge has been stocked at drying bed inside the WwTP since January 2011. Existing municipality's dump, 7km from the WwTP, does not have any protection measures.

General Description of Environmental Situation: Residential area is extending near the WwTP in recent years and some measures against odor should be considered. Sludge stocked at temporary dump will also be a cause of groundwater pollution and it's an urgent matter that ONAS find a controlled dump. The WwTP has enough space for extension, if required, and land acquisition will not be necessary. Water quality of discharge water, flowing into the public beach area, shall be carefully monitored.

WwTP: Jendouba

Current Layout	Sludge Dump inside the WwTP area
	

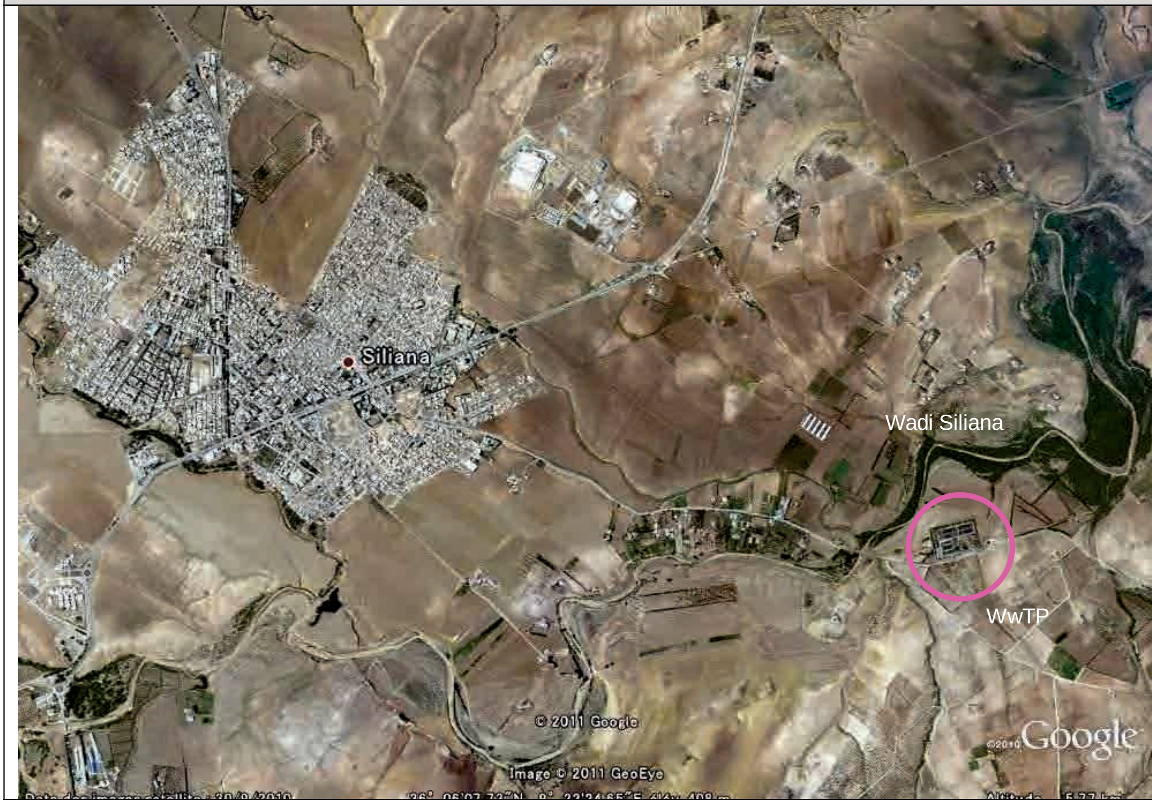
Distance from the City Center: 2 km

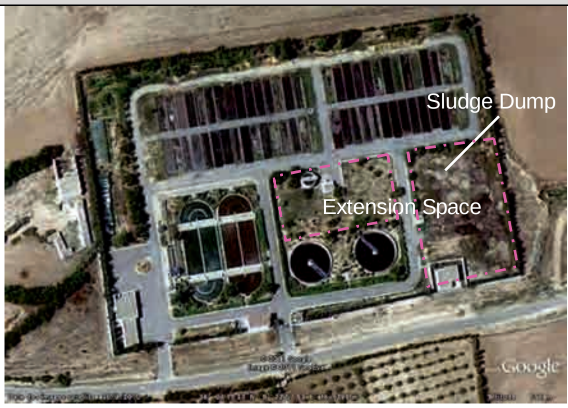
Receiving Environment of Discharge Water: Wadi Medjerda

Disposal of Sludge and Solid Waste: Sludge has been stocked at drying bed and temporary dump inside the WwTP without any protection since 2005.

General Description of Environmental Situation: The WwTP is located in an agriculture area, 2 km distant from the city center, and direct influence to the neighborhood, such as odor and noise, will not be identified. The WwTP has enough space for extension, if required, and land acquisition will not be necessary. On the other hand, sludge stocked at temporary dump will be a cause of groundwater pollution and it's an urgent matter that ONAS find a controlled dump.

WwTP: Siliana



Current Layout	Sludge Dump inside the WwTP area
	

Distance from the City Center: 4 km

Receiving Environment of Discharge Water: Wadi el Kébir

Disposal of Sludge and Solid Waste: Sludge has been stocked at drying bed and temporary dump inside the WwTP without any protection.

General Description of Environmental Situation: The WwTP is located in an agriculture area, 4 km distant from the city center, and direct influence to the neighborhood, such as odor and noise, will not be identified. Space for extension has been reserved, if required. On the other hand, sludge stocked at temporary sludge dump will be a cause of groundwater pollution and it's an urgent matter that ONAS find a controlled dump.

6.8 ENVIRONMENTAL IMPACT

6.8.1 Positive Impacts

Table 6.8-1 presents the expected positive impacts of the project and measures to improve the positive impacts.

Table 6.8-1: Positive Impacts

<table>
<tr><th>Positive impact</th><th>Measures to improve positive impact</th></tr>
<tr><td>Improvement of living condition</td><td rowspan="5">To ensure the positive impact and project sustainability, conducting some public awareness raising campaigns concerning following items are recommended:

Design and Construction Phase
➢ Knowledge of sewerage system,
➢ Knowledge of public health,
➢ Prevention of groundwater pollutions,
➢ Prevention of waterborne diseases, etc.

Operation Phase
➢ Household connection,
➢ Willingness to pay for sewage tariff,
➢ Prevention of illegal connection to the sewerage system,
➢ Prevention of inadequate dumping into the sewerage system,
➢ Water quality standard for inflow water to the WwTP
➢ Enhancement of pre-treatment of industrial wastewater, etc.</td></tr>
<tr><td>Improvement of water environment</td></tr>
<tr><td>Improvement of accessibility of modern sanitation services</td></tr>
<tr><td>Improvement of collection of sanitation tariff</td></tr>
<tr><td>Reduction of medical bills for each household through decreasing waterborne diseases</td></tr>
</table>

6.8.2 JBIC Environmental Checklist

General items to be assessed as negative impact are summarized according to the following JBIC Environmental Checklist.

JBIC Environmental Checklist: Sewage and Wastewater

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
1. Permits and Explanation	(1) EIA and Environmental Permits	① Have EIA reports been officially completed? ② Have EIA reports been approved by authorities of the host country's government? ③ Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? ④ In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	① The GoT will conduct EIA Study after the JICA Study based on the procedure provided in the "Decree No. 1991-2005 of July, 2005". ② EIA report has not been established yet. ③ The contents of the report will be examined and approved by ANPE. ④ Not required.
	(2) Explanation to the Public	① Are contents of the project and the potential impacts adequately explained to the public based on appropriate procedures, including information disclosure? Is understanding obtained from the public? ② Are proper responses made to comments from the public and regulatory authorities?	① From the viewpoint of environmental impacts of the Project, public consultation is not obliged in the EIA procedure provided in the "Decree No. 1991-2005 of July, 2005". ② On the other hand, from the viewpoint of social impacts, public consultation is obliged according to the Tunisian law for expropriation "No. 2003-26 of 14th April, 2003". Any project affected people can express their opposition if they have objection to the project. However, based on the EIA process in Tunisia, any public consultations are not required during EIA. Thus, in order to avoid any problems between stakeholders, such consultations shall be conducted during EIA as same as for the world bank's projects.
2. Mitigation Measures	(1) Water Quality	① Do pollutants, such as SS, BOD, COD contained in effluents discharged by the facility operations comply with the country's effluent standards?	① Water quality of discharge water shall be controlled in compliance with the limit value according to the Tunisian standard "NT 106.02 (1989)" and specification of equipment in WwTPs should be determined according to this standard.
	(2) Wastes	① Are wastes, such as sludge generated by the facility operations properly treated and disposed of in accordance with the country's standards?	① Sludge has been stocked at drying bed and/or temporary dump site inside each WwTP without any protection since several years. Allowable level of heavy metals in sludge is regulated in the Tunisian standard "NT 106.20 (2002)".

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(3) Soil Contamination	① If wastes, such as sludge, are suspected to contain heavy metals, are adequate measures taken to prevent contamination of soil and groundwater by leach from the wastes?	① Sludge stocked at temporary sludge dump site in each WwTP without any protection will be a cause of contamination of soil and groundwater. It's an urgent matter that ONAS find a controlled dump for its sludge.  Photo: WwTP Medjez el Bab
	(4) Noise and Vibration	① Do noise and vibrations generated from the facilities, such as pumping stations comply with the country's standards?	① Every WwTP is located at an average distance from 1 km to 4 km from residential area and no significant impact of noise and vibration is identified. On the other hand, If a pumping station is located in residential area, specification of equipment in the stations should be determined in compliance with the limit value of 50dB.  Photo: Pumping station in the commune Testour

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(5) Odor	① Are adequate control measures taken for odor sources, such as sludge treatment facilities?	① Odor shall be controlled to ensure similar quality in compliance with the limit value of 0.2 mg/m^3 of H_2S in the air according to the Tunisian standard "NT 106.04 (1994)" and specification of equipment in WwTPs and pumping stations should be determined according to this standard.
3. Natural Environment	(1) Protected Areas	① Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	① The Project will not be executed in the protected areas.
	(2) Ecosystem	① Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? ② Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? ③ If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? ④ Is there a possibility that the amount of water (e.g., surface water, groundwater) used by the project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?	① The Project will not be executed in the sites including important ecosystems. ② The Project will not be executed in the protected areas. ③ No significant impacts to the valuable ecosystem. ④ No significant impacts.
4. Social Environment	(1) Resettlement	① Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? ② Is adequate explanation on relocation and compensation given to affected persons prior to resettlement? ③ Is the resettlement plan, including proper compensation, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement?	① No involuntary resettlement will be expected in the Project for extension of WwTPs, as well as for construction of network. ② Tunisian law "No. 2003-26 of 14th April, 2003" provides the procedure of expropriation. Public consultation during the process for evaluating the value of private assets to be compensated is obliged according to the law. ③ Tunisian law "No. 2003-26 of 14th April, 2003" provides the procedure of expropriation. Inventory survey will be carried out during the process for evaluating the value of

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
		④ Does the resettlement plan pay particular attention to vulnerable groups or persons, including women, children, the elderly, and people below the poverty line, ethnic minorities, and indigenous peoples? ⑤ Are agreements with the affected persons obtained prior to resettlement? ⑥ Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? ⑦ Is a plan developed to monitor the impacts of resettlement?	private assets to be compensated. On the other hand, the value of compensation shall be determined based on the value of private assets to be expropriated and the value shall be recognized as a price that includes the cost for recovering former livelihoods. ④ Tunisian law "No. 2003-26 of 14th April, 2003" provides common procedure for all people, including any groups or persons. ⑤ No involuntary resettlement will be expected in the Project. ⑥ONAS has a section for legal matters "Direction Juridique" responsible for expropriation. ⑦ Tunisian law "No. 2003-26 of 14th April, 2003" does not include article regarding monitoring process after compensation.
	(2) Living and Livelihood	① Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? ② Is there a possibility that the amount of water used (e.g., surface water, groundwater) by the project will adversely affect the existing water uses and water area uses?	① Not identified ② Not identified
	(3) Heritage	① Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage sites? Are adequate measures considered to protect these sites in accordance with the country's laws?	① No influence to the heritage sites.
	(4) Landscape	① Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	① No influence to the valuable landscape.
	(5) Ethnic Minorities and Indigenous	① Does the project comply with the country's laws for rights of ethnic minorities and indigenous peoples? ② Are considerations given to reduce the impacts on culture and lifestyle of ethnic minorities and indigenous	① Not identified ② Not identified

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	Peoples	peoples?	
5. Others	(1) Impacts during Construction	① Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? ② If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? ③ If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts? ④ If necessary, is health and safety education (e.g., traffic safety, public health) provided for project personnel, including workers?	①Temporary discomfort during construction shall be mitigated following measures: ・ Divulge routinely all information concerning construction procedures. ・ Enforce safety and protection measures established in the construction contract document. ・ Provide home access to local people and traffic circulation.  Photo: Bizerte Medina Pollution of environment by temporary installation shall be mitigated by following measures: ・ Inappropriate deposit of excavated material and construction waste shall be avoided through Identification of deposit sites before construction and waste must be protected against wind and water erosion by covering. Degradation of borrow pit area shall be mitigated by following measures: ・ Borrow pit areas must be approved by local population as well as authorities ・ Include reclamation works, leveling of terrain, replanting of vegetation ・ Prevent erosion from heavy traffic on temporary gravel roads

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
			・ Identify access roads before construction begins ② Not identified ③ Not identified ④ Requirement of security management plan will be included in the contract document and it will be compulsory for the contractor.
	(2) Monitoring	① Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? ② Are the items, methods and frequencies included in the monitoring program judged to be appropriate? ③ Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? ④ Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	① It is enacted that monitoring should be done under the responsibility of project owner (ONAS) according to the conditions of EIA approval and Environmental management Plan (EMP) according to the "Decree No.1991-2005 of 11st July, 2005". ②Environmental management Plan (EMP) shall be determined through EIA conducted by ONAS after the JICA Study. ③ONAS has a department "Département Central Technique" responsible for environmental issues, including management of EIA studies. ④ Monitoring Reports should be submitted periodically to EIA Authority (ANPE). Frequency of submission shall be determined in EMP based on the characteristics of elements to be monitored.
6. Note	Note on Using Environmental Checklist	① If necessary, the impacts to trans boundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as trans boundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	① Not necessary

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project environmental considerations are made, if necessary.

2) An environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

6.8.3 Analysis of Negative Impacts

The Project components are not identified definitively before the appraisal by JICA and the Detailed Design (D/D) has not been established at this moment. In this context, negative impacts of the project could be assessed generally in accordance with the “Environmental Checklist” of the JBIC Guidelines and relevant laws of the GoT at this IEE level study.

6.8.3.1 Construction Phase

6.8.3.1.1 Land Acquisition:

Land acquisition involves the purchase of land for construction of new pumping stations. Land acquisition may impact the environment and local wealth, especially when purchasing agricultural fields or land within residential areas. Touristic potential and tourism development may also be affected by land acquisition.

Although most land acquisition for new pumping stations shall be executed in public land or through amicable settlement between land owners, there will be some occasions where some land may be acquired through expropriation.

6.8.3.1.2 Involuntary Resettlement:

Regarding involuntary resettlement, it will not be expected in the Project, neither for construction of networks and new pumping stations nor for extension of WwTPs.

6.8.3.1.3 Procurement and Depositing of Surplus Earth:

This concerns the procurement of construction materials (e.g., gravel) or their depositing in the case of surplus earth from construction sites especially when burying pipes. Inappropriate procurement of materials in an illegal manner may have a significant impact on the environment and the lives of people. At the same time as additional pollution issues, inappropriate deposit of surplus earth coming from construction sites may have a similar effect.

6.8.3.1.4 Earth Movements and Concrete Works:

This activity consists of the excavation for trenches and foundations, and concrete works for pumping stations. The main environmental impact would relate to the possible contamination of local underground water by earth movements and other construction activities, like pouring of concrete or uncontrolled deposit of materials.

6.8.3.1.5 Dust, Noise and Vibration:

These impacts will be assessed from all construction works, such as excavation of roads, earthworks and transportation of all construction materials, as well as equipment or machineries. Temporary environmental impact would be assumed including dust, noise and vibrations to the neighborhood.

6.8.3.1.6 Material Transportation:

This includes the transportation of all construction materials such as concrete, pipes or other material, as well as the transportation of equipment or machinery. Temporary environmental impact would be assumed through noise and dust pollution.

6.8.3.2 Operation Phase

6.8.3.2.1 Common issues resulting from expanding of the sanitation system:

- The risk of occupational health accidents may increase, such as staff working at the sanitation facilities may not be sufficiently trained in handling chemical materials and hazardous waste.
- The improvement of accessibility to sanitation system will often attract people from areas without services. This can result in unplanned construction activities and overcrowding, causing social problems, pollution due to overloading of the sanitation systems and soil erosion.
- A changing economy can result in an increase of sanitation tariff and an increase in the cost of land/housing in areas with better services. These effects could prevent the poorest segment of the population from having access to the improved services.

6.8.3.2.2 Networks and Pumping Stations:

Possible impacts due to daily operations, repair and maintenance, to be assessed during operation phase include:

- <u>Dust and Solid and Liquid Waste:</u>

  Periodic maintenance such as cleaning-up of the pipe, repairing the parts of pumps, dredging the sludge from pumping well, etc., are necessary to keep the facility in good condition. Dust and Solid Waste coming from these operations may be a factor of negative impacts, if they will not be properly controlled and treated.

- <u>Noise and Odor:</u>

  Noise and odor from the pumping stations will occur as a normal phenomenon of operations and can affect the neighborhood if they are not properly located and shielded by some structures.

6.8.3.2.3 WwTP:

Possible impacts due to daily operations, repair and maintenance, to be assessed during operation phase include:

- Discharge Water:

  Water quality of discharge water from the WwTP shall be carefully controlled according to the Tunisian standard.

  Especially, some of WwTPs are discharging its treated water to the river flowing to public water area which is used as a resource of drinking water (Béja) or public beach for tourist (Tabarka).

  If the plant is not properly designed or operated, discharge water cannot satisfy the standard and it becomes a cause of water pollution of public water.

- Sludge:

  As it was mentioned above, since several years, sludge from the WwTP has been stocked at drying bed and/or temporary dump site inside the WwTP without any protection against contamination of groundwater.

  If this situation will not be improved, it will cause serious contamination of groundwater as well as problems of nuisance for the neighborhood, such as odor.

- Problems for Neighborhoods:

  Odor from the WwTP will occur as a normal part of operations and can affect the neighborhood if wastewater is not properly treated.

6.9 ALTERNATIVES AND MITIGATION MEASURES

6.9.1 Alternatives

6.9.1.1 Design Phase

6.9.1.1.1 Pumping Stations (Preliminary Survey for Land Acquisition)

ONAS carried out the Preliminary Survey on the construction of new pumping stations (hereinafter referred to as “Preliminary Survey”), in order to examine a possibility of alternatives, to evaluate the public receptiveness to the implantation of the project and to promote the mutual understanding of the project with neighbors in the target communes.

i) Objectives of the Preliminary Survey:

Under the project, planned new pumping stations may require private land acquisitions, and may lead to lawsuits. Furthermore, these infrastructures may create disturbances to local populations (nauseating odors).

The objectives of the Preliminary Survey are as follows:

- To examine a possibility of an alternative to avoid the land acquisition of private asset;
- To reduce the socio-economic impacts due to land acquisition;
- To evaluate and minimize environmental impacts due to the construction of the new pumping stations.

ii) Methodology

Each Regional Department will call the representatives of the different communes affected by the construction of the new pumping station within its jurisdiction and will establish the Preliminary Survey in areas covered by projected pumping stations.

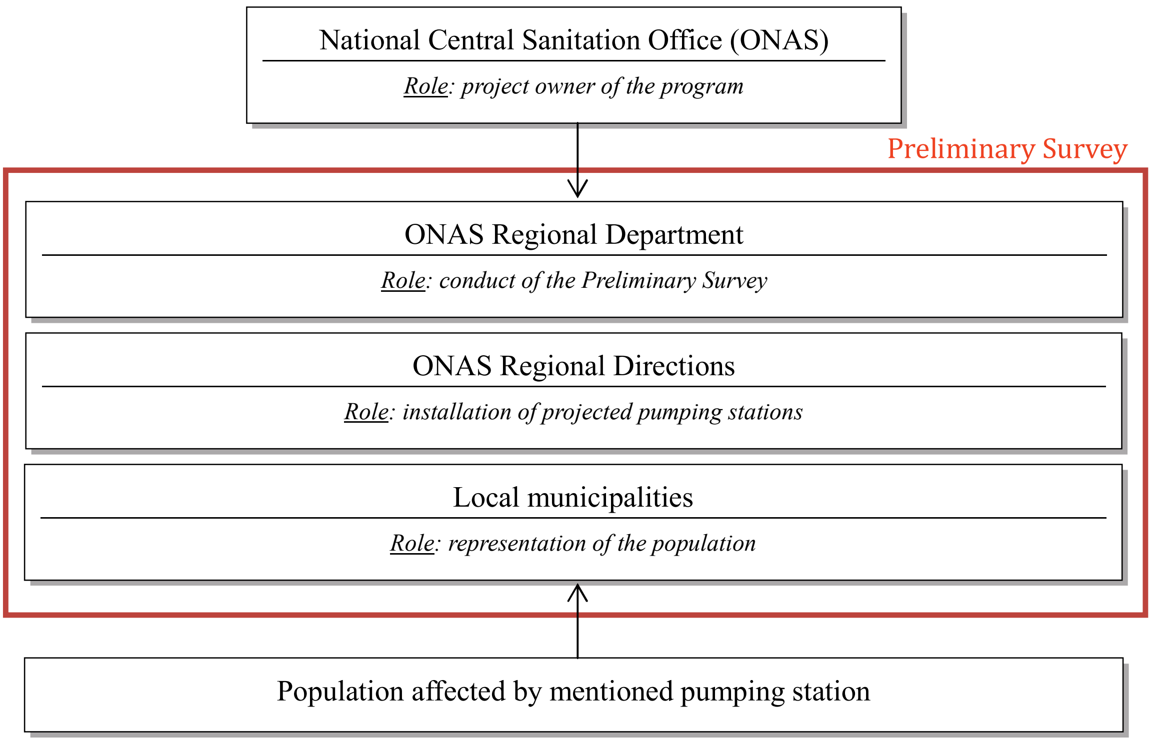


Figure 6.9-1: Participants in the Preliminary Survey

In order to facilitate exchanges between the stakeholders and to arrive at a consensus on the projected pumping stations, the following four documents will be issued during the Preliminary Survey sessions:

- Legal framework for land acquisition in the sanitation area;
- Analysis file on the pumping station (see Figure: 6.9-2) ;
- Location map of the pumping station ;

- Attendance list to Preliminary Survey sessions.

iii) Results of the Preliminary Survey

Based on above methodology proposed by the Survey Team, ONAS conducted the Preliminary Survey during the period from October 2011 to January 2012. The results are summarized in the Table 6.9-1. It is noteworthy that the list of operations studied corresponds to the data of the ONAS feasibility study provided to the Study Team.

According to the lists of participants provided by ONAS, some meetings had been held with local representatives, such as “Omdas” or Secretary Generals of the target commune. However, several results seem to have been studied only by ONAS regional sections, though one of the objectives of the Preliminary Survey is to promote the mutual understanding of the project with neighbors in the target communes. Information of the project shall be disclosed to the public and opinion from project affected areas shall be included before making decisions on the detailed design.

Analysis file on the pumping station

PRELIMINARY SURVEY
FOR THE CONSTRUCTION OF THE NEW PUMPING STATION

FROM TO TO

1. Information on pumping station

GOVERNORATE			
COMMUNE			
CODE			
TYPE (SIZE)[1]	□ Type A (XXm²)	□ Type B (XXm²)	□ Type C (XXm²)

2. Progress in the land acquisition procedure

□ 1. No procedure carried out	□ 2. In the process of negotiations with owners	□ 3. Publication of expropriation decree	□ 4. Obtained by ONAS
□ 5. Other:			

3. Location of the pumping station

TYPE OF LAND	□ State Public Property	□ State Private Property	□ Private Property		
	□ Other :				
SURROUNDING ENVIRONMENT	□ Dense urban area	□ Not dense urban area	□ Non-urban area	□ Agricultural	□ Forest
	□ Other :				

4. Notice

□ 1. Possible installation on Public Property *(indicate position in the plan)*	□ 2. Possible installation only on Private Property	□ 3. To be reviewed, existing problem

5. Origin of problem (in case of *3. To be reviewed, existing problem*)

□ Land problem	:
□ Technical problem	:
□ Environmental problem	:
□ Social problem	:

5. Remarks

(1) To be defined during the submission of the Final Report (draft)

Figure 6.9-2: Analysis file on the pumping station for the Preliminary Survey

Table 6.9-1: Status of Land Acquisition for New Pumping Stations

Governorate	Commune	Code No.	Required Land (m^2)	Type of Land			Remarks
				State Public Domain	State Private Domain	Private Property	
Béja	Maagoula	BEJ-Maa-SP-Ex-1	100	○			The location shall be reviewed during detailed design to optimize the SP to a gravitational pipe.
	Nefza	BEJ-Nef-SP-Ex-1	100	N/A	N/A	N/A	
		BEJ-Nef-SP-Ex-2	100			○	The land is owned by several heirs.
	Teboursouk	BEJ-Teb-SP-Ex-3	100	N/A	N/A	N/A	
	Testour	BEJ-Tes-SP-Ex-1	100			○	The land is owned by several heirs.
Bizerte	Bizerte	BIZ-Biz-SP-Ex-1	100			○	Under negotiation with the owner. The site is prioritized due to the problem of pollution.
	Menzel Bourguiba	BIZ-Men-SP-Ex-1	400		○		The land is a part of lands owned by Tunisian military. To be consulted to the Ministry of Defense.
	Raf Raf	BIZ-Raf-SP-Ex-1	400	○			Under negotiation with the owner. The SP shall be installed in the Public Marine Domain (DPM).
		BIZ-Raf-SP-Ex-2	400	○			Under negotiation with the owner. The SP shall be installed in the Public Marine Domain (DPM).
	Tinja	BIZ-Tin-SP-Ex-1	400	○			Public Marine Domain (DPM) The site is prioritized due to the problem of pollution.
		BIZ-Tin-SP-Ex-2	400	○			The site is prioritized due to the problem of pollution.

Governorate	Commune	Code No.	Required Land (m^2)	Type of Land			Remarks
				State Public Domain	State Private Domain	Private Property	
Jendouba	Boussalem	JEN-Bss-SP-Ex-1	100			○	
	Fernana	JEN-Fer-SP-Ex-1	100			○	
	Ghardimaou	JEN-Gha-SP-Ex-1	100			○	
	Jendouba	JEN-Jen-SP-Ex-1	100			○	
	Tabarka	JEN-Tab-SP-Ex-1	100	○			It is possible to relocate the SP to a state public land.
		JEN-Tab-SP-Ex-2	100	○			It is possible to relocate the SP to a state public land.
Kasserine	Feriana	KAS-Fei-SP-Ex-1	100			○	
		KAS-Fei-SP-Ex-2	100			○	The location shall be reviewed during detailed design.
	Thala	KAS-Tel-SP-Ex-1	100	○			Public Hydraulic Domain (DPH) Measures against flood shall be verified.
		KAS-Tel-SP-Ex-2	100	○			Public Forest Domain (DPF)

Governorate	Commune	Code No.	Required Land (m^2)	Type of Land			Remarks
				State Public Domain	State Private Domain	Private Property	
Kébili	Kébili	KEB-Keb-SP-Ex-1	100			○	
	Kébili Nord	KEB-Ken-SP-Ex-1	100			○	
		KEB-Ken-SP-Ex-2	400			○	
		KEB-Ken-SP-Ex-3	100			○	
		KEB-Ken-SP-Ex-4	100		○		It is possible to relocate the SP to a state public land.
	Kébili Sud	KEB-Kes-SP-Ex-1	100			○	
		KEB-Kes-SP-Ex-2	100			○	
	Souk Lahad	KEB-Sou-SP-Ex-1	100			○	
		KEB-Sou-SP-Ex-2	400			○	
		KEB-Sou-SP-Ex-3	100			○	
		KEB-Sou-SP-Ex-4	100			○	
		KEB-Sou-SP-Ex-5	100			○	
	Jemna	KEB-Jem-SP-Ex-1	400		○		
	Douz	KEB-Dou-SP-Ex-1	100			○	
	Douz Sud	KEB-Dos-SP-Ex-1	100		○		The land is owned by private community.

Governorate	Commune	Code No.	Required Land (m^2)	Type of Land			Remarks
				State Public Domain	State Private Domain	Private Property	
Kef	Kef	KEF-Kef-SP-Ex-1	100		○		The land belongs to regional council of the governorate of Kef.
	Tajerouine	KEF-Taj-SP-Ex-1	100			○	Under negotiation with the owner. The owner already agreed to sell the land to ONAS.
Sfax	Sfax Sud	SFA-Sfs-SP-Ex-1	100			○	
	Sfax Ville	SFA-Sfv-SP-Ex-1	100		○		Public Marine Domain (DPM) Odor shall be technically treated.
	Agareb	SFA-Aga-SP-Ex1	100			○	Odor shall be technically treated.
	Mahres	SFA-Mah-SP-Ex-1	100			○	Odor shall be technically treated.
	Tyna	SFA-Tyn-SP-Ex-1	100			○	Odor shall be technically treated.
Sidi Bouzid	Sidi Bouzid	SID-Sid-SP-Ex-1	100			○	Under negotiation with the owner.
Siliana	Bou Arada	SIL-Bou-SP-Ex-1	100			○	The land is owned by several heirs who are difficult to identify.
Zaghouan	Zaghouan	ZAG-Zag-SP-Ex-1	400			○	
		ZAG-Zag-SP-Ex-2	100		○		
		ZAG-Zag-SP-Ex-3	100			○	
	Hammam Zriba	ZAG-Ham-SP-Ex-1	400	○			
Total Land required (m^2)				**2,500**	**1,300**	**4,100**	

6.9.1.1.2 WwTP (3 Solutions for each WwTP)

During the JICA survey, 3 solutions are examined for each WwTP as alternatives from the viewpoints of technical aspect, environmental considerations aspects and social considerations aspects. Proposed solutions are summarized in the Annex III.1 and the cost is detailed in the Chapter 5.

For determining the above solutions, the following points were considered.

i) <u>Land Acquisition</u>

Instead of finding extension space in outside areas, every solution for rehabilitation and extension of the WwTP is proposed within existing plant area by modifying the existing treatment process as an alternative, in order to avoid any land acquisitions.

ii) <u>Sludge Management</u>

In addition to above, dewatering process will be proposed as an alternative for minimizing the volume of sludge from the WwTP to avoid an extension of the existing drying beds.

iii) <u>Odor</u>

From the view point of environmental and social considerations aspect, odor is one of the most important issues to be assessed for avoiding any problem with the neighborhoods.

Replacing the existing WwTP and creating new one far from the residential area is of course one of the solutions, but to find new plant site and to undertake land acquisition takes a lot of time and, thus, such kind of solution is not recommendable and not feasible considering the current situation.

As an alternative which will be realized within the existing plant site, an odor treatment system with bio-filter shall be proposed for all solutions against the problem due to odor.

Initially, the buildings for preliminary treatment, thickener, sludge storage basin and dewatering are covered and odor will be sealed inside them. Odor from preliminary treatment, thickener, sludge storage basin and dewatering building will be treated by installing such system.

6.9.2 Mitigation Measures

6.9.2.1 Design Phase (Measures to be taken in Short Term)

6.9.2.1.1 Networks and Pumping Stations (Noise and odor)

Two types of pumping stations have been taken into consideration for this survey, according to the required capacity and specific condition of its location.

Due to the sensitivity of the urban environment and the location planned for most of the pumping stations, it is necessary to adopt solutions that permit a highly reliable operation and which should mitigate any negative impacts.

Thus, measures against noise and odor have been also taken into consideration.

i) For capacities up to 10 L/s

Two different options have been studied according to the space available in order to implement the pumping station:

SP1A: Pumping stations with valves inside the well

SP1B: Pumping stations with valves in a valve chamber next to the well

ii) For capacities between 10 L/s and 150 L/s

Concrete pumping stations with two equipment levels have been considered:

SP2A: Vertical screening basket

SP2B: Vertical mechanical screen, odor treatment and emergency electricity generator

iii) For capacities above 150 L/s

Concrete pumping stations with two equipment levels have been considered:

SP3A: Screening basket in the channel

SP3B: Mechanical screen in the channel, odor treatment and emergency electricity generator

6.9.2.1.2 WwTP

i) Discharge Water:

Water quality of discharged water shall be controlled to ensure the environmental sustainability. The specification for each WwTP was determined in compliance with the water quality standard provided in the Tunisian standard “NT 106.02 (1989)”.

ii) Sludge Management:

Dewatering process will be proposed for all solutions in order to minimize the volume of sludge from the WwTP. Sludge shall be controlled to ensure the quality in compliance with the limit value for parameter of heavy metals indicated in the Tunisian standard “NT 106.20 (2002)”.

iii) Odor:

Noise and odor from the WwTP will also occur during regular operation.

Although the 5 WwTPs of the Project are located far from city center thus serious impacts to the neighborhoods are not observed at this moment, regarding future expansion of residential area, mitigation measures to control the odor shall be proposed.

As described above, an odor treatment system with bio-filter shall be proposed for all solutions in order to mitigate negative impacts due to odor.

iv) Reduction of Greenhouse Gas (GHG) emission:

One of the solutions for each WwTP, a system for mesophilic anaerobic digestion with energy recovery of biogas will be also examined as an option.

The primary sludge and excess of biological sludge will be stabilized in an anaerobic digester operating under mesophilic conditions. The biogas produced during the digestion will be recovered and used in a cogeneration system and the electric power produced will be reused for operating the WwTP.

This system will mitigate the GHG emission and the reduction of GHG emissions associated with this system is mainly due to the substitution of the electric power from public network.

The specifications for the Pumping stations and WwTPs were examined considering above mitigation measures identified through the IEE and the cost estimated in the chapter 5 includes all necessary equipment required.

6.9.2.1.3 From the JICA Study to Avant-Projet Détaillé (APD)

a) Land Acquisition:

During this phase, community involvement shall be a part of the process of land acquisition.

ONAS will start to contact local authorities to confirm the possibility of land acquisition for new pumping station, according to the official procedure for land acquisition provided by the MDEAF. It will be the first step of public consultation with landowners and include site visits and negotiations on land values. Location of new pumping station is only vaguely defined (in a radius of about 100 m) which allows to consider its implementation in different sites and thus to obtain some flexibility in the negotiations with the owners.

Final location of new pumping stations will be decided based on the result of topographic survey conducted by ONAS between the JICA study and Detailed Design (Avant-Projet Détaillé - APD).

Information of the project shall be disclosed to the public, in order to promote mutual understanding of the Project between neighborhoods and to avoid any problems, thus, not only the land owners directly affected by land acquisition but also project affected people near the stations shall be included in the process of making decisions on the APD.

Above all, determination of the land values is the most important procedure at this stage and the information useful for the owners shall be disclosed as much as possible.

b) Sludge Management:

Since several years, every WwTP has not found a final dumping site and the sludge has been stocked inside WwTP temporary without any protection against contamination of groundwater. Management of the Sludge from the WwTP is the most important issues to ensure the Project sustainability.

It‘s an urgent matter that ONAS find a controlled dump and it seems to be a serious risk that this issue will be a bottleneck, not only for the approval of EIA report by ANPE, but also for the appraisal of the Project by the government of Japan.

6.9.2.1.4 Detailed Design / Avant-Projet Détaillé (APD)

The candidate sites for construction of new pumping stations shall be selected preferably within the public domain. If some land acquisition of private lands are unavoidable, it shall be settled to an adequate distance from residential areas in order to mitigate the impact of noise and odor, and shall avoid land used for agricultural purposes, so as to reduce as much as possible the impact regarding the lives of indigenous people and local wealth.

In the best configuration, the main sewers also shall follow existing road and be buried within actual Right of Way (RoW) in order to avoid the need for land acquisition of private lands. There could be cases where sewers cannot follow roads, then the mitigation measures for land selection shall be set as per above policy for construction of installations.

6.9.2.1.5 Environmental impact Study (EIA)

As it mentioned above, each of the 5 WwTPs of the Project will be required separate EIA study after the JICA Study.

a) Public Consultation during EIA study

In Tunisia, although necessary items and procedures for the EIA study are provided in the “Decree No. 1991-2005 of July, 2005”, there is no article concerning the public consultation during EIA.

Considering an underlying principle of JBIC guideline “Projects must be adequately coordinated so that they are accepted in a manner that is socially appropriate to the country and locality in which the project is planned”, it is highly recommended that ONAS includes a public consultation in the Terms and References (TOR) in the tender document for engaging EIA consultant as same as the case of World Banks’ projects[2]. By providing information of the Project during design phase and ensuring a process of public participation, public opinions should be considered in the final design. This kind of public consultation could be placed not only as a process to identify some alternatives and mitigation measures but also as an opportunity to encourage mutual understanding between neighborhoods to avoid any problems.

b) Necessary Contents for EIA Report

EIA study is necessary for approval of the Project by the GoT and the following table indicates a sample of the necessary contents for EIA Report based on the JBIC guideline, Terms and References (TOR) for EIA provided by ANPE and the operational policies provided by World Bank.

[2] World Bank: Operational Policies (OPs) OP 4.01 - Environmental Assessment (1999)

Table 6.9-2: Contents of EIA Report

－ Sample －

Executive Summary

Main Text

1. Objectives of the Project
2. General Description of the Project and Existing Facilities
3. Determination of the Project Affected Area
   3.1. Project Affected Area
   3.2 Scale of Population directly and/or indirectly affected by the Project
4. Baseline Study for Environmental Characterization in the Project Affected Area
   4.1. Physical Aspects (Geology, Hydrology, Climatology, etc)
   4.2. Socio-Economic Aspects (Industry, Tourism, Agriculture, Public Health, etc)
   4.3. Ecological Aspects (Biodiversity, etc)
   4.4. Cultural Aspects (Natural and Cultural Heritage, Valuable Landscape, etc)
5. Detail Description of the Project Components
   5.1 Design Criteria (Location, Layout, Dimension, Capacity, Water Quality, etc)
   5.2 Specification of the Facilities
   5.3 Liquid and Solid Waste (Sludge, Discharge Water, Toxic materials, etc)
6. Environmental Impact Assessment
   6.1. Design Phase
   6.2. Construction Phase
   6.3. Operation Phase
   6.4. Impact on Environment (Water, Air (Odor), Noise, Sludge, Solid Waste, etc)
   6.5. Impact on Socio-Economy
   6.6. Impact on Biodiversity, Heritage, etc
7. Mitigation Measures and Alternatives
8. Environmental Management Plan (EMP)

Appendixes

(i) List of EIA consultants
(ii) List of Tables
(iii) Record of interagency and consultation meetings
(iv) Bibliography
(v) List of associated reports (if any)

6.9.2.2 Construction Phase (Measures to be taken in Mid Term)

For this phase, it is recommended that the implementation of mitigation measures should be included in the tender documents for engaging the contractors, contract document and bill of quantities for the construction work because of the following reasons:

i) Mitigation measures shall be implemented as a part of construction management;

ii) Costs for implementation of mitigation measures are reflected in the prices quoted from the contractors;

iii) The major part of mitigation measures shall be implemented under the responsibility of the contractors.

According to the potential threats seen above, the following measures are proposed to mitigate the negative impacts:

6.9.2.2.1 Construction Works and Rehabilitation after works:

In the best configuration, the construction work shall be executed within existing road and be buried within actual Right of Way (RoW).

Where buildings may be affected by installation of sewers, it is important to ensure the necessary information shall be provided to local people, and that they are involved in a timely manner. Where the RoW passes through or near environmentally fragile areas, it is important that the contractor is contractually obliged to take all appropriate measures to avoid any major impact on the local environment and to restore the environment as per the state before construction.

6.9.2.2.2 Procurement and Deposit of Construction Materials:

The Contractor shall be responsible for procurement of materials from registered suppliers. Any uncontrolled carrying shall be strictly forbidden. At the same time, deposit sites shall be legal deposit places, eventually registered with the competent authority. The carrying and deposit places shall be managed so as to reduce the impact on the local environment, and the Contractor shall be responsible to ensure that all mitigation measures are taken.

6.9.2.2.3 Earthworks and Concrete Works:

The Contractor shall avoid contamination of local underground water when pouring concrete and when washing formworks or equipment with detergents by applying, if necessary, a protection layer and by treating washing water in purpose-designed basins before releasing the water into the natural environment.

6.9.2.2.4 Dust, Noise and Vibration:

In any case, the contractor shall take all measures to avoid dusts, vibrations and noises through periodical monitoring.

In order to prevent the negative impacts, the contractor shall take in account the following measures:

a) Dust

The problem due to dust may occur during earthworks and material transportations.

In order to mitigate this kind of impacts, the following measures shall be taken during construction:

- Covering transport trucks with sheets if they contain sand and earth;
- Cleaning tires of transport trucks at the departure of construction site to prevent the dust diffusion from the construction site to the public roads;
- Watering the road in front of the construction site during construction and sweeping the road daily after the work, etc.

b) Noise and Vibration

Above all, where the construction site located near residential areas, construction works during the night shall be prohibited. Construction works on holiday shall be also avoided.

In order to execute the construction under mutual understanding by neighborhoods, the construction schedule and working hours (weekday/weekend, morning/night, etc.) shall be informed to neighborhoods before execution.

Noise and vibration level during construction shall be monitored and controlled through periodically inspection in order to avoid any problem with neighborhoods.

A general technical guideline to control noise during construction has been established in Tunisia and the facility shall be designed and constructed in compliance with following limits of the permissible emergence E dB (A)[3]:

[3] Emergence is a temporary modification of the ambient level caused by the appearance or disappearance of a specific noise. "Permissible emergence E dB (A)" means the difference between the equivalent A-weighted continuous acoustic pressure levels of ambient noise (during construction work) and residual noise (in the absence of noise generated by construction work but measured over the period of work); in the case of a construction work to be controlled, residual noise does not include the noise generated by the work.

Table 6.9-3: Permissible Emergence in Residential Zone

Limit value of noise (Municipal Decree in Tunis)				Permissible Emergence E dB (A) (General technical	
Type of Zone	Limit value (dB)				
	Day	Intermediate Time 6h-7h, 20h-22h	Night	Day 7h-22h	Night 22h-7h
Suburban residential zone with low traffic	50	45	40		
Urban residential zone	55	50	45	5	3
Residential zone near the commercial, traffic, etc.	60	55	50		

Regarding the standards to control vibration during construction, no standard has been established in Tunisia, thus, following standard will be recommended taking example on the case of a Japanese standard.

Table 6.9-4: Standard values of Vibration in dB during construction in Tokyo

Type of work	Standard level
Vibration	
Piling	< 70 dB
Excavation of trench	< 70 dB
Paving	<70 dB

Source: Tokyo metropolitan government

6.9.2.2.5 Material Transportation:

Material transportation shall be controlled through frequent checking of transportation trucks and by scheduling transportation routes so as to avoid influencing populated places, schools, universities, etc. Furthermore, all commitments shall be taken and enforced, if necessary, by special training of truck and engines drivers so as to avoid any accidents and problems related to traffic safety.

6.9.2.2.6 Security management plan:

In order to protect the construction workers against any accidents during construction and to establish a concrete security management system for preventing the accidents during construction, the contractor shall prepare a security management plan that will be a part of contract document between ONAS and contractor.

At least, the following content is required for the security management plan:

- Establishing an organization structure, role and service for security management;
- Identifying a security manager in charge of security management;
- Identifying the methodology for periodical security inspection during construction;

- Identifying the material to report the results of periodical security inspection;
- Training program of security management for construction workers;
- Concrete procedures for communication with the client in case of accident;
- Emergency manual in case of accident including detailed communication system;
- Condition of insurance, etc.

6.9.2.3 Operation Phase (Measures to be taken in Long Term)

For this phase, mitigation measures shall be ensured through:

i) Inclusion in Detailed Designs (D/D)

ii) Awareness campaigns for population and staff

iii) Training and capacity development of responsible institutions[4]

According to the potential threats seen above, the following measures are proposed to mitigate the negative impacts:

6.9.2.3.1 Common results of expanding of sanitation:

- Appropriate staff training for WwTP is required for the proper handling of toxic materials to avoid any accidents and for smooth operation of the facilities.
- The distribution modalities of water shall be thought to be fair and socially oriented so as to avoid discrepancies between areas and to avoid improper development processes.
- The pricing of the sanitation shall be decided through a proper consultation process so that all the opinions of representatives of the population shall be considered, including poorer citizens.

6.9.2.3.2 Networks and Pumping Stations:

<u>a) Dust and Solid and Liquid Waste</u>

Dust and Solid Waste coming from daily maintenance and operations such as cleaning-up of the pipe, repairing the parts of pumps, dredging the sludge from pumping well, etc., shall be properly collected, carried and deposited to controlled dump site.

Periodical monitoring is required to satisfy the conditions indicated in the Environmental Management Plan (EMP) of the EIA which ANPE approved.

[4] It is recommended that the details of awareness campaigns, training programs and capacity building programs shall be identified through the technical assistance scheme provided by JICA, e.g. JICA experts, Oversees volunteers, etc., after the JICA Study.

b) Noise and Odor

Noise and odor from the pumping stations will occur during regular operations and can affect the neighborhood if they are not properly controlled. Thus periodical monitoring is required from ONAS to satisfy the Tunisian standards.

If a pumping station is located near the residential area, noise and odor shall be carefully controlled to avoid any problem with neighborhoods. This can be done by covering the facilities by wall, roof, etc., in order to seal the odor.

Odor shall be controlled to ensure a quality in compliance with the limit value of 0.2 mg/m3 of H_2S in the air according to the Tunisian standard "NT 106.04 (1994)" and specification of equipment in pumping stations should be determined according to this standard.

In the residential area, noise shall be controlled in compliance with the limit value 50 dB according to the Decree No. 84-1556 29th December 1984.

6.9.2.3.3 WwTP:

a) Discharge Water

The water quality of discharged water shall be controlled to ensure the water quality standard provided in the Tunisian standard "NT 106.02 (1989)" and a periodical monitoring is required to satisfy the quality indicated in the law.

b) Sludge Management

Sludge shall be controlled to ensure the quality in compliance with the limit value for parameter of heavy metals indicated in the Tunisian standard "NT 106.20 (2002)".

According to the Tunisian standard "NT 106.20 (2002)", sludge must be dehydrated till less than 30% before deposit to a public dump site.

Table 6.9-5: Limit value for heavy metals in the sludge

Parameter	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Limit value Mg/kg MS	20.0	500.0	1,000.0	10.0	200.0	800.0	2,000.0
Fecal Coliform < 2 10^6 CF NPP/g MS							

Source: Tunisian Standard, NT 106.20 (2002)

c) Dust, Solid and Liquid Waste

Dust and Solid and Liquid Waste coming from daily maintenance and operations such as cleaning-up of the pipe, repairing the parts of pumps, dredging the sludge from pumping well, etc., shall be properly collected, carried and deposited at controlled dump site.

A periodical monitoring is required to satisfy the conditions indicated in the Environmental Management Plan (EMP) of the EIA which ANPE approved.

d) Noise and Odor

Noise and odor from the WwTP will also occur during regular operation. However, the 5 WwTPs of the Project are located far from city center thus serious impacts to the neighborhoods are not observed at this moment.

On the other hand, regarding a WwTP, residential area seems to be extending near existing WwTP and coordination between urban development plans is necessary, in order to avoid any potential problem.

6.10 RECOMMENDATION FOR IMPLEMENTATION

As a conclusion of this Initial Environmental Examination (IEE), the following items could be recommended for implementing the project.

6.10.1 Institutional Arrangements

6.10.1.1 Sludge Management

It‘s an urgent matter that ONAS find a controlled dump and it seems to be a serious risk that this issue will be a bottleneck for the approval of EIA report by ANPE.

Until 1998, the sludge from WwTP of ONAS was reutilized for agricultural purpose. However, since 1998 and for more than 10 years, this type of reutilization has been prohibited until establishment of a standard in Tunisia.

Considering this situation, ONAS has tackled this issue by taking various actions as follows:

- ONAS had conducted a study in order to establish a management plan for the sludge from WwTP in greater Tunis area in 2006-2007, including improvement of the drying bed facility in WwTP, introduction of mechanical dryer to reduce the volume and creation of ONAS's own dump, these kinds of actions covering only the greater Tunis and certain towns;
- ONAS conducted pilot projects for reutilization of sludge in order to examine the condition of reutilization for agriculture in 2007-2008 and 2008-2009;
- Since 2009, a study, in collaboration with ANGed, is under execution in order to identify the discharge standard allowing ONAS to deposit the sludge to the dumps controlled by ANGed.
- The GTZ provided a technical assistance for establishing a program for sludge management from 2008 to 2012, including creation of traceable system for sludge management, reinforcement of the capacity to prepare a guideline of sludge management, reinforcement of institutional framework, etc.
- ONAS also is researching on a new way of reutilization in cement factories from the end of 2012.

By integrating the results of these actions, ONAS should establish the following institutional framework and enhancing it to every regional WwTPs:

Short term

- Reinforcing the ONAS's capacity for sludge management by allocating staff and budget for conducting necessary study to find a final dump and identifying hygiene standard;
- Installing equipment to reduce the sludge (mechanical dryer, etc.);
- Creating a Tunisian standard for reutilization of sludge for agricultural purpose;
- Finding a final dump with adequate protection against contamination (e.g. membrane, etc.) for each WwTP of the Project (in collaboration with ANGed);

Middle term

- Reutilizing the sludge and ash after burning for multipurpose (cement, brick, etc.)

6.10.1.2 Consultation and Monitoring of Social Considerations issues

Although Tunisian law concerning EIA does not provide any condition for public consultations, considering an underlying principle of JBIC guideline "Projects must be adequately coordinated so that they are accepted in a manner that is socially appropriate to the country and locality in which the project is planned", it is highly recommended that ONAS carries out public consultations during the design phase for all WwTP. Public consultations shall be included into a task of the EIA study.

In the case of networks, land acquisition for new pumping station is the most sensitive issues from the view point of social considerations aspect. A department "Département central administratif et juridique" is the responsible organization for the procedure of land acquisition in ONAS central level and "Service des affaires juridiques" control the procedure of land acquisition in ONAS regional department level. The progress of land acquisition shall be monitored and reported to JICA periodically and a solid implementation system, such as nominating a person in charge, etc., shall be established based on the good relationship between ONAS central and regional levels.

6.10.2 Time Frame

Based on above recommendations for establishing a sludge management system, following time table could be proposed considering the timing when the WwTP of the Project will start its service:

Table 6.10-1: Time Frame for Establishing a Sludge Management System

Item/Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Loan Period (Japanese ODA Loan)										
Construction Period (WwTP)										
Commencement of Service (WwTP)										
Reinforcing the ONAS's capacity and conducting necessary study										
Creating a Tunisian standard for reutilization of sludge										
Finding a final dump for sludge										
Reutilizing the sludge for multipurpose										

The project implementation schedule related to the environmental and social considerations procedures are detailed in the following table:

Table 6.10-2: Time Frame for Environmental and Social Considerations Procedure

Item/Year		2013				2014				2015				2016			
		T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
EIA (WwTP)	EIA Study																
	Approval by ANPE																
Land Acquisition (Pumping Station)	Topogra-phic Survey																
	Compen-sation																

6.10.3 Budget

The total cost for land acquisition, including land purchase and compensation, shall be borne by Tunisian side as a non-eligible portion of the Japanese ODA loan.

Table 6.10-3: Budget to be allocated by the GoT (Case 3)

Non Eligible Potion	Item	Unit Price (TND/m^2)	No. of New Pumping Station	Quantity (m^2)	Estimated Amount (Million TND)
Land Acquisition Cost	- Land purchase - Compensation	100	33	5,100	0.51

6.10.4 Technical assistance to be proposed

In order to maximize the Project effect and to provide and ensure environmental sustainability of the Project, technical assistance shall be considered as one of key elements.

A comprehensive approach, including administration (as policy maker), the ONAS staffs (as operator) and the public (as user), is also necessary when technical assistance will be provided.

For policy maker level, JICA could provide a technical assistance by JICA experts into administrative level, such as MAE, ANPE, ANGed, ONAS, etc. Sludge management is the most urgent issues to ONAS and some assistance for this field could be proposed before operation phase of the Project.

For operator level, JICA provided following training programs until now, for example, through inviting some project related staffs from recipient country to Japan:

- Operation & maintenance of sewerage facilities;
- Water environmental monitoring;
- Domestic wastewater treatment technique, etc.

To develop its capacity of environmental monitoring, ONAS has established his own laboratory in maintenance center in each governorate for monitoring and analyzing water quality, e.g. inflow and outflow in WwTP.

Providing some training programs for environment monitoring to the ONAS laboratory staffs is recommended. Considering the necessity of monitoring the parameters indicated in the Environmental Management Plan (EMP) from construction phase to operation phase, the training shall be provided to the staffs during the design phase.

Providing a technical assistance by JICA experts to the ONAS laboratories is also recommendable. Even if some equipment in the laboratories are required from ONAS in order to develop the capacity of laboratories for monitoring, its feasibility shall be carefully analyzed by confirming the technical skill and capacity of staffs to deal with the equipment, such as operation, maintenance, calibration, etc., through this assistance.

For user level, awareness raising campaign to citizens will be proposed.

In Tunisia, the Study Team sometimes observed that some sewer pipes face a problem of solid wastes inadequately disposed into the facilities.

In order to enhance the Project sustainability, providing some public health and environmental education programs to the children, students, and woman groups by JICA overseas volunteers and/or local NGOs may be a good option as grass roots approach.

Table 6.10-4: Technical Assistance to be proposed

Type of Assistance	Target Group	Relevant assistance scheme provided by JICA	Timing
Technical assistance for environmental management	A Section responsible for environmental management (MAE, ANPE, ANGed, ONAS, etc.)	JICA experts	Design Phase – Operation Phase
Technical assistance for sludge management	A Section responsible for environmental management (MAE, ANPE, ANGed, ONAS, etc.)	JICA experts	Before Operation Phase
Training program for environment monitoring	ONAS laboratory staffs	JICA training program	Design Phase
Technical assistance for capacity development of ONAS laboratories	ONAS laboratory staffs	JICA experts	Design Phase – Operation Phase
Awareness raising campaign (Public health and Environmental education	Citizens	JICA overseas volunteers	Design Phase – Operation Phase

6.10.5 Measures to be taken for the Monitoring

Monitoring of environmental impact caused by the Project shall be undertaken as part of an activity of the Environmental Monitoring Plan (EMP) by the Tunisian side. The EMP and the items to be monitored will be established through the EIA study after the JICA survey.

It is important that monitoring shall be undertaken not only in the affected areas but also the non-affected areas in order to establish references for the various parameters.

Based on the review of the monitoring form established by ANPE, a monitoring form prepared by ONAS[5] and an EIA report for the previous project by ONAS, the EMP during construction and operation phase shall include the following items:

a) Environmental Considerations:

Initially, a system to monitor the relevant biological, physicochemical parameters in discharge water, groundwater, receiving environment such as river, sea and lake shall be established in order to avoid the negative impacts to the environment through each phase.

[5] See Annex-VI.
Tunisian monitoring form: The form is also available from the following ANPE's web site.
http://www.anpe.nat.tn/images/stories/racourcis/EIE/fiches%20annexes%20EIE.pdf

At present, a list which indicates the limit values for each parameter provided by the latest Tunisian standards is posted on a notice board inside WwTP as a reference for monitoring during operation phase.

ONAS monitors and reports each value periodically by using the form[5] monthly and annually in compliance with the latest standards.

In addition to above, the negative impacts during construction shall be also controlled by monitoring the parameters identified through the IEE.

b) Social Considerations:

Although the Tunisian monitoring form does not address social considerations issues, it shall be included in the EMP according the JBIC guideline.

Monitoring of social aspects during operation of the water facilities shall be undertaken form the viewpoints of following aspects:

i) Quality of sewage services;

ii) Sewage tariff and affordability for the poor;

iii) Public health (number of water related diseases, diarrhea, etc.).

A recommended framework for the EMP, including the parameters to be monitored, method and frequency, and responsible agency during each phase, is detailed in the following table:

Table 6.10-5: Framework for Monitoring Plan (Recommendation)

a) Environmental Considerations

Phase	Items to be monitored	Method / Frequency	Responsible Body
Design Phase	Status of Detail Design in compliance with the condition of EIA approval and periodic submission of Monitoring Report	Monitoring Report (Periodically)	ONAS S/V consultant
	Status of Detail Design (D/D) in compliance with required specification	Supervision of Detail Design, Periodic Meeting	ONAS S/V consultant D/D consultant
	Status of application of measures to prevent noises and odor from the project facilities	Supervision of Detail Design, Periodic Meeting	ONAS S/V consultant D/D consultant
Construction Phase	Construction method in compliance with the condition of EIA approval and periodic submission of Monitoring Report	Monitoring Report	ONAS S/V consultant
	Status of procurement and depositing of construction materials in compliance with relevant laws	Supervision of Construction, Periodic Meeting	Contractor S/V consultant
	Status of application of measures to prevent dusts, uncontrolled deposits of earth and wastewater treatments	Supervision of Construction, Periodic Meeting	Contractor S/V consultant
	Status of application of measures to prevent noises from construction sites	Supervision of Detail Design, Periodic Meeting	Contractor S/V consultant
	Status of application of measures to prevent dusts and noises and to secure from accidents during material transportations (routes for transportation, operation schedule, etc.)	Supervision of Construction, Periodic Meeting	Contractor S/V consultant
Operation Phase	Compliance with the condition of EIA approval and periodic submission of Monitoring Report	Monitoring Report (Periodically)	ONAS Auditor designated by ANPE
	Water quality of discharge water in compliance with the national standards “NT 106.02 (1989)”	Monthly report / Every Month	ONAS, External Laboratory
	Water quality of ground water and receiving environment	Monthly report / Every Month	External Laboratory
	Noises from the project facilities (55 dB in the Day, 45 dB in the night)	Monitoring Report (Periodically)	ONAS
	Odor from the project facilities in compliance with based on the national standards “NT 106.04 (1994)”	Monitoring Report (Periodically)	ONAS
	Adequate management of sludge in compliance with the national standards Heavy metals: “NT 106.20 (2002)” Dehydration in drying bed: <30%	Monitoring Report (Periodically)	ONAS
	Management of toxic materials, solid and liquid waste	Monthly report / Every Month	ONAS Municipality

b) Social Considerations

Phase	Items to be monitored	Method / Frequency	Responsible Body
Design Phase	Compliance with the condition of EIA approval and periodic submission of Monitoring Report	Monitoring Report (Periodically)	ONAS S/V consultant
	Situation of Public Consultation	Proper Timing	ONAS
	Status of Detail Design in compliance with the Right of Way (RoW) (especially alignment of pipe lines)	Supervision of Detail Design, Periodic Meeting	ONAS D/D consultant
	Status of application of measures to avoid involuntary resettlements and land acquisitions during Detail Design (especially new pumping stations)	Supervision of Detail Design, Periodic Meeting	ONAS D/D consultant
Construction Phase	Compliance with the condition of EIA approval and periodic submission of Monitoring Report	Monitoring Report (Periodically)	ONAS S/V consultant Auditor designated by ANPE
	Status of construction works in compliance with the Right of Way (RoW)	Supervision of Construction, Periodic Meeting	Contractor S/V consultant
	Status of involuntary resettlements and land acquisitions (including progress of compensation process)	Every 6 months	ONAS
	Inspection of speculative trade of real estate	Proper Timing	Municipality
Operation Phase	Compliance with the condition of EIA approval and periodic submission of Monitoring Report	Monitoring Report (Periodically)	ONAS Auditor designated by ANPE
	Number of residents who connect to developed sewage system	Annual report / Every Year	ONAS
	Service hour of sanitation / day	Monthly report / Every Month	ONAS
	Number of patients due to water diseases	Annual data / Every Year	Ministry of Health
	Sewage Tariff (Affordability for poor)	At the timing when tariff will be revised	ONAS Ministry of Finance
	Increasing of land prices around project sites	Annual data / Every Year	Municipality