CHAPTER 5

STUDY ON SEAWATER DESALINATION PLANT

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5.1 Basic Planning of Seawater Desalination Plant

5.1.1 Selection of Seawater Desalination Process

There are two processes for desalination. One is the thermal process, which changes the phase of raw water from liquid (water) to gas (steam) or liquid to solid (ice). In the phase-change process, dissolved solid is separated from raw water. The other is the electric dialysis or the membrane process, which utilizes electrical energy or special membrane by separating dissolved solid in the raw water without any phase-change. Energy requirements of both methods and experiences in Tunisia are as follows:

(1) Energy Requirements

The membrane process requires less energy than the thermal or the electric dialysis processes. Therefore, the membrane process is more popular in non-oil production countries since it consumes less energy. Among the membrane processes, RO membrane process is predominant. Table 5.1-1 shows energy requirements for each process. The table clearly presents that the advantage of the RO membrane process is less energy consumption at only 10% compared to other processes. The recovery ratio of RO means the percentage of desalinated water against intake volume.

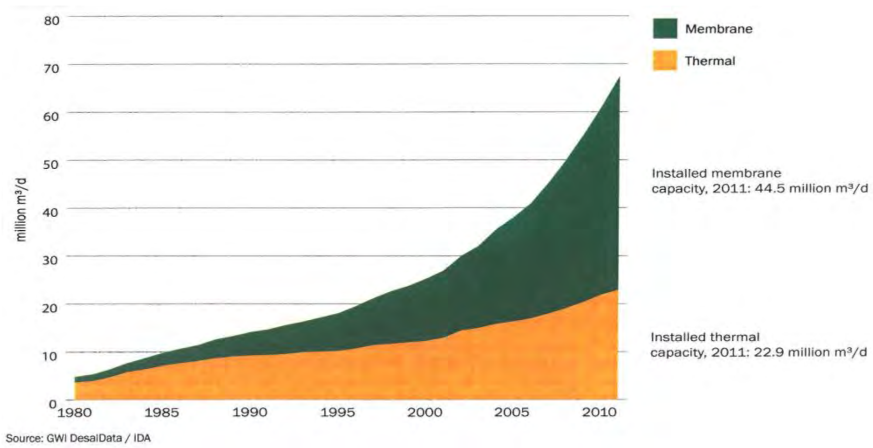
Table 5.1-1 Required Energy for Seawater Desalination by Process

Process	Necessary Power (kWh/m^3)	Necessary calories (kcal/m^3)
Flashing	62.9	54,000
Electric dialysis	32.2	27,692
RO (recovery: 30%)	4.7	4,020
RO (recovery: 40%)	3.5	3,010

Source: p355, Suido Kogaku, Kenji Fujita, et al, 2006

(2) Installation of desalination plant in the world

Figure 5.1-1 shows the desalination plants of the membrane and the thermal process in the world. From this figure, it is obvious that an application of the membrane process has been rapidly increasing since 1990. The employment of the flushing process has been the main stream in the Middle East countries, but the rate of increase of the process went down. Instead, the RO process has been on the upswing because of improvements of the liability of the process



Source: GWI IDA Desalination Year book 2012-2013

Figure 5.1-1 Desalination Plant Capacity vs. Process

In Tunisia, the RO membrane process has been installed at all existing desalination plants (see Table 5.1-2). Large scale seawater desalination plant under construction or planning, i.e. Djerba; 50,000m^3/day[1] and Zarat; 100,000m^3/day, shown in Table 1.5-2, employed RO membrane method. In addition, on-going 10 and planned 6 brackish water desalination plants under financial assistance of KfW also employed the RO method.

Table 5.1-2 Existing Desalination Plants in Tunisia

Project	Location	Feed water	Capacity(m^3/d)	Process	Year start-up
Gabes	Gabes	Brackish	22,500 +3,000 +8,500	RO	1995 +1999 +2005
Djerba	Medenine	Brackish	12,000 +3,000 +5,000	RO	1998 +2003 +2007
Zarzis	Medenine	Brackish	15,000	RO	1999
Ben Guerdane	Medenine	Brackish	1,800	RO	2013
Kerkennah	Sfax	Brackish	3,300 +300	RO	1983 +2001
TIFERT Company	Skhira	Seawater	12,000	RO	2013

Source: SONEDE

Note: Column in Capacity, Year : "+" shows expansion capacity in mentioned year.

(3) Selection of desalination process

According to the required energy and the installation inventory, it is obvious that RO membrane process has more advantages than the other processes in Tunisia. Considering said advantages, the RO membrane process is selected for a proposed desalination plant.

5.1.2 Design Criteria of Seawater Desalination Plant

As a result of the field survey, the design criteria of the desalination plant were planned as follows.

[1] Initial capacity is 50,000m^3/day, but expandable to 75,000m^3/day in future.

1) TDS concentration of the desalinated water is less than 500 mg/L.

2) Recovery ratio at the desalination plant is 45 %.

3) Water production capacity shall be 200,000 m^3/day according to the study in Chapter 4.

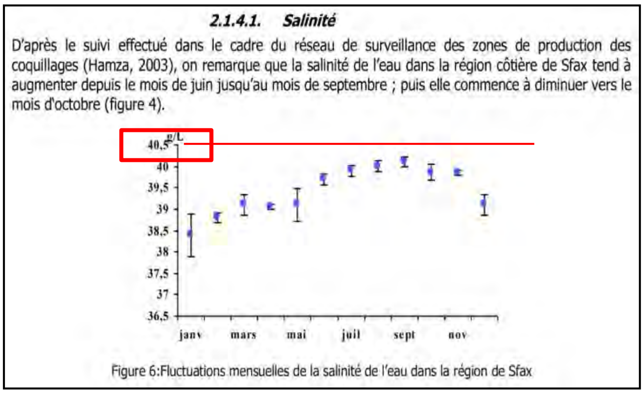
The following describes the raw seawater quality and the recovery ratio.

(1) Seawater quality

1) General

The design condition for seawater quality is evaluated by the comparison of the water quality investigated in this survey, and the report (*) on marine investigation around Sfax region implemented by a joint collaboration of public and private organizations. Variation of seawater qualities presented in the report is shown in Figures 5.1-2 to 5.1-4. Furthermore, the specification for the construction project of Djerba seawater desalination plant, the tender of which was announced in 2012, is also considered in the comparison. Based on the comparison, the design range presented in Table 5.1-3 is selected. Next consideration is to review the ranges based on the applicability in the actual condition. After reviewing the ranges of TDS concentration and temperature, the design condition presented in Table 5.1-6 is selected.

(*) Sfax University and other public organization such as MDCI, Ministry of Environment, Ministry of Equipment, and Governorate of Sfax, etc. joins this study team. The name of project is "SMAPIII". Its result was presented in March, 2007 at "5th European Conference on Sustainable Cities" in Sevillia, Spain, with the title of "Integrated Management Strategies of Coastal Areas of the South of Sfax City (Tunisia)". Refer to Figure 5.1-5

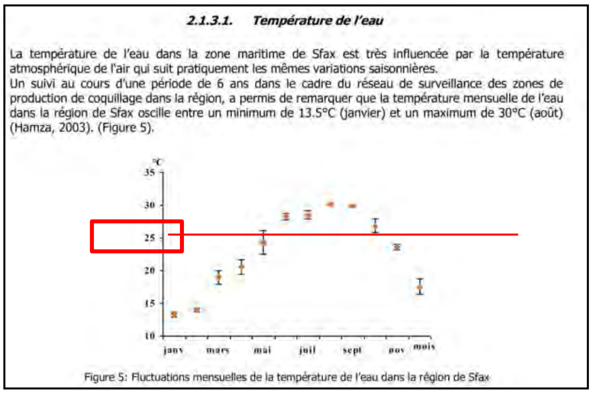

2.1.4.1. Salinité

D'après le suivi effectué dans le cadre du réseau de surveillance des zones de production des coquillages (Hamza, 2003), on remarque que la salinité de l'eau dans la région côtière de Sfax tend à augmenter depuis le mois de juin jusqu'au mois de septembre ; puis elle commence à diminuer vers le mois d'octobre (figure 4).

Figure 6:Fluctuations mensuelles de la salinité de l'eau dans la région de Sfax

Source：SMAPIII

Figure 5.1-2 TDS Variation

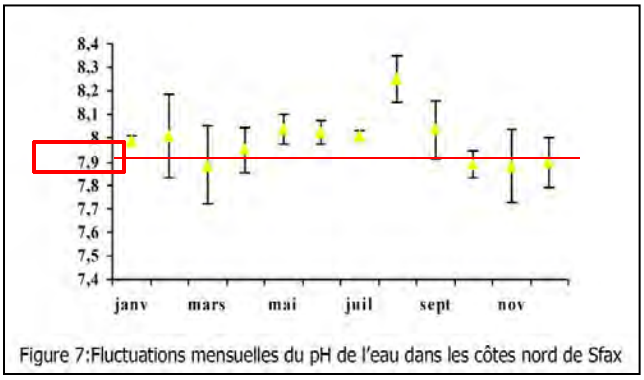

2.1.3.1. Température de l'eau

La température de l'eau dans la zone maritime de Sfax est très influencée par la température atmosphérique de l'air qui suit pratiquement les mêmes variations saisonnières.
Un suivi au cours d'une période de 6 ans dans le cadre du réseau de surveillance des zones de production de coquillage dans la région, a permis de remarquer que la température mensuelle de l'eau dans la région de Sfax oscille entre un minimum de 13.5°C (janvier) et un maximum de 30°C (août) (Hamza, 2003). (Figure 5).

Figure 5: Fluctuations mensuelles de la température de l'eau dans la région de Sfax

Source：SMAPIII

Figure 5.1-3 Temperature Variation



Source : SMAPIII

Figure 5.1-4 pH Variation

Source: SMAPIII

Figure 5.1-5 Part of Presentation Papers on SMAP, and its Participants

2) Seawater salinity (TDS concentration)

According to Figure 5.1-2, the highest TDS concentration in September was about 40,200mg/L. On the other hand, TDS concentration reached to 41,000mg/L based on the result of investigation in this survey. The TDS concentration analysis in Japan was 42,000mg/L. From these data, a design concentration of TDS in seawater is selected at 41,000mg/L.

3) Seawater temperature

Figure 5.1-3 shows that seawater temperature increases up to 30 ^{o}C in the summer, while it goes down to 14 ^{o}C in the winter. If a range of temperature is designed from 14 to 30 ^{o}C, the facility will be complicated[2] and the cost is higher. Through a discussion with SONEDE, the maximum design temperature is set at 25 ^{o}C.

4) pH

The average pH of 7.9 described in SMAP report. Since the result of investigation conducted by the

[2] Water Flux of RO membrane increases by 3 % against 1 ^{o}C increase of water temperature. Therefore, it is necessary to provide facilities with complicated specifications to enable change of membrane area and filtration pressure to cope with wide range of water temperature. This arrangement requires high capital cost and high level operation technique. In case of 30 ^{o}C, out range of warranty, water quality will be worse than that at 25 ^{o}C as show in Figure 5.1-6. It can be judged allowable.

JICA Survey Team was also pH 7.9. Therefore, pH 7.9 was employed for the design.

5) Others

All analysis data by SCET[3] in February 2014 is presented in Table 5.1-3.

Table 5.1-3 shows the analytical result conducted by each laboratory. The result of the analysis indicated that the water quality is ordinary as sea water. Although some exceedances are found, these can be treated by pre-treatment and desalination within the allowable range with no special treatment required,

Table 5.1-3 Seawater Quality and Design Condition

Items	unit	Drinking water Standard*1	Collected at depth of *2	Data analyzed by this study			Reference data from the other studies			Design	
				SCET	Central Labo.	Chiba, Japan	INSTM	SMAP 3	Djerba	Design range	Design (Guarantee)
Temperature	deg C						25.6--27.6	14-30	20	14-30	14-25
pH	-	6.5-8.5	5m	7.9	-	-	7.8--8.12		8.04		7.9
			+50cm	7.9	-	-	-	-			
EC (Electric Conductivity)	mS/cm	0.3-2.5	5m	52.4	79	-	-	-		-	-
			+50cm	52.4	77	-	-	-		-	-
Salinity	mgNacl/L	-	5m	38,800	34,400	-	-	-		-	-
			+50cm	38,000	35,200	-	-	-		-	-
Total Dissolved Solid (TDS)	mg/L	200-2,000	5m	40,000	-	42,200	39,500-40,300	38,500-40,500	41,210	38,500-42,000	38,500-41,000
			+50cm	41,000	-	42,200					
Sodium (Na^+)	mg/L	200	5m	12.889	10,400	-	-	-	11,668	-	12,889
			+50cm	13.028	20,000	-	-	-		-	-
Potassium (K^+)	mg/L	-	5m	370	926	-	-	-	325	-	370
			+50cm	381	436	-	-	-		-	-
Calcium (Ca^{++})	mg/L	200	5m	400	432	-	-	-	451	-	400
			+50cm	420	411.5	-	-	-		-	-
Magnesium (Mg^{++})	mg/L	100	5m	1516	1,358	-	-	-	1,367	-	1,516
			+50cm	1512	1,381	-	-	-		-	-
Chloride (Cl^-)	mg/L	500	5m	21,540	23,040	-	-	-	20,556	-	21,540
			+50cm	21,810	23,040	-	-	-		-	-
Sulfate (SO_4^{--})	mg/L	500	5m	2154	2,203	-	-	-	3,648	-	2,154
			+50cm	2591	2,657	-	-	-		-	-
Bicarbonate (HCO_3)	mg/L	-	5m	213	-	-	-	-		-	213
			+50cm	213	-						
Nitrate (NO_3^-)	mg/L	45	5m	9.2	-	-	-	-	0	-	9
			+50cm	<2	-	-	-	-		-	-
Silica (SiO_2)	mg/L	-	5m	1.48	2.6	-	-	-	0	-	1.5
			+50cm	1.85	4.2	-	-	-		-	-
Boron (B^+)	mg/L	2.4	5m	4.89	6.6	-	-	-	-	-	5.6
			+50cm	5.63	6.1	-	-	-		-	-

note *1: NT09.14(2013) *2: "5m" means 5 m below water surface. "+50cm" means 50cm above seabed.

Right two columns show specifications for tender recommended by the JICA Survey Team."Design range" Allowable range for design, "Design (Guarantee)": Design condition for performance guarantee

Source：JICA Survey Team

(2) Recovery ratio

Higher recovery ratio is required in terms of construction cost and O&M cost. Since recovery ratio of 45% was considered to be possible for the seawater quality, the ratio for the project was assumed at 45%. The existing Tifert seawater desalination plant employed this recovery ratio[4], as well as the existing

[3] Sampling was carried out on 22/02/2014. Analysis was conducted by Laboratory of Radio-Analysis and Environment, National Engineering School of Sfax. Further, several items were also analyzed by the central laboratory of Ministry of Industry, Energy and Mining in Tunisia, and the Analysis Center of Pharmacist Association of Chiba Prefecture in Japan.

[4] The seawater desalination plant owned by Tifert, chemical fertilizer production company, is located at Skhira 80km far from Greater Sfax southwestward along Gabes Bay. The plant has been operated from 2013 with a capacity of 12,000 m^3/day. Desalinated water is used in the factory of Tifert. This plant has been operated with the recovery ratio of 45%.

Djerba desalination plant. Appropriateness of this recovery ratio was examined as stated below:

Although high recovery ratio is desirable in terms of smaller flow at intake and discharge, since the water flux quality is dependent on raw water quality and temperature the appropriateness of the recovery ratio at 45% is evaluated by a trial calculation among fed and permeated TDS concentration, and water temperature based on the market commodity of RO membrane (salt rejection: 99.8%, water flux: 32 m^3/d) indicated in Table 5.1-4. Total share of RO membrane products listed on Table 5.1-4 is about 90 % in world market, and therefore it was judged appropriate when referring to the characteristics of those products.

Table 5.1-4 Basic Characteristics of RO Element

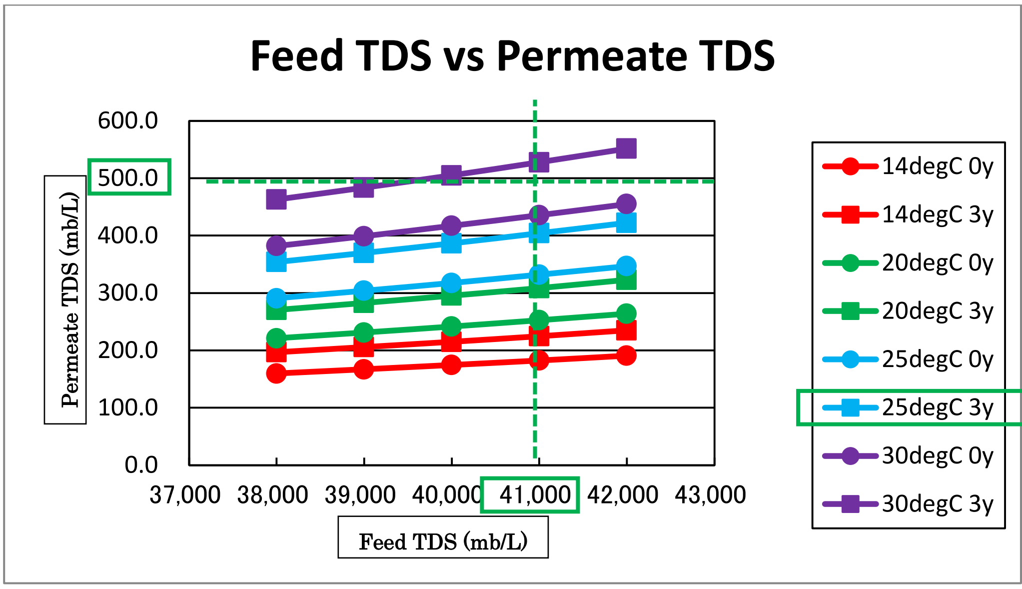
Items	TM820R-400	TM820V-400	SW30HR LE-400	SWC5
	Toray	Toray	DOW	Hydranautics
1. Basic specification				
1) Salt Rejection（%）	99.8	99.8	99.8	99.8
2) Water flux (m^3/d)	32.2	34.1	28	34
2. Test conditions				
1) Feed salinity(mg/L)	32,000	32,000	32,000	32,000
2) Operating pressure (MPa)	5.5	5.5	5.5	5.5
3) Feed temperature (^oC)	25	25	25	25
4) Recovery (%)	8	8	8	10

Source: Manufacturers catalogue, and arranged by JICA Study team

The result of the trial calculation is indicated in Figure 5.1-6. When TDS concentration of raw water quality and water temperature is 41,000mg/L and 25 ^oC, respectively, TDS concentration of the water flux is about 300 mg/L. The membrane is deteriorated with the operational hours. After three years, TDS concentration is still 400mg/L achieving the target TDS concentration of 500mg/L. According to the result, the recovery ratio of 45 % is achievable.

Above discussion is from the view point of having a guarantee. The operation itself is possible even when out of the range. As an example, when TDS concentration of raw water quality and water temperature is 41,000mg/L and 30 ^oC, respectively, TDS concentration of the water flux is about 420 mg/L. However, after three years, it is expected that TDS concentration is 530mg/L due to the deterioration of the membrane (see Figure 5.1-6). However, this is just the trial estimation. Based on the operational management, it is possible to have better quality of the water. Therefore, even the guarantee water quality is not achieved, the water flux quality is better than the current quality. Consequently, the target on the improvement of drinking water quality will be achieved.

Thus, it is considered that a recovery ratio of 45% on the design is appropriate.



Source：JICA Survey Team

Figure 5.1-6 Product Water Quality vs. Temperature, Salinity and Operation Period (45% recovery)

(3) Other parameters on desalinated water quality on design

The other parameters on desalinated water quality follow the Tunisian drinking water standard, NT09.14;1983. The standard for the major parameters related to the desalination is summarized in Table 5.1-5. Water quality is regulated at the water tap, not at outlet of the plant.

The new drinking water quality, NT09.14;2013 standard was circulated to the related ministries/agencies in December 2013. Verification of relevant authorities was completed as of October 2014, and said standard is already being used. Legalization of this standard, however, is still underway as of March 2015.

Table 5.1-5 New Drinking Water Standard of Tunisia relating to Desalination Plant*

Items	unit	Tunisia (NT09.14:1983)		Tunisia	WHO	EU Drinking	Japan
		Recommend	Acceptable	NT0.9.14 (2013)	(4th ed.)	Water Directive	
pH	-	7.0-8.0	6.5-8.5	6.5-8.5	-	6.5-9.5	5.8-8.6
Total Dissolved Solid (TDS)	mg/L	<500	<2,500	200-2,000	1,000	(EC: <2,500μS/cm)	<500
Turbidity	NTU	<5	-	<3	1	Acceptable to consumers	<2deg ***
Chloride (Cl^-)	mg/L	<200	<600	<500	<250**	<250	<200
Boron (B)	mg/L	-	-	<2.4	<2.4	<1	<1

:*: items important for design of desalination plant only. **: bad taste. No standard.
***: Kaolin. 0.8NTU=approximately 1 deg.
Source：SONEDE

SONEDE requested a concentration of Boron at 1.2 mg/L with a guarantee period of one year in the bidding document of Djerba seawater desalination plant construction. However, the standard in Tunisia does not regulate Boron. According to the expected new standard, the regulation against Boron is at 2.4 mg/L. The discussion was made with SONEDE for the design value of Boron as 1.2 mg/L for 1-year guarantee or 2.4 mg/L for 3-year guarantee. As a result, the new standard of 2.4 mg/L for 3-year guarantee is selected for the design.

(4) Conclusion

Table 5.1-6 summarizes the design values related to the water quality in this project.

Table 5.1-6　Design Condition for Product Water

Items	SFAX, for design	Djerba (reference)	Reference
Produce water quality (TDS)	500mg/L	400mg/L	
Seawater salinity (TDS)	Less than 41,000mg/L	At 41,210mg/L	
Seawater temperature	Less than 25 °C	At 20 °C	
Guarantee period (after feeding water)	3 years	3 years	
Recovery ratio	45%	45%	
Boron	2.4 mg/L	1.2 mg/L	New drinking water standard NT09.14(2013) : 2.4mg/L
Guarantee period (after feeding water)	3 years	1 year	
Membrane replacement ratio per year	20%/year	-	
Production capacity per unit	25,000m³/day/unit	25,000m³/day/unit	
Water flux	13 L/m²/h	13 L/m²/h	
Electric power consumption	4.2 kWh/m³	4.2 kWh/m³	

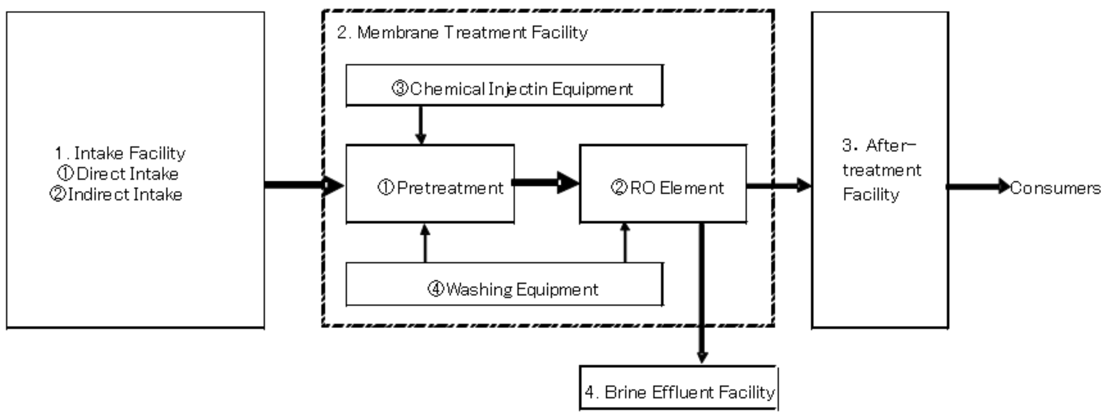
Source：JICA Survey team

5.1.3 Outlines of Seawater Desalination Plant

The outline of the seawater desalination plant is discussed below.

(1) Components

The membrane system consists of four components excluding power receiving facility, buildings, warehouses, and offices. The outlines of each component are described in next section.



Source JICA Survey Team

Figure 5.1-7　Components of Membrane System

(2) Outlines of Each Facility

1) Intake Facility

The function of this facility is to take seawater and convey this to the plant. There are two major methods for intake such as direct intake and indirect intake. After the evaluation, the direct intake by pipeline is applied for the project. Due to a difficulty of the intake pipe installation, the intake pipes for the entire plan of a capacity at 444,400m^3/d (= 200,000 m^3/d / 45%) is to be installed in Phase 1. The details are described in Section 5.3.

a) Direct Intake

There are two methods for direct intake. One is to take seawater at shore. The other is to take seawater offshore through pipeline requiring large-scale facilities. The intake at offshore is required to dose chlorine at the intake point in order to prevent a growth of shellfishes and seaweeds inside the pipeline.

b) Indirect Intake

The typical method for indirect intake is the beach well. This method is to intake seawater in the tube-well installed along to shore. The advantage on the method is to eliminate turbidity in seawater before infiltrating to the tube-well. A low concentration of turbidity prevents the contamination to the membrane, and contributes a longer operational condition of the membrane. However, there are negative points. One is that the tube-wells have potential of depletion. If depleted, new tube-wells have to be installed. The other is that the well water quality has potential to change suddenly by an effect on the surrounding geological condition and groundwater. Avoiding these issues, the appropriate investigation shall be performed before the selection.

There is another indirect intake method, called as seabed intake method. This method is to take water from seabed, which functions as filter.

2) Membrane Treatment Facility

Membrane treatment equipment consists of four main facilities as follows (see Figure 5.1-8). It is relatively easy to expand membrane treatment equipment. For this reason, the installation of the equipment is planned at a capacity of 100,000m^3/d in Phase 1.

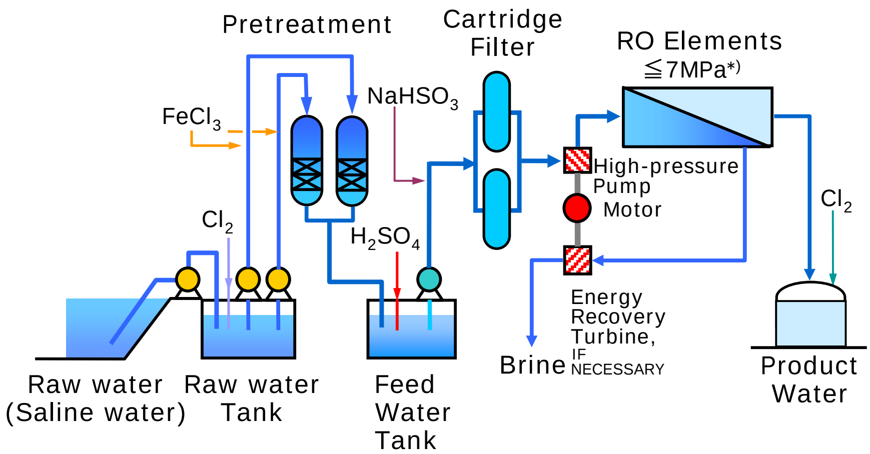


Figure 5.1-8 Flow Diagram of Membrane Treatment Equipment

a) Pre-treatment

In seawater desalination plant, when advanced treatment is necessary due to higher requirement for raw water, the pre-treatment is required in order to convey clean seawater to the RO membrane. The typical pre-treatment is sand filtration process. In recent year, the pre-treatment filtered by membranes such as MF (Microfiltration) membrane or UF (Ultrafiltration) membrane is employed. Table 5.1-7 presents the characteristics of the pre-treatments.

Table 5.1-7 Characteristics of Pre-treatment Methods

Item	Sand filtration	Membrane filtration
1. Cleanness of treated water	Required cleanness for RO Membrane treatment can be obtained.	Treated water is cleaner than sand filtration.
2. Stability	Treated water quality deteriorates when seawater quality changes suddenly by storm and others.	Treated water quality is stable even when seawater quality changes suddenly by storm and others.
3. Initial cost	Less expensive than membrane filtration	Higher than sand filtration. If raw water quality is bad, cost for pre-treatment facility becomes high. Sand filtration before pre-treatment of membrane filtration may be required when seawater quality is beyond acceptable level.
4. O&M cost for pre-treatment	Replacement of filter media is not required for a long period. Less pre-treatment cost than that of Membrane filtration.	Regular replacement for membrane unit of pre-treatment is required. If raw water quality is bad, cost for pre-treatment becomes high.
5. O&M cost for RO membrane	Frequency of replacement of RO membrane becomes high, and its operation cost becomes higher.	Frequency of replacing RO Membrane is reduced because cleaner pre-treated water reduces deterioration rate of RO membrane.
6. Experience	Many ・Okinawa/Japan 40,000m³/d	Not many ・Fukuoka/Japan 50,000m³/d (practically

Item	Sand filtration	Membrane filtration
	・Hamma/Algeria 200,000m^3/d ・Sydney/Australia 250,000m^3/d ・Al Jubail/Saudi Arabia 90,000m^3/d ・Ashkelon/Israel 330,000m^3/d	sand filtration by applying Seabed Intake Method) ・Ras al-Khaimah Investment Authority /UAE 2,000m^3/d ・SAWACO/Saudi Arabia 2,500m^3/d
7. Others	Applied at Djerba Seawater Desalination Project	-
8. Evaluation: Technical Aspect	Applicable	Applicable
9. Evaluation: Financial Aspect	More advantageous than membrane filtration	Less advantageous than sand filtration
10. Evaluation: Total	Applied in this survey	Not applied in this survey

Source: JICA Survey Team

According to the above table, sand filtration as pre-treatment is employed in this project. Therefore, the sand filtration process was selected in terms of economy and past record. Since detailed initial cost and O&M cost for both methods have not been opened by manufacturers, the above comparison was made based on the qualitative judgement.

After the pre−treatment, the necessary chemicals, described in b) below, are dosed in accordance with the allowable condition of the membrane. After that, the pre−treated water flows through cartridge filters for eliminating particles of $5 - 20 \times 10^{-6}$ μm. Then the water flows into RO element.

b) Chemical Injection Equipment (Cl_2, $FeCl_3$, $NaHSO_3$, etc.)

Disinfectant must be dosed for preventing bacteria growth in the entire system. Sodium hypochlorite (NaClO) is frequently used. Ferric chloride ($FeCl_3$) is employed as a flocculant before sand filtration. pH is controlled for protecting the membrane and preventing scale production. For pH adjustment, sulphuric acid (H_2SO_4) or hydrochloric acid (HCl) is often used.

At present, a high market share of the membranes is polyamide composite membranes, which does not have a high durability against chloride. Therefore, a reductant is dosed for neutralizing chloride at places contacting the membrane. Sodium bisulfite ($NaHSO_3$) is often employed as a reductant.

c) RO element

The required number of RO membrane units will be installed. High pressure pumps are considered as a part of this equipment. Energy recovery equipment will be installed to the pumps in order to reduce energy consumption.

d) Washing Equipment

The particles of sands and planktons caught at the pre-treatment unit, especially the sand filter, shall be washed out. In order to do so, washing equipment is necessary. Membranes are also washed at several times a year. Thus, the washing chemicals preparation equipment is to be installed.

3) Post-treatment Facility

For drinking water, the addition of hardness such as calcium or pH adjustment is required to meet the drinking water standard. A disinfectant (e.g. chlorine) is injected in order to prevent the generation of bacteria at reservoirs and pipes.

4) Brine Effluent Facility

When clean water is produced through a membrane process, brine, concentrated seawater is also produced. This brine is returned to the sea. As discussed in Section 5.4, underwater water discharge - offshore discharge - multi-nozzle discharge method is employed in the project. Because an additional pipe installation would not be easy, the effluent pipe at a capacity of 244,400m^3/d (= Intake 444,400 m^3/day – Production 200,000 m^3/day) is to be installed. This is the planned capacity in the entire plan.

5) Product Water Storage Facility

The product water storage facility is installed in order to store water for on-site use, for emergency use during a power failure or malfunction of the plant, and for smooth operation of transmission pumps. In Phase 1, a storage tank with a capacity of 25,000 m^3, an equivalent to 6-hour production volume, to be installed. For Phase 2, a space of the same size is reserved.

6) Transmission Pump House

The pumps, which convey the desalinated water from the product water storage facility to PK11 reservoir, are installed in the desalination plant site. The details are discussed in 5.6.2.

5.2 Construction Site for Seawater Desalination Plant

The construction site for a seawater desalination plant needs a space for a seawater desalination facility, a raw water tank, a product water tank, transmission pumps transmitted to the existing reservoirs, receiving and transforming power facilities, a storage for consumables, an administration building, and parking lots. The required area is about 200,000 m^2 for the plant at a capacity of 200,000 m^3/d.

The site for the plant is to be selected from seven sites, consisted of four sites selected by SONEDE at the beginning of the survey, and three sites proposed by JICA Survey Team after the survey started as shown in Table 5.2-1.

Table 5.2-1 Result of Site Selection for Desalination Plant

No	Location	Primary Selection		Secondary Selection		Evaluation of APAL	Final Judgement
		Result	Judgement	Priority order	Judgement		
1	El Amra Nord (Sfax)	Inferior					
2	El Amra Sud (Sfax)	Inferior					
3	Agareb (Sfax)		Pass to next stage	2	Consultation with APAL	Accept	Select
4	Chebba Sud (Mahdia)	Inferior					
5	Nakta (Sfax)		Pass to next stage	1	Consultation with APAL	Reject	
6	Chebba Nord (Mahdia)		Pass to next stage	3			
7	Mahres (Sfax)		Pass to next stage	4			

Source: JICA Survey Team

During Phase 1 in this survey, the proposed sites were evaluated with emphasis on location. Then the top four sites evaluated at first were selected for the second evaluation using factors of construction cost and consuming power as a life cycle cost. From the second evaluation, the top two sites were selected for the final evaluation. These two sites are located inside of DPM (Domain Public Maritime), where the permission from APAL (Agence de Protection et d'Aménagement du Littoral) is required. The top ranked candidate site is located near the sandy beach used for tourism. According to APAL, permission to use the site for the plant installation will not be granted in order to conserve the beach. The other site does not have any plan. Neither is there any objection to construct the plant. Therefore, this site has been selected for the plant installation.

The exact site for the plant installation was officially identified after APAL studied the location in detail. The location is just the southwest side of the selected site. Based on this site, all facilities for the desalination plant have been planned. After approval of EIA by ANPE, APAL officially will permit the site for utilization to set up the plant.

5.3 Seawater Intake

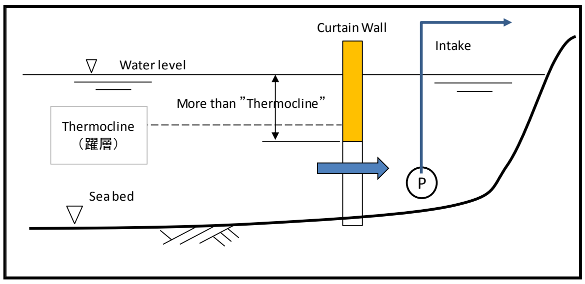
5.3.1 Intake System

There are two intake systems such as direct and indirect intake. Both systems can be classified as presented in Table 5.3-1.

Table 5.3-1 Comparison of Major Intake Method

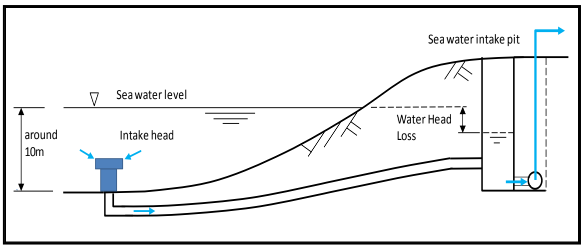
Intake system	Method	Feature	Evaluation
Direct intake (Deep seawater) (Fig 5.3-1)	Intake through sea wall (Curtain wall intake)	• Intake deep seawater in front of sea wall • Intake deep seawater under thermocline where water quality does not have influence by wind and waves. Partition wall panels are installed in a zone of thermocline. • Less influence by waves • Appropriate for a large amount of intake • Considerable depth is needed in front of the intake.	The 10m deep dredging is required in case of the project site. Not applied in this project.
Direct intake (Deep seawater) (Fig 5.3-2)	Direct intake through pipeline	• Intake deep seawater at offshore continuously • Possible to avoid intake of surface water • Less influence by waves • Appropriate for a large amount of intake • Considerable depth of is needed at the intake	Applied for this project
Indirect intake (Infiltration) (Fig 5.3-3)	Seaside well intake (Beach well intake)	• Water quality is better than direct intake because of filtration by soil. But some matters in soil may be included. • Necessary to monitor a filtration rate with time • No influence by waves • Appropriate for small to medium size intake	This method is not appropriate for a large-scale project. Not applied in this project.
Indirect intake (Infiltration) (Fig 5.3-4)	Seabed intake	• Water quality is better than direct intake because of filtration by soil. But some matters in soil may be included. • Necessary to monitor a filtration rate with time • No influence by waves	A large-scale seabed investigation is required. Not applied in this project.

Source: JICA Survey Team



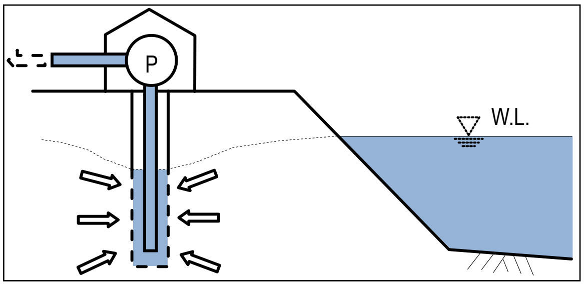
Source: JICA Survey Team

Figure 5.3-1 Curtain Wall Intake Method



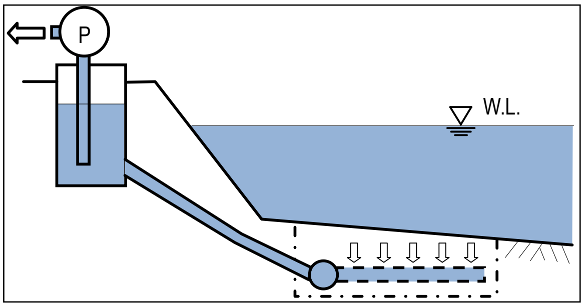
Source: JICA Survey Team

Figure 5.3-2 Direct Intake through Pipeline



Source: Tokyo Kyuei Co., Ltd.

Figure 5.3-3 Beach Well Intake Method



Source: Tokyo Kyuei Co., Ltd.

Figure 5.3-4 Seabed Intake Method

5.3.2 Selection of Intake Method

In the direct intake system, there is a curtain wall intake method, involving the installation of a weir along the shore. The method requires dredging of sand or sludge on the seabed as low as 10 m deep.

With the geographical condition at the plant site, the installation of pipes offshore is more practical based on the construction cost. As a result, direct intake through pipeline is selected.

Regarding beach well method, the possibility for its application was reviewed based on the existing data and the interview survey. The result shows that infiltration volume is not sufficient due to a higher density of soil. As a reference, Sur desalination plant in Oman, called as a largest beach well intake for desalination plant in the world, has wells with a capacity of 5,000 - 10,000m^3/d/well[5]. If the same infiltration volume is applied, 45-90 wells are required for a production capacity of 200,000 m^3/d. The requirement for land is a few kilometres only for wells if a well is installed with an interval of several tens metres. Because occupying such a long horizontal land is unpractical, the beach well method is not applied.

5.3.3 Basic Plan of Intake Facility

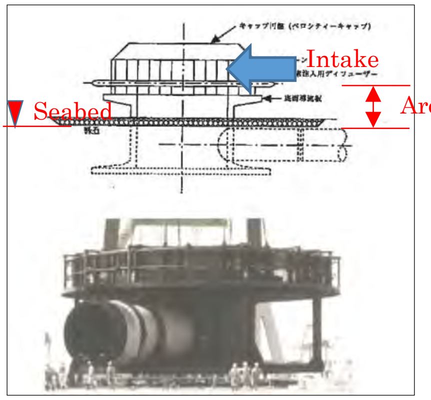
(1) Intake Point

As mentioned in Section 5.3.2, the direct intake through pipeline is selected for the project. Marine work is special and its cost is high because workable period is limited and dependent on weather. The intake and the brine discharge pipelines are installed in parallel on the same route in order to save on construction cost and construction period. After surveying the actual condition of the seabed for the candidate route of the pipelines, the intake tower and the brine discharge tower are to be installed at 3,600 m (water depth of eight m at low tide) and 4,400 m (water depth of 10 m at low tide), respectively, away from the south of the desalination plant.

The intake level is selected at eight metres under the sea surface after considering; i) 1 - 1.5 metres or higher above the seabed, where an effect on turbulence to sand is not extreme, and ii) 1 - 1.5 metres or deeper

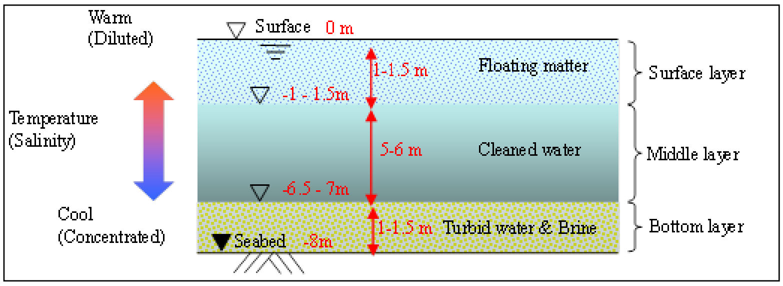
[5] Source: GWI, Alden Desalination Intake Solutions Workshop, Holden Massachusetts, 16 October 2008.

under the sea surface, where an effect on ambient temperature is not extreme (see Figure 5.3-7). An image of intake tower is shown in Figure 5.3-5.



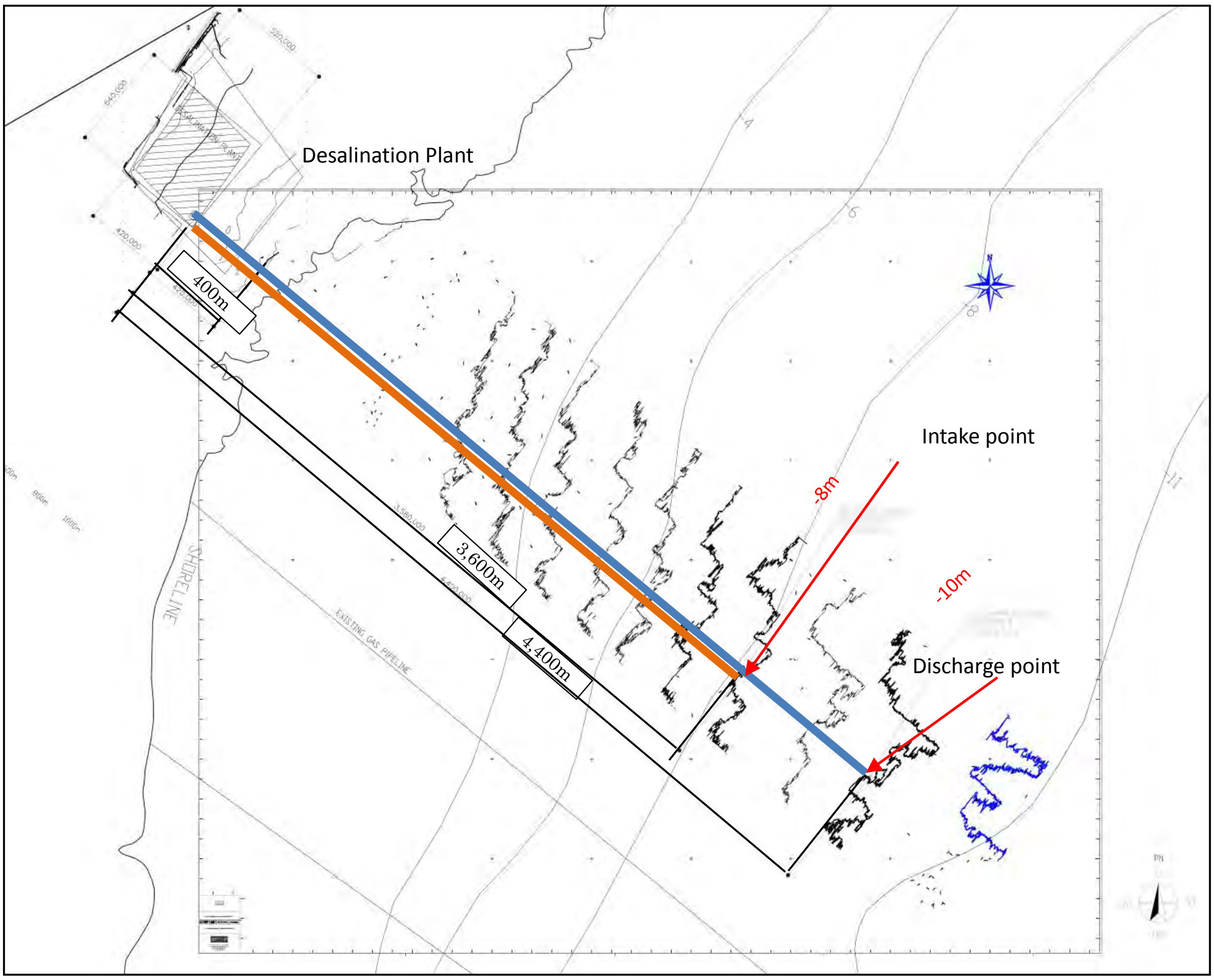
Source: Tokyo Kyuei Co., Ltd.

Figure 5.3-5 Intake Tower



Source: Tokyo Kyuei Co., Ltd.

Figure 5.3-6 Cross Section of Sea at Intake Point



Source: JICA Survey Team

Figure 5.3-7 Intake and Brine Discharge Point

(2) Intake volume: 444,400m^3/day

As mentioned in Section 5.1.2, the recovery ratio is set at 45%. Based on the ratio, the intake quantity is calculated as 444,400 m^3/d (= 200,000 / 0.45). The amount of on-site use presently negligible because the amount is relatively small compared to the production volume of 200,000 m^3/d.

(3) Length of intake pipeline

Length of the intake pipeline is 3,600 metres including 400 metres in land (see Figure 5.3-8).

(4) Pipeline head loss

In order to avoid deep excavation at coast, which will make construction works difficult and raise cost, excavation depth at the intake pit was set to be less than 10m below ground level. Therefore, as shown in Figure 5.3-8 and the calculation shown below, the bottom level of the intake pit will be around 8.5m below ground level in case the diameter of intake pipeline is 2m. Consequently, friction loss of the pipeline shall be less than about 1.8m.

Ground Level at Intake `Pit (Sea Level +2m)
= Intake Pit Bottom Level + Allowance 1m + Intake Pipe Diameter 2m + Allowance 0.5m
+ Loss of Intake Pipeline Flow Loss 2m + Allowance 1m + Ground H. above Sea Level 2m
= Intake Pit Bottom Level + 8.5m (for 2m dia. Intake pipeline)
Loss of Intake Pipeline Flow Loss 2m = Inflow Loss at Intake Head 0.1m + Pipe Friction Loss 1.8m
+ Inflow Loss at Intake Pit 0.1m

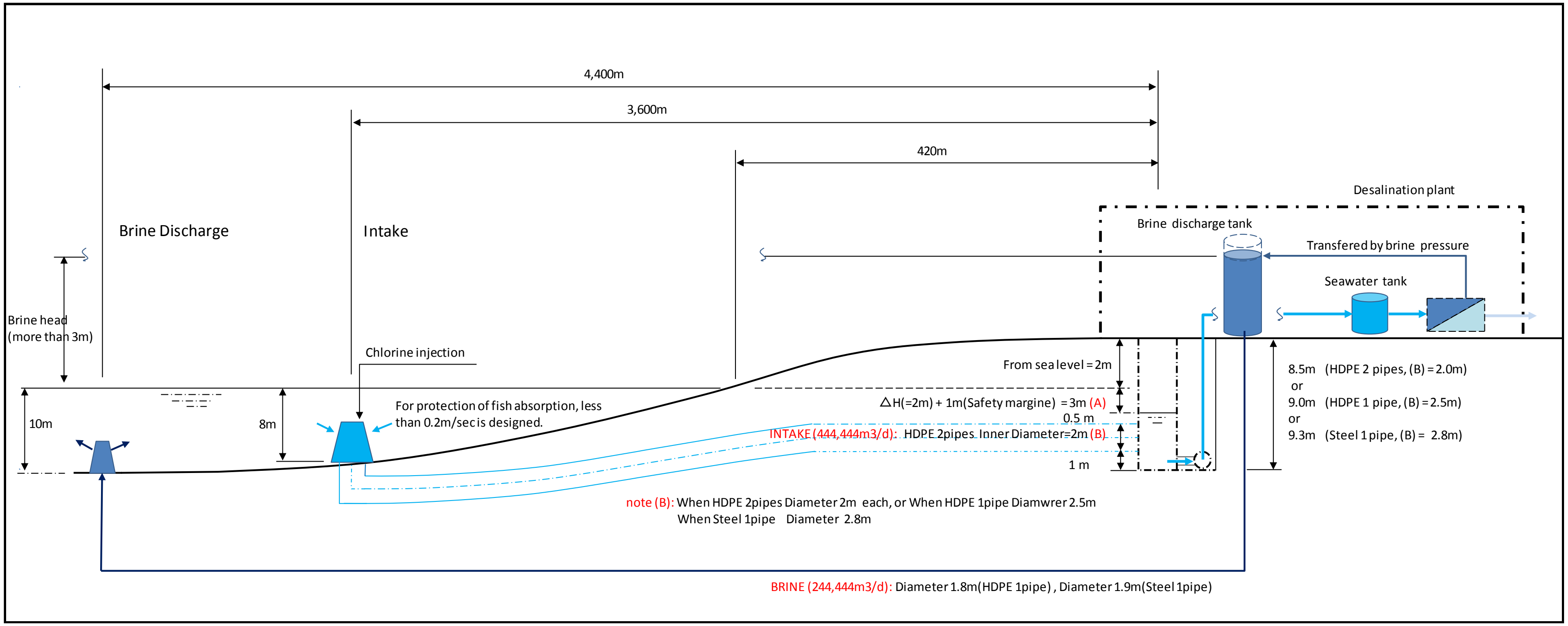
(5) Number of intake pipelines

The basic approach is for the single intake pipeline. Reliable manufacturing experience is important especially for a large diameter of pipes. The details are described in Section 5.3.4.

(6) Pipe material

Candidate materials for pipe are i) HDPE, ii) glass fibre reinforced plastic (GRP), and iii) steel pipe with electrode for corrosion protection and concrete covering, which have been applied for the similar projects. GRP has been applied more in Middle East, but less in Europe than HDPE. On the other hand, steel pipe requires the attachment of electrodes for the corrosion protection. The electrodes need regular maintenance, which is not easy to implement based on SONEDE’s first-hand experience at maintaining it. As a result, HDPE is selected for the project.

(7) Sodium hypochlorite will be injected to prevent the growth of shellfish, oyster, seaweed, etc. at the inside of the pipe. The HDPE pipe with a diameter of 4-inch will be applied (see Appendix for details).



Source: JICA Survey Team

Figure 5.3-8 Schematic Diagram for Intake/Brine Discharge Pipeline

(8) The pipeline including brine discharge is installed at a full capacity considering the difficulty in installation. Construction under the sea is highly dependent on the weather and special technology is needed as well. The interval of Phase 1 and with Phase2 is a short five years. In order to minimize the cost and to shorten the period of construction, the entire facility shall be constructed at this stage.

5.3.4 Estimation of Intake Pipe Diameter

(1) Estimation of intake pipe diameter

Figure 5.3-8 presents a schematic diagram for intake/brine discharge pipeline.

Based on Section 5.3.3, HDPE is selected for pipe material. As a reference, information on steel pipe is described as well. The pipe diameter is calculated as;.

- intake volume: 444,400 m^3/d
- total head loss: approximately 2 m (pipeline head loss : about 1.8m)
- roughness coefficient: 0.016
- Formula: Manning formula

The roughness coefficient is selected as 0.016, which is referred from a similar project. Chlorine is injected at the inlet of the intake pipeline to prevent marine organisms from attaching itself inside the pipe, which. increases the roughness of the pipe’s internal wall. To be on the safety side, the coefficient for a relatively rough surface is selected.

As a result of the calculation, a diameter of 2500mm for HDPE is required in case of the single pipeline. Presently, not many manufactures have the experiences in manufacturing large diameter of HDPE pipes, In case of the double pipeline, a diameter of 2000 mm is required, and there are manufacturers that have sufficient level of reliability and experience in the manufacture of said pipeline. Having a double pipeline is advantageous. When one pipeline malfunctions, the other pipeline is available for the intake, thus the plant can produce desalinated water continuously. In Phase 1, one pipeline can transmit the full capacity of the intake volume. Even though the cost is higher, the double pipeline is selected for the above reasons. Table 5.3-2 presents a comparison between the single and double HDPE pipelines. In the comparison, a cost of brine discharge pipe is included as this will be installed in the same time. The details of the brine discharge pipe are described in Section 5.4.

As a reference, steel pipe is included in Table 5.3-2. In case of single pipeline, a diameter of 2,800 mm is required. For such a large diameter of the steel pipe, there are many experiences with a sufficient level of reliability. Therefore, the indication of steel pipe is single pipeline (see Appendix for details).

Table 5.3-2 Comparison of Construction Cost

Material	HDPE x1line	HDPE x 2lines	Steel x 1line
Intake (3,600m)	Around 2500mm ID	Around 2000mmID	Around 2800mmID
Brine discharge (4,400m)	Around1800mm ID	—	Around 1900mmID
Total	USD 68.5 million	USD 77.8 million	USD 74.0 million
Estimated dredging area (m^2)	161,600	161,600 (application of 2 phases construction, 260,000)	168,800
Evaluation: cost	A	B	-
Evaluation: technical	B	A	-
Evaluation: total	B	A	-

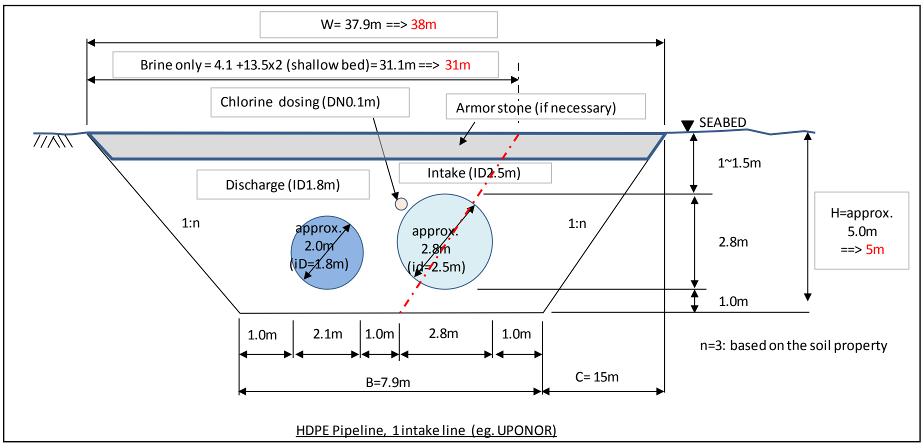
Note: Evaluation means "A" for "advantageous" and "B" for "less advantageous".
Source: JICA Survey Team

(2) Cross section of intake and brine discharge pipeline

Schematic drawings for the cross section of the intake and brine discharge pipeline are presented in Figure 5.3-9 - Figure 5.3-11. The selected pipeline above is indicated in Figure 5.3-10. The brine discharge pipeline is described in Section 5.4.

The pipe installation work in the seabed is at a length of 3,600 metres from the intake to the seawater desalination plant which is around 30 - 40 metres wide. For excavation, the open-cut method is to be employed. As alternative methods, there is the pipe-jacking or shield tunnelling method. If the arriving pit can be prepared off-shore, pipe-jacking or shield tunnelling method is applicable. However, these methods are not applicable in this project due to a relatively high cost because of ;i) the long distance work off-shore, and ii) sealing a large amount of seawater.

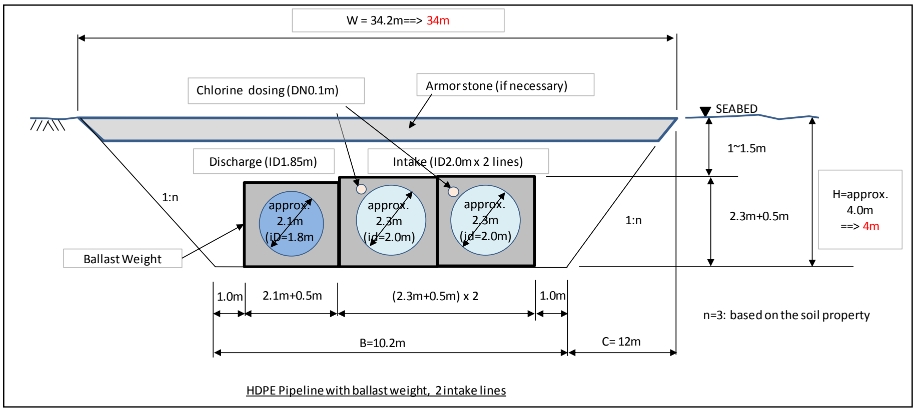
Figure 5.3-9 shows HDPE single pipe, whose dimension is assumed as a product of UPONOR company. UPONOR pipe is made with square sections at the outer surface. By filling mortar resin into this square part, their pipe becomes heavier than water. As the result, this type of pipe is like ballast weight.



Source: JICA Survey Team

Figure 5.3-9 Schematic Drawing on Intake (HDPE x 1) and Brine Discharge (HDPE x 1) Pipelines

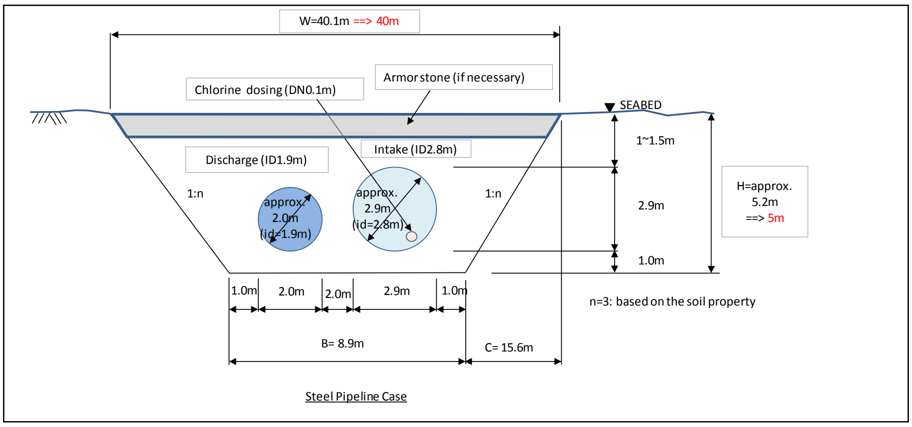
Figure 5.3-10 presents double HDPE pipeline (PIPELIFE and/or AGRU product). This type of the pipe is lighter than water. Therefore, the ballast weight is necessary to keep the pipes under seawater. A size of the ballast weight is estimated at 0.5-0.6 metres larger than the pipe diameter.



Source: JICA Survey Team

Figure 5.3-10 Schematic Drawing on Intake (HDPE x 2) and Brine Discharge (HDPE x 1) Pipelines

Figure 5.3-11 presents single steel pipeline. The diameter of pipes is larger than HDPE mainly due to an installation of electrodes and chlorine dosing pipe.



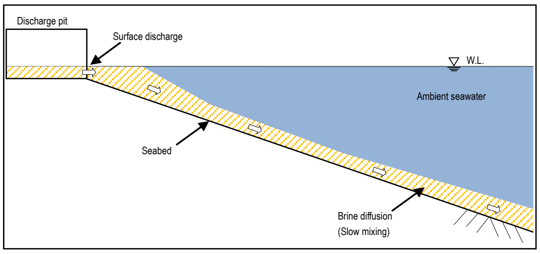
Source: JICA Survey Team

Figure 5.3-11 Schematic Drawing on Intake (Steel x 1) and Brine Discharge (Steel x 1) Pipelines

5.4 Brine Discharge

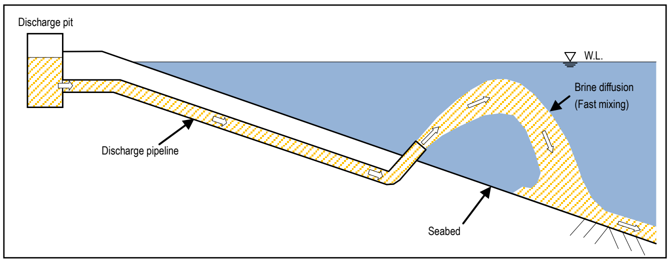
5.4.1 Brine Discharge System

The major brine discharge systems are; i) discharge from shore, and ii) discharge through submerged pipeline as presented in Figure 5.4-1 and 5.4-2, respectively. In the discharge from shore, the brine is diffused and diluted along the seabed. In the discharge through submerged pipeline, the brine is diffused and diluted in the sea. When reaching the seabed, the brine is highly diluted.



Source: Tokyo Kyuei Co., Ltd.

Figure 5.4-1 Discharge from Shore



Source: Tokyo Kyuei Co., Ltd.

Figure 5.4-2 Discharge through Submerged Pipeline

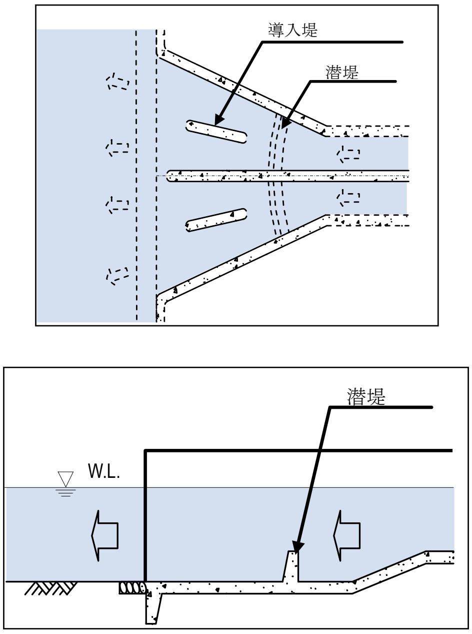
The following is discharge methods. Among the methods, the offshore discharge is classified by the type of nozzle.

(1) Surface discharge - Discharge from shore - Open channel system (Discharge directly from shore to sea), See Figure 5.4-3.

(2) Underwater discharge - Discharge at offshore - Single nozzle system (Discharge from single nozzle installed at offshore), See Figure 5.4-4.

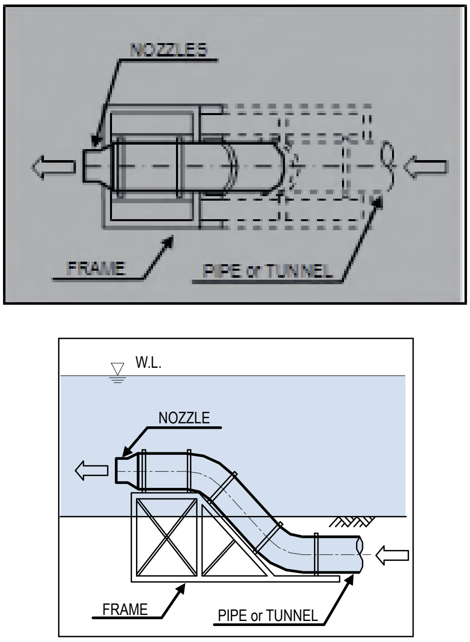
(3) Underwater discharge - Discharge at offshore - Multi-nozzle system (Discharge from multi-nozzle of discharge tower installed at offshore), See Figure 5.4-5.

(4) Underwater discharge - Discharge at offshore - Port riser system - (Discharge from nozzles directly connected to the discharge pipe), See Figure 5.4-6.



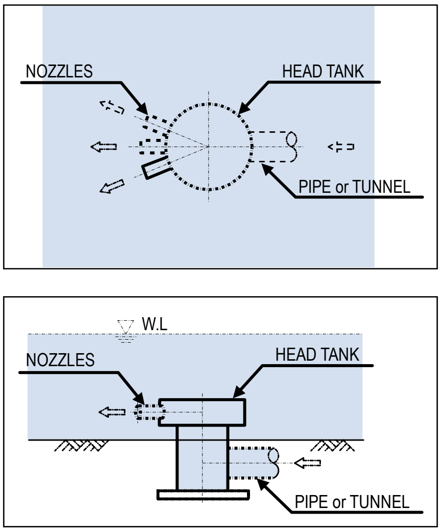
Source: Tokyo Kyuei Co., Ltd.

Figure 5.4-3 Open Channel Discharge



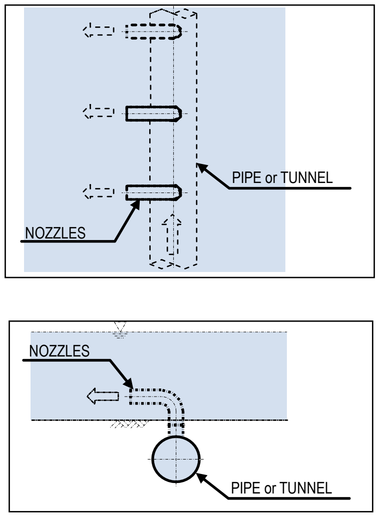
Source: Tokyo Kyuei Co., Ltd.

Figure 5.4-4 Single Nozzle Discharge



Source : Tokyo Kyuei Co., Ltd.

Figure 5.4-5 Multi-Nozzle Discharge



Source : Tokyo Kyuei Co., Ltd.

Figure 5.4-6 Port Riser Discharge

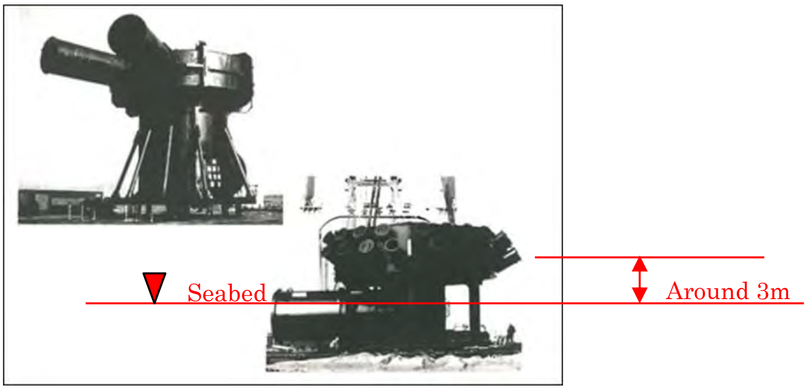
5.4.2 Selection of Discharge Method

Based on the comparison made in the following table, the multi-nozzle type is selected for brine discharge.

Table 5.4-1 Selection of Discharge Type

Type	Outline	Evaluation
(1) Open channel type	Discharge facility is installed near revetment on the shore. Based on an environmental consideration, the sufficient depth near revetment is required. However, the depth is not enough on the site. Therefore, this type is not appropriate.	Not recommendable
(2) Single nozzle discharge type	Pipeline work is required from shore to offshore. Due to single nozzle, the efficiency of diffusion is lower.	Not recommendable
(3) Multi-nozzle type	Pipeline work is required from shore to offshore. Due to multi-nozzle, the efficiency of diffusion is higher.	Selected
(4) Port riser type	Pipeline work is required from shore to offshore. A balanced discharge volume at nozzles is designed by flow resistance and a diameter of nozzles. But the flow at each nozzle is not balanced by attaching sludge or something inside pipes after some time.	Not recommendable

As indicated in Figure 5.3-7, a brine discharge tower is to be installed 4.4 kilometres away from the seawater desalination plant (water depth of 10 m at low tide). It is desirable to install the discharge pipes deeper into the seabed in the zone where there is less sea grass to reduce environmental impact. Based on the site condition, the construction cost increases considerably if the pipeline is installed at that depth. After discussions through ANPE on diffusion effect, it was decided that the discharge tower will be installed at a depth of 10 metres. The discharge nozzles are to be installed at three metres on the seabed in an upward diagonal direction off-shore. The discharge nozzle is to be located at 800 metres from the intake tower. The distance is far enough to avoid any impact of the brine to the intake. Figure 5.4-7 shows an image of the brine discharge tower.



Source: Tokyo Kyuei Co., Ltd.

Figure 5.4-7 Image of Brine Discharge Head

5.4.3 Basic Plan of Brine Discharge Facility

(1) Discharge system: underwater discharge - off shore discharge multi-nozzle type

(2) Brine discharge volume : 244,400 m^3/d

(3) Length of brine discharge pipeline

The total length of the brine discharge pipeline is 4.4 kilometres, which includes 0.4 kilometres in land, and 4.0 kilometres in the sea. The distance between intake and discharge towers is 800 metres.

(4) Pipeline head loss

As shown in Figure 5.3-8, considering the loss at the discharge nozzle and in the pipe, the total head loss is approximately 3mH as precondition. Therefore, pipeline head loss shall be about 2.1m.

(5) Number of discharge pipeline

The basic approach is the single discharge pipeline. However, the manufacturing experience with reliability is important especially for a large diameter of pipes. The details are described in Section 5.4.4.

(6) Pipe materials

HDPE is selected. Refer to 5.3.3 (6).

(7) Marine construction is considered as a special requirement. Based on this, the brine discharge pipeline is to be installed together with the intake pipeline.

5.4.4 Estimation of Brine Discharge Pipe Diameter

(1) Calculation of brine discharge pipe diameter

The diameter of brine discharge pipe is calculated as well as the intake. Total head loss in the pipeline is assumed at approximately 3 mH as precondition. For a coefficient of roughness, the potential substances adhering to the pipes are reviewed. The brine is the water before RO membrane filtration, which is very clean. Under this quality, few marine organisms are expected to adhere to the pipes. Based on this consideration, a coefficient of roughness is applied at 0.012[6]. As the result, a diameter of 1,800 mm is required for HDPE. In case of steel pipe, a diameter of 1,900 mm is required because of attachment of electrodes inside of the pipe (see Appendix for details).

(2) Work for brine discharge pipe installation

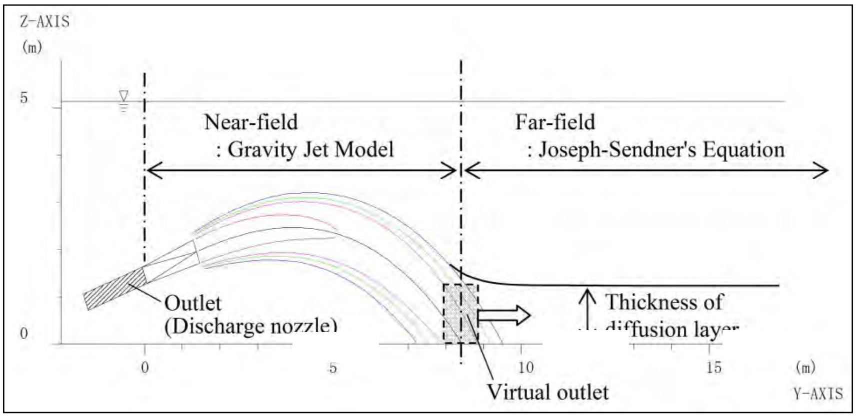
The work for brine discharge pipe installation shall be performed at the same time with the intake. Figures 5.3-9 to 5.3-11 present schematic drawings of the brine discharge pipeline.

5.4.5 Simulation on Dilution and Diffusion of Brine Discharge

(1) General

A water temperature of brine discharged from seawater desalination plant increases within 1 ^{o}C as compared to the intake. Therefore, there is no issue on discharge water temperature, which are issues of electric power or LNG gasification plants. However, the salinity impact is 1.8 times higher (TDS: 70,500 ~ 74,100mg/L), compared to the raw seawater (TDS: 39,000 ~ 41,000mg/L). This has to be investigated for the surrounding condition by dilution and diffusion.

Simulation is divided into two fields based on the flow direction (see Figure 5.4-8). After the brine is discharged from the discharge nozzle, the brine is diluted by mixing with surrounding seawater, and reaches on seabed (Near Field). After that, the brine is diffused on seabed, and diluted simultaneously (Far Field). Due to different phenomena, the formulas for Near Field and Far Field are applied separately to the Gravity model and Joseph-Sendner's Equation, respectively.



Source: Tokyo Kyuei Co., Ltd.

Figure 5.4-8 Image of Brine Diffusion

[6] Manning's roughness coefficient is 0.010 for smooth wall surface of plastic pipes. Wall surface of HDPE pipe, however, is slightly rough, and seems to be larger than 0.010. In this survey, it was set at 0.012 based on the suggestion of the Tokyo Kyuei Co., Ltd. who has many experiences of designing and construction work of marine discharge pipeline.

(2) Assumption of simulation

1) Seawater concentration

Referring to Figure 5.1-3 and Figure 5.1-4 in 5.1.2(1), the maximum concentration of TDS is selected at 41,000mg/L (see Table 5.4-2). The simulation was performed for summer, during the largest difference of salinity.

Table 5.4-2 Condition of Temperature and Salinity

Month		1-3	4-6	7-8	9-11	12
		Winter	Spring	Summer	Autumn	Winter
Seawater temp	°C	15	25	30	25	15
Brine temp	°C	15	25	30	25	15
Original seawater salinity (TDS)	mg/L	39,000	40,000	41,000	40,000	39,000
Brine salinity (TDS)	mg/L	70,800	72,500	74,300	72,500	70,800
Difference of salinity ΔS	psu (*)	31.8	32.5	33.3	32.5	31.8

Source : JICA Survey Team (*) psu = Practical Salinity Unit, equivalent to 1000mg/L

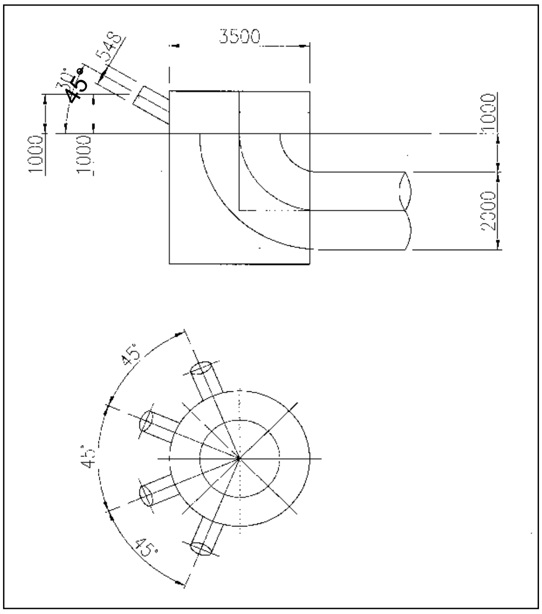
2) Other conditions

- Discharge speed: 3m/s
- Elevation angle: 45 degree, (see Figure 5.4-9)
- Elevation from seabed to Nozzle: 1.3 metres
- Seawater movement: 0[*1]

(*1) Seawater moves at surface. But this movement decreases with a water depth. Near seabed, a depth of the discharge, the movement is considered as negligible. Therefore, the movement is assumed to be zero in the simulation.

- Diffusion direction: 180 degree[*2]

(*2) The density of brine is greater than the raw seawater. As the result, brine spreads more easily to the deeper zone from the discharge point. The diffusion in the horizontal direction is applied at 180 degree to the southeast (See Figure 5.4-11).



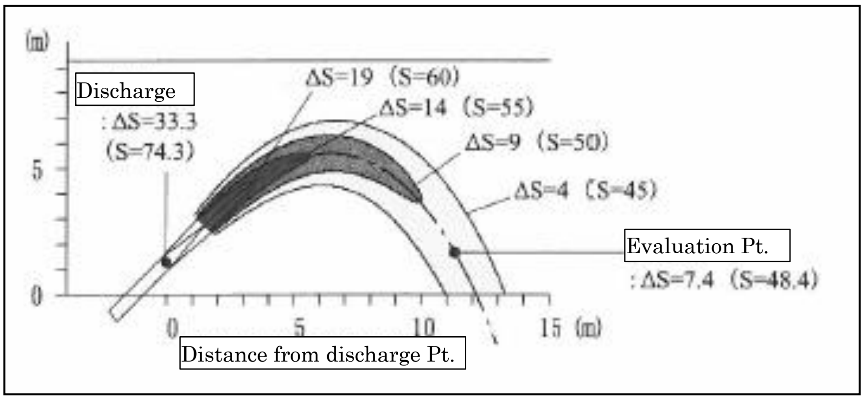
Source: Tokyo Kyuei Co., Ltd.

Figure 5.4-9 Brine Discharge Head

(3) Simulation result

1) Near Field: Application of "Gravity Jet Model"

Brine is discharged, and mixed with raw seawater at the difference of salinity or ΔS of 33.3, i.e.74,300mg/L. When reaching the seabed at 12 m from the discharge tower, the brine is diluted until ΔS of 7.4 . i.e. 48,400mg/L (see Figure 5.4-10).



Source: JICA Survey Team

Figure 5.4-10 Image of Brine Diffusion in Near field

2) Far field: Application of Joseph-Sendner's Equation

The brine, reaching the seabed at 12 m from the discharge tower, is continuously diffused and diluted. In this zone, the diffusion of the salinity is expected as indicated in Table 5.4-3.

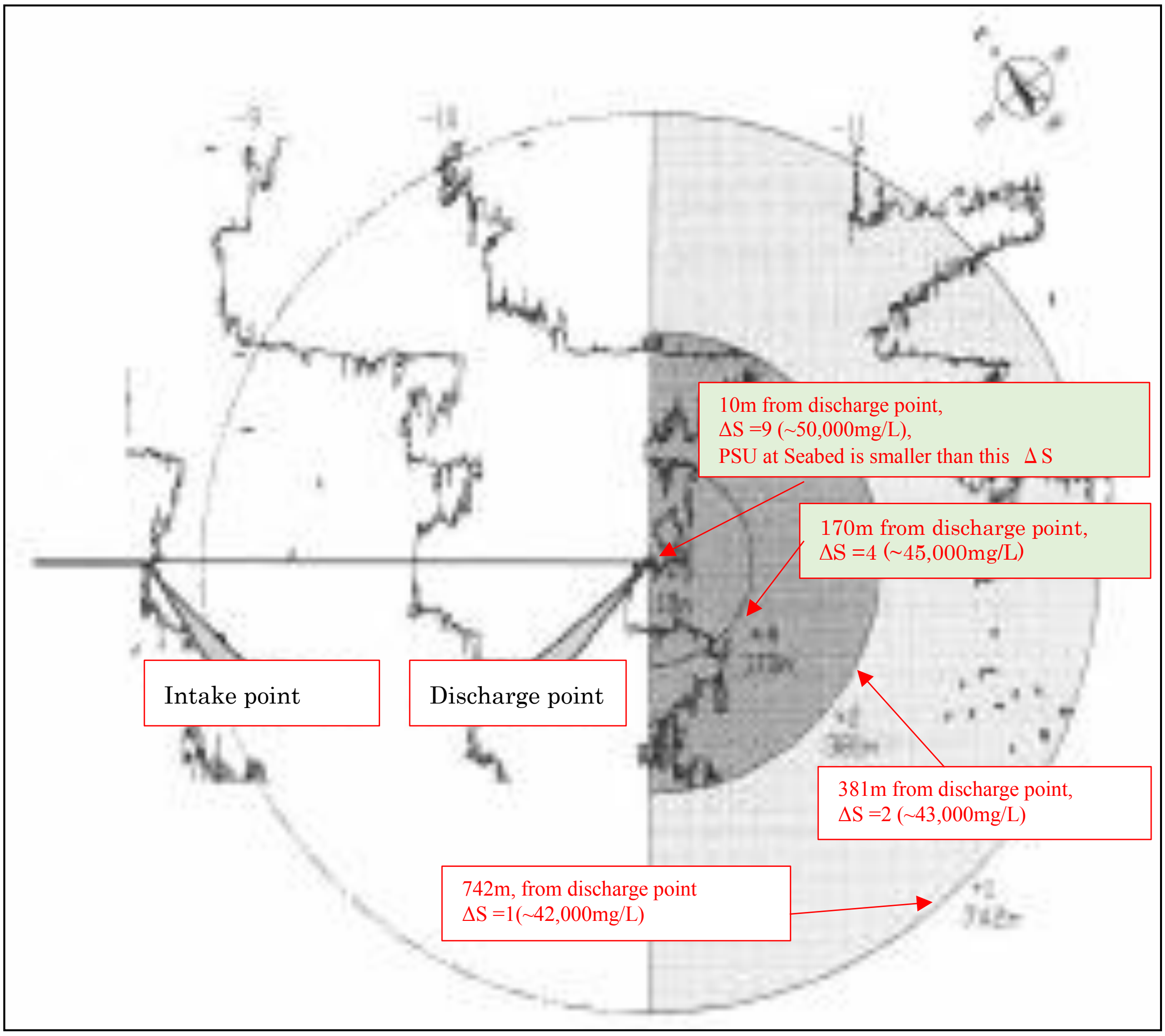
Table 5.4-3 Estimation of Salinity in Far Field

ΔS	Radius of influenced area *1	Estimated concentration at seabed (Seawater at discharge point: 41,000mg/L)	Influence to *Posidonia oceanica* *2
>4	12m (reaching point)	48,400	May die after long period
	170m	48,400～45,000	
>2	381m	45,000～43,000	Almost no influence
>1	742m	43,000～42,000	No influence

Source : JICA Survey Team

(*1) This distance is from the discharge nozzle. See Figure 5.4-10 and Figure 5.4-11.

(*2) According to ANPE, *Posidonia oceanica* die immediately by contact of salinity over 52,000mg/L, die at 52,000～50,000mg/L, and may die at 50,000～45,000mg/L after contacting for a long period. As additional information, Yolanda Fernandez-Torquemada et al. reported in Estuarine Coastal and Shelf Science that salinity over 46,000mg/L gives serous impact to death of *Posidonia oceanica*.



Source: JICA Survey Team

Figure 5.4-11 Brine Diffusion

(4) Conclusion

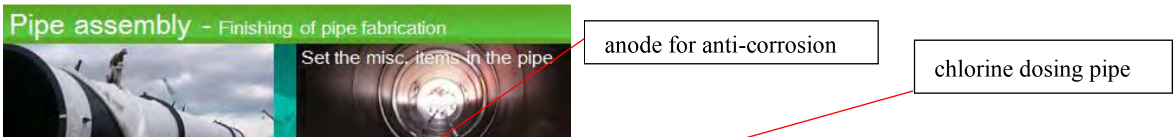
1) Some influence to *Posidonia oceanica* may be observed in the limited area near the discharge point. The salinity is diluted at TDS 45,000 mg/L or little influence to *Posidonia oceanica* at 170 metres from the discharge point.

2) The salinity assumed in this simulation is the maximum value. Usually the salinity is lower concentration. Therefore, it is expected that the influence area is smaller than the result of the simulation.

5.5 Image of Pipe Installation in Seabed (Reference)

Images on pipe installation are presented in Figure 5.5-1 ~ Figure 5.5-6.

Figure 5.5-1 presents the anode for anti-corrosion, and the chlorine-dosing pipe installed inside steel pipe. Figure 5.5-2 presents transportation of long HDPE pipe, a product of IPEFLOW Company, by tugboat.



Source: Tokyo Kyuei Co., Ltd

Figure 5.5-1 Steel Pipe with Electrode and Anti-Corrosion Painting

Source: Tokyo Kyuei Co., Ltd

Figure 5.5-2 HDPE Pipe Transportation

Figure 5.5-3 presents ballast weight for sinking HDPE to the seabed. Figure 5.5-4 presents steel pipe with flange connection.

Source: GWI

Figure 5.5-3 HDPE Pipe with Ballast Weight

Source: GWI

Figure 5.5-4 Steel Pipe Construction

Figure 5.5-5 presents various types of pipes installed in seabed.

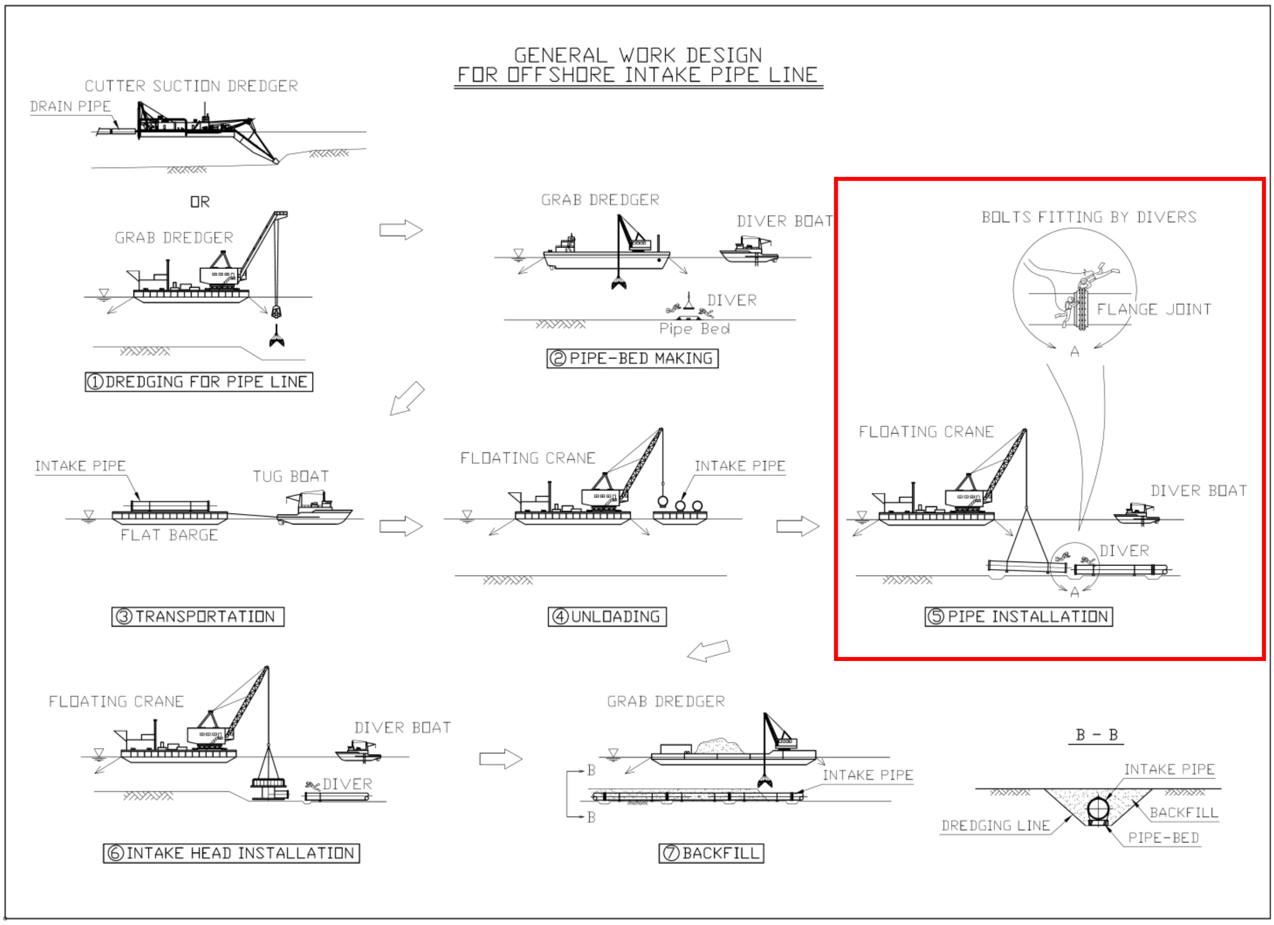
1.Steel with anti-corrosion 	2. High Density Polyethylene (HDPE) pipe ・Extruding pipe（PIPELIFE Company） 
3. Glass fiber Reinforced Plastic (GRP) pipe 	・Box section pipe (UPONOR) 
4. Box Calvert 	5. RC pipe（BONNA pipe） 

Source：Manufacturer's catalogue, etc.

Figure 5.5-5　Several Types of Pipes

Figure 5.5-6 presents a schematic diagram for installing steel pipes on the seabed. Pipeline route is dredged until the required depth from the barge. Then the bed of pipes is prepared by mechanical equipment and divers. After that, pipes are submerged, and connected on the seabed by divers.

For a small diameter of HDPE, pipe connection work can be performed on the barge. However, for a large diameter of HDPE such as 2metres, which applied in this project, the pipes are connected on seabed. Therefore, the pipe connection in this project is expected as presented in Figure 5.5-6.

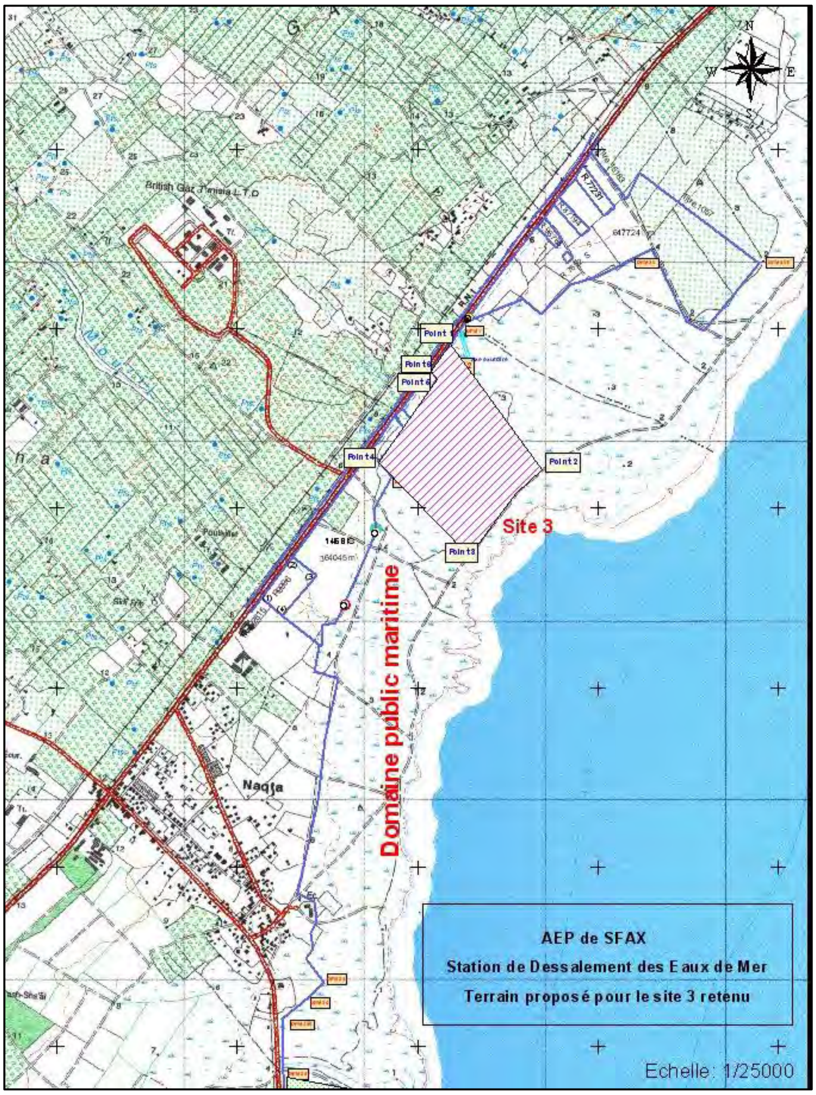


Source : Tokyo Kyuei Co., Ltd.

Figure 5.5-6 Schematic Diagram for Installing Pipes on Seabed

5.6 Facility Layout Plan

The permitted site is approximately 60 ha belonging to sea side area of DPM (Domain Public Maritime) boundary indicated in the hatched area in Figure 5.6-1. The plan for placing of the desalination plant facilities is prepared at a capacity of 200,000 m^3/d. The basic concept and the result of the plan are described in the following section.



Source: APAL/SONEDE/JICA Survey Team

Figure 5.6-1 Permitted Site by APAL

5.6.1 Basic Approach to Planning Facility Layout

i) In the site along the national road, there is the dried river (Oued or Wadi), which discharges rain water from mountainside of the national road. For this reason, the west (Mahres) side of the land is mainly allocated to the facilities rather than the northeast (Sfax) side.

ii) A width of around 50 metres is reserved for the service road in side of the southwest (Mahres) and northwest (inland).

iii) The southeast (sea) side, which faces public space, is considered for simple partition on the boundary rather than the installation of green area.

iv) Equipment is allocated in accordance with the desalinating process flow; i.e. seawater receiving tank => pre-treatment => desalination => product water tank => transmission pump to reservoirs at outsides.

v) Water transmission pipe is to be installed along the national road. The route connecting the transmission pump station to the transmission pipeline will not pass be private land, the product water tank that stores the intake from the southeast, is to be installed at the northeast side.

vi) The space for the future expansion has been reserved.

vii) Receiving power facility is to be installed at the northwest (National road) side because it is assumed that the power line will be brought from National road side.

viii) All electric facilities are to be installed near the receiving power facility.

ix) All chemical and cleaning facilities are to be installed near the pre-treatment facilities. The storage for the materials and the equipment is to be installed near the pre-treatment facility because the materials and the equipment are utilized more at pre-treatment and desalination facilities.

x) Pits for intake and brine discharge are to be installed inside the plant site from the view point of the management.

5.6.2 Facilities at Desalination Plant Site

The facilities planned to be constructed in Phase 1 are summarized in Table 5.6-1.

Table 5.6-1 Components of Phase 1 Project

Facility	Contents
Seawater Intake Pipe	・ Intake Volume: 222,200m^3/d (capable of flowing 444,400 m^3/d after the completion of Phase 2) ・ Pipe Material: HDPE ・ φ2000mm ×2, L=3.6km (Buried, off-shore; 3.2km, on-shore;0.4km) ・ Submerged Water Intake Head: 2
Seawater Desalination Plant	・ Land Acquisition: Approximately 20ha ・ Desalination Method: Reverse Osmosis (RO) Membrane Method ・ Desalinated Water: 100,000m^3/d ・ RO Units: 25,000m^3/day × 4 units
Brine Discharge Pipe	・ Discharge Volume: 122,200m^3/d (applicable to total capacity of 244,400 m^3/d in Phase 2) ・ Pipe Material: HDPE ・ φ1800mm, L=4.4km (Buried, off-shore; 4.0km, on-shore;0.4km) ・ Submerged Water Discharge Head: 1

The following facilities are to be installed at the desalination plant site. Intake tower and brine discharge tower are described in 5.3 and 5.4, respectively.

(1) Major facilities

1) Seawater intake facility

- Seawater conveyed at offshore of 3.2 kilometres from the shore is to be stored at seawater intake pit. Then the raw water is transmitted to the pre-treatment facility by pump. This facility is installed at the site. However, based on the further study, the facility could be installed near the shore.

- To complete marine work at one time, the facility capable for 444,400 m^3/d is prepared in an operational condition of the recovery rate at 45%. In this facility, the amount of in-site use of water is negligible.
- Necessary space is 42m x 20m considering required volume.

2) Pre-treatment facility

- After removing suspended matters and adjusting pH, seawater is fed to the RO membrane. The pre-treatment facility consists of coagulation tank, sand filter, filtration tank, and cartridge filter. The capacity of pre-treatment facility is planned at 222,200 m^3/day plus an amount of on-site use, which is small.
- Transmission pump and chemical dosage line are installed in between tanks mentioned above. The chemical dosage facility is controlled at a different house from the pre-treatment facility.
- The facilities for backwash of sand filter and chemical tank of cleaning desalination membrane are controlled at a different house from the pre-treatment facility.
- The required space is 80m x 130m according to the preliminary design.
- The same size of the space is reserved for Phase 2.

3) Seawater desalination plant

- Seawater whose suspended matters are removed at an acceptable concentration for RO membrane at the pre-treatment facility is fed to the RO membrane. The major facility is high-pressure pump capable of boosting to 65-70 bar at 222,200m^3/d, and desalination units of RO membrane.
- The energy recovery facility is to be installed at a capacity of 222,200 m^3/d. In the intake volume of 222,200m^3/d, 100,000m^3/d is filtered. The remaining volume of 122,200 m^3/d is transmitted to the energy recovery facility. Then the remaining is transmitted to the brine discharge facility
- Necessary space is 63m x 86m according to equipment layout plan.
- The same size of the space is reserved for Phase 2.

4) Product water tank

- The tank capacity is planned for an equivalent to six hour-operation of 25,000 m^3/d (=100,000m^3/d x 6hours/24hours). A capacity of the standard tank in SONEDE is at 5,000m^3. Therefore, five tanks of 5,000m^3 are planned.
- A diameter of the tank is roughly 45 m including the slope. The clearance between tanks is 15 m.
- The same size of the space is reserved for Phase 2.

5) Transmission Pump

- In Phase 1, three pumps are installed. Two pumps are to be used for regular operation, and the other is for stand-by.
- Necessary space is 20m x 53m according to the equipment layout plan.
- The same size of the space is reserved for Phase 2.

6) Brine discharge facility
   - Seawater of 122,200m^3/d, which is not filtrated at the RO membrane is discharged to the sea 4.0 kilometres from shore. Brine discharge tank is to be installed at place adjoining the seawater intake facility mentioned in 1).
   - Necessary space is 22m x 8m considering required volume.

(2) Auxiliary facilities

1) Substation and emergency backup equipment
   Required electricity is around 40 MW, which is supplied from the STEG grid. In case of power failure, the generator is to be installed. In addition to main power receiving sub-station, three sub-stations are planned. Details are discussed in Chapter 7.
2) Administration building
   Administration offices and conference rooms etc. are included. Building size is planned as 40m x 16m, three-storey building.
3) Gate keeper house
   The 24-hour security system is to be installed. The gate keeper house's is planned as 5mx5m.
4) Warehouse
   Spare filter, RO membrane, chemicals, mechanical and electrical parts for maintenance, and the others are to be stored in a warehouse with a size of 50m x 20m.
5) Welfare facility
   Welfare facility is to be installed for operators. Because the work would be done in shifts sleeping facilities are to be constructed. This facility is located in the administration building.

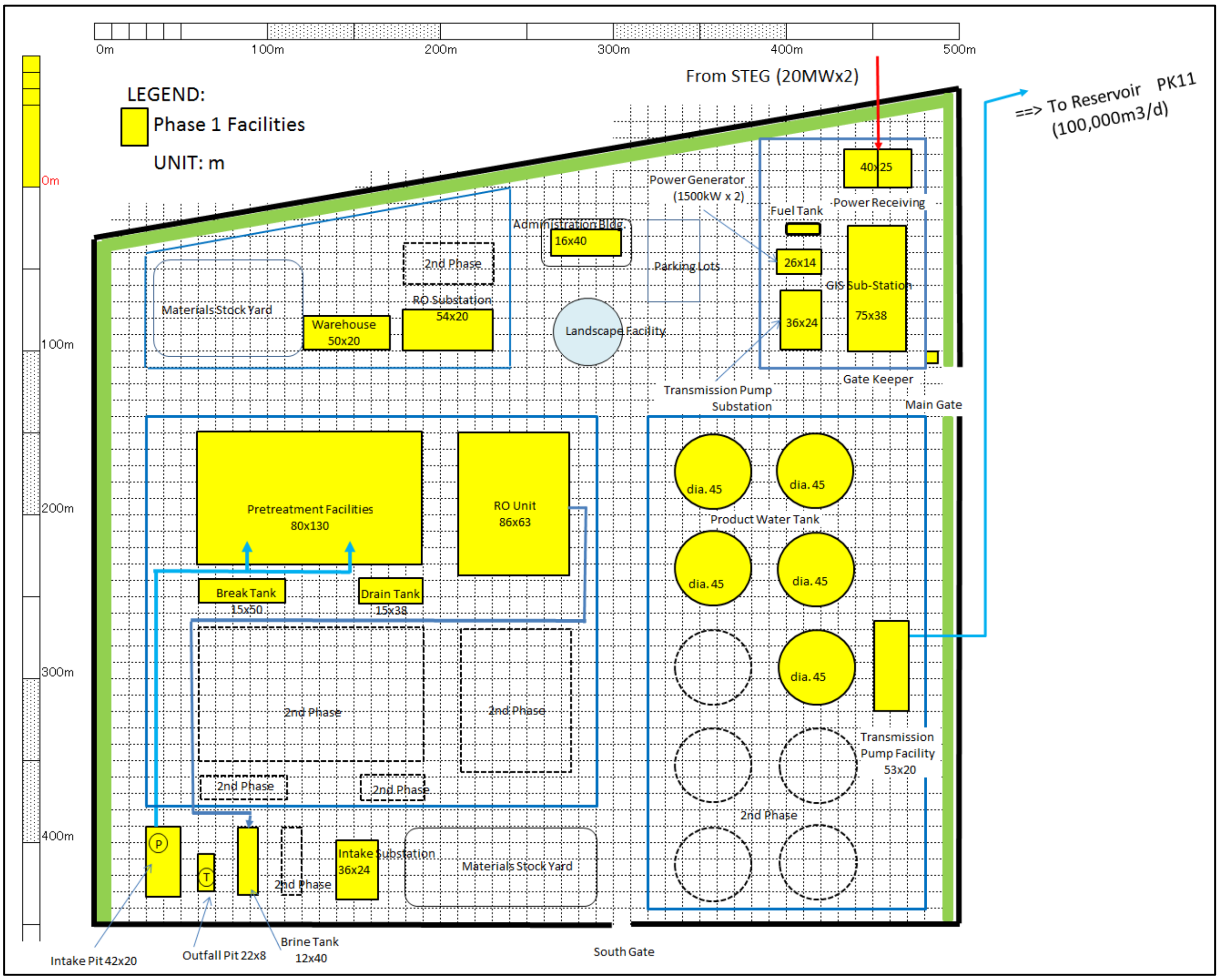
(3) Others

1) Road inside of the plant
   Straight and wide road is planned in the plant, which is considered for the future expansion work in Phase 2.
2) Parking lot
   Parking lot is to be constructed around administration building.
3) Multi-purpose space
   Multi-purpose space is to be prepared for storing large size materials and equipment for the future expansion, and welfare space for operators.
4) Green area

Fences or walls are to be installed at the boundary of the site. Along the fences or the walls, green area made of lawn or trees is planned. In addition, around the administration building, fountain or a water park is to be installed as part of the environmental aspect.

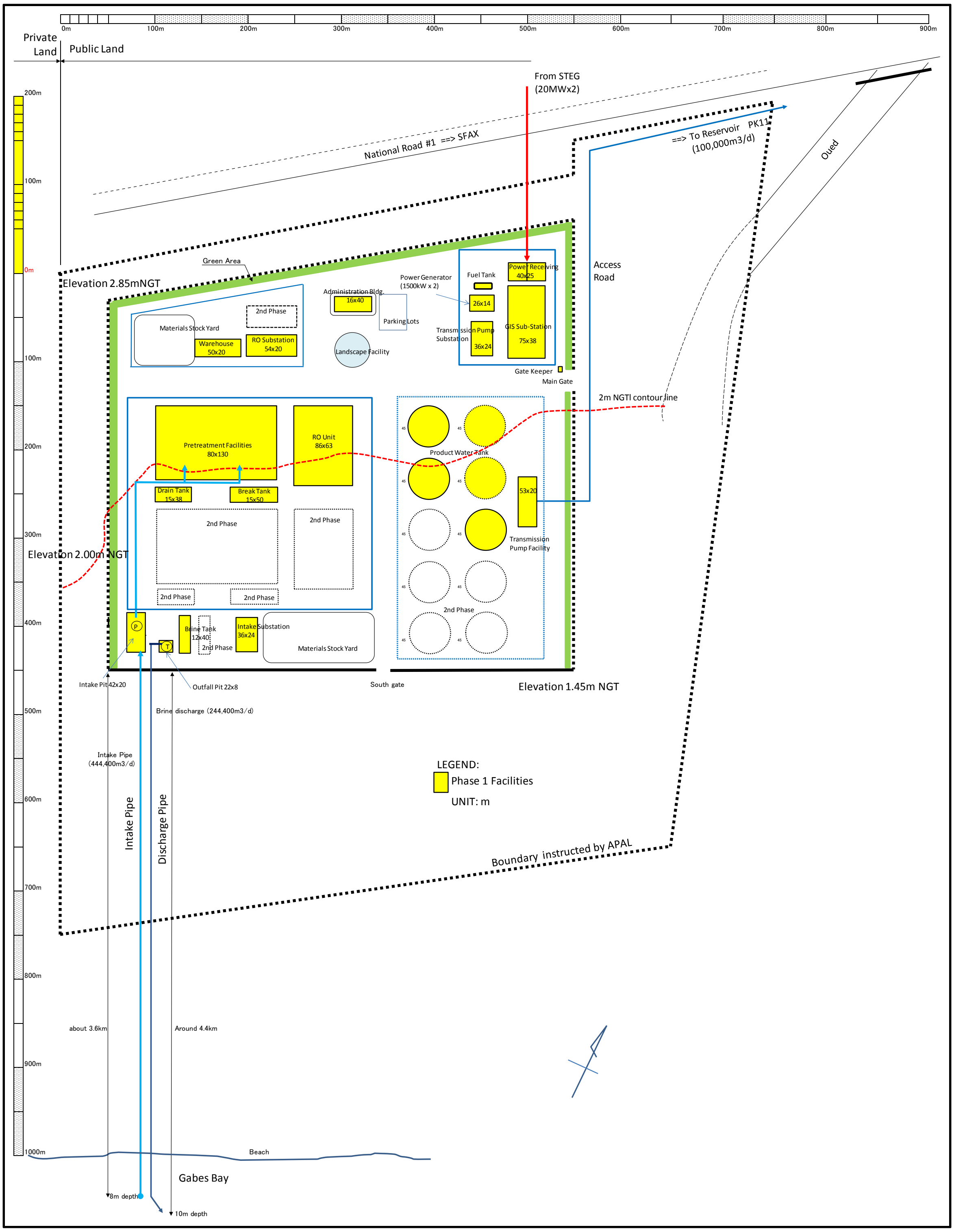
5.6.3 Layout Plan

The layout of the facilities is planned based on the pre-condition mentioned in Section 5.6.2. The result is presented in Figure 5.6-2 and Figure 5.6-3. Detailed layout is presented in Figure 5.6-2. Figure 5.6-3 is enlarged from the hatched land indicated in Figure 5.6-1.



(Source: JICA Study Team)

Figure 5.6-2 Layout of Desalination Plant Facilities (Details)



(Source: JICA Survey Team)

Figure 5.6-3 Layout of Desalination Plant

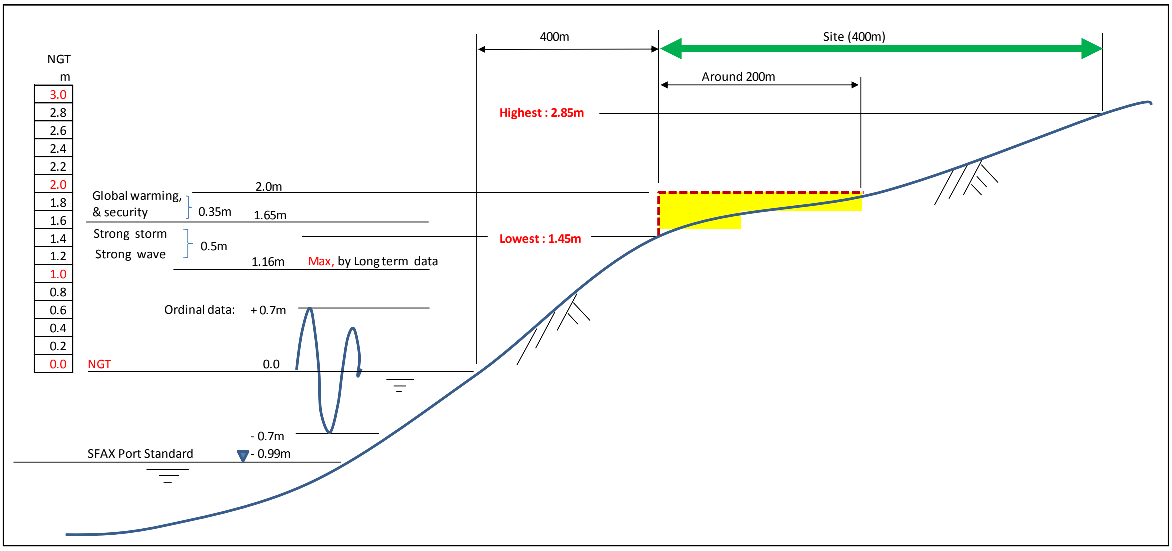
5.6.4 Relationship between Seawater Level and Desalination Plant Site

In Section 2.1.3, Table 2.1-3 shows that the highest level at Sfax sea port is +2.15m. But there is 0.99m difference between the Standard at Sfax sea port and the Standard level for onshore (NGT), which means Sfax port standard is minus (-) 0.99m in NGT base. Refer to Figure 5.6-4. When this highest height in Table

2.1-3 is converted to NGT base, the height is calculated to be +1.16m NGT (=2.15-0.99).

Considering strong wind and extraordinary high waves, 0.5m is added. Due to future global warming, seawater level is expected to increase by 0.35m, and is also considered, including other surplus factor. Thus, total +2m NGT is concluded to be safety height from sea level.

After the topographical survey, the height of project site is reported as per Figure 5.6-2. End of south-south east of site is +1.45m NGT, and end of north-north west is +2.85m NGT. From these reports, when important equipment are laid at south-south east area, land height should be increased by around 0.5m in detailed design stage. Table 2.1-4 shows the highest tidal level at Sfax port is 2.0m and the lowest tidal level is 0.1m. Those figures are based on datum line of Sfax port as shown in Figure 5.6-4, those can be converted to +1.01mNGT (= 2 - 0.99) ~ -0.98m NGT (= 0.1 - 0.99), and are almost coincident with ordinal wave height, ±0.7m NGT.



Source：JICA Survey Team

Figure 5.6-4　Relationship between Sea Level and Plant Site

CHAPTER 6

PLAN OF WATER SUPPLY FACILITIES

CHAPTER 6　PLAN OF WATER SUPPLY FACILITIES

The necessity, required capacity, and approximate location of the Sea Water Desalination Plant were examined in Chapter 4. The desalination method and construction site were selected in Chapter 5. In this chapter, the plan for the water transmission system and a development plan for required facilities are examined.

6.1 Water Transmission Network Plan

6.1.1 Planning Policy for Water Transmission Network Plan

The proper functioning of water transmission facilities, which transmits water from water sources or water treatment plants, is important to ensure a stable water supply service. Considering this importance, it is essential to formulate a plan ensuring a stable water supply service when such facilities are rehabilitated or expanded. The relevant details are described as follows:

1) Water Supply Area

SONEDE compiled "Plan of Distribution Networks and Distribution in Greater Sfax, French: Etude du Plan Directeur des Reseaux de Repartition et de Distribution de Grand Sfax" in 2003. In this plan, Phase 1 and the final plan year is targeted as 2011 and 2032, respectively. Currently, SONEDE has implemented augmentation and rehabilitation of reservoirs, and the upgrading and the rehabilitation of the transmission and the distribution pipe networks. The distribution service area of the Greater Sfax in this survey is in correspondence with the plan.

2) Continuation of Water Transmission Plan

The water supply system in the Greater Sfax has been developed based on the water transfer plan at the corresponding period considering the main reservoirs as PK11 and PK10. For the planning of the future water transfers, PK11 and PK10 reservoirs are considered as the main facilities for the distribution in this survey, too.

3) Water Quality Improvement

In accordance with the Tunisian Drinking Water Regulation, NT09.14:1983, total dissolved solids (TDS) concentration is regulated at less than 2,500 mg/L as a provisional value for salinity of drinking water. The recommended value, however, is less than 500 mg/L. The application of the provisional value, and not the application of the recommended value, is assumed on the basis that it is not easy to obtain appropriate quality of raw water for achieving TDS concentration of 500mg/L. Presently, the new drinking water standard, NT09.14:2013 is ready to be enforced and the standard for TDS concentration becomes 200 to 2000 mg/L. The TDS concentration of water transmitted to the Greater Sfax is 1600 mg/L from the North Water Transmission System, 1680 mg/L from the Jelma-Sbeitla Groundwater

Transmission System, 3160 mg/L from the wells in Greater Sfax. These are considered as relatively high TDS concentrations. SONEDE distributes water after mixing at reservoirs at present for achieving the target TDS concentration of 2000 mg/L. TDS concentration of distributed water, however, often exceeds this target in reality. As a result, the satisfaction of water quality by the residents is not so high. Through this planned project, SONEDE expects to mitigate water shortages and improve the water quality by mixture with desalinated water containing low TDS concentration.

Under the circumstances, the distribution plan is formulated with a consideration of water quantity and water quality in reservoirs. In detail, water quality is improved by replacement between desalinated water containing low amounts of salinity and groundwater containing high amount of salinity. In addition to contributing to the water quality improvement, the desalination plant also contributes to the conservation of groundwater sources due to a reduction in its intake.

Through this project, SONEDE has a desire to attain TDS concentrations of less than 1,500 mg/L and other parameters for achieving the parameters laid down by the Tunisian drinking water regulations. The TDS concentration of desalinated water at the plant in this project is 500mg/L. Based on this concentration and the production volume in phase, final TDS concentration is targeted less than 1500 mg/L in Phase 1, and less than 1200mg/L in Phase 2, respectively. At present, iron and cupper containing groundwater is an issue in addition to salinity. After commissioning of the desalination plant, however, this issue will be solved due to lowered share of groundwater, provided present deferrization process is continued.

SONEDE desires to distribute water with the same TDS concentration to avoid complaint from the residents about partiality. Implementation of this service, however, requires a large amount of the investment. There are two methods to attain such requirement. The one is that water from each source is led to each reservoir with the pre-set ratio allocated to each source. The other is that waters from all sources are once led to one mixing chamber, and then the mixed water is transmitted to each reservoir.

The former requires stable water quality and quantity of each water source. It also requires continuous monitoring of water qualities of each water source and continuous adjustment of the mixing ratio. In actuality, however, it is quite hard to implement this option because of yearly and seasonal variation of quantity and quality of the water sources. The latter requires treatment of the total volume of water demand in the entire Greater Sfax, and will require a large amount of investment.

In this survey, it may be considered that difference of water quality by reservoir will be allowed to some extent due to significant improvement of water quality comparing with its present status. Therefore, it is planned to minimize the difference of water quality among reservoirs with maximum utilization of existing pipe network to save investment cost. As a result, the difference between the highest and the lowest TDS concentrations will be less than 200% in Phase 1, and less than 180% in Phase 2.

4) Utilization of Existing Resources

In order to reduce the initial investment cost and operational cost, the capacities of the existing facilities will be maximized to include both the water sources and the transmission network.

6.1.2 Considerations on Water Transmission Network Plan

SONEDE's policy is to introduce a new system and update the existing facilities without disturbing the current water service system. Taking this basic policy of SONEDE into consideration, the JICA Survey Team will discuss with SONEDE how to merge and integrate new and existing components smoothly.

(1) Basic Policy for Water Transmission Plan after Installation of the Seawater Desalination Plant in Sfax

The capacity of reservoirs is reviewed for sustainable supply even at peak consumption during the summer after installation of a sea water desalination plant in Sfax. In addition, the distribution system in Sfax is separated into high and low distribution areas, but there is interconnection between them through several reservoirs. By this system, a sustainable water supply service is attained by transmission from under-maximized to maximized consumption areas in case of water shortage.

Taking above-mentioned aspects into account, the water transfer plan is examined on the following conditions.

- Daily maximum water supply volume is utilized as the planning capacity for the facilities.
- The design transmission volume between sea water desalination plant and reservoirs or between reservoirs is determined in consideration of the rational water transfer system over the entire service area.
- In accordance with SONEDE's water service policy, the capacity of the reservoir is planned at 40% of the daily maximum water distribution volume[1].
- The basic approach for new reservoirs is planned at the existing reservoir sites. In addition, the new reservoirs are planned with the standard reservoir of SONEDE as shown in Table 6.1-1 and Figure 6.1-1.

Table 6.1-1 Sizes for Standard Reservoirs of SONEDE

Capacity (m^3)	Internal Diameter (m)	External Diameter (m)	Depth (m)	Depth of Drain Pit (m)	Thickness of Roof Slab (m)	Roof Slab Radius of Curvature (m)
10,000	45.00	45.80	6.30	1.40	0.10	21.50
5,000	31.30	32.00	6.50	1.00	0.15	33.05
2,500	26.00	26.60	4.65	1.00	0.15	33.05
1,500	21.00	21.44	4.37	1.00	0.15	20.45
1,000	17.72	18.16	4.10	1.00	0.22	19.00
500	12.70	13.10	4.10	0.75	0.15	12.95
250	10.00	10.20	3.30	0.60	0.20	10.25
100	7.20	7.50	2.60	0.60	0.15	7.65

[1] No definite regulation or rule exists.

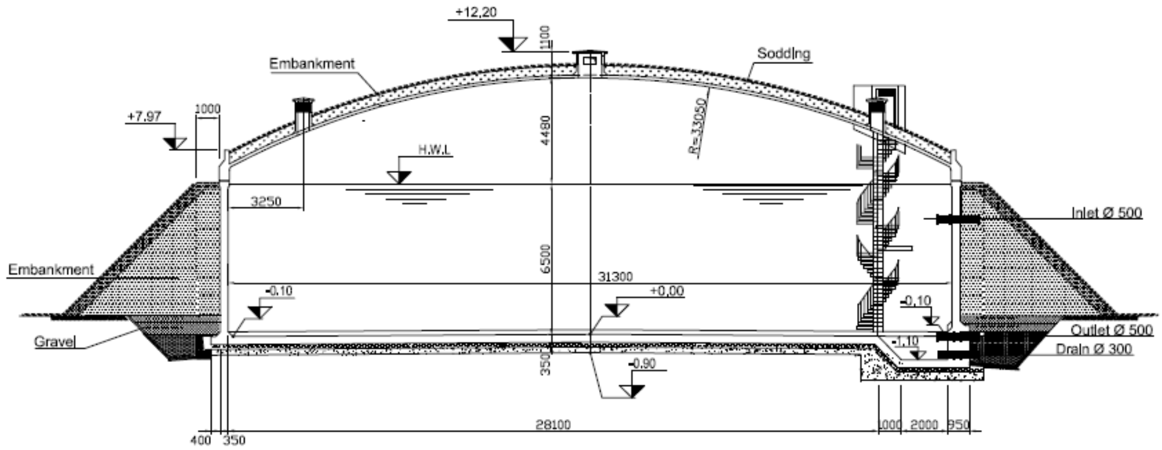


Figure 6.1-1 SONEDE's Standard Reservoir (Capacity of 5,000m^3)

(2) Planning Conditions for Transmission of Produced Water from the Seawater Desalination Plant

The water produced from the sea water desalination plant in Sfax is transferred to the reservoirs in the Greater Sfax area based on the following conditions.

- The sea water desalination plant site is located at lower altitude than the reservoir. Therefore, the water is transmitted by pumping.
- The transmission pump facility at the sea water desalination plant is installed at the same site as the plant. The pump facilities along the route of the transmission are installed at the site of the existing reservoirs.
- The reservoir directly transmitted to from the sea water desalination plant is the PK11 reservoir, which is a main facility of the water distribution in Sfax.
- Water transmission between reservoirs is carried out by pumping from PK11 to Bou Merra, from PK11 to PK10, from PK10 to PK14, and from PK14 to Sidi Salah EH[2].
- Water is transmitted by gravity from Sidi Salah EH Reservoir to Sidi Salah EB Reservoir.

(3) Planning Conditions for Water Transmission from the North Water Transmission System

Water, transmitted from the North Water Transmission System, is pumped up at the Ker Ker Pumping Station in the Mahdia Governorate. After that, the water is transmitted to the Rouadhi Reservoir which is located near the boundary between the Mahdia Governorate and the Sfax Governorate. From the Rouadhi Reservoir, the water is transmitted to the Maharouga Pressure Reducing Reservoir. After adjusting the

[2]: It was found through examination that it is most economical to transmit required water by relay pumping. Further, it was found that a large amount of water from all water sources shall be mixed at one place, and then be sent to each reservoir in order to lessen the difference of water quality at each reservoir. Because of this reason, a mixing tank is set at PK11 to mix water produced in the Sea Water Desalination Plant and the water from existing sources. By this method, land acquisition for reservoir and mixing tank will not be necessary during Phase 1.

pressure at the Maharouga Reservoir, the water is transmitted by gravity to the reservoirs of Sidi Salah EH, PK14, and PK10 in the Greater Sfax. (refer to Figure 6.1-2)

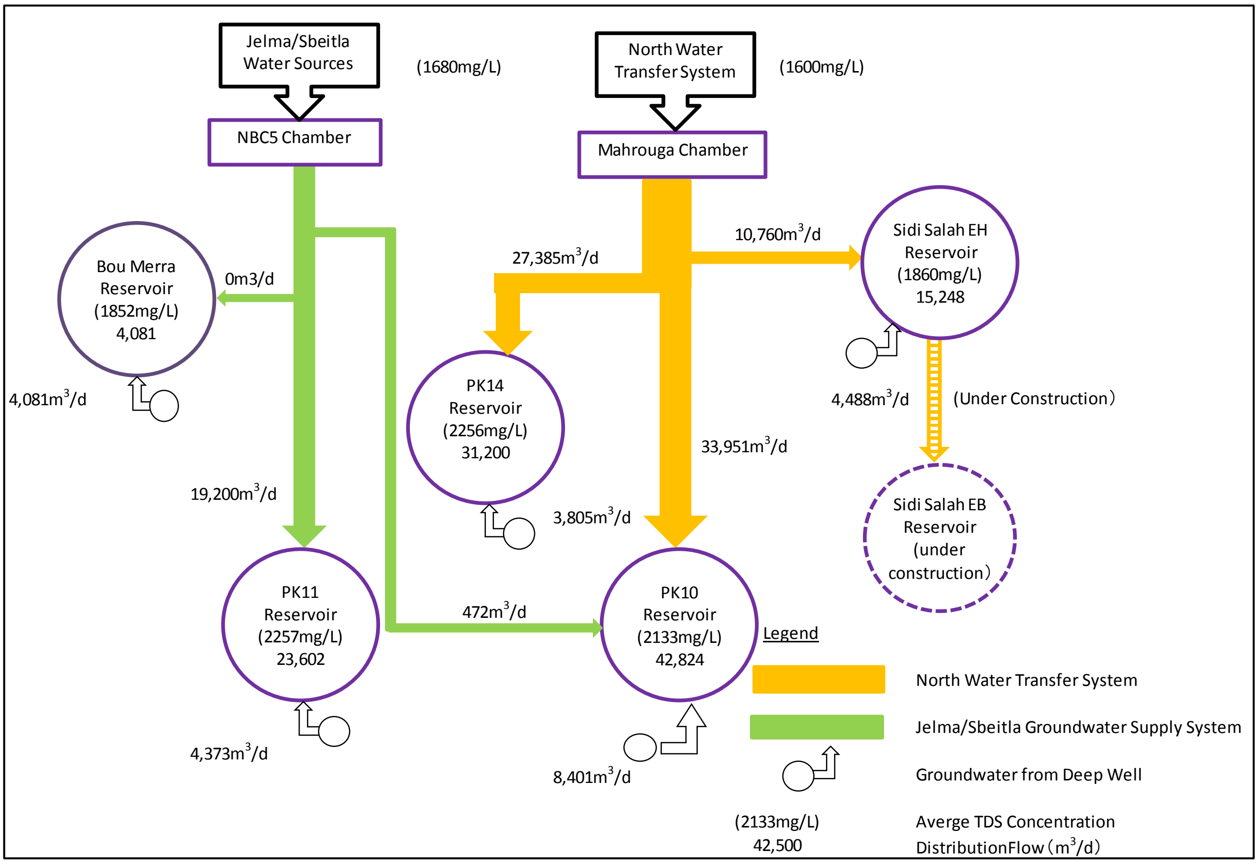


Figure 6.1-2 Schematic Diagram of Water Transmission System in Greater Sfax (Year 2013)

The water from the North Water Transmission System in the Greater Sfax is examined based on the following conditions.

- The water from the North Water Transmission System is basically transmitted to the Sidi Salah EH Reservoir, the PK14 Reservoir, and the PK10 Reservoir.
- The water is also transmitted to the PK11 Reservoir by gravity though the existing pipeline to the PK10 and the PK11 Reservoirs.
- The Sidi Salah EB Reservoir will be operated from 2016. The water to the Sidi Salah EB Reservoir will be transmitted by gravity from the Sidi Salah EH Reservoir.

(4) Planning Conditions for Water Transmission from the Jelma-Sbeitla Groundwater Transmission System

The water from the Jelma-Sbeitla Groundwater Transmission System which is conveyed from the Sidi Bouzid Governorate to the Sfax Governorate is divided at the western area of the Sfax Governorate at first, and then transmitted to the reservoirs in the Greater Sfax area (the PK11 Reservoir and the Bou Merra Reservoir) via the NBC5 Pressure Reducing Reservoir (refer to Figure 6.1-2).

The water from the Jelma-Sbeitla Groundwater Transmission System in the Greater Sfax is examined based on the following conditions.

- The water from the Jelma-Sbeitla Groundwater Transmission System is basically transmitted to the Bou Merra Reservoir and the PK11 Reservoir. Presently, most of water distributed from the Bou Merra Reservoir is taken from the well located in the site of the Bou Merra Reservoir after deferrization.
- here are pipelines, which can transmit the water from the Jelma-Sbeitla Groundwater Transmission System to reservoirs of PK10 and PK14, but are rarely utilized actually.

(5) Planning Conditions for Groundwater in the Greater Sfax

Groundwater in the Greater Sfax area has been pumped up from existing wells located mainly at in the existing reservoirs. Salinity of the groundwater is always high. Since a drought occurred in 2012, new wells were developed with a special permission issued by the government, though groundwater development has been controlled.

Implementing this project will enable reduction of the groundwater pumpage in the Greater Sfax. However, the south area of the Sfax governorate, groundwater source area, and the area along the transmission pipelines are demanding water supply from the Jelma-Sbeitla groundwater transmission system. Therefore, it is unpredictable to expect future stable supply from the Jelma-Sbeitla groundwater transmission system. Though it will be possible to cease pumpage from the wells located at the sites of reservoirs in the Greater Sfax, the JICA survey team examined options about groundwater pumpage in the Greater Sfax as follows:

Option 1: 90 % of current pumpage flow of 25,148m^3/d in 2013 is to be not pumped. (Periodical pumping-up shall be made in order to ready for emergency use)

Option 2: 20 % of the current pumpage will be reduced, and equivalent flow of pumpage will be reduced from water supply by the Jelma-Sbeitla Groundwater Transmission System.

Option 3: 20 % of the current pumpage will be reduced. The equivalent flow of a 1/2 of pumpage will be reduced from water supply by the Jelma-Sbeitla Groundwater Transmission System. And the equivalent flow of a 1/2 of pumpage will be reduced from water supply by the North Water Transmission System.

Groundwater pumpage supplying to reservoirs in the Greater Sfax has varied every year. The daily maximum pumpage was recorded in 2011at 26,105m^3/day in total. Therefore, the daily maximum groundwater supply capacity may be considered as 26,100m^3/day. During the period of water shortage before completion of the project, however, the expected pumpage shall be increased to 27,100 m^3/day taking account of the largest pumpage of each well in last four years from 2010 to 2013. The current pumpage stated in the options above means 25,148m^3/day recorded in 2013. Percentages of reduction are considered to this pumpage.

Table 6.1-2 Options of Groundwater Pumpage Reduction

Option	Characteristics of the plan	Advantage	Disadvantage	Evaluation
1	● 90% of the pumpage will be decreased.	● Conservation of underground resources ● Improvement of the water quality of the tap water	● Increase of flow of pumps	Not selected because of relatively high dependence to water resources from other governorates.
2	● 20% of the pumpage will be decreased. ● Equivalent flow will be decreased from Jelma-Sbeitla groundwater transmission system	● Securing flexibility of Jelma-Sbeitla groundwater transmission system ● Decrease of the Pumping up capacity ● Alternatives for the water source will be secured	● Degree of water quality improvement is low ● Degree of conservation of the water resources is low	Not selected because of higher dependence to North water resources than option 3, though it is better that that of Option 1.
3	● 20 % of the current pumpage will be decreased. ● 1/2 of the equivalent pump-up flow will be decreased from Jelma-Sbeitla groundwater transmission system. ● 1/2 of current pumpage flow from the North Water transmission system will be decreased.	● Securing flexibility of Jelma-Sbeitla groundwater transmission system for the underground water ● Securing flexibility of North Water transmission system ● Decrease of pumping capacity ● Alternatives for the water source will be secured	● Degree of water quality improvement is low ● Degree of conservation of the water resources is low	Employed because; 1. Less dependence to resources in other governorates than Option1. 2. Less dependence to North water transmission system than Option 2. 3. Superior balanced option among 3 options.

Options shown above are technically possible to implement. Required facilities for each option have no difference because pumpage amount is very small compared to water volumes from other water sources. SONEDE agreed to employ the Option 3 after the discussion of the advantages and disadvantages of options because of flexibility in operation of water sources, smaller water volume to be transmitted, less influence by change of water demand. In terms of water quality, TDS in the Option 3 is rather higher than that of the Option 1. However, the TDS concentration of less than 1500mg/l which was requested by SONEDE, can be secured.

(6) Flow diagram of present water transmission system in the Greater Sfax

Flow diagram of present water transmission system in the Greater Sfax is shown in Figure 6.1-2.

6.1.3 Water Transmission Plan for Greater Sfax

Following the policies and considerations stated in Section 6.1.2, the water transmission plan was formulated with a defined water transmission volume from each water source in each year until the target year.

(1) Distribution of Flow by Reservoir

The strategic plan of SONEDE includes water demand volume for the Sfax Governorate, but the plan of water volume for distribution at each reservoir is not included in it. In this survey, therefore, distribution volumes at each reservoir were planned based on the ratios of distribution volumes at each reservoir planned in the Plan of Distribution Networks and Distribution in Greater Sfax and capacities of the existing reservoirs. Planned distribution volumes by each reservoir are as shown in Table 6.1-3.

Table 6.1-3 Distribution Volume by Reservoir

Daily Maximum (m^3/d)

Zone	Daily Max. (m^3/d)	2013	2022	2025	2030	2035
Low Dist. Zone	PK11	23,602	37,300	43,200	49,700	59,100
	PK10	42,899	48,300	50,100	61,700	73,200
	Sidi Salah EB	-	20,400	27,200	40,100	50,400
High. Dist. Zone	Bou Merra	4,081	13,100	15,100	18,900	23,100
	PK14	31,200	33,700	34,600	36,000	43,100
	Sidi Salah EH	15,248	16,700	17,800	18,000	21,900
All	Greater Sfax	117,030	169,500	188,000	224,400	270,800

Daily Average (m^3/d)

Zone	Daily Ave. (m^3/d)	2013	2022	2025	2030	2035
Low Dist. Zone	PK11	16,900	26,600	30,900	35,500	42,200
	PK10	30,600	34,500	35,800	44,100	52,300
	Sidi Salah EB	-	14,600	19,400	28,600	36,000
High. Dist. Zone	Bou Merra	2,900	9,400	10,800	13,500	16,500
	PK14	22,300	24,100	24,700	25,700	30,800
	Sidi Salah EH	10,900	11,900	12,700	12,900	15,600
All	Greater Sfax	83,600	121,100	134,300	160,300	193,400

Source: JICA Survey Team

Capacities of reservoirs were examined based on the distribution volumes shown in Table 6.1-3 to attain the target minimum capacity of reservoirs in Phase 1 at around 6 hours of daily maximum distribution volume[3], equivalent to 8.4 hours of daily average distribution volume as a minimum. The results are as shown in Tables 6.1-4 and 6.1-5. Table 6.1-6 presents development plan of reservoirs, and their planned retention time.

Table 6.1-4 Capacities of Reservoirs (m^3)

Zone	Reservoir	2013	2021	2025	2030	2035
Low Dist. Zone	PK11	22,000	22,000	22,000	22,000	**24,500**
	PK10	20,000	20,000	20,000	**30,000**	30,000
	Sidi Salah EB	-	5,000	5,000	**15,000**	**20,000**
High. Dist. Zone	Bou Merra	1,500	**6,500**	6,500	**9,000**	9,000
	PK14	10,000	10,000	10,000	**15,000**	**17,500**
	Sidi Salah EH	7,500	7,500	7,500	7,500	**10,000**
All	Greater Sfax	61,000	71,000	71,000	98,500	111,000

Source: JICA Survey Team

[3]: Since urgency and cost saving are requested for Phase 1, the minimum requirement for capacity is set at around 6 hours which is sufficient to buffer hourly fluctuation in a day. In Phase 2, it is planned to satisfy requirement, i.e. 40% of average daily distribution volume.

Table 6.1-5 Capacities of Reservoirs (hours to Daily Maximum Distribution Volume)

Zone	Reservoir	2013	2021	2025	2030	2035
Low Dist. Zone	PK11	22.4	14.2	12.2	10.6	9.9
	PK10	11.2	9.9	9.6	11.7	9.8
	Sidi Salah EB	-	5.9	4.4	9.0	9.5
High. Dist. Zone	Bou Merra	8.8	11.9	10.3	11.4	9.4
	PK14	7.7	7.1	6.9	10.0	9.7
	Sidi Salah EH	11.8	10.8	10.1	10.0	11.0
All	Greater Sfax	12.5	10.1	9.1	10.5	9.8

*: The project for development of Sidi Salah EB Reservoir is on-going to complete 5,000m^3 capacity in 2016. Since Hourly fluctuation of distributed water in a day can be buffered with a 6 hours retention capacity, it was judged that the capacity of Sidi salah EH reservoir is enough to cover capacity shortage of Sidi Salah EB reservoir, and then it is not required to acquire land for an additional reservoir.

Retention time for Sidi Salah EB+EH = (5000m^3+7500m^3) / (272000m^3/day+17200m^3/day) x 24hours/day =6.8 hours

Source: JICA Survey Team

Because of yearly variations of available water volume from each water source, the allocation plan of available water from each source varies every year. In this survey, the following policies were applied for the allocation of available water from each water source.

1) Drinking Water Quality Standard in Tunisia NT09.14:1983 is as shown in Table 5.1-6. In the new standard NT09.14:2013 being processed to be enforced, Salinity or TDS concentration is 200-2000 mg/L. WHO's drinking water quality guidelines indicates TDS concentration shall be less than 1000mg/L. Considering said standards, SONEDE considers TDS concentration at each reservoir shall be less than 1500mg/L. As a result of calculation, it was found possible to achieve less than 1500mg/L in Phase 1 and less than 1200mg/L in Phase 2.

   Further, SONEDE also requested that ratio between the highest TDS concentration and the lowest one shall be small as far as possible. It, however, requires centralization of waters from water resources to the PK11 reservoir where the water produced in the seawater desalination plant is transmitted to. It will require a large amount of cost for provision of required facilities and energy for transmission. In this survey, with consideration that difference of water quality by reservoir will be allowed to some extent due to significant improvement of water quality comparing with its present status. Therefore, it is planned to lessen the difference of water quality among reservoirs as small as possible under the condition of full use of existing pipe network to save investment cost. As a result of calculation under the given conditions, it is less than 200% in Phase 1, and less than 180% in Phase 2.

   The water quality and the rate stated above can be achieved provided appropriate allocation of water from each water resource is conducted. Further it shall be noted that water quality will be worse and the ratio between the highest and the lowest TDS will be larger, if allocation of water from each water resource is not proper.
2) Pumpage from wells transmitted to existing reservoirs shall be kept at 80% of present pumpage in total.
3) Water from the North water transmission system and the Jelma-Sbeitla groundwater transmission system shall be utilized as much as possible in order to lessen water production costs.

4) A half of water volume equivalent to pumpage from wells shall be reduced from water supply volume by the North water transmission system and the Jelma-Sbeitla groundwater transmission system respectively.
5) The amount of water to be produced in the Sfax Seawater Desalination Plant shall be decided with due consideration of above item 1).

Allocation plan of water sources by reservoir is presented in Table 6.1-6. TDS concentrations calculated based on the water source allocation plan presented in Table 6.1-6 are summarized in Table 6.1-7.

Table 6.1-7 Planned TDS Concentrations by Reservoir

Unit: TDS mg/L、Q m^3/day

TDS(mg/l)			Phase 1				
Reservoir	2020	2021	2022	2023	2024	2025	
PK11	1,800	1,861	733	888	866	901	
Bou Merra	2,293	2,243	1,289	1,464	1,344	1,350	
PK10	1,888	1,906	1,215	1,109	1,096	1,119	
PK14	1,822	1,820	1,396	1,283	1,293	1,303	
Sidi Salah EH	1,835	1,810	1,459	1,487	1,378	1,381	
Sidi Salah EB	1,835	1,810	1,459	1,487	1,378	1,381	
Highest TDS	2,293	2,243	1,459	**1,487**	1,378	1,381	< 1,487
Lowest TDS	1,800	1,810	733	888	866	901	
Highest/Lowest	127%	124%	**199%**	168%	159%	153%	< 199%
Desalination Q	0	0	90,000	100,000	100,000	100,000	

TDS(mg/l)	Phase 2-1					
Reservoir	2026	2027	2028	2029	2030	
PK11	709	648	599	587	596	
Bou Merra	1,171	1,102	1,040	1,013	1,003	
PK10	931	868	755	749	795	
PK14	1,126	1,066	863	930	964	
Sidi Salah EH	1,192	1,134	928	1,015	1,042	
Sidi Salah EB	1,192	1,134	928	1,015	1,042	
Highest TDS	**1,192**	1,134	1,040	1,015	1,042	< 1,192
Lowest TDS	709	648	599	587	596	
Highest/Lowest	168%	**175%**	174%	173%	175%	< 175%
Desalination Q	135,000	150,000	180,000	180,000	180,000	

TDS(mg/l)	Phase 2-2					
Reservoir	2031	2032	2033	2034	2035	
PK11	606	643	685	622	661	
Bou Merra	995	1,010	1,032	964	985	
PK10	803	831	860	796	830	
PK14	1,020	1,037	1,052	992	1,012	
Sidi Salah EH	1,089	1,119	1,129	1,072	1,087	
Sidi Salah EB	1,089	1,119	1,129	1,072	1,087	
Highest TDS	1,089	1,119	**1,129**	1,072	1,087	< 1,129
Lowest TDS	606	643	685	622	661	
Highest/Lowest	**180%**	174%	165%	172%	165%	< 180%
Desalination Q	180,000	180,000	180,000	200,000	200,000	

Source: JICA Survey Team

Table 6.1-6 Allocation Plan of Water Sources by Reservoir (Daily Maximum, m^3/day)

Phase	Actual				Pre-Construction								Phase 1				Phase 2									
Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Available Quantity from Water Sources																										
North Water Transmission System	62,208	62,813	70,589	72,144	70,243	95,213	81,648	66,182	50,458	34,819	128,390	102,816	65,059	38,016	86,659	75,082	62,554	46,483	13,651	23,846	29,462	48,902	51,494	56,765	62,294	67,219
Jelma-Sbetla Groundwater Trans. System	29,808	27,994	29,635	19,699	31,450	31,018	30,586	30,154	29,722	29,376	28,858	28,685	21,686	21,514	20,909	20,563	20,390	19,699	19,094	18,749	18,317	17,539	17,194	16,416	15,811	15,206
Groundwater in Greater Sfax	20,563	26,093	19,786	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142	25,142
Total Distribution Volume (m^3/d)	112,752	116,813	120,701	117,158	129,100	133,700	138,400	142,600	147,800	152,600	157,900	163,300	169,500	175,300	181,500	187,900	194,900	201,900	209,200	216,800	224,400	233,200	242,400	251,400	261,000	270,900
PK11 (distribution flow*)	24,125	26,514	28,777	23,802	33,700	36,200	36,500	36,000	36,600	38,900	36,700	36,600	37,300	38,800	41,000	43,100	44,100	45,100	46,500	48,100	49,700	51,100	52,900	54,500	56,700	59,200
Wells	4,048	4,330	4,610	4,373	4,600	4,000	4,600	4,600	4,600	4,600	4,600	4,600	4,222	4,600	4,300	4,300	4,300	4,200	4,300	4,300	4,300	4,300	4,200	4,300	4,300	4,000
North Water	0	0	0	0	0	18,913	4,748	1,272	0	0	17,777	6,256	3,584	27,016	36,386	36,152	19,786	9,285	0	0	-0	7,224	11,293	16,817	13,885	22,785
Jelma-Sbeitla Water	20,077	22,184	24,167	19,229	29,100	13,288	27,152	26,654	25,222	23,876	22,358	21,185	9,045	11,457	-0	6,634	0	2,501	6,285	4,193	5,788	981	3,999	5,469	0	0
Sfax Desalination													90,000	100,000	100,000	100,000	135,000	150,000	180,000	180,000	180,000	180,000	180,000	180,000	200,000	200,000
Mixed Water Transmission													-69,552	-104,273	-99,686	-103,986	-114,986	-120,986	-144,086	-140,393	-140,386	-141,286	-146,686	-154,086	-161,486	-167,886
Total	24,125	26,514	28,777	23,802	33,700	36,200	36,500	32,526	29,822	28,476	44,735	34,041	37,300	38,800	41,000	43,100	44,100	45,100	46,500	48,100	49,700	51,100	52,900	54,500	56,700	59,200
TDS (mg/l)	**1,609**	**1,648**	**1,974**	**2,257**	**1,882**	**1,802**	**1,856**	**1,886**	**1,908**	**1,919**	**1,800**	**1,861**	**733**	**888**	**866**	**901**	**709**	**648**	**599**	**587**	**596**	**606**	**643**	**685**	**622**	**661**
Bou Merra (max. dist. flow*)	4,062	4,651	3,548	4,081	5,100	6,100	7,100	8,100	9,100	10,100	11,100	12,100	13,100	13,800	14,400	15,100	15,900	16,600	17,400	18,100	18,900	19,700	20,600	21,400	22,300	23,100
Wells	4,062	4,651	3,548	4,081	4,600	4,000	3,739	4,600	4,600	4,600	4,600	4,600	3,000	3,500	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
North Water																										
Jelma-Sbeitla Water	0	0	0	0	500	2,100	3,361	3,500	4,500	5,500	6,500	7,500	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mixed Water													10,100	10,300	11,400	12,100	12,900	13,600	14,400	15,100	15,900	16,700	17,600	18,400	19,300	20,100
Total	4,062	4,651	3,548	4,081	5,100	6,100	7,100	8,100	9,100	10,100	11,100	12,100	13,100	13,800	14,400	15,100	15,900	16,600	17,400	18,100	18,900	19,700	20,600	21,400	22,300	23,100
TDS (mg/l)	–	**1,405**	**1,721**	**1,852**	**3,015**	**2,650**	**2,459**	**2,520**	**2,428**	**2,354**	**2,293**	**2,243**	**1,289**	**1,464**	**1,344**	**1,350**	**1,171**	**1,102**	**1,040**	**1,013**	**1,003**	**995**	**1,010**	**1,032**	**964**	**985**
PK10 (max. distribution flow*)	40,845	36,374	42,089	42,824	43,400	44,000	44,600	45,300	45,900	46,500	47,100	47,700	48,300	48,900	49,500	50,100	52,400	54,700	57,100	59,400	61,700	64,000	66,300	68,600	70,900	73,200
Wells	3,918	8,726	8,086	8,401	8,700	8,000	8,700	8,700	8,700	8,700	8,700	8,700	8,400	8,700	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400	8,400
North Water	33,714	26,200	32,985	33,951	32,543	36,000	35,900	20,910	18,300	6,086	38,400	35,650	30,834	6,000	6,000	6,000	6,000	6,000	0	0	6,000	6,000	6,000	6,000	6,000	7,000
Jelma-Sbeitla Water	3,213	1,448	1,018	472	0	0	0	0	0	0	0	0														
Mixed Water													58,452	93,973	88,286	91,386	102,086	107,386	129,686	125,293	124,486	124,586	129,086	135,686	142,186	147,786
Mixed Water Transmission												0	-49,386	-59,773	-53,186	-50,186	-64,086	-67,086	-80,986	-74,293	-77,186	-74,986	-77,186	-81,486	-85,686	-89,986
Total	40,845	36,374	42,089	42,824	41,243	44,000	44,600	29,610	27,000	14,786	47,100	44,350	48,300	48,900	49,500	50,100	52,400	54,700	57,100	59,400	61,700	64,000	66,300	68,600	70,900	73,200
TDS (mg/l)	**1,404**	**1,525**	**1,779**	**2,133**	**1,929**	**1,884**	**1,904**	**2,058**	**2,103**	**2,518**	**1,888**	**1,906**	**1,215**	**1,109**	**1,096**	**1,119**	**931**	**868**	**755**	**749**	**795**	**803**	**831**	**860**	**796**	**830**
PK14 (max. distribution flow*)	29,515	34,971	35,404	31,200	31,500	31,800	32,000	32,300	32,800	32,900	33,100	33,400	33,700	34,000	34,300	34,600	34,900	35,200	35,400	35,700	36,000	37,400	38,800	40,300	41,700	43,100
Wells	4,728	4,287	3,834	3,805	4,700	3,800	4,700	4,700	4,700	4,700	4,700	4,700	3,800	4,700	3,800	3,800	3,800	3,800	3,800	3,800	3,800	3,800	3,800	3,800	3,800	3,800
North Water	18,270	26,286	27,091	27,395	26,800	28,000	27,300	27,600	17,058	13,033	28,400	28,700	11,000	5,000	11,000	11,000	10,000	10,000	0	7,493	7,500	14,000	14,000	14,000	14,000	14,000
Jelma-Sbeitla Water	6,517	4,398	4,479	0	0	0	0	0	0	0	0	0														
Mixed Water													49,386	59,773	53,186	56,186	64,086	67,086	80,986	74,293	77,186	74,986	77,186	81,486	85,686	89,986
Mixed Water Transmission													-30,486	-35,473	-33,686	-36,386	-42,986	-45,686	-49,386	-49,886	-52,486	-55,386	-56,186	-58,986	-61,786	-64,686
Total	29,515	34,971	35,404	31,200	31,500	31,800	32,000	32,300	21,758	17,733	33,100	33,400	33,700	34,000	34,300	34,600	34,900	35,200	35,400	35,700	36,000	37,400	38,800	40,300	41,700	43,100
TDS (mg/l)	**1,460**	**1,509**	**1,702**	**2,256**	**1,833**	**1,786**	**1,829**	**1,827**	**1,937**	**2,013**	**1,822**	**1,820**	**1,396**	**1,283**	**1,293**	**1,303**	**1,126**	**1,066**	**863**	**930**	**964**	**1,020**	**1,037**	**1,052**	**992**	**1,012**
Sidi Salah EH (max dist. flow*)	14,088	14,471	13,817	15,248	15,400	15,600	15,700	15,900	16,100	16,200	16,400	16,500	16,700	17,100	17,400	17,800	17,800	17,900	17,900	18,000	18,000	18,800	19,600	20,300	21,100	21,900
Wells	3,838	4,111	3,267	4,488	4,500	3,300	4,500	4,500	4,500	4,500	4,500	4,500	614	4,327	614	614	614	614	614	614	614	614	614	614	614	614
North Water	10,250	10,360	10,550	10,760	10,900	12,300	13,700	16,400	15,100	15,700	25,400	29,000	6,000	0	8,000	8,000	4,000	4,000	2,800	5,000	5,000	5,000	7,000	7,000	7,000	7,000
Jelma-Sbeitla Water																										
Mixed Water													30,486	35,473	33,686	36,386	42,986	45,686	49,386	49,886	52,486	55,386	56,186	58,986	61,786	64,686
Mixed Water Transmission							-2,500	-5,000	-7,500	-10,000	-13,500	-17,000	-20,400	-22,700	-24,900	-27,200	-29,800	-32,400	-34,900	-37,500	-40,100	-42,200	-44,200	-46,300	-48,300	-50,400
Total	14,088	14,471	13,817	15,248	15,400	15,600	15,700	15,900	12,100	10,200	16,400	16,500	16,700	17,100	17,400	17,800	17,800	17,900	17,900	18,000	18,000	18,800	19,600	20,300	21,100	21,900
TDS (mg/l)	–	**1,643**	**1,939**	**1,860**	**2,056**	**1,930**	**1,986**	**1,936**	**1,958**	**1,948**	**1,835**	**1,810**	**1,459**	**1,487**	**1,378**	**1,381**	**1,192**	**1,134**	**928**	**1,015**	**1,042**	**1,089**	**1,119**	**1,129**	**1,072**	**1,087**
Sidi Salah EB (max. dist. flow*)							2,500	5,000	7,500	10,000	13,500	17,000	20,400	22,700	24,900	27,200	29,800	32,400	34,900	37,500	40,100	42,200	44,200	46,300	48,300	50,400
Wells																										
North Water																										
Jelma-Sbeitla Water																										
Mixed Water (thru SS EH)							2,500	5,000	7,500	10,000	13,500	17,000	20,400	22,700	24,900	27,200	29,800	32,400	34,900	37,500	40,100	42,200	44,200	46,300	48,300	50,400
Total							2,500	5,000	7,500	10,000	13,500	17,000	20,400	22,700	24,900	27,200	29,800	32,400	34,900	37,500	40,100	42,200	44,200	46,300	48,300	50,400
TDS (mg/l)							**1,986**	**1,936**	**1,958**	**1,948**	**1,835**	**1,810**	**1,459**	**1,487**	**1,378**	**1,381**	**1,192**	**1,134**	**928**	**1,015**	**1,042**	**1,089**	**1,119**	**1,129**	**1,072**	**1,087**

Source: JICA Survey Team

6-11

The development plan of facilities till 2035 is as follows. Facilities which are underlined are those to be developed in Phase 1 of the Project. *Facilities written in Italic are those to be developed outside of the Project.* In the plan, the Seawater Desalination Plant, Saida reservoir, and Kalaa Kebira reservoir and water treatment plant are planned to be developed based on SONEDE's plan.

1) 2022: Just after start of operating Sfax Seawater Desalination Plant (Phase 1)

The Sfax Seawater Desalination Plant will be commissioned in 2022. Receiving/mixing chambers, reservoir, transmission pipeline, transmission pup station, etc. shall be ready to be operated before completion of the plant. Those facilities will be subject for JICA ODA loan.

Besides of facilities stated above, the project for Saida reservoir, Kalaa Kebira reservoir and Water Treatment Plant shall be implemented to start operation in 2020.

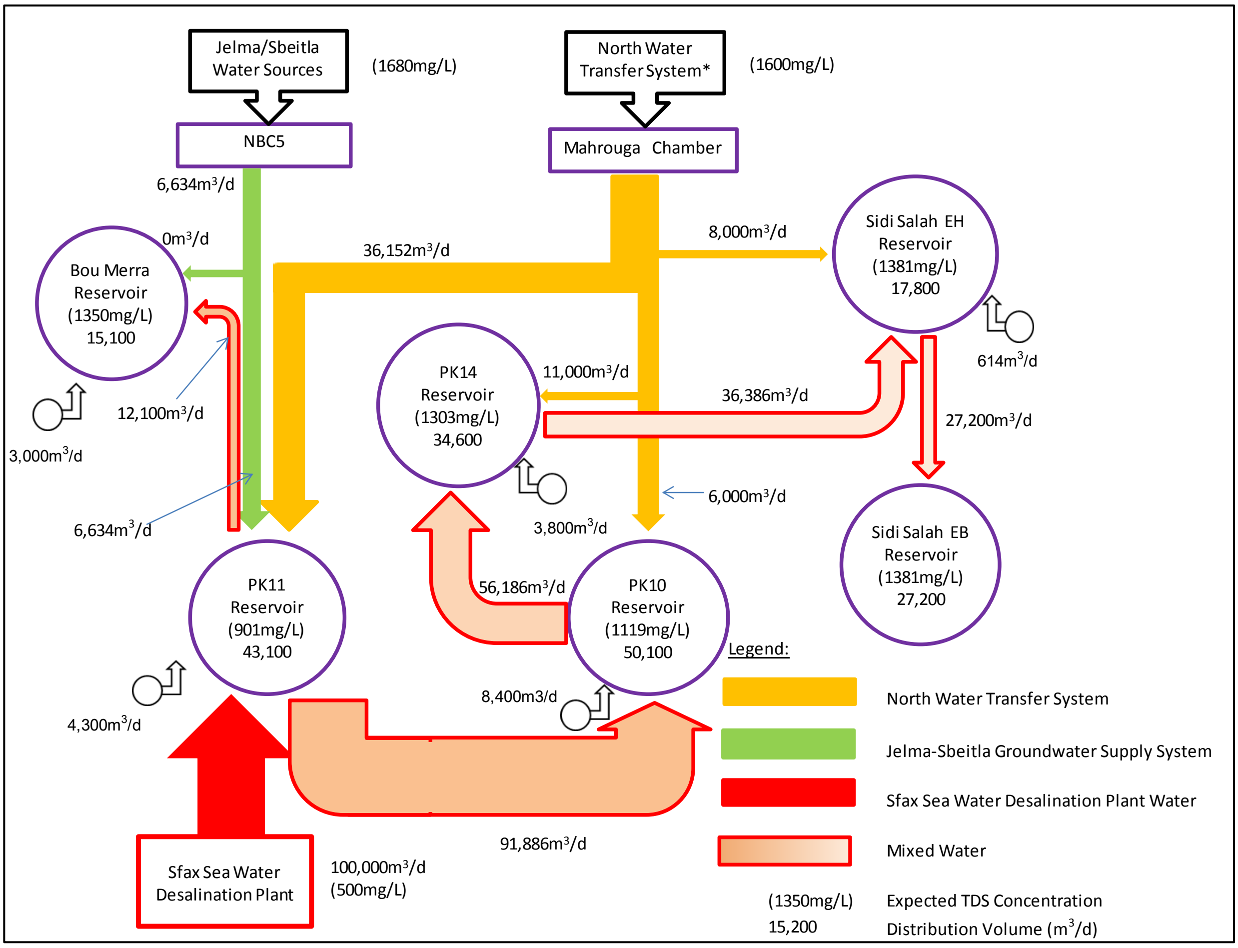
- *in 2020: Inauguration of Saida Reservoir, and Kalaa Kebira Reservoir and Water Treatment Plant (capacity; 1,500 L/sec = 129,600 m^3/d)*
- in 2022: Start of operation of Phase 1 of Seawater Desalination Plant in Sfax (capacity; 100,000m^3/d)
- in 2022: Start of operation of the transmission pipelines from the desalination plant to the 5 reservoirs, i.e. PK11, Bou Merra, PK10, PK14, and Sidi Salah EH.
- by 2022: Capacity augmentation of 5,000m^3 at Bou Merra (total capacity; 6,500m^3)

2) 2022 to 2025: Target year of Phase 1 for Sfax Seawater Desalination Plant Construction Project, Preparation of Phase 2 project (See Figure 6.1-3)

Since the Sfax Seawater Desalination Plant Phase 1 facility can supply water to meet demand till 2025, period of Phase 1 of the project is set till 2025. The Sfax Seawater Desalination Plant Phase 2 shall be prepared for its implementation. Reservoirs shall be augmented during this period.

Besides of above, the Kalaa Kebira Water Treatment Plant shall be augmented. Its surplus water will be supplied to the Greater Sfax through the North water transmission system.

- *by 2024: Capacity augmentation of Kalaa Kebira Water Treatment Plant (total capacity; 3,000L/sec = 259,200m^3/d)*
- by the end of 2025: Capacity augmentation of 100,000m^3/d at Sfax Sea Water Desalination Plant (total capacity; 200,000m^3/d. It is necessary to examine phased augmentation.)
- by the end of 2025: Capacity augmentation of 2,500m^3 at Bou Merra (total capacity; 9,000m^3)
- by the end of 2025: Capacity augmentation of 5,000m^3 at PK10 (total capacity; 25,000m^3)
- by the end of 2025: Capacity augmentation of 5,000m^3 at PK14 (total capacity; 15,000m^3)
- by the end of 2025: Capacity augmentation of 10,000m^3 at Sidi Salah EB (total capacity; 15,000m^3)



Source: JICA Survey Team

Figure 6.1-3 Desalinated Water Supply Plan in Greater Sfax (Year 2025)

3) 2026 to 2030: Just before start of operating the Sahel Seawater Desalination Plant

Augmentation of the Sfax Seawater Desalination Plant is required by 2026. Phase 2 period of the project is set after 2026. Since there is 10years before target year of 2035, required facilities during first 5 years are shown below. During this period, reservoirs shall be augmented to cope with the water demand increase,

Besides of above, the Kalaa Kebira Water Treatment Plant shall be augmented and completed. Further, preparation of the Sahel Seawater Desalination Plant project shall be conducted,

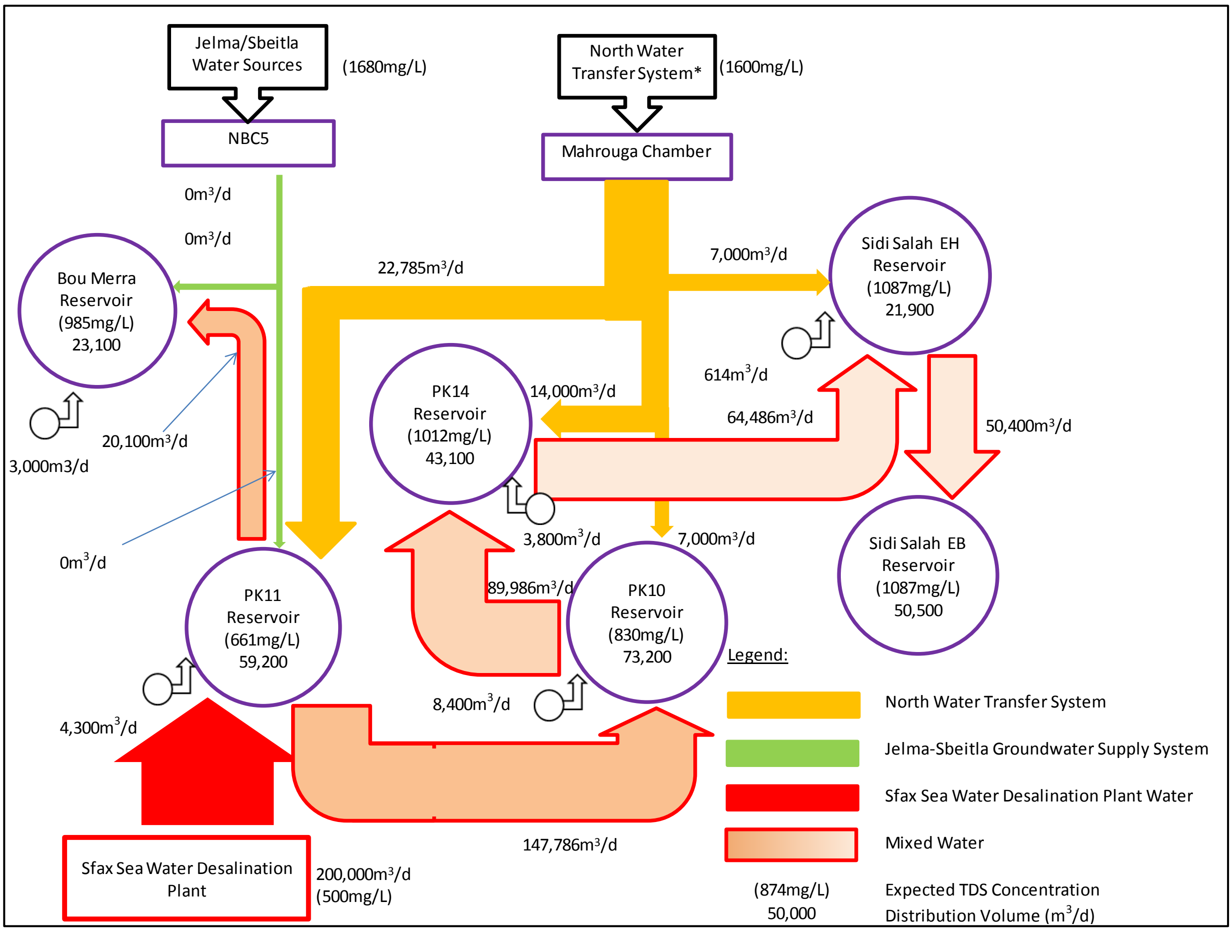
- *by 2029: Capacity augmentation of Kalaa Kebira Water Treatment Plant (total capacity; 4,000L/sec = 345,600 m^3/d)*
- by 2030: Capacity augmentation of 5,000m^3 at PK10 (total capacity; 30,000m^3)
- by 2030: Capacity augmentation of 5,000m^3 at Sidi Salah EB (total capacity; 20,000m^3)

4) 2031 to 2035: Target year of this survey (See Figure 6.1-4)

This period is the latter half of Phase 2 period. During this period reservoirs shall be augmented to cope with the water demand increase,

Besides of above, augmentation of the Sahel Seawater Desalination Plant shall be conducted,

- *by 2031:* Inauguration *of Sahel Sea Water Desalination Plant (capacity; 50,000m^3/d)*
- by 2032: Capacity augmentation of 2,500m^3 at PK14 (total capacity; 17,500m^3)
- by 2032: Capacity augmentation of 2,500m^3 at Sidi Salah EH (total capacity; 10,000m^3)
- by 2033: Capacity augmentation of 2,500m^3 at PK11 (total capacity; 24,500m^3)
- *by 2035: Sequential capacity augmentation of 200,000m^3/d at Sahel Sea Water Desalination Plant (total capacity; 250,000m^3/d)*



Source: JICA Survey Team

Figure 6.1-4 Desalinated Water Supply Plan in Greater Sfax (Year 2035)

In this water transfer network plan regarding the seawater desalination plant, facilities constructed in Phase 1 and Phase 2 will be operated from 2022 and 2026, respectively, considering procedures required for Japanese Yen Loan Project. Between 2022 and 2026, and after 2026, an expansion or new installation of reservoirs and desalination plant shall be implemented. The expansion of Bou Merra Reservoir is required by 2021. Therefore, Phase 1 of the Project, in which facilities to be installed under Japanese Yen

Loan Project, will consists of; i) Phase 1 facility of Sfax sea water desalination plant, ii) transmission pipelines from the desalination plant to reservoirs, iii) receiving/mixing chambers receiving the desalinated water or mixed water, iv) a reservoir, v) pumping facilities transmitting the desalinated water to each reservoir, and auxiliary facilities required at facilities mentioned in i) to v). With regard to distribution pipelines, it was judged that enhancement of distribution pipelines is not necessary in Phase 1 of the Project because development of distribution pipelines has been implemented in accordance with the Plan of Distribution Networks and Distribution in Greater Sfax and the distribution the plan in this survey followed the said plan in principle.

The years mentioned in the plan are based on the SONEDE's Plan subject to change in accordance with the Project implementation schedule to be established.

6.2 Water Transmission Facilities

(1) Transmission Pump

The transmission pumps, transmitting the desalinated water reserved at the product water tank to reservoirs, are installed at the pump house of the sea water desalination plant. In Phase 1, 3 pumps (2 for regular use, 1 for standby) capable of transmitting a volume of 100,000 m^3/d are to be installed.

In the pump house, a space for installation of pumps in Phase 2 is reserved. The size of the space is the same as Phase 1 due to the same volume of the transmission. In consideration of energy efficiency avoiding the replacement of pumps, two pumps for Phase 1 are selected from variable-speed drive (VSD) type.

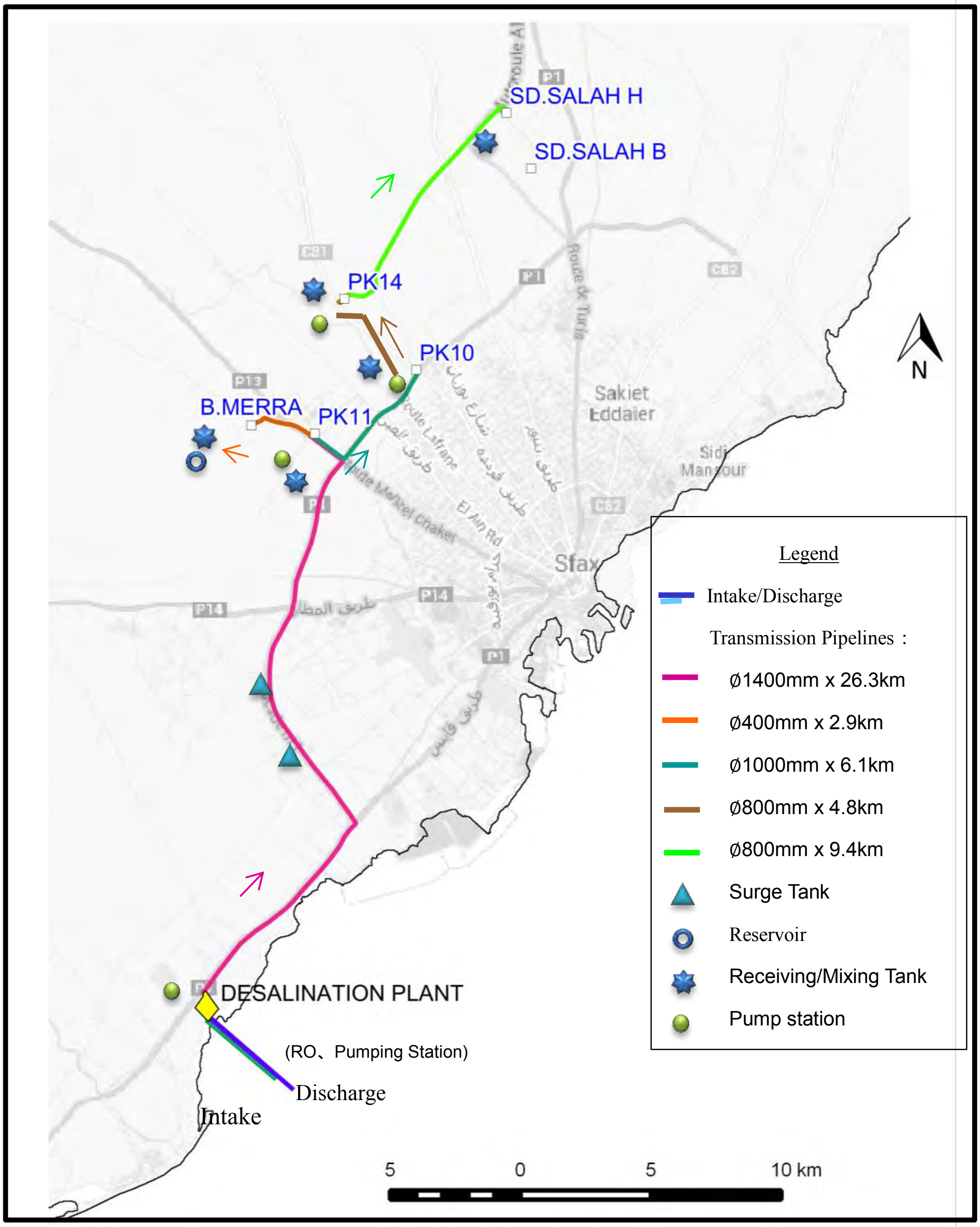
After reviewing the elevation of the desalination plant and each reservoir, the volume of the water transmission, and the diameters of the transmission pipeline, the specification of the pumps are selected as follows:

- Transmission Pumps
  Phase 1: flow rate; 34.8m^3/min/pump, total head; 95m, output; 800kW x 2 pumps (＋1 pump for standby), total 3pumps (2pump: variable-speed drive (VSD))
  Phase 2: flow rate; 34.8m^3/min/pump, total head; 95m, output; 800kW x 2 pumps (＋1 pump for standby), total 3pumps (2pumps: variable-speed drive (VSD))

(2) Transmission Pipeline

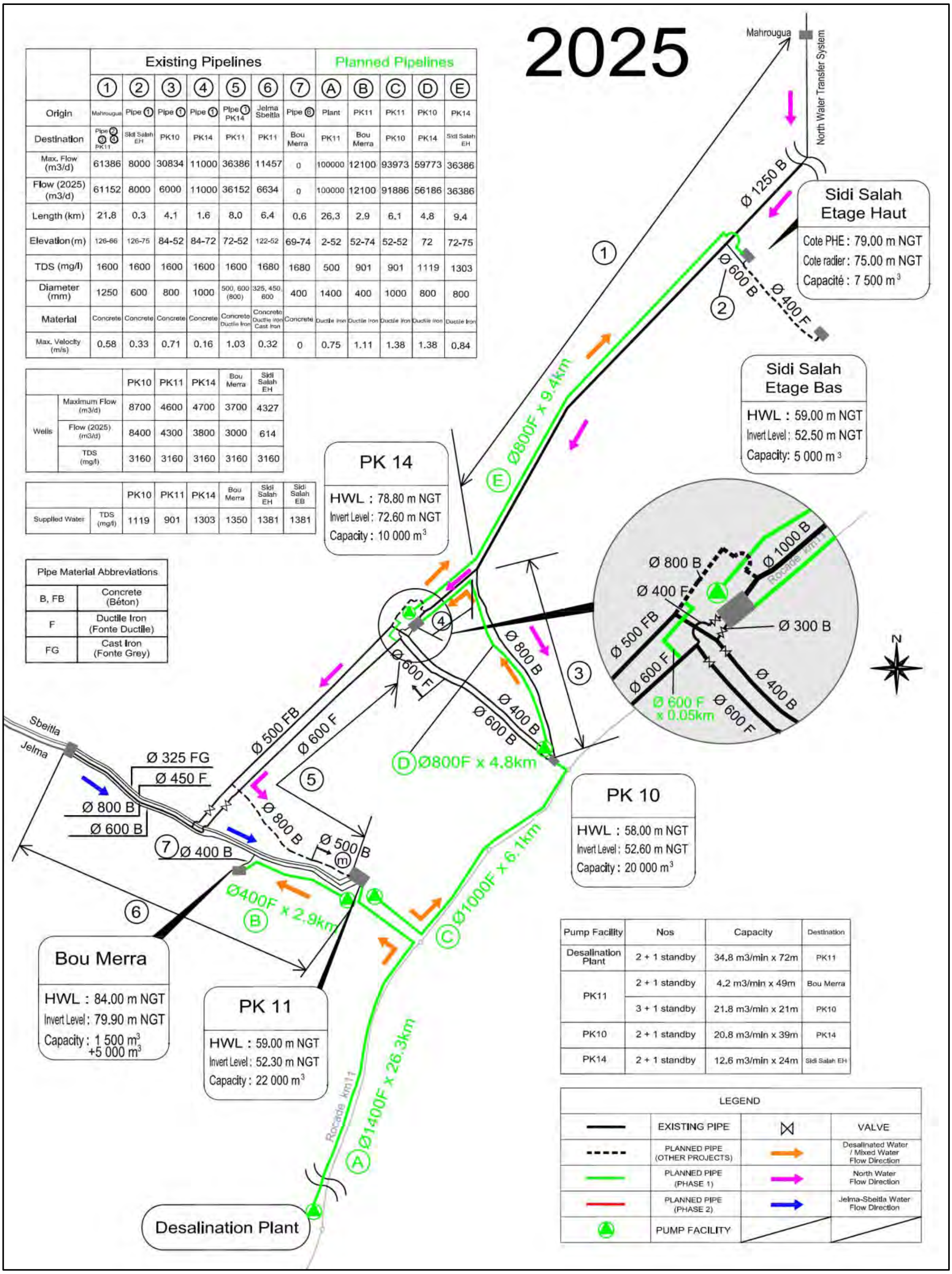
The transmission pipeline will be installed to transmit the desalinated water and mixed water; i) from the transmission pump facility at the Sfax Seawater Desalination Plant to the PK11 Reservoir, ii) from the PK11 Reservoir to the Bou Merra Reservoir, iii) from the PK11 Reservoir to the PK10 Reservoir, iv) from the PK10 Reservoir to the PK14 Reservoir, and v) the PK14 Reservoir to the Sidi Salah EH Reservoir. The transmitted water in the pipeline is the water desalinated at the plant or a mixture of the desalinated water and water from the existing water source. The transmission pipeline route is along the national roads from the desalination plant to the PK10 and the PK11 Reservoirs, along the local roads from the PK11 to the Bou Merra Reservoir, and along the water pipeline land owned by SONEDE from the PK10 to the PK14 Reservoir, and from the PK14 to the Sidi Salah EH Reservoir.

The transmission pipeline route is shown in Figures 6.2-1 to 6.2-3. Diameters of the pipelines were decided considering transmitted flow and pump head as presented in Table 6.2-1.



Note：There is a possibility that a part of the pipelines are eliminated from the project.
Source：The JICA Survey Team

Figure 6.2-1 Transmission Pipeline Route



	Existing Pipelines							Planned Pipelines				
	①	②	③	④	⑤	⑥	⑦	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
Origin	Mahrougua	Pipe ①	Pipe ①	Pipe ①	Pipe ① PK14	Jelma Sbeitla	Pipe ⑥	Plant	PK11	PK11	PK10	PK14
Destination	Pipe ② ③ ④ PK11	Sidi Salah EH	PK10	PK14	PK11	PK11	Bou Merra	PK11	Bou Merra	PK10	PK14	Sidi Salah EH
Max. Flow (m3/d)	61386	8000	30834	11000	36386	11457	0	100000	12100	93973	59773	36386
Flow (2025) (m3/d)	61152	8000	6000	11000	36152	6634	0	100000	12100	91886	56186	36386
Length (km)	21.8	0.3	4.1	1.6	8.0	6.4	0.6	26.3	2.9	6.1	4.8	9.4
Elevation (m)	126-66	126-75	84-52	84-72	72-52	122-52	69-74	2-52	52-74	52-52	72	72-75
TDS (mg/l)	1600	1600	1600	1600	1600	1680	1680	500	901	901	1119	1303
Diameter (mm)	1250	600	800	1000	500, 600 (800)	325, 450, 600	400	1400	400	1000	800	800
Material	Concrete	Concrete	Concrete	Concrete	Concrete Ductile Iron	Concrete Ductile Iron Cast Iron	Concrete	Ductile Iron	Ductile Iron	Ductile Iron	Ductile Iron	Ductile Iron
Max. Velocity (m/s)	0.58	0.33	0.71	0.16	1.03	0.32	0	0.75	1.11	1.38	1.38	0.84

		PK10	PK11	PK14	Bou Merra	Sidi Salah EH
Wells	Maximum Flow (m3/d)	8700	4600	4700	3700	4327
	Flow (2025) (m3/d)	8400	4300	3800	3000	614
	TDS (mg/l)	3160	3160	3160	3160	3160

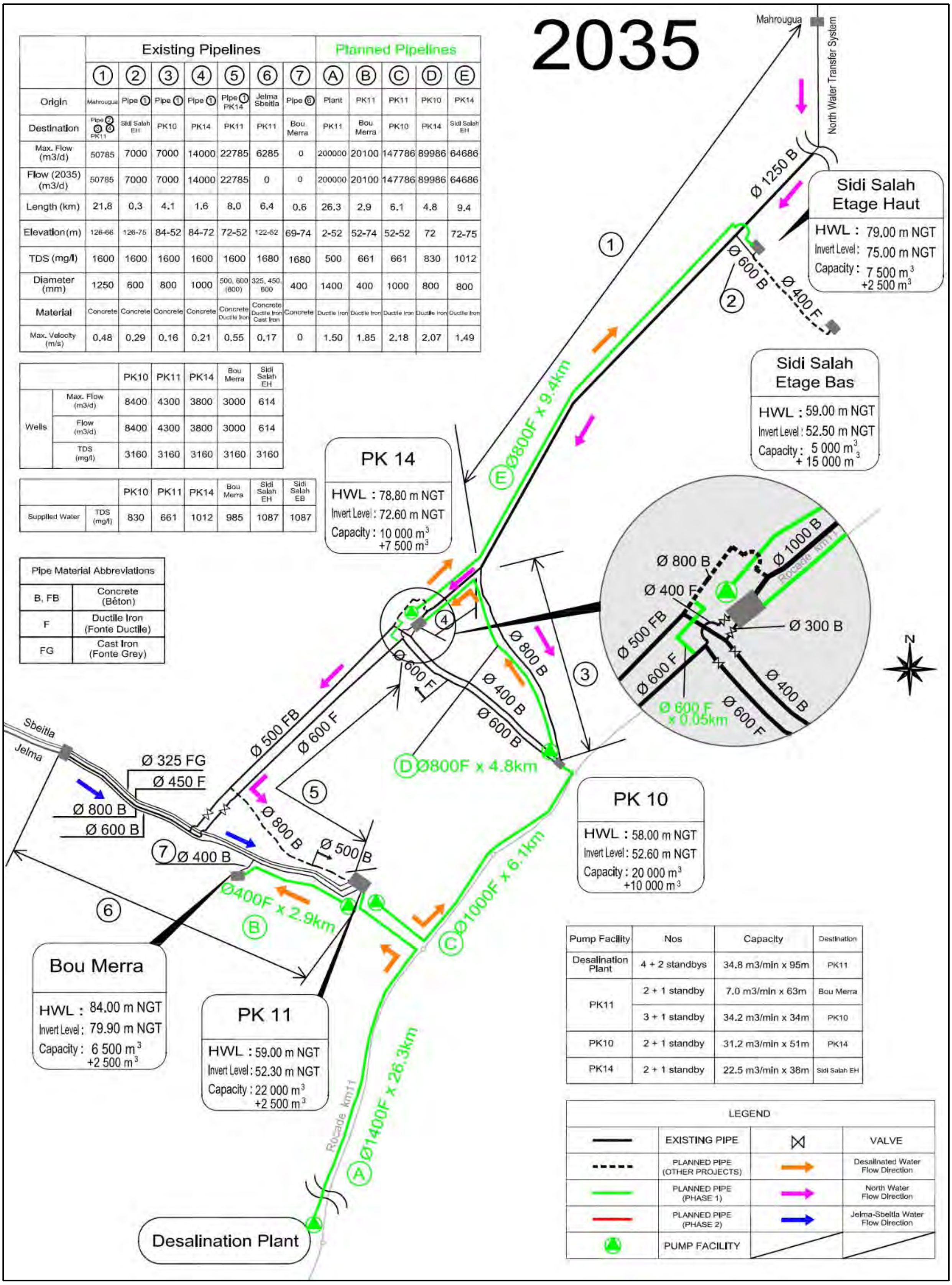
		PK10	PK11	PK14	Bou Merra	Sidi Salah EH	Sidi Salah EB
Supplied Water	TDS (mg/l)	1119	901	1303	1350	1381	1381

Pipe Material Abbreviations	
B, FB	Concrete (Béton)
F	Ductile Iron (Fonte Ductile)
FG	Cast Iron (Fonte Grey)

Pump Facility	Nos	Capacity	Destination
Desalination Plant	2 + 1 standby	34.8 m3/min x 72m	PK11
PK11	2 + 1 standby	4.2 m3/min x 49m	Bou Merra
	3 + 1 standby	21.8 m3/min x 21m	PK10
PK10	2 + 1 standby	20.8 m3/min x 39m	PK14
PK14	2 + 1 standby	12.6 m3/min x 24m	Sidi Salah EH

Source：The JICA Survey Team

Figure 6.2-2 Water Transmission Plan (Phase 1)



	Existing Pipelines							Planned Pipelines				
	①	②	③	④	⑤	⑥	⑦	Ⓐ	Ⓑ	Ⓒ	Ⓓ	Ⓔ
Origin	Mahrougua	Pipe ①	Pipe ①	Pipe ①	Pipe ① PK14	Jelma Sbeitla	Pipe ⑥	Plant	PK11	PK11	PK10	PK14
Destination	Pipe ② ③ ④ PK11	Sidi Salah EH	PK10	PK14	PK11	PK11	Bou Merra	PK11	Bou Merra	PK10	PK14	Sidi Salah EH
Max. Flow (m3/d)	50785	7000	7000	14000	22785	6285	0	200000	20100	147786	89986	64686
Flow (2035) (m3/d)	50785	7000	7000	14000	22785	0	0	200000	20100	147786	89986	64686
Length (km)	21.8	0.3	4.1	1.6	8.0	6.4	0.6	26.3	2.9	6.1	4.8	9.4
Elevation (m)	126-66	126-75	84-52	84-72	72-52	122-52	69-74	2-52	52-74	52-52	72	72-75
TDS (mg/l)	1600	1600	1600	1600	1600	1680	1680	500	661	661	830	1012
Diameter (mm)	1250	600	800	1000	500, 600 (800)	325, 450, 600	400	1400	400	1000	800	800
Material	Concrete	Concrete	Concrete	Concrete	Concrete Ductile Iron	Concrete Ductile Iron Cast Iron	Concrete	Ductile Iron	Ductile Iron	Ductile Iron	Ductile Iron	Ductile Iron
Max. Velocity (m/s)	0.48	0.29	0.16	0.21	0.55	0.17	0	1.50	1.85	2.18	2.07	1.49

		PK10	PK11	PK14	Bou Merra	Sidi Salah EH
Wells	Max. Flow (m3/d)	8400	4300	3800	3000	614
	Flow (m3/d)	8400	4300	3800	3000	614
	TDS (mg/l)	3160	3160	3160	3160	3160

		PK10	PK11	PK14	Bou Merra	Sidi Salah EH	Sidi Salah EB
Supplied Water	TDS (mg/l)	830	661	1012	985	1087	1087

Pipe Material Abbreviations	
B, FB	Concrete (Béton)
F	Ductile Iron (Fonte Ductile)
FG	Cast Iron (Fonte Grey)

Pump Facility	Nos	Capacity	Destination
Desalination Plant	4 + 2 standbys	34.8 m3/min x 95m	PK11
PK11	2 + 1 standby	7.0 m3/min x 63m	Bou Merra
	3 + 1 standby	34.2 m3/min x 34m	PK10
PK10	2 + 1 standby	31.2 m3/min x 51m	PK14
PK14	2 + 1 standby	22.5 m3/min x 38m	Sidi Salah EH

LEGEND			
(black line)	EXISTING PIPE	⋈	VALVE
(dashed line)	PLANNED PIPE (OTHER PROJECTS)	(orange arrow)	Desalinated Water Flow Direction
(green line)	PLANNED PIPE (PHASE 1)	(magenta arrow)	North Water Flow Direction
(red line)	PLANNED PIPE (PHASE 2)	(blue arrow)	Jelma-Sbeitla Water Flow Direction
(pump symbol)	PUMP FACILITY		

Source：The JICA Survey Team

Figure 6.2-3 Water Transmission Plan (Phase 2)

Table 6.2-1 Diameters of Transmission Pipelines

Section	Distance (km)	Flow (m^3/d)*	Diameter (mm)
Desalination Plant—PK11	26.3	200,000	1400
PK11—Bou Merra	2.9	20,100	400
PK11—PK10	6.1	147,786	1000
PK10—PK14	4.8	89,986	800
PK14—Sidi Salah EH	9.4	64,686	800

*: Maximum flow till 2035
Source: JICA Survey Team

There are instances of rivers crossing the pipeline route. However, there is no water in the rivers during dry season. The pipeline is to be installed by the open-cut method, which SONEDE has employed in the installation of the existing transmission pipelines. A water pipe bridge is not being installed. There is one place on the pipeline route which is crossed by a railway line, and there are five places crossed by the national highways. At these places, a trenchless method will be applied. Basic concepts of installing the transmission pipeline are being planned according to the following conditions.

1) Earth covering: 1m

2) Excavation will be made without retaining walls. Excavation width will be 0.3 m on each side plus outer diameter of pipe. Slope of excavation will be 1:0.5.

3) Sand base of 0.2m thick as a pipe base will be applied.

4) Cutting pavement is not permitted by the road management authority. Pipes are therefore to be installed under non-paved road shoulders or on property of the road authority off the roadway. In case of crossing paved road, trenchless method is applied.

Pipe materials were studied as shown in Table 6.2-2. As a result, ductile iron pipe is selected for the present project.

Table 6.2-2 Pipe Materials for Transmission Pipeline

Material	Advantage	Disadvantage	Applicability to the project
Concrete Pipe	- rigid structure having a high strength against external pressure - many experiences in Tunisia - inexpensive for local product	- relatively heavy - relatively low workability	- less reliability against connection and breaking. - not recommendable for a transmission pipeline subject to hydraulic pressure
Cast Iron Pipe	- high resistance against corrosion - many experiences in Tunisia - little less cost for materials and installation than steel pipe	- fragile against impact - relatively heavy - requirement of special fitting protection for some types of joints	- not recommendable from the viewpoint of sustaining pipe body during and after installation
Ductile Iron Pipe	- high resistance against corrosion - high strength, high ductility, and resistant to impact	- relatively heavy - requirement of special fitting protection for some types of joints	- flexible mechanical joints, capable of absorb ground deformation by chain-structure

Material	Advantage	Disadvantage	Applicability to the project
	- high durability - able to absorb large expansion, contraction, and ground deformation - high workability - less expensive than steel pipe in terms of pipe material and installation cost		- recommended for the project.
Steel Pipe	- high strength, high ductility, and resistant to impact - high durability - able to unify by welding, and absorb a certain range of ground deformation	- requirement of special techniques for welded joints - consideration for electric corrosion - easier to corrode if anticorrosion surface is damaged - more expensive than ductile iron pipe in terms of pipe material and installation cost	- not recommended for the project because of requirement of special techniques for welding with no local experience, and risk of corrosion by high salinity in ground
Unplasticized Polyvinyl Chloride Pipe	- high resistance against corrosion - light weight, high workability - non-changed roughness on inner surface	- less strength than the other type of pipe - less durability against heat and ultraviolet ray - requirement of special fitting protection for some types of joints - no large diameter product	- less strength than the other type of pipe - not recommended for a large diameter transmission pipeline because of high hydraulic pressure and its importance
High-density Polyethylene Pipe	- high resistance against corrosion - light weight, high workability - able to unify by welding, able to absorb ground deformation by material flexibility - non-changed roughness on inner surface	- less strength than the other type of pipe - low durability against heat and ultraviolet ray - difficult to unify by welding in rainy weather and on spring ground - careful workmanship is needed for installation.	- requirement of controllers and special tools for welding - not recommended due to difficulty in maintenance for characteristic of joint

Source: JICA Survey Team

(3) Intermediate Pumping Stations

It is necessary to install the intermediate pumping stations at PK10, PK11, and PK14 for transmission; i) from PK11 to Bou Merra, ii) from PK11 to PK10, iii) from PK10 to PK14, and iv) from PK14 to Sidi Salah EH. The number of pumps and pumps with a function of VSD in Phase 1 and Phase 2 is determined in consideration of the water transmission network plan and the pump characteristics. Since Phase 2 is expected to be implemented 5 years later after completion of Phase 1 project, it is considered that pumps installed in Phase 1 shall also be used in Phase 2. Table 6.2-3 presents the selected pumps including the transmission pump mentioned previously.

Table 6.2-3 Intermediate Pumping Stations

Pump station	Flow rate (m^3/d,max)	Flow rate (m^3/min/unit)	Total head (m)	Output (kW/unit)	Phase 1 Number (standby)	Phase 1 VSD	Phase 2 Number (standby)	Phase 2 VSD
Desalination plant — PK11	100,000	34.8	(72)	(600)	3(1)	2	-	-
	200,000	34.8	95	800	3(1)	2	3(1)	2
PK11 — Bou Merra	12,100	4.2	(49)	(75)	3(1)	2	-	-
	20,100	7.0	63	132	3(1)	2	-	-
PK11 — PK10	93,973	21.8	(21)	(160)	4(1)	3	-	-
	147,786	34.2	34	355	4(1)	3	-	-
PK10 — PK14	59,773	20.8	(39)	(250)	3(1)	2	-	-
	89,986	31.2	51	450	3(1)	2	-	-
PK14 — Sidi Salah EH	36,386	12.6	(24)	(110)	3(1)	2	-	-
	64,686	22.5	38	250	3(1)	2	-	-

Legend: Upper line: Phase 1, Lower line: Phase 2
Source： JICA Survey Team

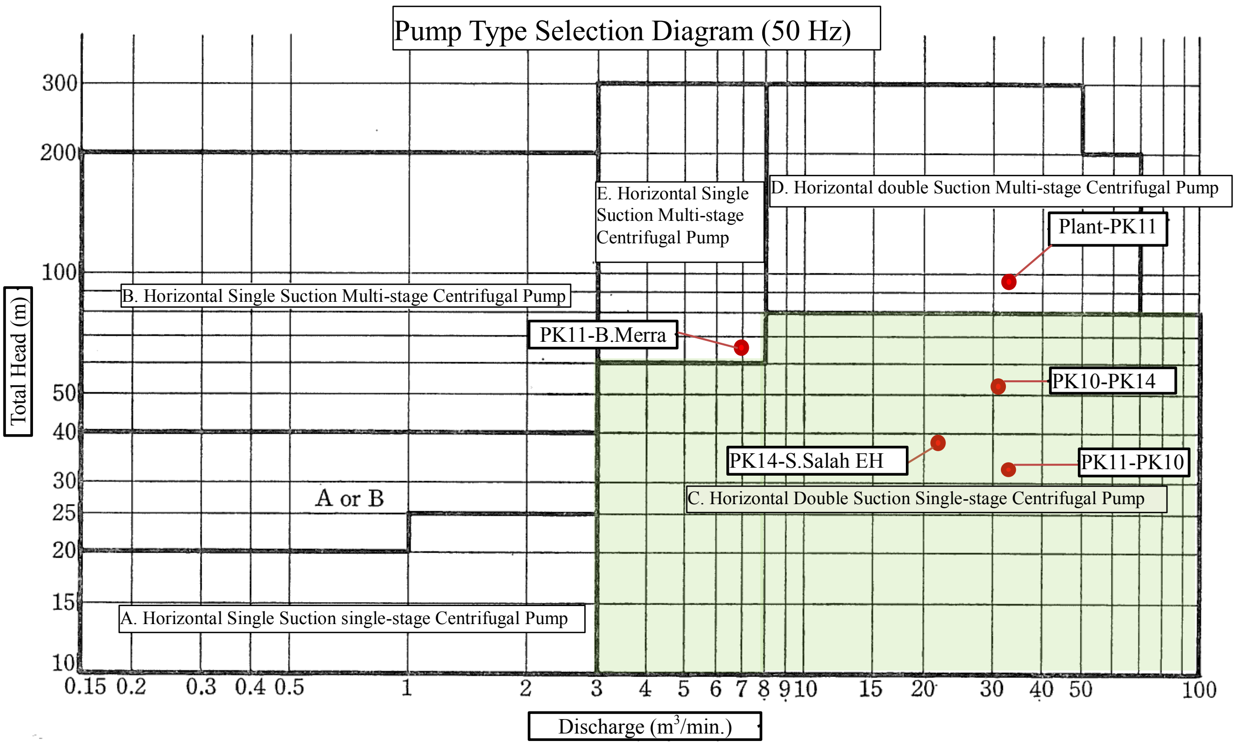
Basic specification of the pump is selected in consideration of a condition of water transmission and the existing pump facilities. The following is the specifications applied.

a) Type of pump: Horizontal separable casing, double suction single stage volute pump
Characteristics: Suitable for transmitting a large quantity of water. This type of pump can accommodate high total head because of volute casing and centrifugal impeller. Selection diagram of this type is presented in Figure 6.2-4. The diagram indicates pumps for transmission to PK11 and Bou Merra are out of range of this type. Based on the information of pump manufacturers, it was found that said type is also applicable for both pumps. Advantages of this pump type are as follows:

- Removal of casing and rotor is easy and therefore, maintenance work is easy.
- Less equipment cost than multi-stage type.
- Less equipment cost than vertical type.
- Civil and architectural work is easier and less cost than those of vertical type.
- Easier installation work than vertical type

b) Main material of pump:
Impeller: Austenite stainless steel
Characteristic: widely used for the impeller with corrosion resistance and good machinability
Shaft: Martensitic stainless steel
Characteristic: suitable to use for motor and the shaft of the pump that require high strength due to higher strength than austenite stainless steel
Casing: Cast iron
Characteristic: suitable for pump casing due to good machinability and wear resistance

c) Power: squirrel-cage induction motor
Characteristic: used for general type of pumps, suitable for operating variable speed drive (VSD)



Source: Guidelines for Design of Water Works

Figure 6.2-4 High Head Centrifugal Pump Selection Diagram (50Hz)

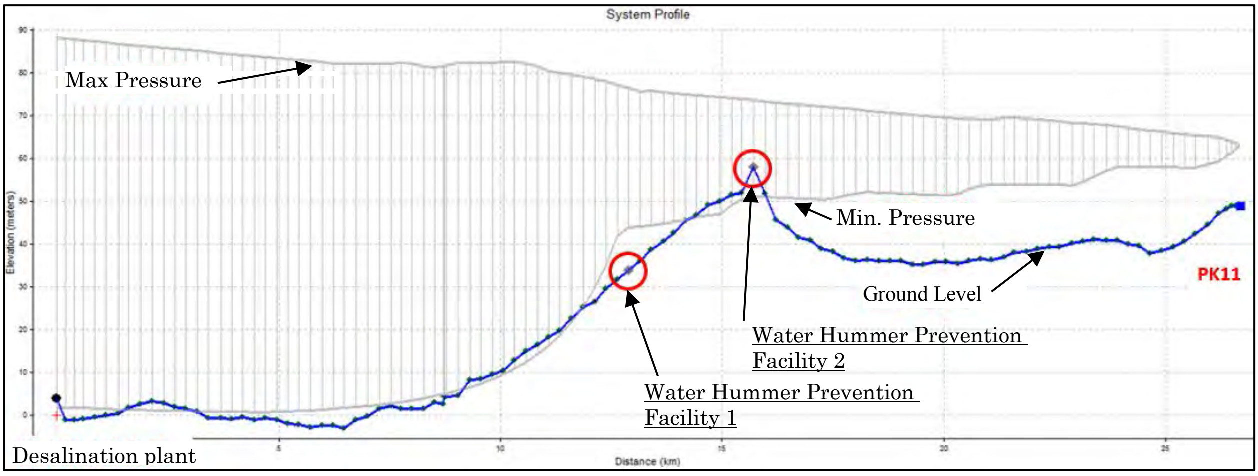
d) Painting of casing inner surface: Painting material, certified for potable water, shall be applied.

e) Operation: VSD, control for operating number of pumps, intermittent operation
Characteristic: Transmission volume largely varies from 2022 to 2035. For applications of the operations above, the same pumps can be utilized from 2022 to 2035. In addition, the energy consumption can be reduced.

(4) Measures against Water Hammer

Water hammer phenomenon might occur in the transmission pipeline in the event of shutoff of the transmission pumps at the desalination plant due to power interruptions and blackouts etc., especially as a large amount of water is transmitted to the inland reservoirs with a high water level of 59 m through pumping. Measures against the water hammer phenomenon will be necessary because it could damage the pipeline.

According to the results of a water hammer analysis based on the topographical survey results, measures against the water hammer phenomenon are needed to be installed at approximately 13kilometres and 16kilometres away from the desalination plant. The result of water hammer analysis is shown in Figure 6.2-5. Red coloured circles shown on the figure indicate the locations where the measures against the effect of water hammer phenomenon are needed. There are several types of water hammer prevention measures; i.e. flywheel, surge tank, one-way surge tank, air chamber, and so on. In this case a one-way surge tank[4] will be adopted. At a minimum, a cylindrical tank with a diameter of 10metres and a water depth of 15metres will be needed at the respective sites. Each site will therefore require a land with a space of approximately 20m x 30m wide, and it will has to be adjacent to the pipeline route. Figures 6.2-6 and 6.2-7 show the outlines of the one-way surge tank.

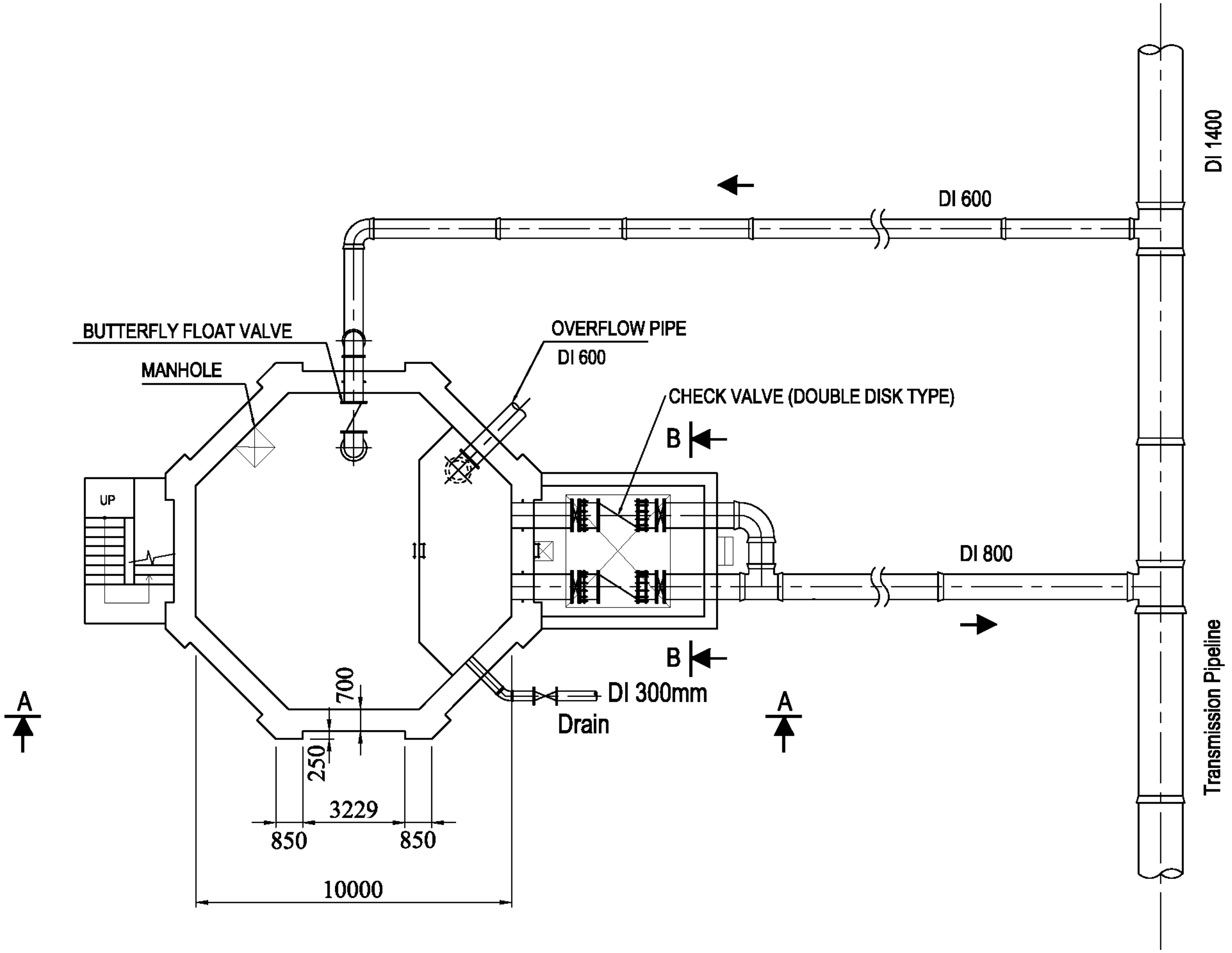


Source： JICA Survey Team

Figure 6.2-5 Result of Water Hammer Analysis in Transmission Pipeline

An impact on the water hammer phenomenon is also analysed for the other sections between; i) PK11 and Bou Merra, ii) PK11 and PK10, iii) PK10 and PK14, and iv) PK14 and Sidi Salah EH. As presented in Table 6.2-4, the water hammer phenomenon can be prevented by flywheels or an air chamber to be installed at the pump facilities. The column "necessary moment of inertia" means total moment of inertia to be held by one set of pump, motor, and flywheel. If the air chamber will be installed, flywheels will not be necessary for the pumps for Bou Merra. Therefore, "no need" is indicated in the column of flywheel. A device which functions equalize the pressure in the transmission pipe with that of the atmosphere will be needed at the highest point in the section between PK10 and PK14

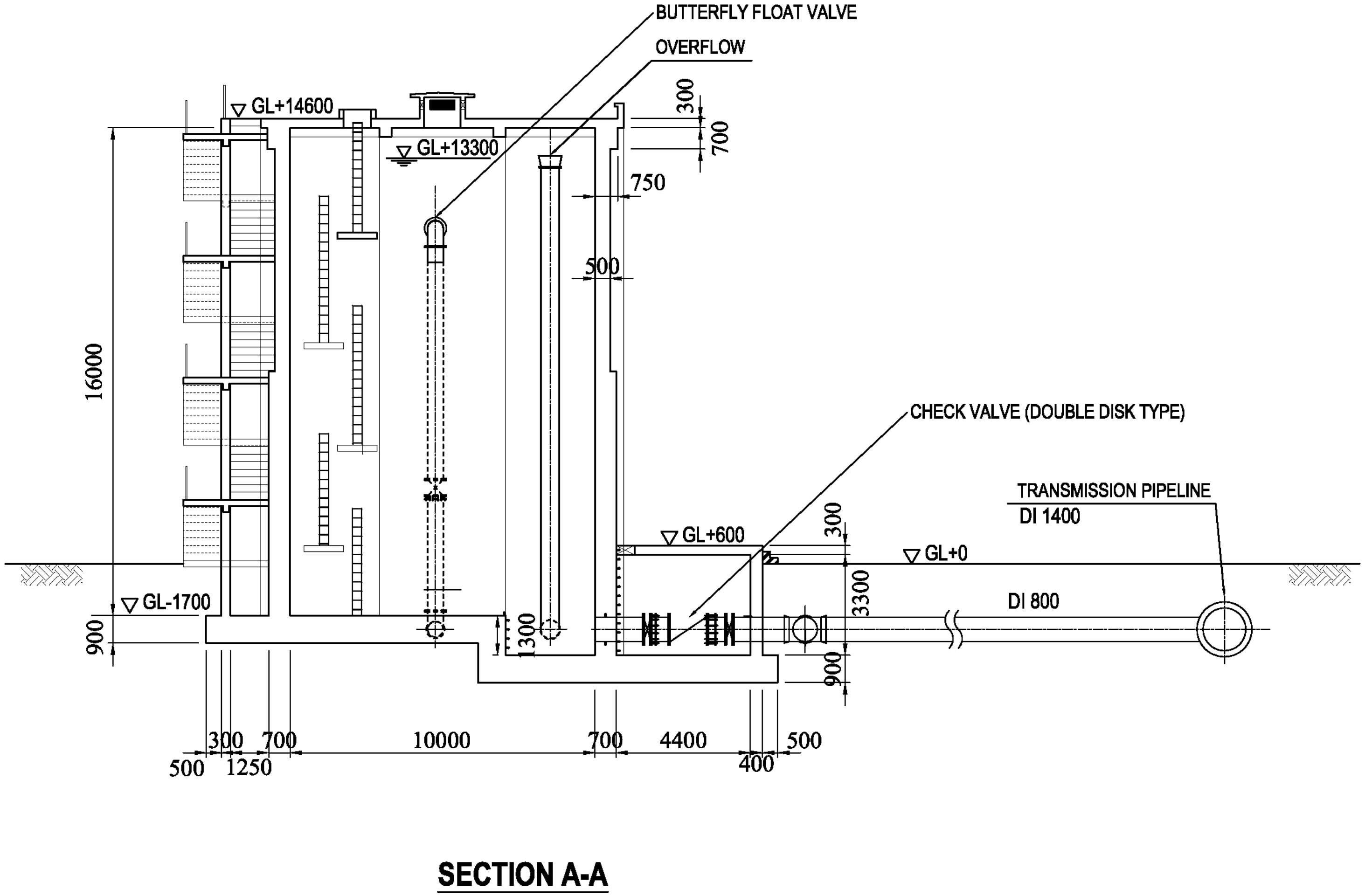
[4] In case water head of pressure in the pipeline becomes lower than the water level of the tank, the one-way surge tank supplies water to the pipeline to prevent occurrence of water column separation.



PLAN AT BOTTOM LEVEL

Source : JICA Survey Team

Figure 6.2-6 General Plan of One-Way Surging Tank (Plan)



Source： JICA Survey Team

Figure 6.2-7 General Plan of One-Way Surging Tank (Section)

Table 6.2-4　Measures against Water Hammer

Section	Flow rate (m^3/d, max)	Countermeasure	Dimension (diameter x height)	Quantity	Distance from source side	Flywheel	Necessary moment of inertia WR^2($N\text{-}m^2$)
Plant Site —PK11	200,000	One-way surge tank	φ10m x15m	2	Approx,13km,16km	Need	2,400x4
PK11 —Bou Merra	20,100	Air chamber	φ1.5m x1.7m	1	inside pump facility	No need	—
PK11—PK10	147,786	No need	—	—	—	Need	1,300x3
PK10—PK14	89,986	No need	—	—	—	Need	2,700x2
PK14 —Sidi Salah EH	64,686	No need	—	—	—	Need	2,500x2

Source： JICA Survey Team

(5) Reservoir

As described in 6.1.3, it will be necessary to construct an additional reservoir at the site of Bou Merra with a capacity of 5,000m^3.

- Capacity augmentation of Reservoir：5,000m^3 by Phase 1 project at Bou Merra

(6) Receiving-Mixing Chamber

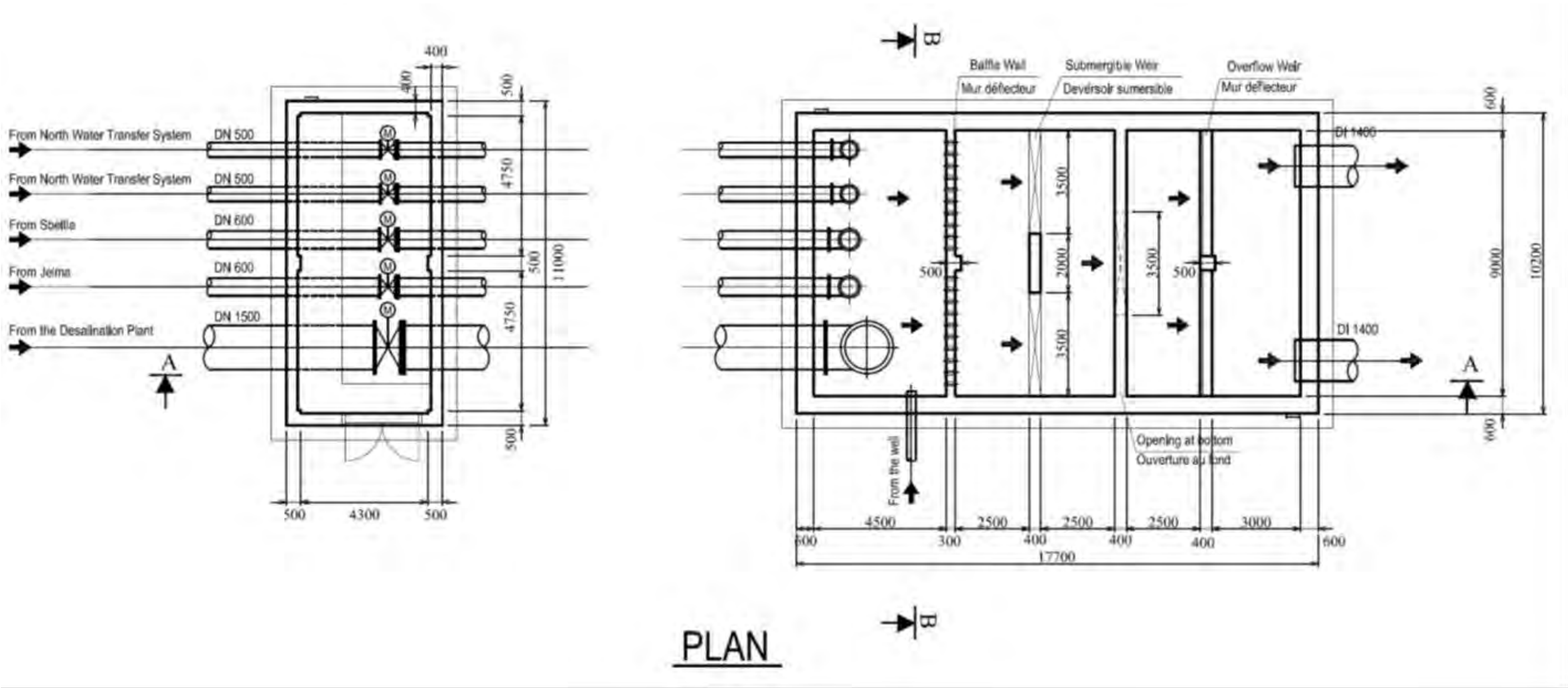
In each reservoir, one receiving chamber will be installed as indicated in Table 6.2-5. In these chambers, the desalinated water or the mixture of the desalinated water with the water from the other sources transmitted by pumping will be mixed with the water from the existing water sources. Figures 6.2-8 and 6.2-9 present the outline of the receiving chamber at PK11.

Table 6.2-5　Receiving-Mixing Chambers

Reservoir	Receiving Volume	Water Resource	Internal Dimensions* (m) & Retention Time
PK11	227,086 m^3/day	North Water Jelma-Sbeitla Groundwater Groundwater in Sfax Desalinated Sea Water	9.0W x 15.0L x 5.0D 4.3 minutes
Bou Merra	23,100 m^3/day	Groundwater in Sfax Mixed Water in PK11	4.0W x 3.0L x 5.0D 3.7 minutes
PK10	163,186 m^3/day	North Water Groundwater in Sfax Mixed Water in PK11	7.0W x 10.0L x 5.0D 3.1 minutes
PK14	107,786 m^3/day	North Water Groundwater in Sfax Mixed Water in PK10	7.0W x 7.0L x 5.0D 3.1 minutes
Sidi Salah EH	72,300 m^3/day	North Water Groundwater in Sfax Mixed Water in PK14	6.0W x 5.0L x 5.0D 3.0 minutes

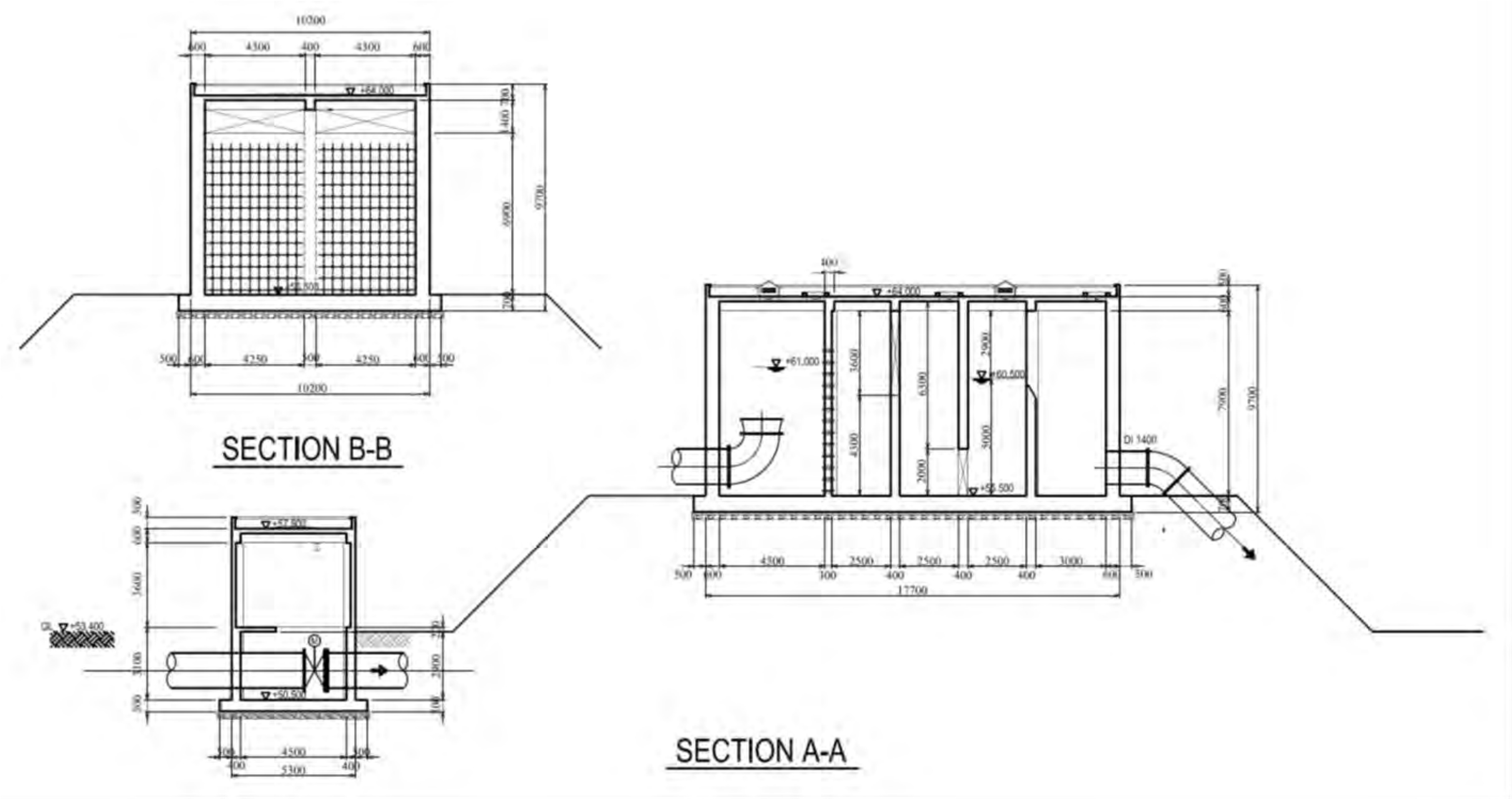
*: Planned with maximum water depth of 5m and minimum retention time of 3 minutes. PK11 has planned to have sufficient capacity to receive the water volume equivalent to water demand of entire Greater Sfax to have flexibility of change of water transmission plan.

Source：JICA Survey Team



Source： JICA Survey Team

Figure 6.2-8 General Plan of Receiving-Mixing Chamber at PK11 Reservoir (Plan)



Source： JICA Survey Team

Figure 6.2-9 General Plan of Receiving-Mixing Chamber at PK11 Reservoir (Section)

6.3 Plan of Phase 1 of the Project

The facilities planned to be constructed in Phase 1 except the Seawater Desalination Plant and its related facilities are summarized in Table 6.3-1.

Table 6.3-1 Components of Phase 1 Project

Facility	Contents
Pumping Station	・ Transmission Pumping Station x 1 (at Desalination Plant Site) ・ Intermediate Pumping Station x 3 (at PK10, PK11 and PK14 Reservoir Site)
Transmission Pipe	・ Pipe Material: Ductile Iron Pipe ・ φ1400mm: L=26.3km (Desalination Plant to PK11 Reservoir) ・ φ1000mm: L=6.1km (PK11－PK10 Reservoir) ・ φ800mm: L=4.8km (PK10－PK14 Reservoir) ・ φ800mm: L=9.4km (PK14－Sidi Salah EH Reservoir) ・ φ400mm: L=2.9km (PK11－Bou Merra Reservoir) ・ Total Length: about 49.5km
Water Hummer Prevention Measures	・ Desalination Plant – PK11 Reservoir One-way Surge Tank 10m (dia.) x 15m (water depth) x 2, Necessary Site Area: 20m×30m×2 sites ・ PK11– Bou Merra Air Chamber φ1.5m ×1.7mL×1 (at PK11 site) ・ Flywheels of each pumps
Reservoir	To augment Bou Merra Reservoir by additional capacity of 5,000m^3 within the existing precincts
Receiving/Mixing Chamber	Five receiving/mixing chambers. One each at following reservoir site: PK11: 9.0W × 15.0L × 5.0D Bou Merra : 4.0W × 3.0L × 5.0D PK10: 7.0W × 10.0L × 5.0D PK14: 7.0W × 7.0L × 5.0D Sidi Salah EH: 6.0W × 5.0L × 5.0D (internal dimensions: W; width, L; length, D; depth, unit: m)

Source： JICA Survey Team

CHAPTER 7

ELECTRIC FACILITY PLAN

CHAPTER 7　ELECTRIC FACILITY PLAN

7.1 Necessary Power Supply

(1) Sea water desalination plant

The power consumption at a desalination plant with the installation of the RO membrane method with energy recovery system is generally 4 kWh/m^3. The Djerba sea water desalination plant is designed at a power consumption of less than 4.2 kwh/m^3 according to the bidding document of the plant construction project. Depending on the system or manufactures, the required power varies. Therefore, for this project the plant selected had a design value of 4.2 kWh/m^3 which was considered to be appropriate. This project is therefore planned using same value. If 4.2 kWh/m^3 is applied to this project, the desalination plant of 200,000 m^3/d requires 35 MW of power according to the following figure.

Desalinated water production　200,000 m^3/d = 8,333 m^3/h
Power　4.2 kWh/m^3 x 8,333 m^3/h = 35,000 kW = 35 MW

(2) Transmission pumps

The required power for the transmission pumps is calculated to be 3.1 MW at a flow rate of 8,333 m^3/h, with a head of 95 metres, and efficiency of 70 %.

(3) Required power

The required power is 38.1 MW. For the plan, 40 MW is applied for the design.

35 MW (sea water desalination plant) + 3.1 MW (transmission pumps) = 38.1 MW

7.2 Receiving Voltage and Possibility of Power Supply

7.2.1 Transmission Power Line

(1) Receiving voltage

The receiving voltage for large electricity users is classified by STEG as shown in Table 7.2-1. Since the required power demand of the sea water desalination plant will be more than 10MVA, the receiving voltage is classified into the high voltage class.

In the case of the high voltage class, 150 kV and 225kV lines are available as receiving voltages. A 150 kV will be suitable for the plant because its construction cost is relatively moderate and its maintenance is easier than that of 225 kV lines.

Table 7.2-1 Maximum Demand and Receiving Power

Voltage Class	Maximum Demand (MVA)	Receiving Voltage (kV)
High Voltage	Over 10MVA	150kV, 225kV
Middle Voltage	Less than 10MVA	30kV

Source: JICA Survey Team

(2) Power receiving method

Existing STEG's high voltage supply lines are as shown in the Figure 7.2-1.

The electric supply system in Sfax is one of the trunk power supply lines to connect the Northern system and the Central-Southern system.

STEG has two gas turbine power plants in Sfax and this fact means there is an advantage to secure the power supply for new plant.

Figure 7.2-1 STEG Transmission Lines

Table 7.2-2 Power Plant around Greater Sfax

Power Plant	Capacity	Owner
Sfax Power Plant	120MW x3, Maximum Capacity 360MW	STEG
Gremda Power Plant	20MW x2, Maximum Capacity 40MW	STEG
Z.I. Aguareb Power Plant	5MW x3, Maximum Capacity 15MW	Poulina (Private)
Central Barca	Maximum Capacity 500MW	BG Group (Private)

Source: STEG

7.2.2 Availability of Electricity for Seawater Desalination Plant

In response to SONEDE's inquiry letter, STEG answered that the required 40MW of power will be possible to be supplied to the desalination plant. The JICA Survey Team has also confirmed the possibility of the power supply of 40 MW to the plant considering the power supply situation in Tunisia. The reception of 150 kV is considered to raise the possibility of the supply as described in Section 11.3.

In case the Djerba Sea Water Desalination Plant, which was contracted in September 2014 for a capacity of 50,000 m^3/d, and the Sfax Seawater Desalination Plant with a capacity of 100,000 m^3/d for Phase 1, are operated at the same time, the power consumption by both plants will be 192GWh/year assuming 3.5 kWh/m^3 (refer to Table 5.1-1). This will increase the share of the Water Supply and Sewerage Sector in the national total power sales from 3.9% (Figure 2.2-8) to 5.3% on the basis of 2013 values. Power consumption by both plants will account for 1.3% of national power sales. This figure of 1.3% is not a large figure for discussion about availability of power supply, and power consumption of about 22MW[1] will be equivalent to about 0.5% of power generation capacity in Tunisia. Further, augmentation of the power supply capacity in future may be expected before commencing operation of both plants[2]. Because of above reasons, it was concluded that the required power supply to the Sfax plant will be possible. As an emergency case, if power supply is in danger at the peak power demand hours, operation of the desalination process can be tentatively suspended for a few hours because the storage capacity of produced water for 6 hours and power generators with sufficient capacity of transmission pumps will be provided for the plant, and those will enable continuous water transmission to reservoirs, although total production water volume becomes less.

7.3 Electrical Facility Plan

The electrical facilities and the design criteria at the desalination plant and reservoirs are as follows:

(1) Sea water desalination plant

1) Receiving power facility plan

- After discussion with STEG, the receiving system is expected to be for a three-phase, three-line 150kV 50Hz, high voltage two-line (loop system).

- Against possible power failures, power generators will be installed. However, the frequency of the power failure is not expected to occur frequently. Therefore, the capacity of the generator will be of the minimum requirement for ease of O&M.

- The receiving power facilities consist of primary and secondary units. The primary unit is to be installed at the entrance of the site. The secondary units are to be installed at four places at the intake site, the seawater desalination plant (Phase 1), the seawater desalination plant (Phase 2), and the transmission facility.

- Extension of the required transmission power line is to be executed from the 150 kV trunk line of STEG, which is responsible for the electrical works in Tunisia. SONEDE will pay the cost for the extension work to STEG. The cost of the work is estimated to be 7,283,000 TND.

The following is the detail of the receiving power facility.

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[1] (50,000m3/d+100,000m3/d)00m3/d+100sion Linesnts Lineplya

[2] For example; a combined cycle power plant (430-500MW) in Rades will be operated from 2018.

a) Receiving power lines

Power to the sea water desalination plant will be supplied from the nearest transmission power line of 150kV through two lines. High voltage power lines are installed at many places like mesh in the nation. Therefore, a secure power supply is possible by receiving two lines.

b) Receiving power system

As mentioned above, the receiving power is to be obtained from two lines of the existing transmission power line of 150 kV. The receiving power system has two options to be considered. One is two line power receiving system, which will receive the power from two different substations of STEG. This system is not possible according to the existing power network. The other is a loop power receiving system, which will receive the power from the existing STEG's transmission line by separating two lines. This system is applicable to the site. Therefore, the loop system will be selected for the project. Route of the transmission line will be decided based on the detailed study by STEG.

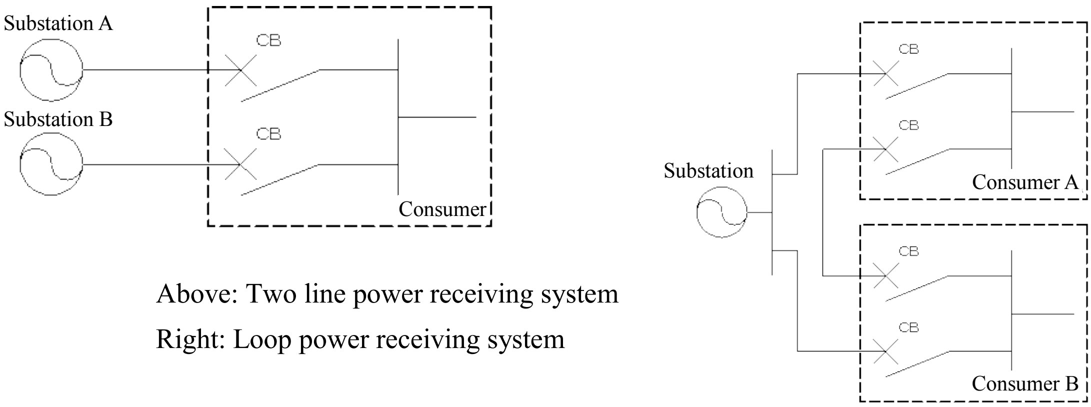


Figure 7.3-1 Two Line and Loop Power Receiving Systems

c) Primary substation facility

Primary substation facility of 150 kV is applied for Gas-Insulated Switchgear (GIS) which has an advantage on O&M and compactness. The facility is set for two units including one as standby. In case of stopping one system for O&M, the facility will not sustain any damage. The first and second voltages for the transformer are 150 kV and 30 kV, respectively. The supplied power to the secondary substation facility is 30 kV x 2 supply system. The capacity of the transformer is 63 MVA x 2 banks, which includes the capacity for the future expansion. The transformer will be an inexpensive general oil type.

d) Secondary substation 1: intake facility

From the primary substation, the power will be supplied through 30 kV x 2 lines. The transformers are 2 banks system of regular - standby. The secondary voltage of the transformer is 400 V. The capacity of the transformer is designed as 4 MVA including possibility of any future expansion. However, the power supply facilities to the reserved transformer and each pump for the future expansion are planned in Phase 2. Vacuum circuit breakers (VCB) of 30 kV, and the oil type transformers have been selected.

e) Secondary substation 2: sea water desalination plant (Phase 1 project)

From the primary substation, the power is supplied through 30 kV x 2 lines. The transformers are 2 banks system of regular and standby units. The capacity of the high voltage pump is 3,000 kW. Because the terminal voltage of the motor is 6 kV, the secondary voltage of the transformer is designed as 6 kV. The capacity of the transformer is planned at 20 MVA for Phase 1. Vacuum circuit breakers (VCB) of 30 kV and 6 kV, and the oil type transformers have been selected.

f) Secondary substation 3: sea water desalination plant (Phase 2 project)

In Phase 2, the same facility as the Phase 1 is constructed.

g) Secondary substation 4: transmission facility

From the primary substation, the power will be supplied through 30 kV x 2 lines. The transformers are 2 banks system of regular and standby units. The capacity of the high voltage pump is 800 kW. Because the terminal voltage of the motor is 6 kV, the secondary voltage of the transformer is designed as 6 kV. The capacity of the transformer is planned at 6 MVA. However, the power supply facilities to the reserved units and each pump for the future expansion are planned for Phase 2. Vacuum circuit breakers (VCB) of 30 kV and 6 kV, and the oil type transformers have been selected.

2) Power generator

Due to reserving 6 hours of supply capacity at the reservoirs, there will be enough time to re-operate the desalination plant after a short period in case of a power failure. In addition, the loop type reception of two 150 kV high voltage lines will ensure that the power failure rarely occur. Furthermore, a large capacity generator will be required due to the power requirement of the desalination plant. As a result, the cost of the generator will be extremely high. Therefore, the generator for operating the desalination plant will not be installed.

On the other hand, a generator will be designed for the transmission pump with minimum required O&M purpose on the other facilities. The type will be selected for a diesel generator with a radiator. The capacity of the generation will be at 2,000 kVA in order to operate the two transmission pumps planned in Phase 1. A generator is capable of being installed in the future facilities is planned to planned in Phase 2. The building for the generators is constructed beside the secondary substation facility of the transmission pump.

3) Operation and control facility

Seawater desalination plants have many power loading points with a small capacity such as a pre-treatment sand filtration facilities. For supplying the power to these points, a control centre will be installed. For supplying a large amount of power, an individual power control panel is to be installed at intake and transmission pump facilities. For all facilities, on-site control panels are to be installed beside the equipment.

The operational system is basically automatic from the control centre. However, all facilities will be designed for manual operation as well by installing a manual control panel. In addition, the remote control for main loading facilities such as intake and transmission pumps is designed from a central monitoring centre.

4) Instrumentation facilities

The instrumentation facilities will be installed at the required locations. The major instrumentation and types are listed as follows:

Table 7.3-1 Instrumentation Equipment

Instrumentation Equipment	Type
Flow rate: intake	Electromagnetic flow meter
Flow rate: transmission water	Electromagnetic flow meter
Pressure: Transmission water	Diaphragm type pressure gage
Water level: water treatment plant, reservoir	Throw-in type (pressure type) water gage
EC: raw water	Electric resistance
pH: transmission water	Glass electrode type
Residue Chlorine: transmission water	Polarograph type
Turbidity: transmission water	Permeation scattered light type
Temperature	Thermocouple type

5) Operation and control facility

By installing SCADA, a control centre at an administration building staff can monitor and operate the main facilities. In addition, the centre can conduct; i) data management of the operational conditions such as flow rate and other parameters, and ii) preparation of daily or monthly reports. The outline of SCADA is as follows:

- Four sets of PLC (Programmable Logic Controller) will be installed at each electricity room for collecting local information.
- The data collected by the PLC will be transferred to a server of SCADA through a LAN connected through optical cables.
- The data stored in a server will be referred for remote control at each facility through graphic or graph on the monitor called SCADA client.

- SCADA client will be able to control three facilities simultaneously through 3 large screens.
- UPS will be installed for printers used for data preparation against any possible power failures.

(2) Pump facility

1) Outline

Three pumps will be installed at the desalination plant to transmit water produced in the plant. Other three pump facilities will be provided at three locations. The pump facility at the desalination plant and reservoirs mentioned above is described in detail in Table 7.3-2.

Table 7.3-2 Outlines of Pump Facility

Reservoir	Pump facility (new)	Remarks
Production tank at sea water desalination plant (new installation): New: 25,000m^3 (Phase 1) Expansion:25,000m^3 (Phase 2)	To PK11 reservoir Phase 1: 34.8m^3/min x 2 (+1) Phase 2: 34.8m^3/min x 2 (+1)	Head: 95m VSD control: 2 units VSD control: 2 units
PK11 reservoir Existing 22,000m^3	To Bou Merra reservoir Phase 1: 7.0m^3/min x 2 (+1) Phase 2:-	Head: 63m VSD control: 2 units
	To PK10 reservoir Phase 1: 34.2m^3/min x 3 (+1) Phase 2: -	Head: 34m VSD control: 3 units
Bou Merra reservoir Existing: 1,500m^3 Expansion: 5,000m^3 (Phase 1) Expansion: 2,500m^3 (Phase 2)	-	-
PK10 reservoir Existing: 20,000m^3 Expansion: 10,00m^3 (Phase 2)	To PK14 reservoir Phase 1: 31.2m^3/min x 2 (+1) Phase 2: -	Head: 51m VSD control: 2 units
PK14 reservoir Existing: 10,000m^3 Expansion: 5,00m^3 (Phase 2)	To Sidi Salah High reservoir Phase 1: 22.5m^3/min x 2 (+1) Phase 2: -	Head: 38m VSD control: 2 units
Sidi Salah High reservoir Existing: 7,500m^3	-	-
Sidi Salah Low reservoir New: 5,000m^3 (out of this project) Expansion: 15,000m^3 (Phase 2)	-	-

2) Receiving power facility plants

The transmission pumps will be installed at the PK11, the PK10, and the PK14 reservoirs. The power supply to the reservoirs is 30 kV from one power line reception together with the transformers. Generators, however, will be installed in order to transmit water continuously. One transformer will be installed with a secondary voltage of 400 V. During power cut or malfunctioning of the transformer, the generator can be utilized for the power supply. At the Bou Merra, the Sidi Salah EH, and the Sidi Salah EB reservoirs, low voltage power is supplied due to the power requirement of the instrumentation panels and equipment.

3) Power generators

The selected generators are a deasil type with a radiator. The capacity of each generator is listed in Table 7-2.

Table 7-2 Capacity of Generators

Reservoir	Capacity of Generator
PK11	2,500 kVA
PK10	1,250 kVA
PK14	750 kVA

4) Operation and control facilities

At the reservoirs, a power control panel will be selected for installation as the power loading points are not excessive. The operation system will basically be automatic and determined by the water level of the reservoirs. However, a manual system will also be designed to be used when required from the control room.

5) Instrumentation facilities

The instrumentation facilities at the reservoirs are mainly for the measurement of inflow rates, reserved volume, and water levels. In this project, EC is measured continuously at the outlet of the reservoirs due to an issue on TDS. The water level of the reservoirs is measured by throw-in type (pressure type) water gauges, as they are both simple and highly accurate.. The residual chlorine at the reservoir will be measured in principle by manual analysis. Chlorine metres, however, will be installed in order to cope with an emergency situation,

6) Monitoring and control facilities

The monitoring and control facilities at the control room are being designed to obtain data of; i) the water levels and flow rates at each reservoir, ii) the operational condition of the pumps, and iii) when required raise alarms through telemeter and wireless communication. This data communication will be integrated into SCADA. A wireless UHF system will be installed.

7) Adoption of Renewable Energy

SONEDE requested the JICA Survey Team to examine the possibility and appropriateness of introducing a Solar Power Generation System into the Project as a renewable energy source. Since the solar power system cannot function in night time, it does not contribute to the cost reduction of power related facilities, but will require additional cost for the Project. Because of this reason, it seems to be difficult to obtain a reasonable return against investment, though it will contribute to the overall reduction of power cost.

Among the desalination plants of SONEDE, the Ben Guerdane Desalination Plant has a 210kW capacity

Solar Power Generator. Based on the cost data available when it was augmented to 210kW from the initial 30kW, 900,000 yen/kW was required for the 30kW facility, and 750,000 yen/kW was the cost outlay for the 200 kW facility. The unit cost of solar power generator, however, has decreased rapidly in the recent past because of the expansion of the market.

Assuming that; power unit tariff is 0.148TND (9.6yen)/kWh based on Table 7.4-1, a solar power generator unit cost will be 300,000 yen/kW. Given that the approximate annual operation time of a Solar generator is 20%, it will take almost 18 years to recover initial investment cost:

300,000 yen/kWh/ (24hours/day x 365days /year x 20% x 9.6yen/kWh) =17.8years

In addition to the above, considering the decrease of energy conversion efficiency of solar power units due to aging and high temperature, deterioration of the facilities, needs for reduction of the initial cost because of high project cost, and requirement of additional site area needed to acquire solar power to a significant extent[3], among other considerations, the introduction of solar generation system into the project is not immediately appropriate in this instance. Even if the unit cost becomes far less, considering the characteristics of the solar power system, which not only cannot function a night time and in addition since power output is not stable, the introduction of a solar power system cannot therefore be recommended SONEDE's plant. It would be more appropriate depend on STEG's power supply system in which instability of solar power generation can be compensated for with other power generators.

7.4 Electricity Tariff

The basic tariff will be 10.5 TND/kW/month for receiving two power lines. Since the tariff is varied on a seasonal basis, the annual average tariff is 0.148 TND/kWh (Table 7.4-1).

[3] About 1.5ha/MW

Table 7.4-1 Electricity Tariff

STEG: Tariff for receiving high voltage	Basic	Tariff			
	(TND/kW /month)	Daytime (TND/kWh)	Peak hour (TND/kWh)	Night (TND/kWh)	Late night (TND/kWh)
	Winter (9/1～5/31)	0700～1800	1800～2100	-	2100～0700
	Summer(6/1～8/31)	0630～0830 1330～1900	0830～1330	1900～2200	2200～0630
hourly rate	7.5	0.148	0.233	0.218	0.111
Backup	3.0	0.168	0.290	0.255	0.120
Basic tariff	10.5				
Contract power ＝ 0.4 x "contracted maximum power in winter" + 0.3 x "contracted maximum power in summer" ＋ 0.2 x "contract power in daytime" + 0.1x "contracted power in night"					

Average tariff	Day time	Peak hour	Night	Late Night	Average
Winter (9/1～5/31) (TND/kWh)	0.148	0.233	0.212	0.111	
Hour	11	3	0	10	24
Tariff (TND)	1.628	0.699	0	1.11	0.143
Summer (6/1～8/31) (TND/kWh)	0.148	0.233	0.212	0.111	
Hour	7.5	5	3	8.5	24
Tariff (TND)	1.11	1.165	0.636	0.9435	0.161
Annual tariff (same rate in summer and winter)		summer: 3 months	winter: 9 months	average tariff	0.148

7.5 Construction Cost for Extension of 150kV Distribution Power Line

The construction cost for the extension of the 150 kV distribution power line (Aerial wire) is presented in Table 7.5-1. This construction will be implemented by STEG. The full amount of the work is required to be paid for by SONEDE. The construction period should be reviewed carefully since it is necessary that it is completed before test running of the seawater desalination plant. STEG estimated the construction cost of power cable construction as 7,283,000TND, including primary equipment such as circuit breaker and construction supervising for secondary.

Table 7.5-1 Construction Cost for Extension of Distribution Power Line

Item	Condition
Extension Length (km)	15
Nos. of Lines	2 lines (duty + backup)
Construction Cost of Extension (TND)	7,283,000

Source: Reply to SONEDE by STEG

7.6 Boundary of Construction Segments

Figure 7.6-1 shows the construction segments of STEG and SONEDE. It was confirmed that STEG will have responsibility to construct the high voltage power distribution lines and incoming lines up to the receiving circuit breaker of the plant.

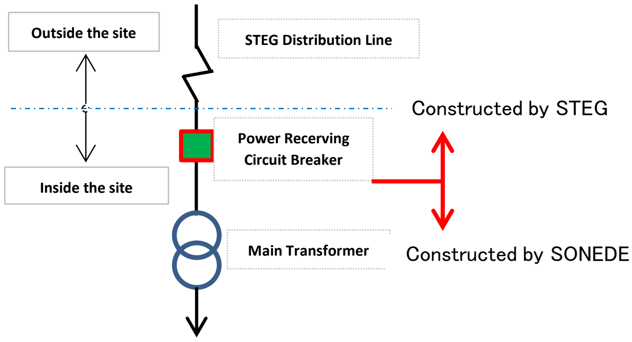


Figure 7.6-1 Construction Segment

7.7 Phase 1 Project for Electrical Facilities

Phase 1 project for electrical facilities are summarized in Table 7.7-1.

Table 7.7-1 Summary of Phase 1 Project

Facility	Specification
Sea water desalination plant	
Substation facility	· three-phase, three line, 150kV 50Hz, high voltage two-line (loop system) · Primary substation facility: regular 1 unit, standby 1 unit, total 2 units, primary voltage 150 kV, secondary voltage 30 kV · Secondary substation facility 1 regular - standby: 2 banks system, secondary voltage of transformer: 400 V · Secondary substation facility 2 regular - standby: 2 banks system, secondary voltage of transformer: 6 kV
Generator	· diesel type with a radiator: capacity 2000 kVA
Operation and control facility	· small loading: control center · large loading: individual power control panel
Instrumentation facility	· intake flow: electromagnetic flow meter · transmission flow: electromagnetic flow meter · transmission pressure: diaphragm type pressure gage · water level at water treatment plant, reservoir: throw-in type (pressure type) water gage · EC at raw water: electric resistance · pH at transmission water: glass electrode type · Residue Chlorine at transmission water: polarograph type · Turbidity at transmission water: permeation scattered light type · Temperature: thermocouple type
Monitoring and control facility	· SCADA system
Pump facility	
Substation facility	· high voltage one power line of 30kV · transformer 1 unit, secondary voltage 400 V
Generator facility	· diesel type with a radiator: capacity 2500 kVA, 1250 kVA, 750 kVA
Operation and control facility	· power control panel
Instrumentation facility	· Inflow: Electro Magnetic Flow Meter · Transmission: Electro Magnetic Flow Meter · TDS: EC meter · water level: pressure type
Monitoring and control facility	· SCADA system

CHAPTER 8

SOCIO-ENVIRONMENTAL CONSIDERATIONS

CHAPTER 8 SOCIO-ENVIRONMENTAL CONSIDERATIONS

8.1 Objectives of Socio-environmental Considerations

Socio-environmental considerations have been examined in accordance with the JICA guidelines issued in April 2010 (hereafter referred to as "JICA Guidelines") as well as from Tunisian legislation currently in force, with the following objectives:

1) Identify elements having negative impacts on the natural and social environment;
2) Suggest mitigation measures to be implemented;
3) Draft recommendations about tasks, schedules and staff needed to undertake the Environmental and Social Impact Studies to be implemented by the Tunisian Government through SONEDE.

8.2 Project Category

JICA classifies this project as falling into the B category from among the four categories stated below:

- A Category; includes projects likely to have a considerable impact on the environment and projects with complex, unprecedented or hard to assess impacts are classified in this category;
- B Category; includes projects with a limited impact on the environment that is specific to the site, that is irreversible but can be mitigated by adopting normal mitigation measures;
- C Category; includes projects with minimal negative impacts or no negative environmental impact;
- FI Category; includes sub-projects classified in the FI Category. These sub-projects will be selected once JICA funding is approved (or the project evaluation) and cannot be specified before approval, consequently, they may have an impact on the environment.

The following environment review was carried out in accordance with procedures required for the B Category projects. During the selection process, JICA classified the project in terms of possible environmental impact taking in consideration factors such as: (1) the project's sector and scope, (2) its foundation (3) the level of uncertainty in terms of possible environmental impact and (4) the environmental and social impact on the site suggested for the project.

The following criteria have been taken into account to confirm that the project belongs with the B Category:

1) For elements that may have an impact on the environment, the project does not involve;

- The large scale involuntary displacement of people;
- Large scale extraction of underground water;
- Polders, soil restoration or large scale clearing operations;

- Large scale deforestation.

2) Sensitive areas that may be affected by the project do not include;

- Wetland areas of international importance (RAMSAR Convention)
- National parks

3) With respect to the natural environment:

- The project has no considerable and large scale impact on the marine environment and on *Posidonia oceanica*, a protected species within the framework of the Barcelona Convention.

4) With regard to cultural and historical heritage:

- The project has no considerable impact on the Thyna Roman archaeological site.

According to Tunisian regulations, the scope of this project requires the execution of an Environmental and Social Impact study. Presently, SONEDE is conducting the said study by hiring a local consultant.

8.3 Project Components and Main Impacts

The project components for Phase 1 are summarized in the following table:

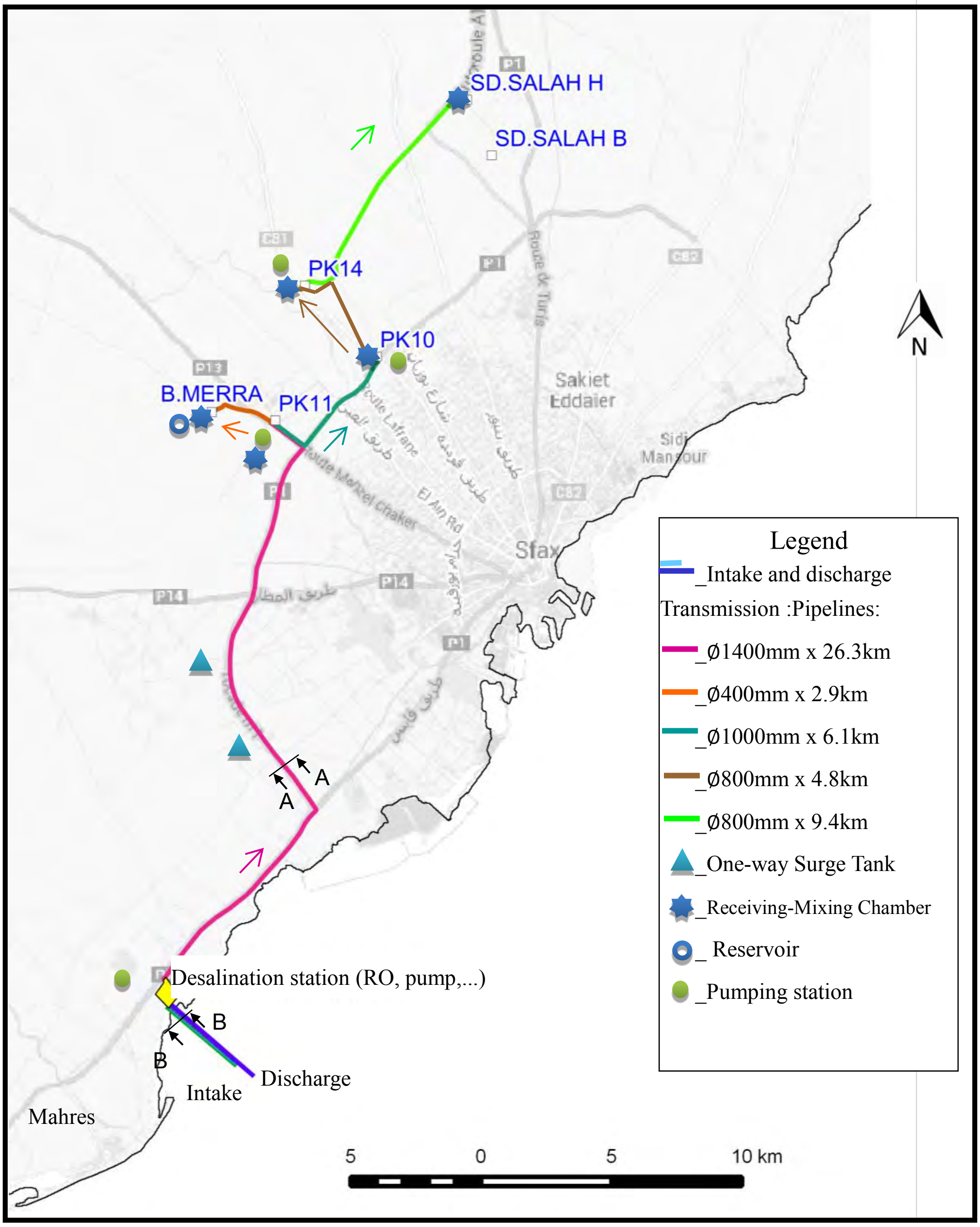
Table 8.3-1 Project Components for Phase 1

Installation	Characteristics
Intake pipeline	Intake volume: 222 200m^3/day, length: about 3.6km (including 400m onshore), entirely buried, diameter: 2000mm×2, material: HDPE, salinity of sea water about 41 000mg/L
Discharge pipeline	Outfall volume 122 200m^3/day, length: about 4.4km (including 400m onshore), entirely buried, diameter : 1800mm, material : HDPE, discharge salinity about 73 000mg/L
Desalination station (Reverse Osmosis)	Capacity : 100 000m^3/day, RO elements: about 8624 or 1232 pressurized tubes, global area (including Phase 2): about 20ha, power consumption: about 4.2kWh/m^3 for reverse osmosis and 0.4kWh/m^3 for transmission hence an annual consumption for Phase I amounting to 4.6×100,000×365×100%(operation rate)= 170GWh/year (≈14,400TEP), electrical power: about 20 MW (40MW for phase II)
Transmission pipeline	Production water: 100 000m^3/day, total length: about 49.5km, entirely buried, diameter: 400~1400mm, material: ductile cast iron
Pumping station	3 pumping stations located in areas of existing reservoirs and 1 pumping station located at the desalination plant site
One-way Surge Tank	Desalination Plant – PK11 10m (dia.) x 15m (water depth) × 2, Necessary Site Area: 20m×30m×2 sites
Reservoir	Additional reservoir for Phase 1 (5 000m^3) is located in the existing Bou Merra reservoir
Receiving-Mixing Chamber	One chamber each at reservoir sites below; (m, W:width, L: length, D:water depth) PK11: 9.0W × 15.0L × 5.0D Bou Merra : 4.0W × 3.0L × 5.0D PK10: 7.0W × 10.0L × 5.0D PK14: 7.0W ×x 7.0L ×5.0D Sidi Salah EH: 6.0W × 5.0L × 5.0D
Power Transmission Line (High Tension)[1]	(STEG Plan) 150kV, 50Hz, 2 lines, 15km, (Assumption by the JICA Survey Tem): Average interval of transmission towers: about 400m Size of tower base: 8m x 8m, height 40m

Source: JICA Survey Team

[1] STEG will plan the required facility upon application by SONEDE, but details are not definitely decided yet. STEG had initially planned a 15.5km power transmission line, but it was changed to 15km.

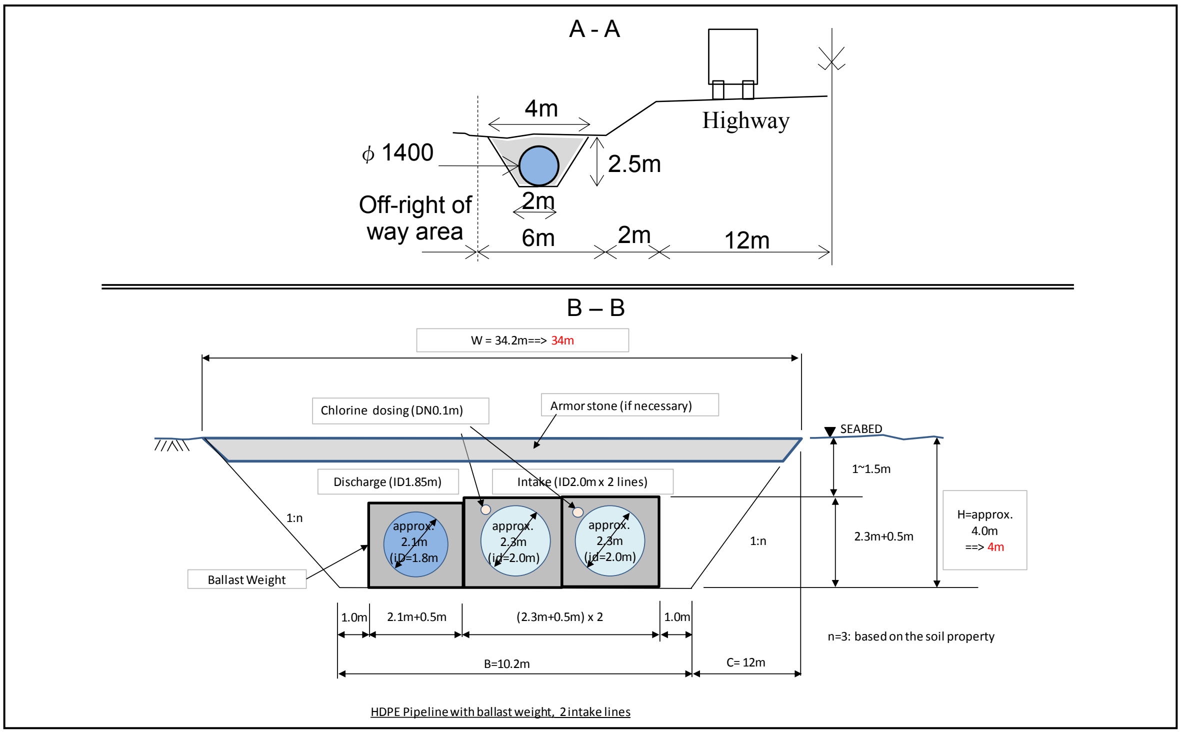
The project site stretches from the south of Sfax (Agareb) to the north-west as shown on the map below:



Source: JICA Survey Team

Figure 8.3–1 Project Location

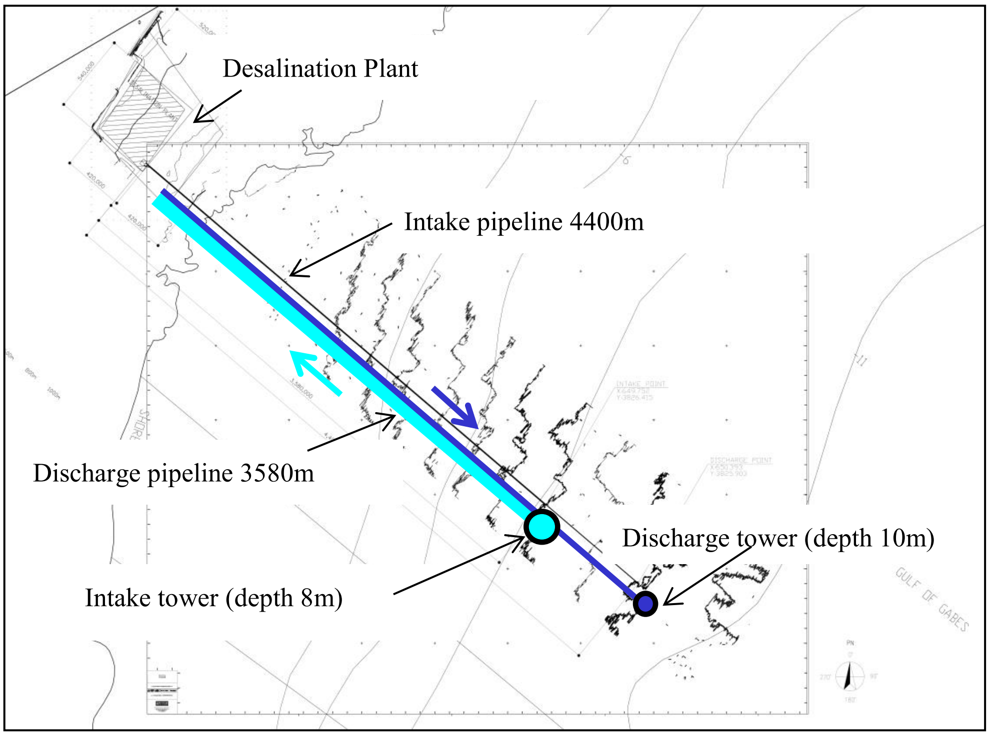
The illustrated sections of the transmission pipeline, the intake and discharge pipes in the sea are shown in the following figure:



Source: JICA Survey Team

Figure 8.3–2 Illustrated Sections of Pipes (Upper: transmission, Lower: intake and discharge)

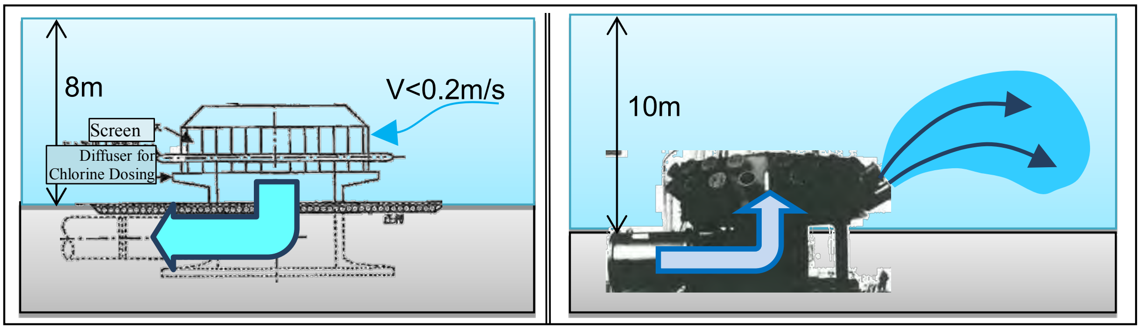
The location of intake and discharge pipes is shown on the plan below:



Source: JICA Survey Team

Figure 8.3–3 Plan of Intake and Discharge Pipes

Intake and discharge towers in the sea are shown below:



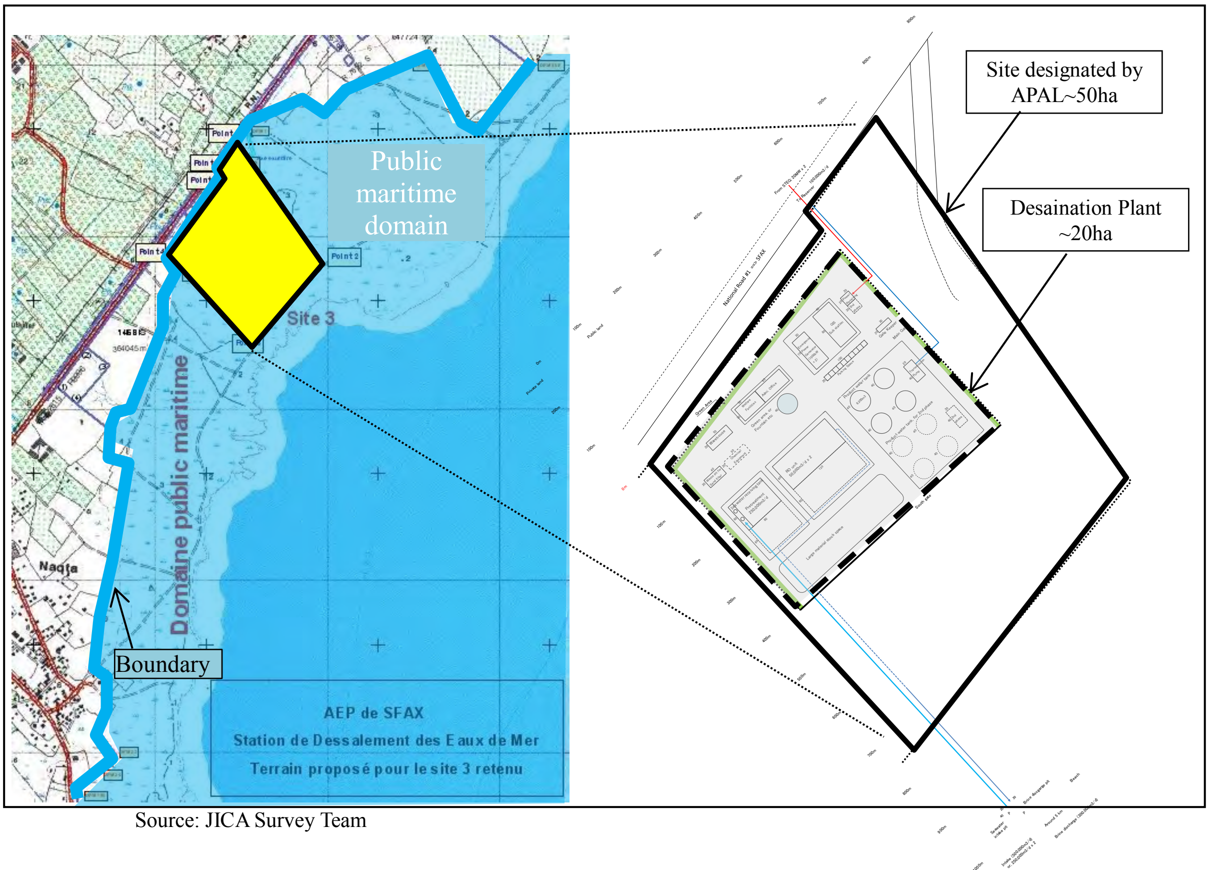
Source: Tokyo Kyuei

Figure 8.3–4 Intake and Discharge Towers in the Sea (image)

Based on sections shown above, it is possible to estimate excavated quantities：

- Onshore excavations (transmission)：((4+2)/2x2.5)m^2 ×45,000m → about 338,000m^3 （7.5=(4+2)/2×2.5）
- Offshore excavations (intake and discharge)：(34+10.2)/2x4)m^2 ×4,000m → about 354,000m^3 （110=(38+10.6)/2×4.5）

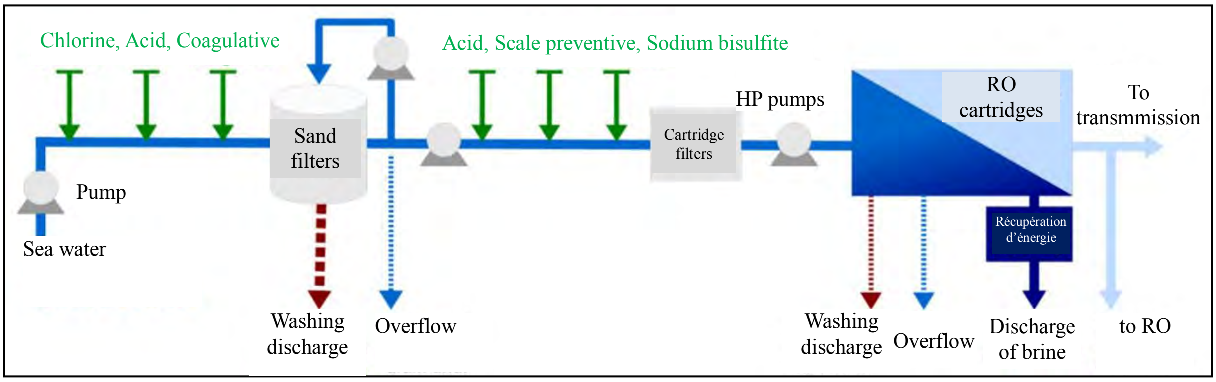
Installation of the desalination station is described in section 5.3. As shown in Figure 8.3-5, the desalination station is entirely located within the public maritime domain.



Source: JICA Survey Team

Figure 8.3–5 General Situation of the Desalination Station

This project uses reverse osmosis as the desalination technique as shown in the Figure 8.3-6:



Source : UNEP (United Nations Environment Program), Directives about desalination projects' impact studies

Figure 8.3–6 Reverse Osmosis Desalination Process
(inputs in straight lines, discharges in dotted lines)

The consumption of chemicals will depend on the size of the desalination plant as well as the operating hours, sea water quality and the target water quality. The majority of the chemicals will be used for filtration and adjustment of pH.

The annual consumption of RO membranes also depends on the capacity of the station and its operating pace, but it is estimated that 20% of all membranes will be replaced every year. For example, in Phase 1, 8,624 RO unit×20% = 1,725 unit/year, which represents about 55 m^3/year in terms of volume and in Phase 2, 110 m^3/year. This product is generally considered to be waste that can be incinerated.

The power transmission line for the seawater desalination plant will be constructed, owned[2] and maintained by STEG. As stated in Chapter 7, a power supply of 40MW is planned from two lines of 150kV high-tension voltage line. In this case, it is assumed that about 40m high power transmission towers with a base of 8m x 8m will be constructed with average intervals of 400m. The actual route will be planned by STEG. Presently the route length is planned to be 15km and the required number of towers is about 40 (=15000/400).

Regarding components, the main impacts of the project are the following:

The project is being designed in order to respond to concerns related to water supply in Sfax. It is expected this project to have considerable positive impacts on the population in Sfax by improving the water supply system. In addition, this project will reduce environmental pressure by stabilizing and even reducing demands on existing resources (underground waters).

As the outline of the transmission pipeline and the location of reservoirs may be adjusted, there is no current plan to displace any population. As for the acquisition of lands, it will be very limited as most new structures will be built in the right of way areas of existing roads or within the sites of reservoirs,

[2] The transmission towers and power cable will be owned by STEG. Sites for transmission towers will be owned by SONEDE.

with the exception of some specific points of the transmission pipeline, sites for one-way surge tanks, i.e. 20m x 30m x 2 sites. As for the sites for the power transmission towers, which will be owned by SONEDE, STEG will select the transmission route such that it will be easy for land acquisition and with minimal social and environment disruptions. The sites for the transmission towers will be selected along the route.

The biggest portion of the transmission pipeline will be laid along the existing express road at a good distance from the roadway. Consequently, traffic will not necessarily be disturbed during construction. The entire area of the desalination station is located within the public maritime domain and no private lands will therefore need to be acquired. The intake and discharge structures will be entirely buried and their location will be officially beyond trawler fishing areas, which means that the project will not have any significant direct impact on fishing activities.

The connection rate to the drainage and sanitation system is high in Sfax. There is currently an ongoing project to renew and modernize the waste water processing station in Sfax. The possible impact of the additional 200,000 m^3/day on rivers (wadis) and the aquifer system is considered to be minimal.

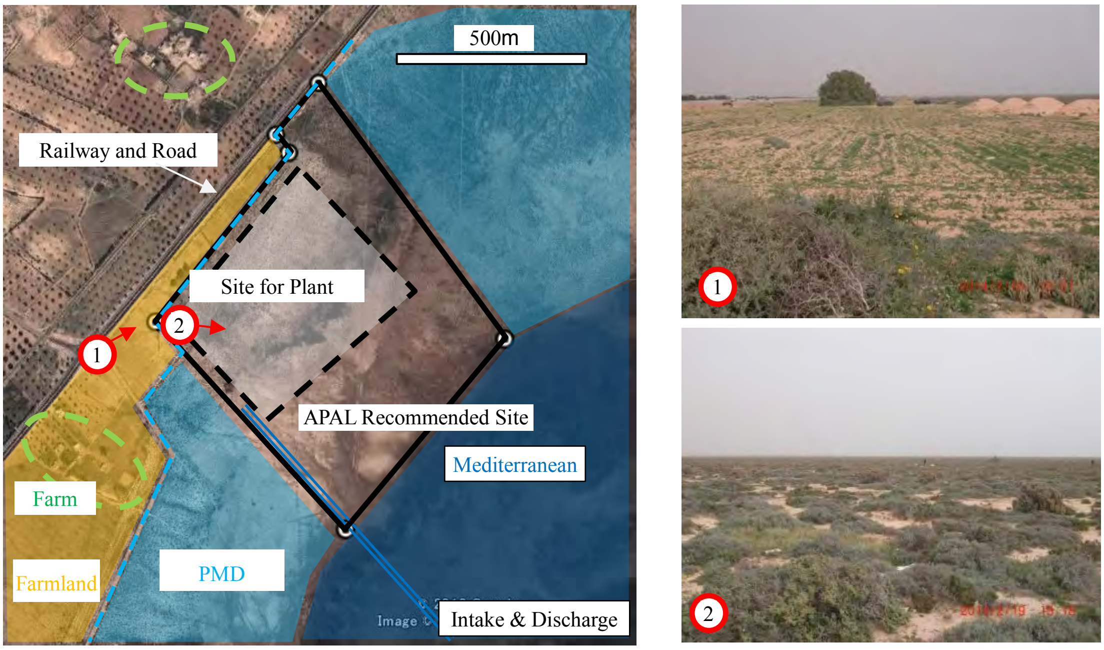
Works for the transmission pipeline will be mainly conducted along the existing express road in an urban environment. Works will not concern any special environmental area or a culturally valuable site, which means that the project will have limited negative impacts on the natural land environment. Though it is not decided as yet, STEG is expected to select the power transmission route so that works have no negative impacts on the environment.

During construction activities, intake and discharge structures will have some impact on the marine environment (destruction of the marine ecosystem along the outline of pipes' layout), but as the pipes will be entirely buried, the existing systems will regenerate with time. Burying all pipes under the seabed also means that the project will have minimal or no adverse impacts on marine currents.

The intake and discharge towers are emerging structures above sea level but since their area is limited, their impact on the exiting marine currents is believed to be very minimal. The permanent impact of brine discharge (Phase 1: 122,222m^3/day, Phase 2: 244,444m^3/day) with high salinity (about TDS 73,000mg/L) will be quite considerable (high salinity is hazardous to marine grasses when TDS exceeds 50,000mg/L). However, the impact would be limited to the area around the discharge head. The area impacted by hazardous salinity resulting from brine discharge is estimated as stated in Section 8.8.

8.4 Natural and Social Environment of the Project Site

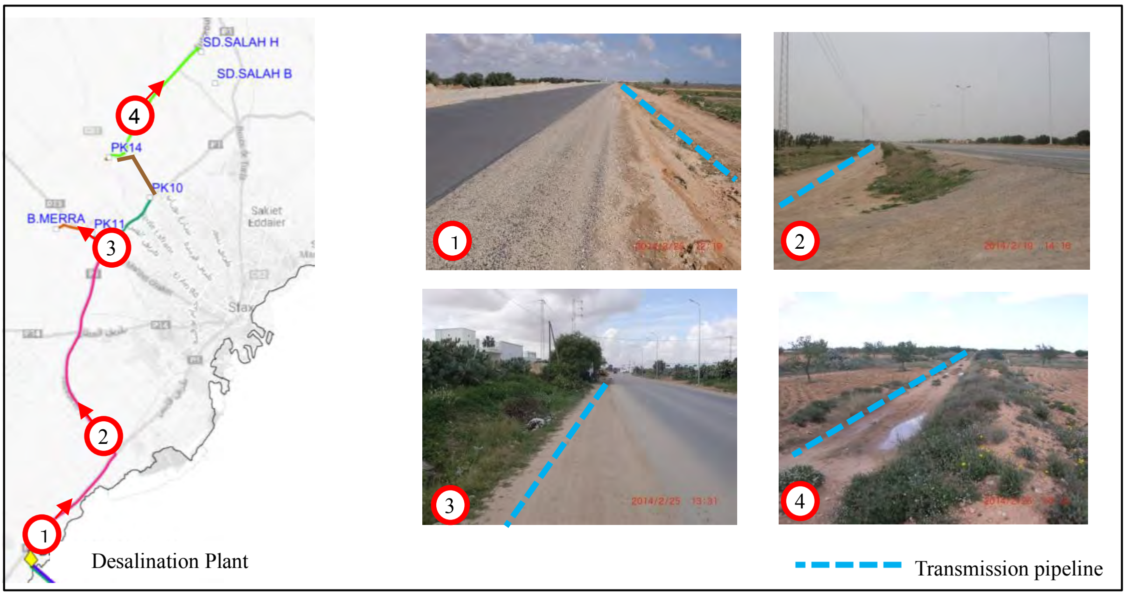
As shown in the image below, the desalination station will be built on coastal salty swamps. The entire area belongs to the public maritime domain bordered on the south east by a farming land, and on the west by the express road and the railways. According to satellite imagery, the closest housings are located about 250 m from the proposed project site.



Source ; Google 2013 (satellite view), JICA survey team

Figure 8.4–1 Present Conditions and Land Occupation at the Level of the Desalination Plant

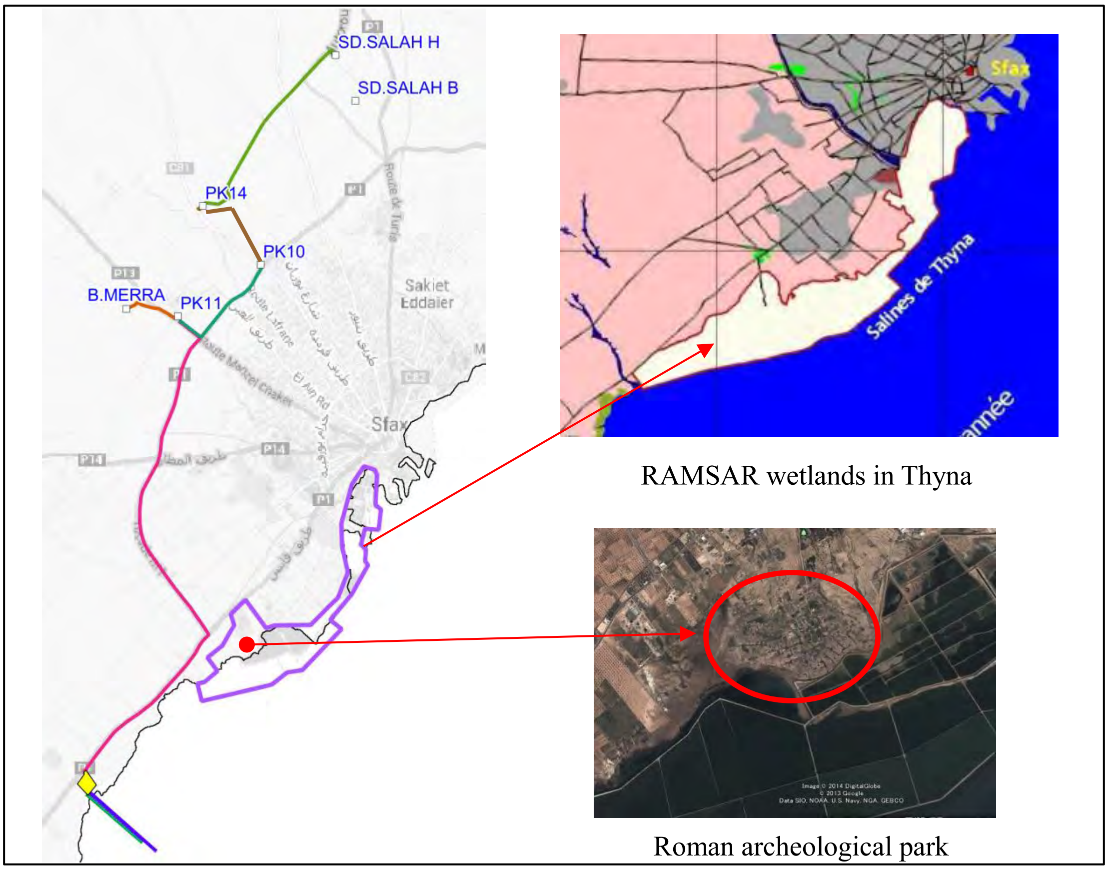
The environment along the transmission pipeline is an urban road landscape as shown in Figure 8.4-2.



Source: JICA survey team

Figure 8.4–2 Environment along the Transmission Pipeline

The transmission pipeline will be laid near Thyna, also hosting the RAMSAR wetlands and the Thyna Roman archaeological site, but the pipeline will not cross any of them as shown in Figure 8.4-3:



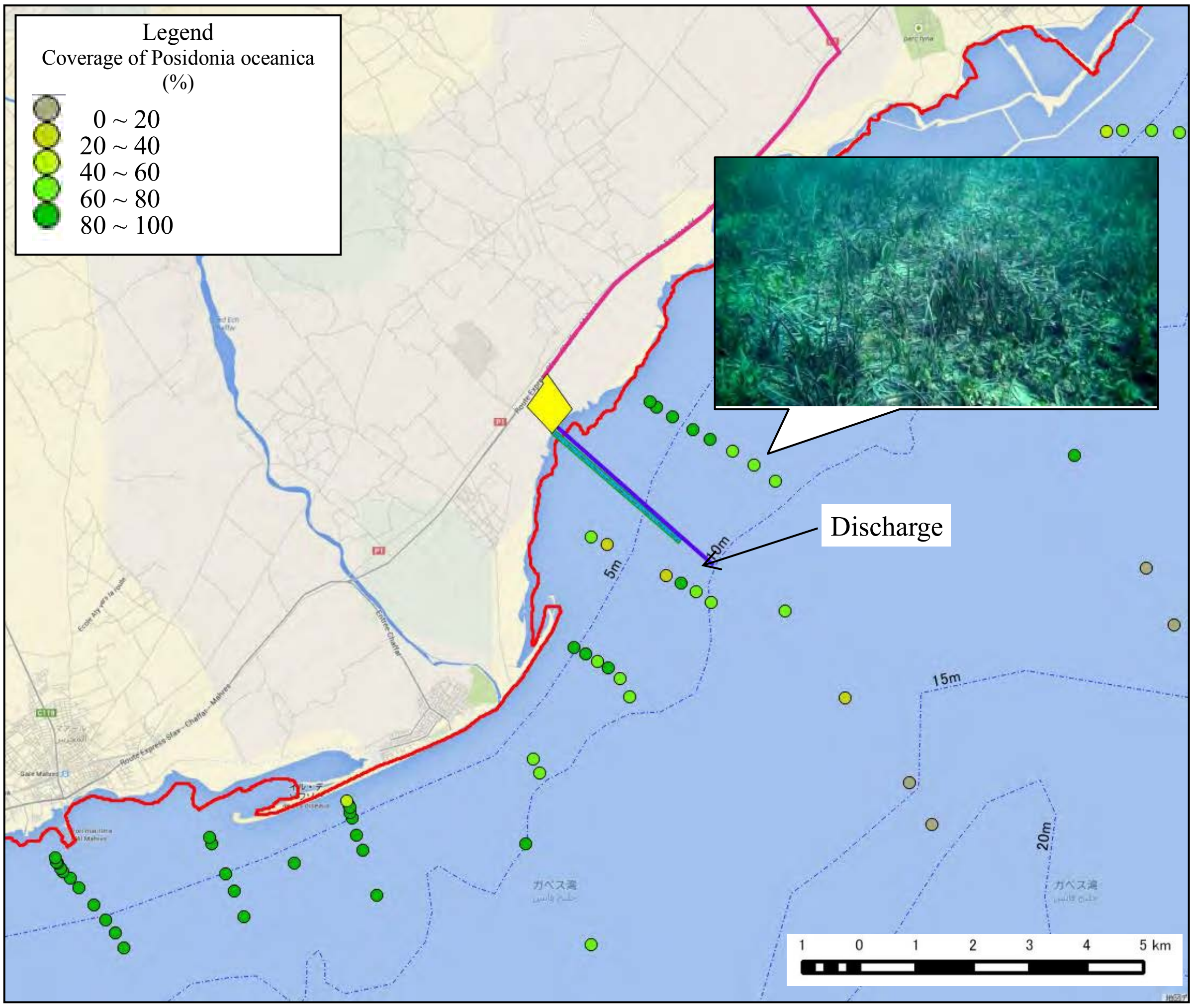
Source : http://ramsar.wetlands.org, JICA survey team

Figure 8.4–3 Thyna Area and Route of the Transmission Pipeline

It should be noted that important marine grasses have been identified as growing in the areas outlined for the intake and discharge pipes. According to the Protocol relating to Specially Protected Areas and Biological Diversity in the Mediterranean, "SPA/BD Protocol, 1995" refers to special protected areas and the conservation of biological diversity in the Mediterranean Sea. This was issued by the Barcelona Conference, joined by Tunisia in 1976. A list of SPAMI (Special Protected Areas of Mediterranean Importance) was designed to implement and monitor protection policies. In Tunisia, sites on SPAMI's list are as follows:

- La Galite Archipelago
- Kneiss Islands
- Zembra and Zembretta National Park

Among the three sites, the Kneiss Islands are located in the Sfax area but are at about 35 km from the project site. Even if the project was not located in the SPAMI area, *Posidonia oceanica* growing in the project area is considered by the SPA/BD protocol as endangered species. The JICA Survey Team collected data and information from INSTM about sea-grasses growing around the project area. According to the obtained data, coverage by *Posidonia oceanica* around the project site and the discharge point is about 60 to 80%. The project's impact on *Posidonia oceanica* is being assessed and mitigation measures are being suggested (see Sections 8.8 and 8.10).



Source : INSTM, Ben Mustapha – World Bank 2008, JICA survey team

Figure 8.4–4 Coverage of *Posidonia oceanica* around the Project Area

On the other hand, *Posidonia oceanica* also hosts "sea horse" *Hippocampus ramulosus* which is a protected species (see Table 8.4.1). As shown in the following table, the Gulf of Gabes offers the most abundant marine biodiversity in Tunisia:

Table 8.4-1 Marine Biodiversity in Tunisia in Number of Species

Species (family)	Examples (near Sfax)	Gulf of Tunis (North)	Gulf of Hammamet (Center)	Gulf of Gabes (South)
Echinoderms (sea stars)	 *Asterina gibbosa*	48	29	46
Cnidaries (jelly fish)	-	23	17	6

Species (family)	Examples (near Sfax)	Gulf of Tunis (North)	Gulf of Hammamet (Center)	Gulf of Gabes (South)
Bryozoairis	-	57	12	57
Annelidaes (worms)	 *Serpulidae*	10	8	11
Crustacean	 *Liocarcinus vernalis*	120	27	24
Sea squirts	-	7	25	17
Sponges	-	80	51	108
Mollusca	 *Cerithium vulgatum*	416	10	171
Fish	 *Hippocampus ramulosus*	106	113	227

Source : INSTM « Marine biodiversity in Tunisia », Afli, 2005 ; Examples : SMAPIII Report, City of Sfax, 2008

8.5 System and Organization of the Socioeconomic Considerations in Tunisia

(1) Legislation related to studies of impact

According to the National Agency for Environment Protection (ANPE), and with reference to Decree issued on July 11, 2005, execution of an Environment Impact Assessment (EIA) is necessary for approval of the Project.

- EIA Decree: Decree 2005-1991 dated July 11, 2005 defines subject of EIA and required terms of reference for EIA

The EIA decree defines projects for which a study of impact on the environment is required. The list of projects concerned by this requirement is attached in the Annex of the Decree. For this type of project, the Project Leader must submit a study of impact (A and B categories of Annex 1 of the Decree) or a tender Document (projects covered by Annex 2 of the Decree). The Tender Document is a preliminary list of measures and conditions specific to the type of project that the contractor shall submit to the

ANPE's approval. The study of impact on the environment in Tunisia is a procedure through which ANPE expresses its rejection or approval of the project. ANPE's approval is a prerequisite to have all necessary administrative authorizations for the execution of the Project (by SONEDE for this project).

The EIA decree covers impacts that may affect the physical and natural environment. However, the text does not explicitly mention the obligation to take into due consideration the social environment in the region.

Comparison between the Tunisian legislation regarding the environment and JICA guidelines shows the following:

Table 8.5-1 Tunisian Legislation and JICA Guidelines

JICA Guidelines	Tunisian legal framework	Gaps between JICA guidelines and Tunisian legal framework	Policy for this project
Regulation related to the study of impact on the environment	Decree 2005-1991.	None	Following decree 2005-1991
EIA Evaluation	The EIA carried out in the framework of the project must be examined by ANPE	None	EIA is implemented by SONEDE and approved by ANPE
Scope of EIA : from the natural environment to the social environment	The natural environment is covered by Decree 2005-1991. Land acquisition and resettlement of the population are covered by Law n° 26 dated April 14, 2003.	Decree 2005-1991 does not cover social considerations	The EIA shall cover both the environmental and social aspects of the project
Meeting of stakeholders and public information about EIA	-	This aspect is not considered in Decree 2005-1991	Considering the size of the project, it will be necessary to hold public consultations with stakeholders during the EIA
Follow up	Follow up is mentioned in Decree 2005-1991 The team in charge of the environment component in this project at SONEDE has an extensive experience in terms of EIA execution and follow-up.	None	The monitoring is done following the decree 2005-1991.There is a person in charge of environment in the Central Department of Research of SONEDE

Source: JICA Survey Team

According to Table 8.5-1, the Tunisian legislation seems to comply with JICA Guidelines in terms of the environment. Nevertheless, due to the scope of the project, it is necessary to consult with stakeholders during the execution of the EIA. It is also necessary to hold public information sessions whenever necessary.

(2) Institutions concerned with socio-environmental aspects in Tunisia

- The Ministry of Environment and Sustainable Development: Started operation in 1991 as the Ministry of Environment. It defines the country policy in the field of environment and pilots activities for the protection and improvement of the living spaces. According to the 11th Development Plan and Agenda 21, the Ministry is working on the formulation of the state sustainable development policy in the middle and short terms, following the Mediterranean Sustainable Development Strategy, with the support of the United Nations Environment Program (Action Plan for the Mediterranean: UNEP/PAM);
- The Environmental Protection Agency (ANPE): This agency was established in 1988 under the authority of the Ministry of Environment and Sustainable Development. The Agency implements policies to prevent pollution and to protect the environment;
- The Coastline Protection and Planning Agency (APAL), was established in 1995 under the authority of the Ministry of Environment and Sustainable Development. The Agency implements policies related to the management and protection of coastal areas and the littoral.

As this project relates to water supply and is located on a coastal area, its socio-environmental aspects will be treated in cooperation with SONEDE, ANPE and APAL. The National Commission for Sustainable Development (CNDD), the National Agency for Waste Management (ANGED) and the National Sanitation Office (ONAS) are also involved in environmental management but are not directly concerned with the project. However, they are involved as stakeholders.

8.6 Alternatives to the Project (including no-project or zero option)

The following points have been considered in the project design:

1. Necessity for the project: zero option, supply from remote areas, sea water desalination. Due to the lack of water resources in Sfax, the further development of the existing water supply network appears to be a non-realistic option. In the case of a zero option or supply from a distant area, water needs in the future cannot be fulfilled and the social impacts on the population in Sfax will be very severe.
2. Site of the desalination station: seven candidate sites have been evaluated and the socio-environmental aspects have been taken in consideration along with other criteria (see section 5.2);
3. Desalination process: RO process, thermal evaporation, electrolysis. These three processes have been evaluated taking in consideration energy use (see Table 5.1-1).

8.7 Scoping and Terms of Reference of the EIA

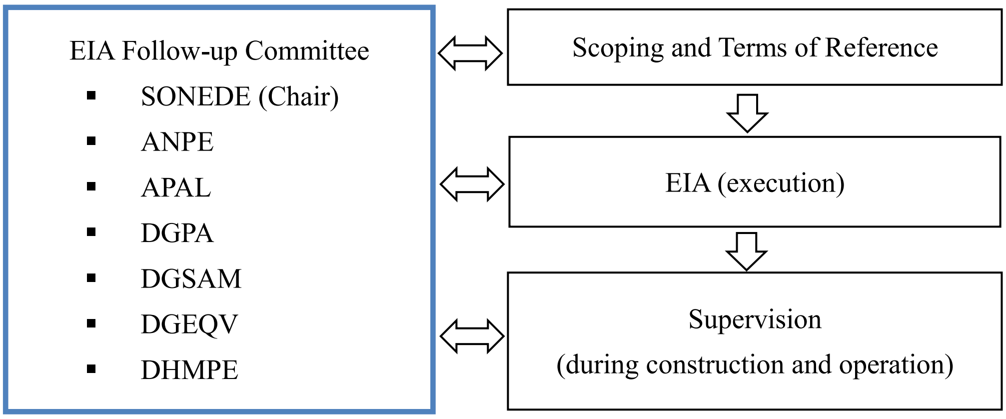
The scoping and terms of reference of EIA (Environmental Impact Assessment for environmental and social impacts) for this project have been conducted based on the following conditions:

- Decree 2005-1991 about protection of the environment and study of impact on the environment;
- JICA Guidelines (2010 version) about the socio-environmental considerations;
- Resource and Guidance Manual for Environmental Impact Assessments: Desalination – UNEP/ROWA, 2008;
- Guidelines for Impact Assessment on Seagrass Meadows, C. Pergent-Martini, C. Le Ravallec, UNEP, 2007;
- Environmental, sanitary and security guidelines – International Financial Corporation (IFC) of the World Bank Group;
- Specially protected areas and biological diversity in the Mediterranean (Barcelona Convention).

JICA Survey Team drafted an initial scoping report and EIA Terms of Reference in consultation with the EIA Follow-up Committee and the participation of a marine environment expert from INSTM (National Institute for Sea Sciences and Technologies). This report has been submitted to SONEDE. Organizations participating in the EIA Follow-up Committee are the following:

- SONEDE：Execution Agency of the project
- ANPE：Environment Protection Agency, Ministry of Environment and Sustainable Development (MESD)
- APAL：Coastline Protection and Planning Agency, MESD
- DGPA：General Directorate of Fishing and Aquaculture ,Ministry of Agriculture, Water Resources and Fisheries
- DGSAM：General Directorate of Air and Maritime Services, MESD
- DGEQV：General Directorate of Environment and Life Quality, MESD
- DHMPE：Directorate of Public Hygiene and Protection of Environment, Ministry of Healthcare.

The EIA Follow-up Committee was created at the recommendation of ANPE in order to compensate for the lack of experience of various institutions concerned by such a large-scope project in Tunisia. The committee was created at the initiative of SONEDE, which is in charge of the execution of the Project, the follow up and approval of the Terms of Reference and different EIA phases (the first session of the EIA Follow-up Committee was held on April 29, 2014 in order to examine the first version of the EIA Terms of Reference). The EIA Follow-up Committee must monitor the EIA's various phases including the follow-up of the project in operation. It is shown in the following Figure 8.7-1:



Source: JICA Survey Team

Figure 8.7–1 Activities of EIA Follow-Up Committee

Scoping results have shown that the project's positive aspects related to improving drinking water supply and water quality, while negative aspects were mainly related to the discharge of brine in the marine environment (TDS 73,000 mg/L). Therefore, the EIA's main components are the following:

- The receiving natural environment and the marine environment must be sufficiently and accurately characterized before execution of the project in order to serve as a baseline for subsequent supervision activities;
- Impacts of intake and discharge operations on the marine environment must be identified during construction and operation including any impacts on fishing activities;
- Depending on the intensity of the various impacts, appropriate mitigation and compensation measures must be implemented;
- Consultation with institutions concerned and with the population living around the project will be necessary;
- Mitigation measures will be adjusted according to the results generated by the supervision of the project whilst in operation.

The scoping study's detailed results are shown in the following Table 8.7-1 for the following evaluation components:

- Evaluation component 1: Desalination Plant (desalination factory, intake and discharge structures);
- Evaluation component 2 : Transmission pipeline (transmission pipeline, pumping stations, water-hammer structures -surge tanks-, reservoirs)
- Evaluation component 3: Power Transmission Line (power transmission line, power transmission towers)

Table 8.7-1 Scoping : Seawater Desalination Plant

Categories		Impact criteria	Evaluation		Justification
			Construction phase	Operation phase	
Pollution	1	Air pollution / Dust	C-	D	**During construction:** – The operation of worksite vehicles during construction will generate dust and gasses (NOx, SOx, etc.). Since large-scale earth works and pavement works are not planned in the project, this impact will not be serious. – Areas surrounding the plant site are mainly farmlands, road and beach, and dust will be generated anyway from the existing natural environment. No significant impact is therefore expected. **During operation:** – Power consumption by the station will generate the emission of greenhouse gasses (As Tunisian power production is based on fossil energies), but not to the extent to produce pollution affecting all of Tunisia.
	2	Water pollution	C-	C-	**During construction:** – Increase of sea water turbidity during dredging operations to lay pipes. **During operation:** – The increase of supplied drinking water quantities will increase volumes of wastewater with a possible contamination of groundwater depending on the extent of development of the sewerage system. – Brine discharge (Phase 1: 122 200 m^3/day at 73,000 mg/L) will locally increase sea water salinity.
	3	Waste	D	D	**During operation:** – The renewal of RO membranes will produce waste (about 200 m^3/year), however this waste is inert and combustible.
	4	Soil contamination	D	D	**During construction, and During operation:** – No specific waste treatment is planned; in addition main materials carried are drinking water, so even in the case of leaks, no soil contamination is expected
	5	Noise; Vibrations	D	D	**During construction:** - There is no population in the vicinity of the factory site and no living organisms sensitive to vibrations, therefore impact of noise and vibrations will be minimal. **During operation:** – Desalination is performed indoors; there are no consistent emissions of noise or vibrations outdoors.
	6	Land subsidence	D	D	**During operation:** – As this is a sea water desalination station, underground water will not be used. Similarly no large underground works will be done.
	7	Odour nuisance	D	D	**During operation:** – No open-air process producing strong odour is planned.

Categories		Impact criteria	Evaluation		Justification
			Construction phase	Operation phase	
	8	Sediments	D	D	**During construction:** - Excavated sand quantities for the laying of intake and discharge pipes are about $110m^2 \times 4000m$ = $440,000m^3$. - This includes the surplus soil generated corresponding to volume of pipes of about $(2.3m^2/2+2.1m^2/4) \times 3.14 \times 4000m = 47092m^3$, armor stones, and gravel pipe beds which will be disposed in the deep sea. The remaining quantity will be stored and backfilled into the excavated trenches. - As this concerns existing sediments, no specific additional pollution is expected.
Natural environment and natural risks	9	Protected natural areas	D	D	**During construction, and During operation:** - Protected areas (RAMSAR site of the salt factories in Sfax and ASPIM in the Kneiss islands) are not impacted upon by the Project.
	10	Natural habitats	B-	C-	**During construction :** - The factory is built within the maritime public domain. - The construction of the factory and mainly of the intake and discharge pipes will partially damage existing natural habitats. Concerned areas cover about 20 ha for the factory and 4000m×34m=14ha for the pipes. - The deposit of 101,600 m^3 excavated materials may have some impact according to characteristics of the natural environment at the level of deposit areas. **During operation :** - The discharge of brine (phase I : $73000mg/L \times 122,200m^3/day$) will induce an impact on the local natural environment; - The seawater intake (Phase I : $222,200m^3/day$) will be made at about 3 m above the seabed and the intake speed will be limited at 0.2 m/s; no major impact is expected on the marine environment.
	11	Hydrology	C-	D	**During construction :** - The laying of intake and discharge pipelines may temporarily modify currents. **During operation :** - Intake and discharge pipes are entirely buried; there will be no significant impact on marine currents.
	12	Morphology and geology	D	D	**During construction, and During operation:** - No major excavation works are planned
Human and social environment	13	Unwilling displacement of the population	D	D	**Design:** - The site of the plant is located within the public maritime domain and no housing facility exists in the project site.
	14	Subsidence means, poverty, vulnerability	C-	D	**During construction:** - As the site of the plan will be located within the public maritime domain, no cultivated land will be impacted. - The construction of intake and discharge pipes may temporarily disturb fishing activities.

Categories		Impact criteria	Evaluation		Justification
			Construction phase	Operation phase	
					- Since, the project will be implemented in the site next to farming and fishery areas, individuals possibly receiving impact are poor farmers and fishermen. Especially, construction work has the possibility to cause temporary impacts on fishermen. **During operation:** - Intake and discharge towers are located outside trawl fishing areas, thus, there will be no impact on fishing activities.
	15	Ethnic minorities	D	D	**During construction, and During operation:** - There are no minorities living in the site of the plant - The construction of the plant will not disrupt the shoreline continuity and will always enable nomadic pasturage activities to take place.
	16	Local economy/ employment	B+	B+	**During construction :** - Offer for local employment will increase; - Possibility to sub-contract services with local providers **During operation :** - Possibility to offer operators' positions at the plant - Possibility to sub-contract services with local providers
	17	Use of land and local resources	D	D	**During construction, and During operation:** - As the plant is located within the maritime public domain, no land acquisition needs to be planned.
	18	Water resources	D	B+/C+	**During operation :** - The over-exploitation of underground aquifers will be reduced by the use of desalinated seawater (B+) - The improvement of water supply should have a positive impact on resident's health (C+)
	19	Public infrastructures and social services	D	B+	**During operation :** - The project will improve the quantities and quality of drinking water supplied.
	20	Social capital and organization	D	D	**During construction, and During operation:** - As this is a sea-water desalination project, we do not expect any impact on social capital and organization.
	21	Distribution of profits and social equity	D	D	**During construction, and During operation:** - The project will be supported by the Greater Sfax population and will not create any regional disparity.
	22	Local conflicts of interest	D	B+	**During operation:** - The project will be developed in the Greater Sfax area for the benefit of the Greater Sfax region. - The project will re-balance the distribution of water resources by reducing the Sfax region's dependence on the transfer of water from the North.
	23	Historical and cultural heritage	C-	D	**During construction :** - The project currently avoids impacting the archaeological park of Thyna but the construction of the station might reveal new ruins.
	24	Landscape	D	D	**During construction, and During operation:** - The height of installations and of embankments will not be expected to modify the landscape.

Categories		Impact criteria	Evaluation		Justification
			Construction phase	Operation phase	
	25	Gender	D	C+	**During operation :** - In the area without water supply, women and children usually have to work to get water. The increase of water supply volume by the project will result in the possibility of extension of the water supply area. This improvement of water supply service may have a significant positive impact on women's conditions
	26	Children's rights	D	D	**During operation :** - Not applicable.
	27	AIDS, TD, hygiene and healthcare	D	D	**During construction :** - The project is implemented in the Greater Sfax area, local manpower expected and they are not likely to modify existing sanitary conditions.
	28	Professional health/security on the worksite	D	C-	**During construction :** - Desalination Plant: Safety management is needed with other ordinary construction works. Since there will be no work with explosives, dangerous substances, etc., special consideration about them will not be needed. - Marine works: Mmarine work will be needed for intake and discharge pipelines, transportation, lifting, and installation of pipes, intake head, and discharge head, but these are not different from other ordinary construction works. Therefore, there is no fear for the safety of workers, provided general safety management is carried out. Marine works, however, will be influenced by weather condition. Therefore, appropriate work schedules will have to be established. Submarine work will be conducted in depths of less than 10m by specialists in such type of work. Because of this reason, there will be a low possibility of the bends affecting workers. **During operation :** - At the desalination plant, chemicals will be used for water treatment. However, there is no need to fear dangerous accidents, because these chemicals are already in use at existing facilities and the quantities used will be small. High-pressure vessels and rotating equipment will be manufactured with designs which specifically consider safety. -Maintenance work will be conducted for marine facilities. Low concerns of accidents are anticipated because experienced divers will conduct such work.
Others	29	Accidents	D	D	**During construction, and During operation :** - No dangerous facilities are being planned and chemical products used in the process are stable (even in the unlikely instances of power failures).
	30	Trans-border effects or climatic changes	D	C-	**During operation :** - The power consumption of the desalination station is about 175GWh/year for Phase 1. This will increase the overall emission of greenhouse gas levels of Tunisia

A+/-: A major positive/negative impact is expected

B+/-: A positive / negative impact is expected to a certain extent
C+/-: Impact is unknown (Additional studies must be conducted to finalize the evaluation)
D: No impact is considered

Table 8.7-2 Scoping : Transmission Pipeline

Categories		Impact criteria	Evaluation		Justification
			Construction Phase	Operation Phase	
Pollution	1	Air pollution / dust	C-	D	**During construction:** - The operation of worksite vehicles during construction will generate dust and gas (NOx, SOx, etc.) Since large-scale earth works and pavement works are not planned in the project, the impacts will not be serious. - Areas surrounding the factory site are mainly farmlands and dust will normally come from the existing natural environments. No additional specific impacts are therefore expected. **During operation:** Power consumption by the station will generate emission of greenhouse gasses (As Tunisian power production is based on fossil energies), but not to the point to produce pollution affecting all of Tunisia.
	2	Water pollution	D	D	**During construction:** - The transmission pipeline is buried at about 3 m deep. The risk for the pollution of underground aquifers is very minimal. **During operation:** - As the transmission pipeline carries water, leaks will not induce any pollution of underground aquifers
	3	Wastes	D	D	**During operation:** - Spare parts for pumps and water hammer balloons represent common waste.
	4	Soil contamination	D	D	**During construction:** - Of the 230,000 m^3 to be excavated for the laying of the transmission pipelines, about 60,000 m^3 will be deposited. Excavated materials are mainly existing soils, so no added contamination is expected.
	5	Noise; Vibrations	D	D	**During construction:** - There are very few homes along the pipeline and no organism that may be sensitive to vibrations has been identified. Therefore no impact is expected. **During operation:** - Pumping stations are located in existing reservoirs' sites so no impact are to be expected (Surge tanks usually do not cause noise and vibration. When it is working, water flow sounds will be generated only for a limited time.)
	6	Land subsidence	D	D	**During operation:** - No use of underground aquifers is expected and no large scale soil excavations are planned
	7	Odour nuisance	D	D	**During operation:** - Only drinking water is transmitted with no emission of unpleasant odours.
	8	Sediments	D	D	**During construction, and During operation:** - Not applicable.

Categories		Impact criteria	Evaluation Construction Phase	Evaluation Operation Phase	Justification
Natural environment and natural risks	9	Protected natural areas	D	D	**During construction, and During operation:** - Protected areas (RAMSAR salt factory site in Sfax and ASPIM of the Kneiss islands) will not be affected by the Project.
	10	Natural habitats	D	D	**During construction :** - The natural environment along the transmission pipeline corresponds to an already developed urban area so no additional impacts are to be expected.
	11	Hydrology	D	D	**During construction :** - The crossing of rivers (wadis) by the pipeline will be underground with no impact on the river beds
	12	Morphology and geology	C-	D	**During construction:** - Of the 230,000m^3 excavated to lay and bury transmission pipes, about 60,000 m^3 will be deposited; it is therefore possible that some to modification of the local constituents of the soil (e.g. 60,000m^3 = height 2m × 3ha) may occur.
Human and social environment	13	Unwilling displacement of the population	D	D	**Design:** - Since the outline of the transmission pipeline can be adjusted to avoid existing housings, the project does not expect any unwilling displacement of people to occur.
	14	Subsidence means, poverty, vulnerability	D	D	**During construction, and During operation:** - Not applicable.
	15	Ethnic minorities	D	D	**During construction, and During operation:** - Not applicable.
	16	Local economy / employment	B+	B+	**During construction :** - Employment opportunities will increase. - Possible sub-contracting opportunities with local service providers **During operation :** - Possibility to work as operators in the plant - Possible sub-contracting opportunities with local service providers
	17	Use of soils and local resources	C-	D	**During construction :** - In general, the transmission pipeline will be laid within the existing road's right of way area. Very limited land acquisitions are expected.
	18	Water resources	D	D	**During construction, and During operation:** - Not applicable.
	19	Public infrastructures and social services	D	B+	**During operation :** - The project will improve the quantity and quality of drinking water supplied.
	20	Social capital and organization	D	D	**During construction, and During operation:** - As this is a sea-water desalination project, we do not expect any impact on social capital and organization.
	21	Profit distribution, social equity	B+	B+	**During construction, and During operation:** - The project will be supported by the Greater Sfax population and thus will not create any regional disparity.
	22	Local conflict of interests	D	B+	**During operation:** - The project is developed in the Greater Sfax area for the

Categories		Impact criteria	Evaluation		Justification
			Construction Phase	Operation Phase	
					benefit of the Greater Sfax. - The project will re-balance the distribution of water resources by reducing the Sfax region's dependence on the transfer of water from the North region.
	23	Historical and cultural heritage	D	D	**During construction :** - The project avoids the archaeological park of Thyna but the construction activities involved in laying of transmission pipes might reveal new ruins.
	24	Landscape	D	D	**During construction, and During operation:** - The height of transmission pipes and of embankments is not expected to modify the landscape.
	25	Gender	D	D	**During operation :** - Discussed in the evaluation component 1
	26	Children's rights	D	D	**During operation :** - Discussed in the evaluation component 1.
	27	AIDS, STDs, health and hygiene	D	D	**During construction :** - As the project is to be implemented in the Greater Sfax area, we expect manpower to be local and will not be expected to modify existing sanitary conditions.
	28	Professional health/safety on the worksite	D	D	**During construction :** - Safety management will be needed similar to any other ordinary construction work. Since there will be, however, no work with explosive, dangerous substances, etc., special consideration about them will not be needed. - The work along roads will require traffic control to avoid traffic accident. Further, deep excavation have to be conducted with earth retaining work in place to avoid collapses caused by heavy traffic loads. - Railway crossing work requires special consideration to avoid collapse. Though it will be carried out by a trenchless method, the work shall be stopped when train pass by the work site. Special request to the railway operation authority will be needed to slow down the speed of trains in the vicinity of the work site. With such considerations, no specific dangers are to be expected. **During operation :** - No specific impact will therefore be expected.
Others	29	Accidents	D	D	**During construction, and During operation :** - No dangerous facilities are being planned.
	30	Trans-border effects and climatic changes	D	D	**During operation :** - Discussed in the evaluation component 1

A+/-: A major positive/negative impact is expected
B+/-: A positive/negative impact is expected to a certain extent
C+/-: Impact is unknown (Additional studies must be conducted to finalize the evaluation)
D: No impact is considered

Table 8.7-3 Scoping: Power Transmission Line

Categories		Impact criteria	Evaluation		Justification
			Construction Phase	Operation Phase	
Pollution	1	Air pollution / dust	C-	D	**During construction:** - The operation of worksite vehicles during construction will generate dust and gasses (NOx, SOx, etc.) Since large-scale earth works and pavement works are not planned for the project, the impact will not be serious. – Areas surrounding the power transmission route are mainly farmlands and normally dust will be expected to come from the existing natural environments. No significant specific impacts are therefore expected. **During operation :** - Not applicable.
	2	Water pollution	D	D	**During construction, and During operation :** - Not applicable.
	3	Wastes	D	D	**During construction, and During operation :** - Not applicable.
	4	Soil contamination	D	D	**During construction, and During operation :** - Not applicable.
	5	Noise; Vibrations	D	D	**During construction, and During operation :** - Not applicable.
	6	Land subsidence	D	D	**During construction, and During operation :** - Not applicable.
	7	Odour nuisance	D	D	**During construction, and During operation :** - Not applicable.
	8	Sediments	D	D	**During construction, and During operation :** - Not applicable.
Natural environment and natural risks	9	Protected natural areas	D	D	**During construction, and During operation :** - The transmission line is not expected to pass over the Thyna area (RAMSAR) shown on Figure 8.4-3.
	10	Natural habitats	D	D	**During operation :** - Mostly olive farming field. No fragile ecosystem present
	11	Hydrology	D	D	**During construction, and During operation :** - Not applicable.
	12	Morphology and geology	D	D	**During construction, and During operation :** - Not applicable.
Human and social environment	13	Unwilling displacement of the population	D	D	**Planning:** - The transmission route is expected to be selected to avoid involuntary resettlement
	14	Subsidence means, poverty, vulnerability	C-	D	**During construction:** - Fear of possible impact on farmland where land acquisition will be conducted for power transmission towers. **During operation:** - Not applicable
	15	Ethnic minorities	D	D	**During construction, and During operation :** - Not applicable.
	16	Local economy / employment	D	D	**During construction, and During operation :** - Not applicable.
	17	Use of land and local resources	C-	D	**During construction:** - there will be land acquisition for construction of power transmission towers

Categories		Impact criteria	Evaluation Construction Phase	 Operation Phase	Justification
					During operation: - Not applicable
	18	Water resources	D	D	**During construction, and During operation :** - Not applicable.
	19	Public infrastructures and social services	D	D	**During construction・During operation :** - Not applicable.
	20	Social capital and organization	D	D	**During construction, and During operation :** - Not applicable.
	21	Profit distribution, social equity	D	D	**During construction, and During operation :** - Not applicable.
	22	Local conflict of interests	D	D	**During construction, and During operation :** - Not applicable.
	23	Historical and cultural heritage	D	D	**During construction, and During operation :** - Not applicable.
	24	Landscape	D	C-	**During construction:** - Same to below. **During operation:** - Fear of impact of landscape by 40m high towers
	25	Gender	D	D	**During construction, and During operation :** - Not applicable.
	26	Children's rights	D	D	**During construction, and During operation :** - Not applicable.
	27	HIV/AIDS, health and hygiene	D	D	**During construction, and During operation :** - Not applicable.
	28	Professional health/safety on the worksite	D	D	**During construction, and During operation :** - STEG will plan, construct and maintain the power transmission facilities. No impact is expected on work site condition.
Others	29	Accidents	D	D	**During construction, and During operation :** - STEG will plan, construct and maintain the power transmission facility. Based on their past experiences, no accidents are expected.
	30	Trans-border effects and climatic changes	D	D	**During operation :** - Evaluated in sea water desalination plant.

A+/-: A major positive/negative impact is expected
B+/-: A positive/negative impact is expected to a certain extent
C+/-: Impact is unknown (Additional studies must be conducted to finalize the evaluation)
D: No impact is considered

Based on the results of the scoping exercise, the JICA Survey Team prepared and submitted a draft of the Terms of Reference (TOR) for the EIA to be conducted by local consultant. SONEDE discussed the matter with APAL and ANPE based on the draft and agreed with them to finalize the TOR based on the draft. The JICA Survey Team compiled and submitted the TOR to SONEDE and SONEDE made a contract with a local consultant to carry out the services of the EIA after bidding. The EIA is being conducted as of June 2015.

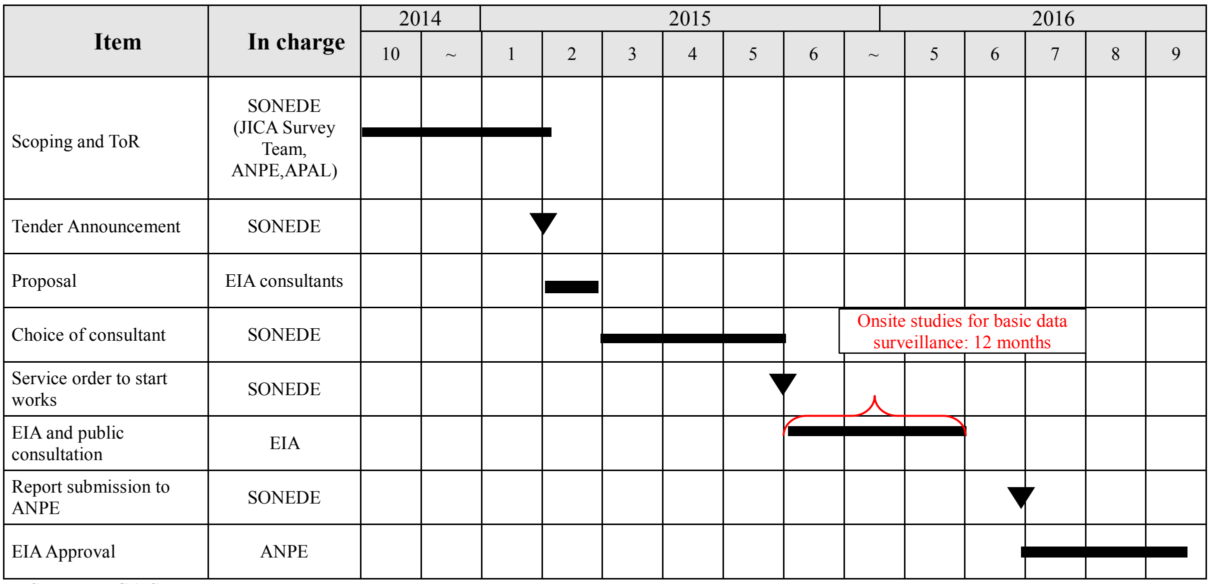
The summary of the EIA's TOR developed based on the scoping study is given in the following table:

Table 8.7-4 Summary of the EIA's Main Terms of Reference

Objective	Point to study	Study Method
Approach and framework of EIA study	① legal and institutional framework of EIA ① EIA methodology, approach, planning, and personnel	1-Refer to EIA scoping report 2-refer to EIA Terms of reference
Define the baseline of the natural and social environment	① Description of the receiving environment : Project area, land and marine physical and biological natural environment, ②Description of the society: population, healthcare, gender effects.	1-Collect and summarize available data and reports 2-Additional studies on site of the marine environment: ➢ Water quality (including plankton) ➢ Description of marine grasses ➢ Description of the ecosystem ➢ 4 sampling points. 2 points at the level of the project (A and B on the figure) and 2 points on pilot areas (C and D).  ➢ Sampling in summer and in winter
Project description	①Description of the project's components ②Project's materials inventory (input/output) ③Construction and operation methods	1- Refer to the report of the project's preparatory study (This report)
Evaluation of the project's variants and the project site	①Project variants ①Project site options	1- Refer to the report of the project's preparatory study (This report) 2-Conduct site visits
Evaluation of impacts on the natural and social environments	①Evaluate impacts with regard to the project's components (during construction and during operation) ①Areas impacted by the discharge of brine and impact on the marine environment	1-Consult reference documents, check each item. 2- Calculate the area affected by the brine discharge 3-Consult documents concerning the relation between salinity and toxicity in the marine environment
Mitigation measures and compensation of related costs	①Suggest appropriate mitigation and compensation measures for each impact	1-Based on the evaluation of site conditions and impact characteristics, elaborate appropriate mitigation measures.

Objective	Point to study	Study Method
	②Evaluate costs and suggest an organization for the implementation of measures	2-Design compensation measures complying with the relevant laws and regulations in force. 3-Jointly with SONEDE, define costs and organization to implement and enforce compensation measures.
Monitoring plan	①Design of a monitoring plan: items to monitor, applicable standards, concerned institutions, costs, implementation organization	1-Definition of supervision modes for each item to monitor 2- Jointly with SONEDE, design a monitoring plan
Consultation with stakeholders and with the population	①Consultation with stakeholders reflecting the results of the project ②Information of the local populations	1- Hold meetings with stakeholders in Sfax in order to explain the characteristics and the impacts of the project. Refer to the stakeholders meeting already held during the preparatory study. Evaluate different proposals and reflect them in the project implementation. 2- Hold information meetings with the local population in order to explain the project characteristics and impacts.

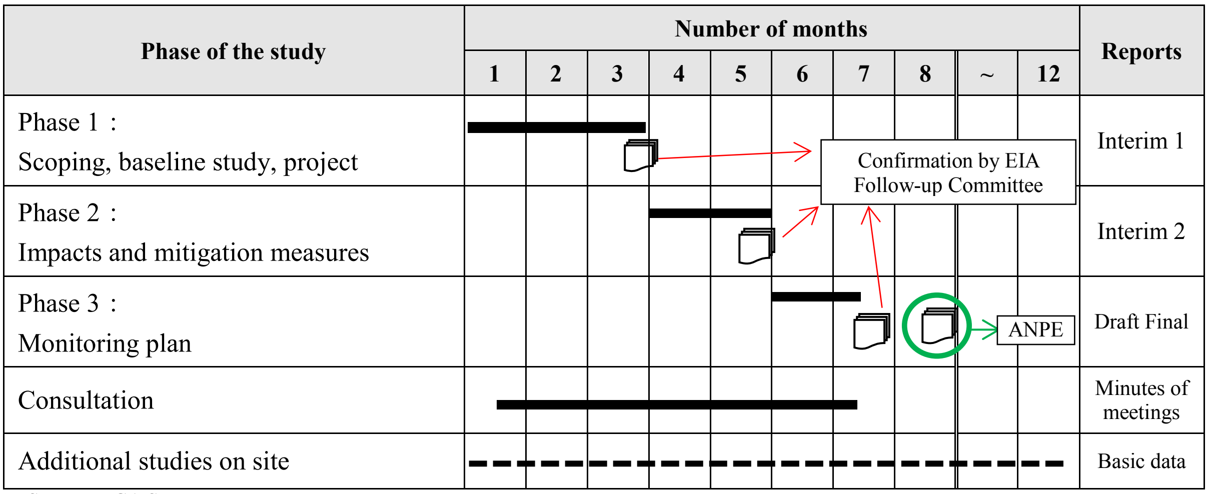
The provisional schedule for the execution of the scoping study, preparation of the terms of reference and the EIA is shown in Figures 8.7-2:



Source: JICA Survey Team

Figure 8.7–2 Provisional Schedule for Scoping, TOR and EIA

The execution of EIA is detailed in Figure 8.7-3:



Source: JICA Survey Team

Figure 8.7–3 EIA Execution Plan (proposal)

Since every phase and intermediate report will be checked by the EIA Follow-up Committee, it may be expected that the final approval by ANPE will raise a few additional comments or reservations.

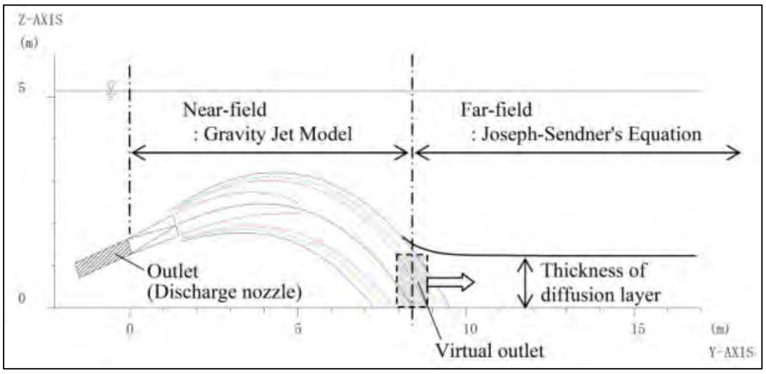
8.8 Results of Socio-Environmental Investigations

Further to the scoping results, characterizing impacts related to brine discharge was subject to a simulation exercise. Data related to marine grass, *Posidonia oceanica,* in the project's surrounding areas have also been collected and analysed.

A social survey was conducted in order to assess the satisfaction rate in terms of drinking water service and impacts on society. The final meeting with the representatives of the British Gas company (hereafter referred to as BG) was organized in order to identify possible impacts of this project on fishing activities. Results are collected in Table 8.8-1:

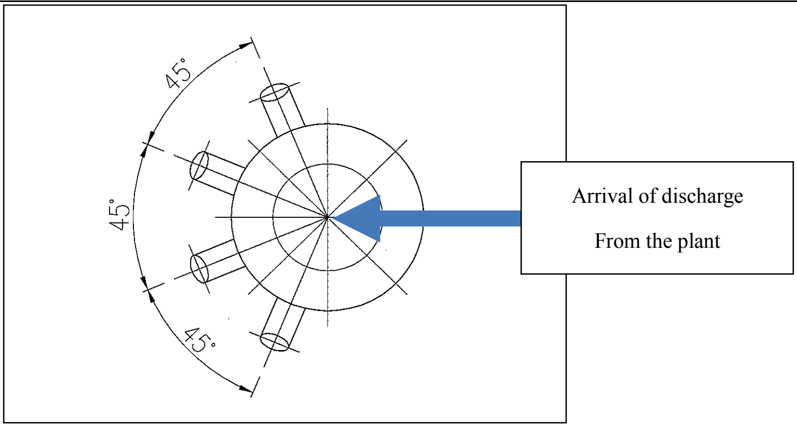
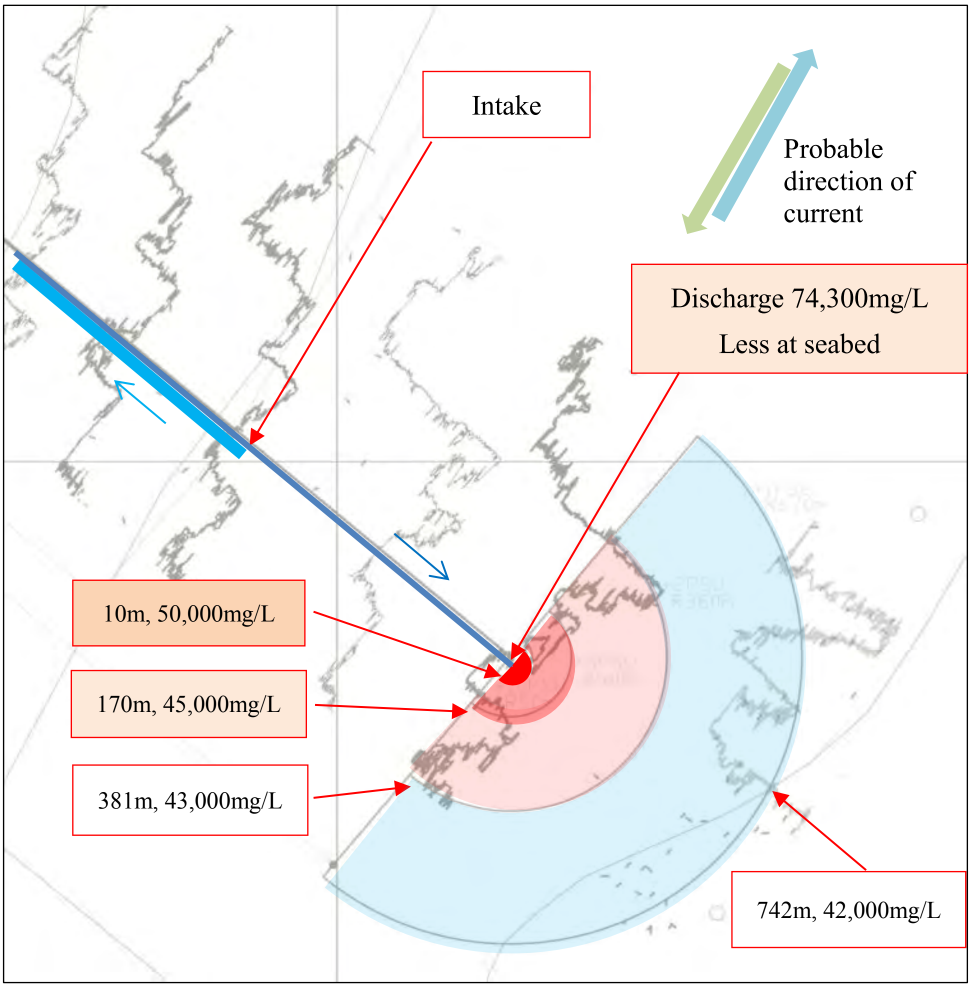
Table 8.8-1 Results of Socio-Environmental Investigations

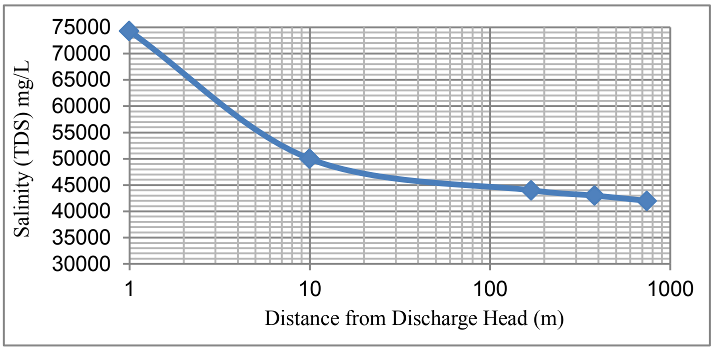
Criteria	Investigations Results
Water pollution	**Simulation of brine dispersion** In order to assess the impact of brine discharge into the natural environment, amounting to about 73000 mg/L TDS at the level of the discharge head, the JICA Survey Team studied the dispersion of brine in surrounding sea water. To do this, we use a two-layer model: 1. First a gravitational jet model at the level of the nearby field (ten meters around the discharge tower): this model takes into consideration the immediate dilution at the level of the circulating jet mixed with surrounding water. It gives information about the form of the jet, the falling point and the evolution of concentration in the jet. It also takes in consideration the form, the inclination of the nozzle, the number of nozzles and the speed of discharge. 2. Then a model for dissemination in remote areas at 2 dimensions following the equation developed by Joseph Sendner : the model is based on the concentration of the jet at the level of the falling point calculated by the nearby field model, and calculates the progressive dilution of salinity through dispersion throughout a plane area. It takes in consideration the total quantity of water discharged as well as the water height and the shape of the dispersion area. This two-layer model is shown in the figure below:

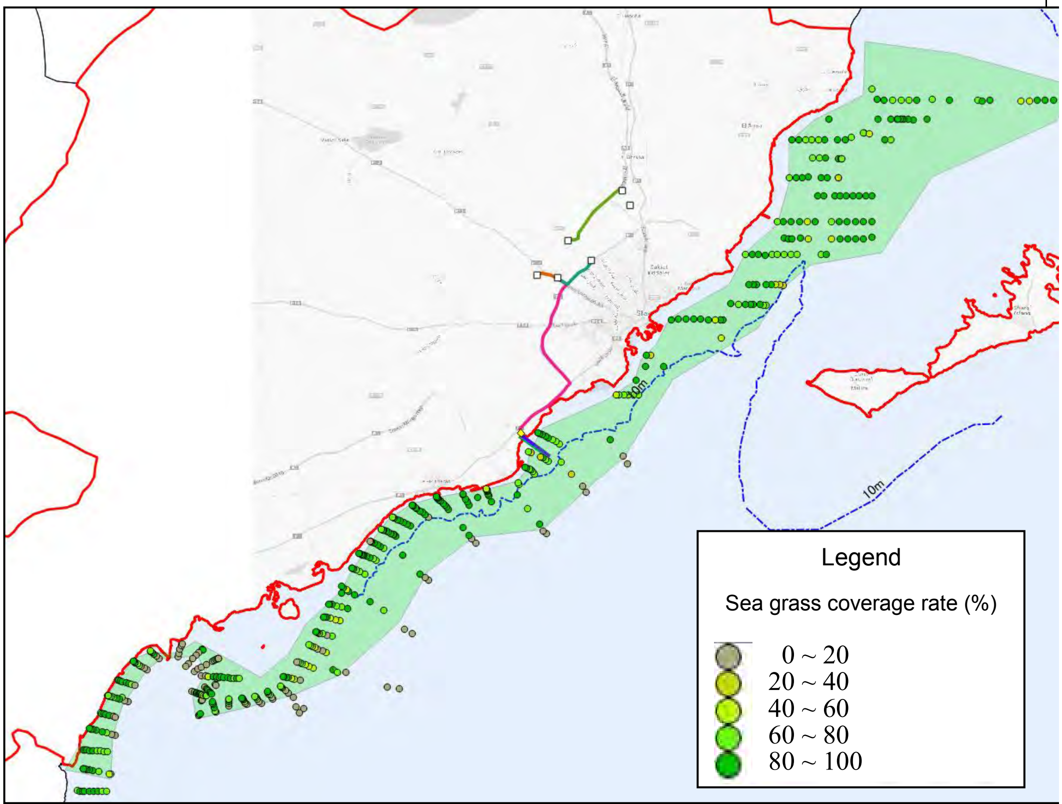
Criteria	Investigations Results
Water pollution	 Source: JICA Survey Team **Figure 8.8–1 Two-Layer Simulation Model** This type of simulation is largely used at the level of the pre-project preparatory studies for conventional or nuclear thermal power plants (floating jet), and for desalination stations (falling jet), and is based on several references. The model was also applied by research laboratories, and suitability and accuracy of it was confirmed. <u>Calculation conditions for this project</u> Simulation was based on unfavourable conditions in the summer period (highest salinity of the environment) as shown in Table 8.8.2. Discharge quantity : :244 ;400 m^3/day (maximal capacity, Phase 2) Discharge speed :3m/s Number of nozzles: :4 Diameter of the nozzle : :0.55m Angle of the nozzle from horizontal line :45deg Height of discharge from the ground (nozzle centre):1.3m Current : 0.01m/s (*1) *(*1) in the absence of more accurate data, we used the pejorative hypothesis of minimal current.* Discharge angle :180deg (*2) *(*2) Since discharge is slightly heavier than sea water, it tends to flow on the highest slope. Based on this phenomenon, a discharge tower of 180deg is adopted, see Figure 8.8.2.* **Table 8.8-2 Temperature and Salinity**

Month		Jan - Mar	April - June	July August	Sep.-Nov.	December
		Winter	Spring	Summer	Fall	Winter
Sea water temper.	C	15	25	30	25	15
Discharge temper	C	15	25	30	25	15
Sea water salinity	mg/L	39,000	40,000	41,000	40,000	39,000
Discharge salinity	mg/L	70,800	72,500	74,300	72,500	70,800
Difference	psu	31.8	32.5	33.3	32.5	31.8

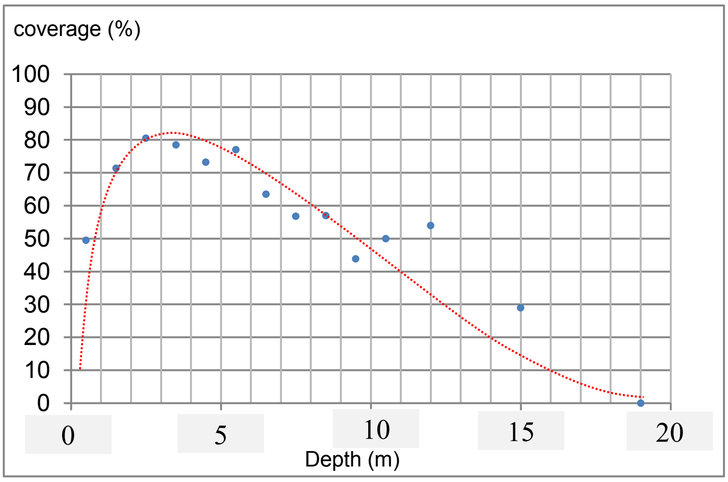
Source: JICA Survey Team

Criteria	Investigations Results
	 Source: JICA Survey Team **Figure 8.8-2 Plan of the Discharge Tower** Results are shown in figure below on the following figure:  Source: JICA Survey Team **Figure 8.8–3 Results of the Brine Dispersion Simulation**

<table>
<tr><th>Criteria</th><th>Investigations Results</th></tr>
<tr><td></td><td>Salinity according to distance from the discharge tower is shown in the graph below:


Source: JICA Survey Team
Figure 8.8–4 Salinity according to Distance to the Discharge Head</td></tr>
<tr><td>Natural habitats</td><td>Baseline of Posidonia oceanica
Data concerning the state of Posidonia oceanica and Cymodocae in the governorate of Sfax were kindly provided by INSTM (L. Ben Mustapha) based on a 2008 World Bank Study. The SIG Analysis of these data shows the following facts:


Source : : INSTM (Ben Mustapha), JICA Study Team
Figure 8.8–5 Current State of Posidonia oceanica and Cymodocea in Sfax Governorate (excluding Kerkennah)
In the Governorate of Sfax, the current conditions of Posidonia oceanica is as follows :
▪ Coverage area : about 130,000 ha (green area above, including surveyed areas)
▪ Average coverage rate (low hypothesis) : 40% => sea grass area = 0.4x130,000 = 52 000 ha
▪ Average coverage rate (high hypothesis) : 60% => sea grass area = 0.6x130,000 = 78,000 ha
In the Governorate of Sfax, excluding Kerkennah, the total area of sea grass is then estimated at about 52,000ha.</td></tr>
</table>

<table>
<tr><th>Criteria</th><th>Investigations Results</th></tr>
<tr><td></td><td>
The correlation between the depth of the water and the average coverage rate observed is represented on the following figure:


Source : JICA Survey team
Figure 8.8–6 Coverage Rate of Sea Grass vs. Water Depth

Relation between the salinity rate and Posidonia oceanica survival
The relationship between the salinity rate and the survival of Posidonia oceanica was studied in Fernandez-Torquemada, Y., Sanchez-Lizaso “Effects of salinity on leaf growth and survival of the Mediterranean sea-grass Posidonia oceanica”, 2005. According to this source, survival of this sea grass is not possible when salinity exceeds 50000 mg/L in TDS. However, we may consider that as of 45000 mg/L in TDS, the environment would have long term damage. This shows the impact of the project on sea grasses, Posidonia oceanica:
▪ Impact due to the construction of the intake and discharge pipes: 34 m (width of excavation) x 4000 m (average length of pipeline) x 80% (sea grass coverage rate at the level of the pipeline) = 11.2 ha (note: partial recovery is possible above the pipeline in coming years)
▪ Impact due to the discharge of salinity: salinity (TDS)< 45000mg/L => radius > 200m => impacted area :
3.1416×200^2 / 2×80%= 5ha (the choice of the coverage rate at 80% is pejorative for this calculation as it increases the impacted area)
<u>Desalination effects in the Gulf of Gabes</u>
In the Gulf of Gabes, 4 sea water desalination projects are in progress :
▪ Sfax (this project) : 200,000m^3/day at the end of the project
▪ Djerba : 75,000m^3/day at the end of the project
▪ Zarat : 100,000m^3/day at the end of the project
▪ Kerkennah : 6,000m^3/day at the end of the project
This represents therefore a total of 381,000m^3/day at the level of the Gulf of Gabes by horizon year 2030. If we consider that the Gulf of Gabes covers a total area of about 12,000km² and if we also consider an average annual evaporation of 1788m/year (ref. National Meteorology Institute), then the daily evaporated water volume would be 12,000,000,000 m² x 1.788 m / 365 days = 58,800,000 m^3/day. Water desalination would then represent at the end of projects about 381,000 / 58,800,000 = 0.6% of the evaporation all over the Gulf of Gabes (by deliberately not calculating additional inputs of soft water discharged by purification stations). Therefore, except the influences at discharge point, the influence on ecology system in the Gulf of Gabes is quite small.
The nearest seawater desalination plant planned is the Kerkennah plant 40km from the Sfax plant, Therefore, discharge water from both plants will not be merged and their combined influence on ecology system is negligible because of sufficient dilution effects.
</td></tr>
<tr><td>Subsidence means, poverty, vulnerability</td><td>
Coastal fishing activities in the vicinity of the desalination station’s site
In 2004, fishing in the Governorate of Sfax represented 47% of the national overall activity, while the port of Sfax represents the largest fishing port in Tunisia (with an annual production of about 15,000 tons). Fishing methods used in Sfax are shown in the following table:
</td></tr>
</table>

Criteria	Investigations Results

Table 8.8-3 Fishing Methods in the Sfax Region

Method	Boats	Target	Area	Status
Coastal shell collection	-	Crustaceans, mollucks	Beach, littoral	Authorized
Line fishing	Sail boats or with engines (1 to 2 fishermen)	cuttlefish, sea bream	*Posidonia oceanica* (depth 2 to 10m) Sfax-Kerkennah Channel (depth +10m)	Authorized
Net fishing (static)	Sail boats or with engines (2 to 5 fishermen)	Octopus, cuttlefish, shrimps, sea bream, flounder		Authorized
Trapping	Sail boats or with engines (1 to 2 fishermen)	Octopus, mullet		Authorized
Fishing with turning seine	Motor boats (6 to 8 fishermen)	Tuna, sardine		Authorized (depth.+20m)
Mini-trawl fishing (« kiss »)	Sail boats or with engines (1 to 6 fishermen)	Octopus, cuttlefish, shrimps, sea bream, flounder		forbidden

Source : SMAPIII report, City of Sfax (Impact study : report on marine environment)

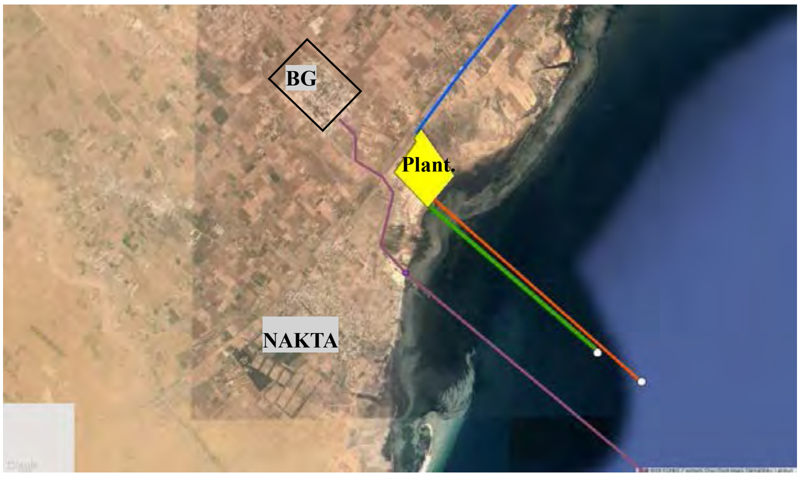
Source : SMAPIII report, City of Sfax (Impact study : report on marine environment)

Figure 8.8–7 Fishing Boats in the Sfax Region (sail boat on the left and motor boat on the right)

Impact of the construction of intake and discharge pipes on fishing activities, the example of British Gas (referred to as BG):
The gas plant of British Gas is located in the vicinity of the project site.
The following observations can be made about gas pipelines linking offshore extraction platforms to the plant:

1) According to the pipelines' coordinates, they neither cross the desalination station's proposed site nor sea pipelines:

<table>
<tr><th>Criteria</th><th>Investigations Results</th></tr>
<tr><td></td><td>

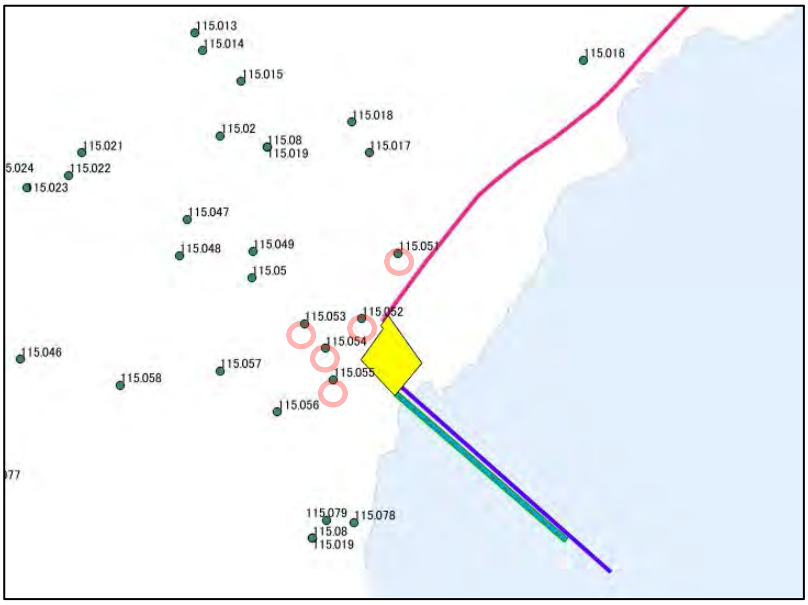


Source : BG (pipelines' coordinates) ; JICA Study Team

Figure 8.8–8 Position of the Project and BG Pipelines

2) When laying a new pipeline in 2008, the following problems emerged:
   1. Since the orientation of sail boats is conditioned by the wind, the limit set for the construction of the pipeline will no longer allow access to a certain fishing areas;
   2. Collection of shells is practiced in the project area by local women. As turbidity increased during excavation works offshore, the quality of the shells dramatically dropped reducing sales;
3) In order to act on these issues, BG set up a compensation system summarized as follows:
   1. During the construction phase of the initial five kilometres of the pipeline, payment of a monthly compensation to populations affected by the project;
   2. For boats or vessels: 300 TD for the captain and 150 TD for crew members;
   3. About 30 TD for women shell collectors.
4) Four staff members of BG devoted 30% of their time for 6 months to settle these issues.

We expect similar works for the construction of intake and discharge pipes. In order to prevent these issues, it is necessary to consult with fishermen and with the local population, explain to them the construction method and define an appropriate compensation programme.
</td></tr>
<tr><td>Historical and cultural heritage</td><td>
The location of archaeological ruins around the site of the desalination plant based on the information of the National Institute of Ruins (Institut National du Patrimoine, INP) is shown in Figure 8.8-9.



Source: : INP, JICA Survey Team

Figure 8.8–9 Location of Archaeological Ruins around the Desalination Plant Site
</td></tr>
</table>

Criteria	Investigations Results
	The archaeological ruins close to the plant site are as shown in the following table. The nearest archaeological ruins No. 115.052 is 290m from the site. **Table 8.8-4 List of Archaeological Ruins near the Plant Site** ID / Name / Longitude* / Latitude 115.051 / Sidi Ghrib / 647127.10 / 3830084.99 115.052 / Jeh el Hr. / 646600.63 / 3829107.43 115.053 / Hr. Farhat / 645748.46 / 3829025.98 115.054 / - / 646063.70 / 3828661.98 115.055 / - / 646191.77 / 3828202.80 Source：INP (http://www.inp.rnrt.tn/Carte_archeo/html/115）、*UTM32N Carthage Datum The law related to conservation of ruins is No. 94-35 (24.2.1994). Clause 69 of the law enables stopping construction work for six months in case new ruins are discovered to enable survey of any newly discovered archaeological ruins.

Source: JICA Study Team

8.9 Evaluation of Impacts

Based on results of Section 8.8 above, the different impacts of the project were evaluated for each evaluation component as described in Table 8.9-1:

Table 8.9-1 Evaluation of Impacts : Seawater Desalination Plant

Categories		Impact criteria	Evaluation		Confirmation		Justification
			Construct. phase	Operation phase	Construct. phase	Operation phase	
Pollution	1	Air pollution / dust	C	D	D	D	**During construction:** - Large-scale earth works and pavement works are not being planned, and areas surrounding the plant site are mainly farmlands, road and beach. Since only dust will be produced, no significant specific impact is therefore expected.
	2	Water pollution	C-	C-	D	D	**During construction :** - Turbidity will temporarily increase due to offshore excavation works, however since turbidity is generated by existing sediments, there is no additional pollution of sea water (impacts on fishing activities are described below) **During operation:** - Since discharges are diluted, salinity drops to +1000mg/L（or +2%）of the natural salinity at about 750m from the discharge head, the situation is therefore not dangerous for human activities. (Concentrations of Na and Cl in Tunisian Standards for Water discharge to Sea, NT106-002,

Categories		Impact criteria	Evaluation		Confirmation		Justification
			Construct. phase	Operation phase	Construct. phase	Operation phase	
							shown in Table 8.11-1, are "No Limit"). (Impacts on natural habitats are described below). - Taking in consideration the nominal capacity of the 4 sea water desalination stations planned in the Gulf of Gabes, the accumulated water intake volume will be 0.6% of water losses through evaporation at the level of the Gulf. There is therefore no significant impact at this level.
Natural environment and natural risks	10	Natural habitats	B-	C-	B-	B-	**During construction :** - Due to excavation works in the sea, 11.2 ha of *Posidonia oceanica* will be lost, which will have an impact on the marine environment. However, when compared with the 52,000 ha of sea grasses living along the Sfax coast, this impact is rather limited and partial recovery will be possible in the long term above the pipelines. - The coverage rate of sea grasses in the pipelines area ranges between 60% and 80%. The deposit of excavated materials in the area may generate additional loss of sea grasse, this is why the impact depends on the choice of the deposit site for the 101,600 m^3 excess excavated material. **During operation :** - The final impact area of discharged water is estimated at about 5.0 ha, however, compared to the 52,000 ha of sea grasses living along the coast of Sfax, the impact is relatively limited.
	11	Hydrology	C-	D	D	D	**During construction :** - After excavation, pipes will be taken to the site by floating them and then they will be laid at the bottom of the sea trench and buried, so there will be no impact on marine currents.
Human and social environment	14	Means of subsidence, poverty, vulnerability	C-	D	B-	D	**During construction :** - Based on the British Gas experience, it is possible that the construction of pipelines impacts fishing activities.
	16	Local economy/Empl	B+	B+	B+	B+	**During construction :** - Local employment will increase;

Categories		Impact criteria	Evaluation		Confirmation		Justification
			Construct. phase	Operation phase	Construct. phase	Operation phase	
		oyment					- Possibility for sub-contracting services with local providers **During operation :** - Possibility for operators' positions at the plant - Possibility for sub-contracting services with local providers
	18	Water resources	D	B+/C+	D	B+/D	**During operation :** - No impact on health by change of water supply system because no relationship between the water supply and diseases has definitely been proved.
	19	Public infrastructures and public services	D	B+	D	B+	**During operation :** - The project will improve the quantities and quality of drinking water
	22	Local conflicts of interest	D	B+	D	B+	**During operation:** - The project facility will be located in the Greater Sfax area. The subject area of the project is the whole Greater Sfax. - As this seawater desalination project will ease the water supply situation in the central area of Tunisia, it will have a positive effect on any impacts of any local conflicts.
	23	Historical and cultural heritage	C-	D	D	D	**During construction :** - As shown on Figure 8.8-9, there are currently no archaeological ruins at the desalination plant site. The route for the transmission pipeline was once excavated for road construction, and therefore, the possibility of discovery of new archaeological ruins is very low. Areas for foundation works of power transmission towers are small, i.e. four piles which are 0.8m in diameters, In addition, it is possible to change the route to avoid any archaeological ruins if they exist. - The results of geotechnical drilling works have shown no hard stratum in the project area, therefore, the probability of archaeological ruins is very limited.
	25	Gender	D	C+	D	D	**During operation :** - Though the increase of water supply volume by the project will allow create the possibility of an extension of the water supply area; as the rate of connection to

Categories		Impact criteria	Evaluation		Confirmation		Justification
			Construct. phase	Operation phase	Construct. phase	Operation phase	
							drinking water supply in Sfax is already very high, the improvement of the water supply service may have only little positive impacts on existing women's conditions.
	28	Professional health /safety on the worksite	D	C-	D	D	**During operation :** - SONEDE's operating stations already use similar chemical products, so the staff has good and appropriate experience in managing any leaks and related hazards.
Others	30	Trans-border effects and climatic changes	D	C-	D	D	**During operation :** - Power consumption in Tunisia for the year 2013 was 14,379GWh (https://www.steg.com.tn), the power consumption by the station: 143GWh will therefore represent 1% or less of the national consumption figures, the increase of CO_2 emissions will then be very limited at the national level.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

Table 8.9-2 Evaluation of Impacts : Transmission Pipeline

Categories		Impact criteria	Evaluation		Confirmation		Justification
			Construct. phase	Operation phase	Construct . phase	Operation phase	
Pollution	1	Air pollution/dust	C	D	D	D	**During construction:** -Large-scale earth works and pavement works are not being planned, and the pipeline route is mainly surrounded by farmland and roads. Since only dust will be produced, no significant specific impacts therefore are expected.
Natural environment and natural risks	12	Morphology and geology	C-	D	D	D	**During construction :** - The construction and laying of transmission pipes will generate 60,000m^3 of excess excavated material. However a large part can be reused on the site of the desalination station, which requires backfilling. On the other hand, several deposit sites nearby Sfax are also available; and there will be no big impact on existing soils.

Categories		Impact criteria	Evaluation		Confirmation		Justification
			Construct. phase	Operation phase	Construct . phase	Operation phase	
Human environment and society	16	Local economy / Employment	B+	B+	B+	B+	**During construction :** - Local employment will increase; - Possibility for sub-contracting services with local providers **During operation :** - Possibility for sub-contracting services with local providers
	17	Use of soils and local resources	C-	D	B-	D	**During construction :** - In general, pipes will be laid in the right of way areas of existing roads. However, some land acquisition will be necessary in several areas and for surge tank areas.
	19	Public infrastructures and social services	D	B+	D	B+	**During operation :** - The project will improve the quantities and quality of drinking water
	21	Repair of benefits, social equity	B+	B+	B+	B+	**During construction, and During operation:** - - The project facility will be located in the Greater Sfax area. The subject area of the project is the whole Greater Sfax.
	22	Local conflicts of interest	D	B+	D	B+	**During operation:** - The project facility will be located in the Greater Sfax area. The subject area of the project is the whole Greater Sfax. - As this seawater desalination project will ease the water supply situation in the central area of Tunisia, it will only positively affect the impacts of any local conflicts.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

Table 8.9-3 Evaluation of Impacts : Power Transmission Line

Categories		Impact criteria	Evaluation		Confirmation		Justification
			Construct. phase	Operation phase	Construct. phase	Operation phase	
Pollution	1	Air pollution/dust	C-	D	D	D	**During construction:** - Large-scale earth works and pavement works are not being planned, and the pipeline route is mainly surrounded by farmland and roads. Since only dust will be produced, no significant specific impacts are expected.
Human and social	14	Subsidence means, poverty,	C-	D	B-	D	**During construction:** – Land acquisition of 10 m x 10m

Categories		Impact criteria	Evaluation		Confirmation		Justification
			Construct. phase	Operation phase	Construct. phase	Operation phase	
environment		vulnerability					each for power transmission pylons. Including additional space for construction work, there is a high possibility of impacts on farmlands. Cutting of olive trees will need to be done.
	17	Use of soils and local resources	C-	D	B-	D	**During construction:** - Land acquisition of 10 m x 10m each for power transmission towers. Including construction work space, there is a high possibility of impacts on farmlands.
	24	Landscape	D	C-	D	D	**During operation:** - The seawater desalination plant site is 10km from the Thyna archaeological park, and also far from the Medina located in Sfax city. Therefore, no impact is expected on landscape of tourist spots. It is expected that the power transmission route will be located in areas surrounded by farmland, and therefore no serious impact on landscape is expected.

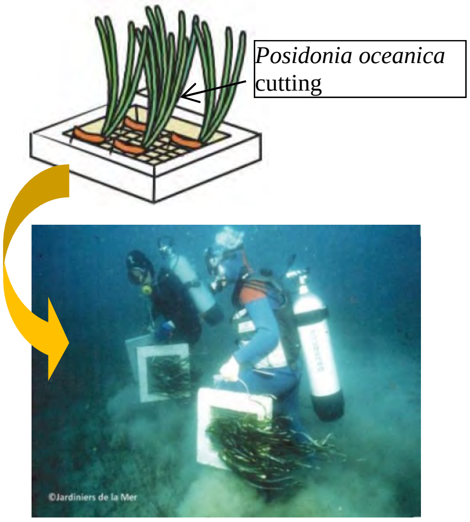
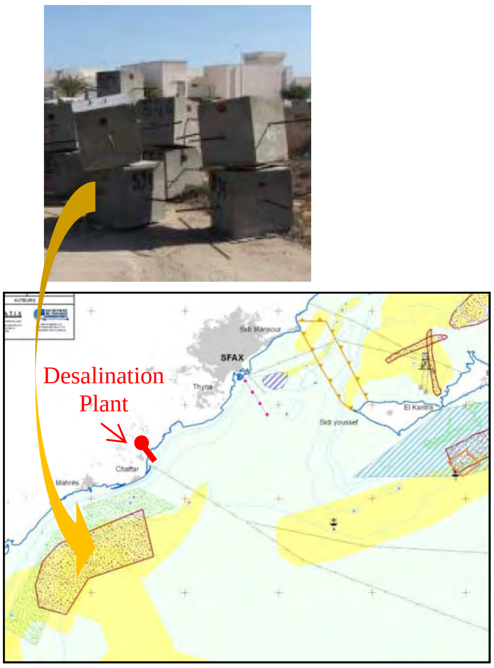
A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected.

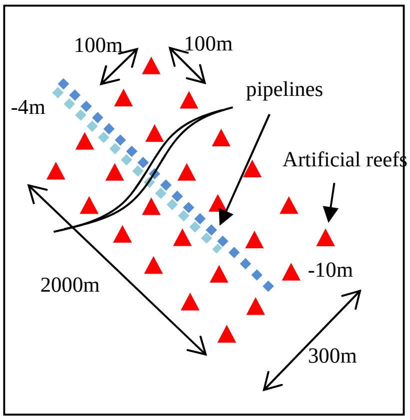
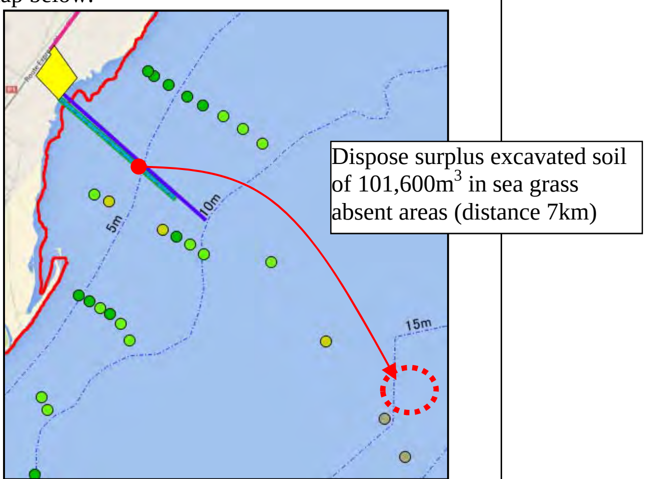
8.10 Mitigation Measures and Implementation Costs

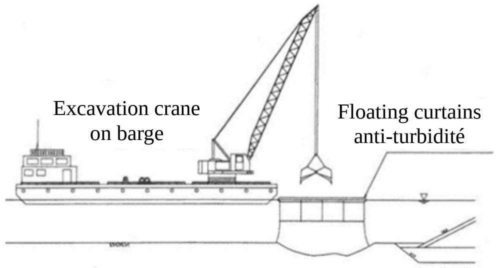
For each impact identified and evaluated in Section 8.9 above, the following mitigation measures are suggested:

Table 8.10-1 Suggestion of Mitigation Measures

No.	Impact	Mitigation measures	Implementation entity	Monitoring entity	Costs
During construction					
1	Loss of sea grass during excavation of intake and discharge pipes (~12ha)	Sea grass may grow again on buried pipelines, but the growth rate of *Posidonia oceanica* is estimated at 3 to 4 cm/year (*Protection and Conservation of Posidonia oceanica, RAMOGE, 2006*). To cover 38 m-large excavations, time required will be 38m / 2 sides / 3.5cm = 543 years. Recovery being very slow, it is therefore necessary to suggest additional mitigation measures. We may first consider the artificial planting of sea grass. Images showing experiments made in the Mediterranean sea on *Posidonia oceanica* are shown below. According to them, the success rate after four years was 84%. Costs amount to 500 man-hours per hectare or about 45,000USD or JPY4,500,000 per ha (*Protection and Conservation of Posidonia oceanica, RAMOGE, 2006*).	Construction company	SONEDE / INSTM / ANPE	JPY 18.18 millions (USD 152,000)

No.	Impact	Mitigation measures	Implementation entity	Monitoring entity	Costs
		 Source : RAMOGE, ONG "Sea Gardens" **Figure 8.10–1 Replanting of *Posidonia oceanica*** However, compared to the 52,000ha of sea grass made up of *Posidonia oceanica* and *cymodocea* of the Sfax coast, replanting some hectares seems not to be an efficient solution (See *Protection and Conservation of Posidonia oceanica, RAMOGE, 2006, p. 139*). In order to efficiently protect sea grasses and related ecosystems, it is possible to lay out artificial reefs all over the project area. Reefs will also protect against mini-trawl fishing. This technique to valorise resources is already implemented by the DGPA in the Gulf of Gabes.  Source : Conservation of fish resources with artificial reefs (DGPA, 2014) **Figure 8.10–2 Installation Plan of Artificial Reefs in the Gulf of Gabes**			

No.	Impact	Mitigation measures	Implementation entity	Monitoring entity	Costs
		An example of the installation of reefs along pipelines in this project is suggested below :  Source : JICA Survey Team **Figure 8.10–3 Artificial Reefs Installation Plan (example)** There will be 4 x 21 = 84 reefs, and each reef will be made up of eight concrete blocks each weighing one ton for a total of 84 × 8 ton = 672 ton or 280m^3 of concrete. Reinforcement bar weighs about 100 kg/m^3 or 28ton. The cost of 1m^3 of concrete is 477 USD and installed reinforcement bar costs 673 USD/ton. The total estimated cost is about 280 x 477 + 28 x 673 = 152,000USD for a protected area of 60ha. **Examination results :** Mitigation measures against the negative influences to sea grasses meadows are; 1) artificial planting, and 2) artificial reef installation. Based on the experience in Gabes Bay Artificial Reefs Project, implementation of 2) is judged to be practical, thus it was selected as the mitigation measure of choice by the project against negative influences on sea grass meadows.			
2	Impact of the deposit of excess excavated materials (~50,000m^3)	Excavated material in excess should be deposited in areas with no sea grasses growing as shown on the map below.  Source : JICA Survey Team **Figure 8.10–4 Sea Deposit Plan (example)** Transportation and depositing costs will be about 5 USD/m^3, total costs will then amount to 101,600m^3 ×	Construction company	SONEDE / INSTM / ANPE	JPY 60.76 Millions (USD 508,000)

No.	Impact	Mitigation measures	Implementation entity	Monitoring entity	Costs
		5 USD/m^3 = 508,000USD. Note : A detailed study about sea weed coverage in the area may suggest further reducing this distance.			
3	Impact of the construction of pipelines works on fishing activities	After explaining in detail the construction methods of pipelines to the local fishermen, anti-turbidity measures may be implemented and where required a suitable financial compensation plan put in place. An example of an anti-turbidity protection system is shown below. Considering unitary costs practiced in Japan, a protection along the pipeline would amount to about JPY 200 million.  Source : Equipe d'enquête JICA **Figure 8.10–5 Anti-Turbidity Protection (example)** The closest fishing port to the project area is Mahres at about 10 km to the project's south-west (photo below).  Source : Conservation of fish resources with artificial reefs (DGPA, 2014) **Figure 8.10–6 Mahres Port** It can be considered that 20 boats and 100 women collectors are going to be impacted by fishing activities in the pipeline area. If the period required for excavations in the coastal area would be about six months, and about one year for the laying of pipes, then based on the BG example, the following is the compensation estimate: 12 months × 20 boats × (300TND + 2 × 150TND) + 6 months × 100 individuals × 30TND ＝ 162,000TND.	Explanations of anti-turbidity methods and measures: Construction company Compensation : SONEDE	SONEDE / UTAP	Anti -turbidity measures : JPY200 millions Compensations : JPY9.89 millions (TND 162,000)
4	Land acquisitions for transmission pipeline and power transmission line	The acquisition of lands and compensations will be made according to Tunisian Law n. 2003-26.	Legal and acquisitions department at SONEDE and STEG	SONEDE / MOA	See Chapter 9

No.	Impact	Mitigation measures	Implementation entity	Monitoring entity	Costs
During operation					
5	Permanent impact of discharge on sea grass	As shown in Figure 5.4-10, salinity concentration of discharged water is reduced to 48,400 mg/L at the seabed through the use of multi-discharge nozzle. This idea is already employed in the design, and is not considered as the mitigation measure, but the dilution of discharge water allows reducing the impact. Further, there are two measures to dilute or reduce the discharge water as explained below to this table; 1) discharge to Thyna Salt-works, and 2) dilution with treated sewage. Both ideas, however, were considered to be not applicable to the Project. Therefore, the impact on sea grass meadows is not avoidable around the discharge head. As an off-set measure, it is recommended to apply mitigation measures at a place different from the discharge head location. The measures are; 1) artificial plantation of sea grass, and 2) installation of artificial reefs. Due to the same reasons as those stated above, installation of artificial reefs is recommended. The installation plan is shown in Figure 8.10-3. Required cost is USD152,000. In addition, due to the permanent character of impacts, it is necessary to regularly monitor sea grasses. A monitoring plan is suggested in Section 8.11.	-	-	Included in No.1

Source : JICA Survey Team

Mitigation measures suggested above represent an investment of about JPY 290 million excluding land acquisitions as shown in Table 8.10-2. This cost is considered as a part of the project cost. Assuming the total project cost to be JPY 50 billion, the said mitigation cost will be equivalent to 0.6% of the total cost.

Table 8.10-2 Cost for Mitigation Measures

Mitigation Measures	Cost	Cost (equivalent Yen) (USD1=JPY119.6) (TND1=JPY61.02)	Item
Artificial Reef	USD152,000	JPY18,179,000	Construction Cost
Deposit of Surplus Material	USD508,000	JPY60,757,000	Construction Cost
Turbidity Prevention	JPY200 million	JPY200,000,000	Construction Cost
Compensation to Fisheries	TND162,000	JPY9,890,000	Compensation

In addition to these measures, the two following measures should also be studied:

1) <u>Connection to Thyna salt-works and reuse of discharge to produce salt</u>

As shown on the following map, the Thyna salt-works stretch from the Port of Sfax to the southern suburbs and are subject of the protection of the international RAMSAR convention (protection of wetlands). The daily harvesting of sea water amounts to about 82,000 m^3/day for an annual salt production of 330,000 ton/year. Salt is exported to America and to northern

Europe to be used as antifreeze for roads in the winter seasons. The salt-works are located 10 km from the desalination plant site, and discussions with the salt-works operator (COTUSAL) have revealed that they have an interest in the technical opportunity to reuse discharges (73000 mg/L) to increase the salt production in the same area.

Source : JICA Survey Team

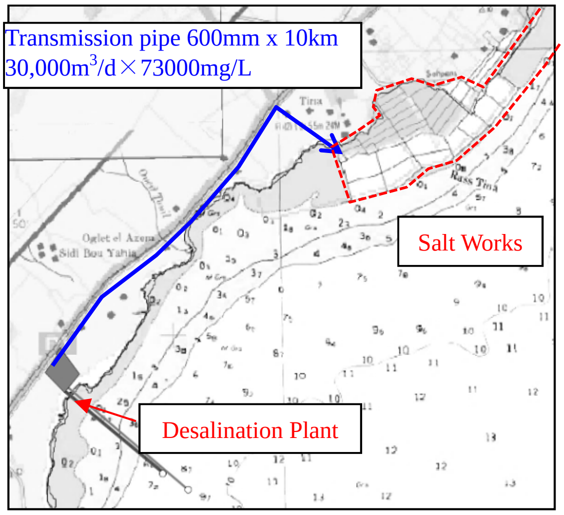
Figure 8.10–7 Scope of Thyna Salt-Works (COTUSAL) and Current Conditions

According to COTUSAL, considering daily variations, the volume of discharge that can be received by the salt-works would be about 30,000 m^3/d. While the technical feasibility has been confirmed, the economic feasibility still needs to be studied. But, the absence of any similar experience worldwide may put this solution into question.

If this solution can be implemented, the volume of brine discharged in the sea will be reduced, which will constitute a mitigation measure. The preliminary plan of this solution is shown in Figure 8.10-8.

Assuming 30,000m^3/day of transmission to the salt-works, discharge from the desalination plant will be about 92,200 m^3/day (= 100,000/0.45 - 100,000 - 30,000) or 76% of the discharge volume in the case without this option. This option requires a 10km long 600mm diameter pipeline and a pumping facility with a pumping head of 35m.

While, as the salt-works are protected as a RAMSAR area, it is necessary to clearly identify the impact on avifauna induced by modification of the basins water composition due to the discharge of brine, and this will take a long time to identify. Considering the urgency of this project, it is judged that its execution shall be considered during Phase 2.



Source : JICA Survey Team

Figure 8.10–8 Thyna Salt-Works Mitigation Measure (COTUSAL) (example)

2) <u>Reuse of the discharge of South Sfax Sewage Treatment Plant to dilute brine discharge</u>

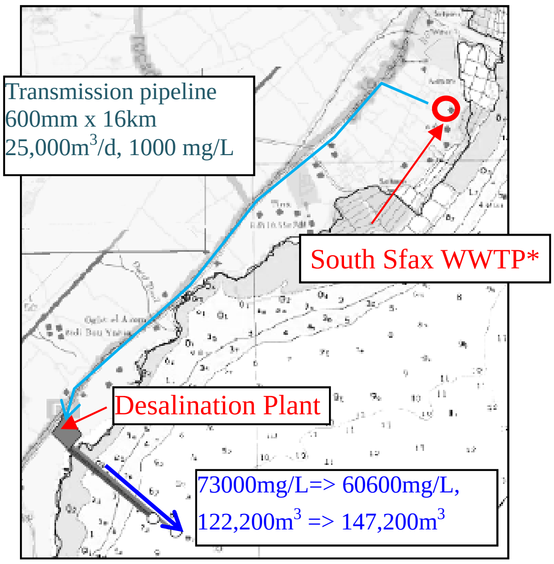
The use of the discharge from the South Sfax waste Water Treatment Plant, it would be possible to dilute brine before it is discharged into the sea. This solution is shown in Figure 8.10-9, and the distance between the two plants is about 16km.

Assuming salinity of treated sewage is 1000mg/L, salinity of discharge from the desalination plant will be as follows:

Discharge in Phase 1 : 122,200m^3/d × 73000mg/L + 25,000m^3/d × 1000mg/L

= 147,200m^3/d ×60,600mg/L.

This concentration is 83% of the case without said option. But, discharge volume will increase by 20%. This option requires a 16km long 600mm diameter pipeline and a pumping facility with a pumping head of 30m.



*: WWTP: Waste Water Treatment Plant

Source : JICA Survey Team

Figure 8.10–9 Mitigation Measure by Using WWTP Discharges (example)

The South Sfax waste water treatment plant (WWTP) currently discharges about 35,000 m^3/day, of which 10,000 m^3/day (or 40%) are already reused in agriculture, and this rate tends to increase. Since the STP discharge is already used in irrigation, this mitigation measure cannot be considered.

As stated above, both mitigation measures cannot be employed in Phase 1. Even though said measures are employed, it is not possible to eliminate the impact on sea grasses by discharge from the desalination plant. Therefore, as a mitigation measure, an off-set measure, the installation of artificial reefs, shall be employed as presented in Table 8.10-1 item 5.

8.11 Monitoring Plan

This project mainly impacts the marine environment, it is therefore necessary to monitor the state of sea grass and sea water quality. In Tunisia, standard NT106-002 regulates discharges within the natural environment. Table 8.11-1 shows the NT106-002 standard concerning sea discharges.

Table 8.11-1 NT106-002 Water Quality Standard concerning Discharges to Sea

Item	Limit value	Unit	Item	Limit value	Unit
Discharge temperature	35	^oC	Chlorine compounds	0.05	mg/L
pH	6.5 - 8.5		ABS	2	mg/L
Suspended solids	30	mg/L	B	20	mg/L
Settlable solid	0.3	mg/L	F	1	mg/L
COD	90 (average in 24h)	mgO_2/L	Cu	1.5	mg/L
BOD_5	30	mgO_2/L	Sn	2	mg/L
Cl	No limit	mg/L	Mn	1	mg/L
Cl_2	0.05	mg/L	Zn	10	mg/L
ClO_2	0.05	mg/L	Mo	5	mg/L
SO_4	1000	mg/L	Co	0.5	mg/L
Mg	2000	mg/L	Br_2	0.1	mg/L
K	1000	mg/L	Ba	10	mg/L
Na	No limit	mg/L	Ag	0.1	mg/L
Ca	No limit	mg/L	As	0.1	mg/L
Al	5	mg/L	Be	0.05	mg/L
Color (PtCo scale)	100		Cd	0.005	mg/L
S	2	mg/L	CN	0.05	mg/L
F	5	mg/L	Cr^{6+}	0.5	mg/L
NO_3	90	mg/L	Cr^{3+}	2	mg/L
NO_2	5	mg/L	Sb	0.1	mg/L
N	30	mg/L	Ni	2	mg/L
PO_4	0.1	mg/L	Si	0.5	mg/L
Phenols	0.05	mg/L	Hg	0.001	mg/L
Mineral oils	20	mg/L	Pb	0.5	mg/L
Hydrocarbons	10	mg/L	Ti	0.001	mg/L

Source : INNORPI, 1989

Monitoring water quality during the construction of pipelines will be based on the monthly measurement of turbidity (as well as pH, temperature and electric conductivity) along the pipelines (one location) and at the level of the beach (one location). Once operation starts, water quality will be measured at the level of the discharge site to check items of the standard cited above (twice a year for the first year and once a year in the two following years at one location).

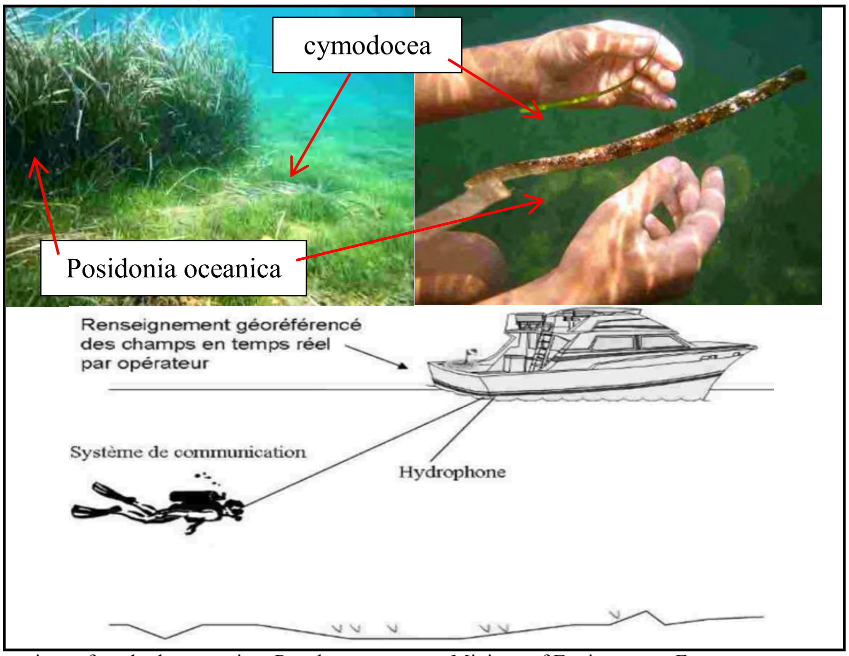
The EIA terms of reference, parameters used to monitor *Posidonia oceanica* are given in the following table:

Table 8.11-2 Monitoring Parameters of Posidonia oceanica

Parameter	Observation
Sea grass pressure (Grass)	L: % of leafs with herbivores
Coverage by invasive algae	T: % cover of algae such as *C. racemosa* on 3 transects along 20 m
Sea grass covering (Cover)	T: % spots of live sea grass over 3
Dead mat cover	T: % dead mats on 3 transects over 20 m
Density of transect beams	T: Number of live beams per quadrant of 40x40 cm taken randomly
Plagiotrope rhizomes (Pl rhi)	T: % per quadrant (3) of 40x40 cm taken randomly
Beam biomass	Dry weight of leaves without epiphytes (gr/beams)
Surface of leafs by beam (Shoot FS)	L: (LAI) surface area of leaves (cm^2 shoot21)
Length and width of leafs (Leaf L)	L: average per type of leaves and by beam (cm)
Others	

Source : INSTM, Ben Mustapha

It should be noted that a diver with a boat is required to monitor *Posidonia oceanica*. It can be considered that SONEDE does not have this know how in-house and that monitoring will be carried out by INSTM (National Institute for Sea Science and Technologies). The method used to monitor *Posidonia oceanica* is shown in Figure 8.11-1 below.



Source : Comparison of methods to monitor *Posidonia oceanica,* Ministry of Environment, France

Figure 8.11–1 Photos of *Posidonia oceanica* and *Cymodocea,* and Monitoring Methods

In order to monitor soil dredging works and the deposit of excess material, monitoring the seabed around the pipes installation site (two locations) and the deposit site (one location) will be carried out twice a year during the construction phase. Before starting operation, monitoring will be carried out in four areas; namely at the artificial reef area, at the discharge point, and at 200 m and 1000 m from the discharge point in order to constitute a baseline reference. Once operation starts, monitoring will be carried out in the same areas, four times on the first year and twice in the two following years. This is summarized in Table 8.11-3.

Table 8.11-3 Monitoring Plan

Environmental aspect	Criteria	Site	Frequency	Entity in charge
Construction phase				
Water quality	Turbidity, pH, Temperature, electric conductivity	Along the pipeline and along the coast Total 2 locations	Every month	SONEDE
Natural habitats (*Posidonia* oceanica)	Criteria of table 8.11-2	2 sites near the pipeline and 1 site near deposit area Total 3 locations	Twice a year	SONEDE (+INSTM)
Operation phase				
Water quality	Criteria of Table 8.11-1	Near discharge tower 1 location	Twice in the first year, once a year in the two following years	SONEDE
Natural habitats (*Posidonia oceanica*)	Criteria of table 8.11-2	Artificial Reef, Water discharge point, 200m from discharge, 1000m from discharge Total 4 locations	Four times in the first year, and twice a year in the two following years	SONEDE (+INSTM)

Source : JICA Survey Team

The Monitoring Form may be used for efficient submission of monitoring results. As shown on the Table 8.11-4, evaluation of monitoring results and preventive action shall be carried out. An example of such action is as follows;

<u>Example:</u>

- Monitoring Item: reduction of sea grass leaf numbers in the area at a distance of more than 170 m from the discharge head.
- Evaluation: There should not be any influence in the area more than 170 m from the discharge tower. Any cause of the phenomenon shall then be investigated and suitable preventive actions shall be taken.
- Preventive actions; 1) Confirm the reason why sea grasses are depleted, 2) If the reason found is related to the salt concentration, check the operation records for salinity concentration at the discharge head, 3) If the salinity of the discharge water has been higher than the designed value, examine the operational status and method, and adjust them appropriately as far as possible, 4) If it is judged that the impact area under the designed normal operational condition is wider than the one predicted, mitigation measures defined for the area shall accordingly be applied to a wider area.

Table 8.11-4 Monitoring Form

1.Comments of national organizations and of Private Sector

Monitoring Criteria	During construction	During operation
Comments of national organizations (ANPE,APAL, etc.)	(Comments and measures)	(Comments and measures)
Comments of Private Sector (UTAP, NGO etc.)	(Comments and measures)	(Comments and measures)

2.Seawater quality

Criteria for the quality of sea water	Reference value	Contract value	During construction						During operation			
			Near the coast			Near the pipeline			Near the discharge tower			
			Month 1	Month 2	…	Month 1	Month 2	…	1st time	2nd time	3rd time	4th time
Turbidity												
pH												
Water temperature												
Conductivity												
Results and preventive actions												
Criteria of Table 8.11-1												
	…	…										
Results and preventive actions												

3.Natural environment：State of submarine *Posidonia oceanica*

Criteria	During construction									During operation											
	Near the pipeline 1			Near the pipeline 2			Site of soil deposit			Art. Reef			Discharge tower			At 200m from the tower			At 1000m from the tower		
	1st time	2nd time	…	1st time	2nd time	…	1st time	2nd time	…	1st time	…	8th time	1st time	…	8th time	1st time	…	8th time	1st time	…	8th time
Criteria of Table 8.11-2																					
Results and preventive actions																					

Source : JICA Survey Team

8.12 Stakeholders Meeting

The Tunisian legislation does not formally state the need and obligation of consultations with stakeholders in the execution of projects. This practice is already common and it is also recommended in the JICA Guidelines. To take into consideration the opinions of all parties concerned by the project, a meeting with stakeholders was suggested by the project's steering committee.

This meeting was held once the projects components were defined. The purpose was to explain the project's outlines as well as the scoping works related to the EIA. Participants represented concerned organizations (ANPE, APAL, ONAS, ANGED, etc.), local authorities (the City of Sfax, the Governorate, Fisheries related groups, Farming related group) as well as nongovernmental organizations. The policy regarding land acquisition and compensation were also explained verbally. An advance announcement was previously carried out by posting a printed poster on the notice boards of SONEDE, the universities, and governorate offices.

The summary of this meeting is provided below:

Announcement: The public announcement for the meeting was made in Sfax one week in advance. (SONEDE Sfax, the Universities, the Governorate offices, etc.) with the poster shown in Figure 8.12-1 (Original format: A3).

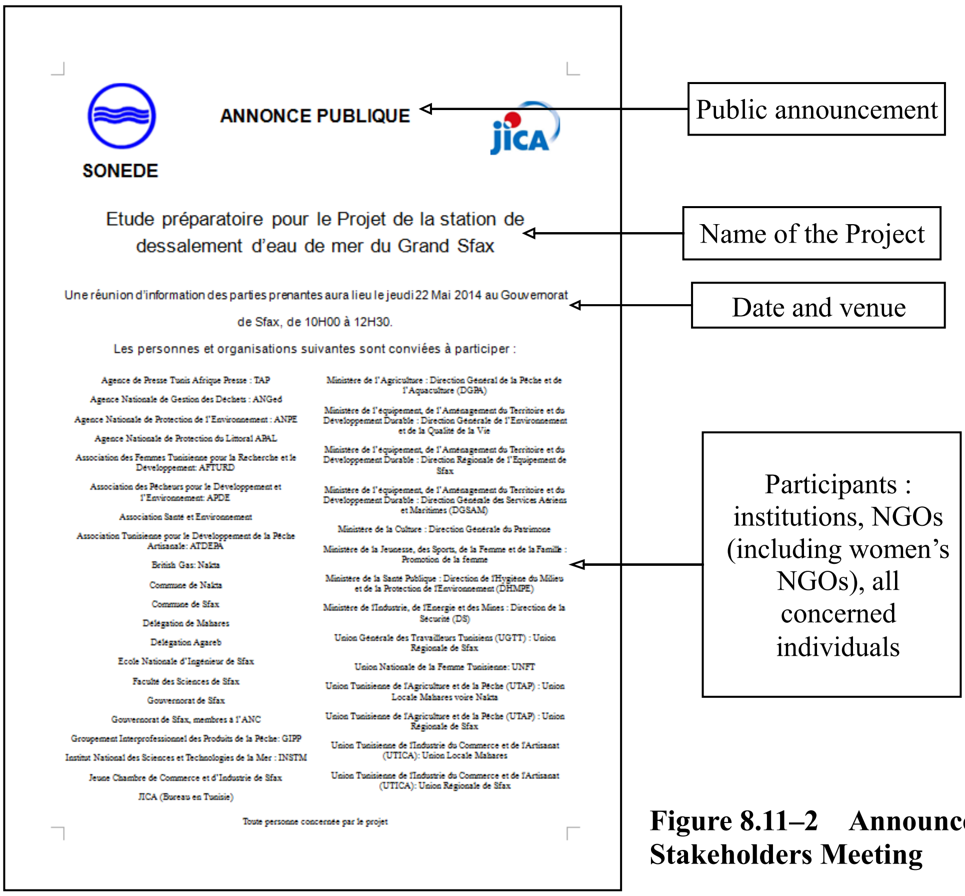


Figure 8.11–2 Announcement for the Stakeholders Meeting

Venue: May 22, 2014, Syphax Hotel

Registration: Registration of participants was conducted at the entrance and there was no limit to the participation of all the applicants.

Participants : There were 79 people in total including: the Governor, ANC representatives, delegations with Mahres, Agareb, Sakkiet Eddaier, Ministry of Infrastructures, Ministry of Health, the University of Sfax, ANPE, APAL, INSTM, STEG, ANGED, UTAP, INP, representatives of each delegation, private people. Minutes of the meeting and the list of participants are attached to this report.

Meeting:

Table 8.11-5 Meeting Agenda

<table>
<tr><th>Agenda</th><th colspan="2">Content and photos</th></tr>
<tr><td>10:40~10:45 :

Governor’s welcoming speech</td><td colspan="2">

</td></tr>
<tr><td>10:45~11:00 :

A. Boubaker, Director of Studies, SONEDE, Presentation : “Execution of the Sea Water Desalination Project in Sfax”</td><td>

</td><td>Table of Content
1. Project Target Area
2. Water Supply conditions
3. Project Context
4. JICA Study Schedule</td></tr>
<tr><td>11:00~11:30 :

Presentation by JICA Survey Team of the project and scoping works</td><td>

</td><td>Table of Content
1. Water needs
2. Candidate sites
3. Summary of the Project
4. Scoping study
5. (Provisional) schedule</td></tr>
</table>

11:30~12:30: Q & A session	

Source : JICA Survey Team

Questions & Answers :

Questions and comments	Answers and orientations
ENIS: Sfax National Engineering Institute, Lecturer 1- Renewable energies for the project? 2- Connection with salt production units in Sfax to reinforce project benefits and reduce discharge impacts? 3- Involvement of the Sfax University in the project	(SONEDE, Boubaker) 1- Energy concerns were thoroughly examined and contacts with STEG to connect the station have already been made (JICA Survey Team, Arnaud). 2- Connection to salt production facilities is a possible idea. Contacts have been made with the company in charge of operating subject facilities. This company showed some interest but was very cautious about quality. The impact on birds and the RAMSAR reserve must still be confirmed. Due to the urgency of the project, the policy of SONEDE is not to consider this alternative in this phase. This can be discussed in the framework of future developments. 3- Several institutions have been involved in the project and an EIA steering committee was set up with representatives of ANPE, APAL, and several ministries. Sfax University may be contacted during the execution of the EIA.
National Heritage Institute, Archaeologist: Impact of the project on archaeological sites?	(Arnaud) The Thyna archaeological site is not impacted upon by the Project's components
Ministry of Health (Sfax representative): 1- The British Gas pipeline is in the vicinity of the station and associated risks? 2- Problem related to deballasting vessels and distribution reserves in tanks in case operation is interrupted? 3- Warning system if distributed water is contaminated? 4- Water aggressiveness for metal pipes, corrosion of the distribution system?	(Arnaud) 1- The Survey team met with BG. The pipeline mainly conveys gas which evaporates in case of leak. As for the liquid fraction, we believe it floats on the water surface. The intake tower of the project is designed to take water at a depth of 2 to 3 meters above seabed in an 8 m high water column. Therefore, surface water is not absorbed which reduced contamination risks. 2- Vessels navigate at about 8.5 km from the intake tower. Nevertheless, in case of small oil discharge induced by ballast, risks are limited due to the design of the intake tower for the reason mentioned above. In case of an urgent interruption of operations, water reserves represent approximately eight supply hours. 3- Standard equipment includes real time monitoring (conductivity meter, pH, etc.) and will be installed in the

Questions and comments	Answers and orientations
	station with a centralized monitoring and control system. As for the detection of contamination, no particular system is designed but the risk that bacteria or even viruses can penetrate through reverse osmosis membranes is very limited. 4- (Nouicer) Before reaching the distribution network, water is mixed with mineral additives in the post-processing phase, so that desalinated water is not more aggressive than standard running water.
INSTM Sfax branch: 1-Involvement of INSTM in the project? 2-Live organisms other than *Posidonia* oceanica such as phyto and zoo plankton? 3-Pilot sites? 4-Is the distance of 800 m between intake and discharge towers sufficient?	(SONEDE, Nouicer) 1-SONEDE is very keen on involving INSTM in the project, and JICA Survey Team met several times with INSTM experts in Tunis. An invitation was also sent to INSTM-Tunis to join the EIA follow up committee. Unfortunately no reply was received. (Arnaud) 2- During the EIA, the study of water quality and sediments, including biological characteristics and several points will be made. 3- Our sampling areas were defined: Two samples in the project area and two other samples at the pilot sites. 4- The 800 m distance between the aspiration and discharge towers is enough for discharge water salinity to be sufficiently diluted before being aspirated again. In addition, the main current direction is almost perpendicular to the alignment of intake and discharge towers, which prevents the risk of feeding intake with discharged water.
UTAP, member: 1-Compensations to fishermen for impacts on fishing during construction and operation 2-Water turbidity caused by illegal fishing such as kiss and danger for water intake?	(Arnaud) 1- Considerations about projects' social impacts represent a key component of the donor, and public consultations represent one major mission of the EIA. There is an experience on compensations provided to fishermen of Nakta carried out by BG. This experience may be considered within the framework of the desalination project. 2- The intake tower is designed to take water at 2 to 3 m from the seabed which reduces the risk of absorbing water with high turbidity. Absorbed water is then conveyed through sand filters in the pre-treatment phase which will eliminate water turbidity.
Sfax Engineering Association, Chairman: Problem of leaks in the distribution system of Sfax and cost of produced water?	(Boubaker, Noucier) There are currently several programs carried out by SONEDE to reduce leaks at the national level. The leakage rate in the region of Sfax is about 20% which is reasonable and represents one of the best rates in Tunisia. However, due to the high cost of desalinated water, SONEDE will make all efforts to reduce water leakage.
APAL Office, Sfax: Modification of currents around the intake tower and consecutive impact on the ecosystem?	(Arnaud) The intake tower is designed to take water at a speed of 0,2m/s, which is close to the average current of water around the aspiration nozzle head (0,1m/s). Besides, the intake head is concentrated in a local area so no substantial modification of the current can be expected.
ANPE Office, Sfax: Q: 1- Project sustainability? 2- Involvement of Sfax University? 3-Relation with Nakta fishermen due to the current concerns related to the construction of the British Gas pipeline?	(Arnaud) 1- The presentation is just a summary of the orientation report. Sustainable development is JICA's basic policy and environmental and social aspects represent the EIA's objectives for the project to be viable. 2- Several institutions have been involved in EIA follow up committee: ANPE, APAL, Ministry of Agriculture, Ministry of Equipment and Environment, and Ministry of Health. Besides several INSTM persons were consulted. The involvement of the University may take place when implementing the EIA. 3- During the EIA implementation, public consultations, including those with Nakta fishermen will be held to listen to their opinions and suggest appropriate measures. The

Questions and comments	Answers and orientations
	experience of providing compensations for Nakta fishermen made by British Gas may be considered as applicable for compensations to be eventually granted within the framework of this project.

Source : JICA Survey Team

The following comments are reflected in the project as follows:

- Several institutions are already involved in the EIA preparation (ANPE, APAL, INSTM, etc.), but during the EIA implementation phase, the Sfax University and the local branches of ANPE, APAL and INSTM may be involved.
- The BG experience implies the launch during construction of collaboration channels with local fishermen and UTAP to explain construction methods and eventually define a compensation plan.
- The project development is supported by measures to improve the present system while evaluating it in a global and integrated way.

During the EIA implementation phase (in 2015), meetings with stakeholders will be held, together with meetings to inform the general population to be held in different communities affected by the project. It is appropriate to hold the explanatory meetings at the places where land acquisition will be conducted or construction affected area, i.e. Mahres (on place), Agareb (two places), and Sfax South (two places). At the explanatory meetings, it is required to explain and discuss about the contents of the project, such as the power transmission line, implementation schedule, land acquisition procedure, compensation plan, and cut-off-date regarding compensation.

CHAPTER 9

LAND ACQUISITION AND RESETTLEMENT

CHAPTER 9 LAND ACQUISITION AND RESETTLEMENT

9.1 Needs for Land Acquisition and Resettlement

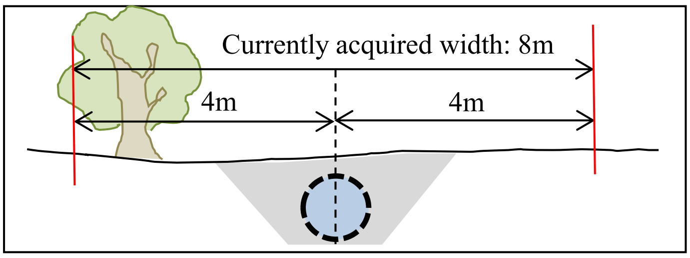
The need for land acquisition and resettlement for the Project is summarized in Table 9.1-1. This Project will not require the displacement of people and will not require large scale land acquisition.

Table 9.1-1 Needs for Land Acquisition and Resettlement

Component	Use	Land acquisition and procedure requirements	Resettlement requirements
Intake pipe Discharge pipe Desalination plant (RO Process)	Maritime public domain (public land)	The use of the maritime public domain is conditioned by a special authorization	None
Transmission pipeline	Generally in the right of way areas of existing roads (public lands) with the possibility to acquire some private lands (underground)	Normal procedure with the permission of the authority in charge of road networks or the road operators. Possibility of having to acquire lands in some areas	This Project was designed so as to avoid the resettlement of people by adjusting the outline of pipes and the location of structures where necessary.
Pumping station	Within the desalination plant area or in current reservoirs sites (public or SONEDE's lands)	None	
Water hammer/surge tank	According to the final choice of sites, possibility of having to acquire some private land	Possibility of having to acquire lands	
Distribution reservoirs	Within sites of existing reservoirs	None	
Power transmission line	Farmland (Private)	Possibility of having to acquire lands. SONEDE will possess the lands.	

Source: JICA Study Team

Acquisition operations conducted by SONEDE concern agricultural lands and mainly for the laying of transmission pipes. As shown in the following figure, SONEDE will acquire the corresponding lands, 8 m wide or 4 m on both sides of the pipe. Agricultural activities are allowed around the pipeline with the exception of olive trees and arboriculture.



Source: JICA Survey Team

Figure 9.1–1 Plan of Current Land Acquisitions being conducted by SONEDE

9.2 Tunisian Legal Framework for Land Acquisition and Resettlement

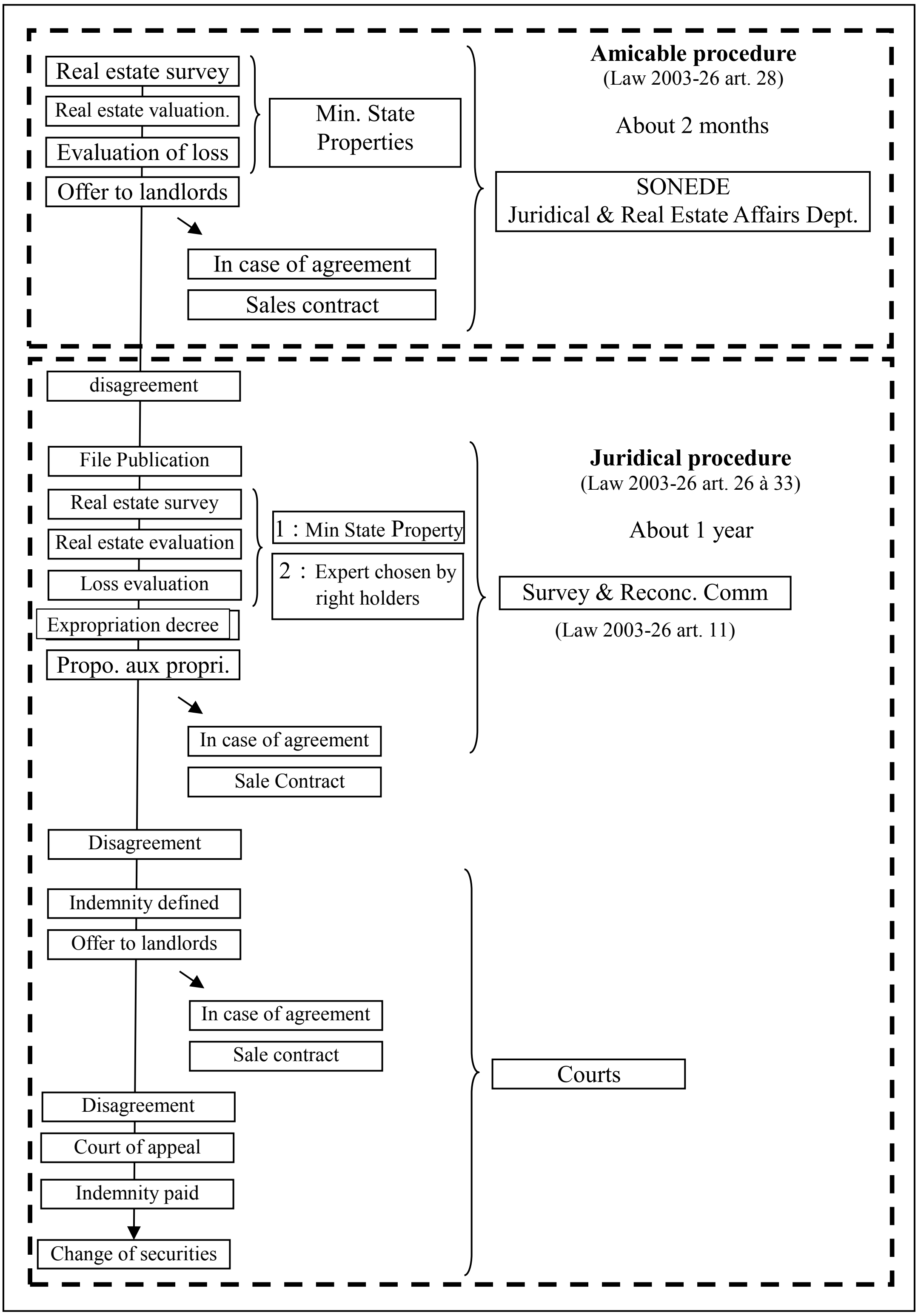
(1) Outline of the Tunisian legal framework for the acquisition of land and resettlement

The most pertinent legislative framework is Law 1976-85 dated August 11, 1976 as amended by Law 2003-26 dated April 14, 2003 related to resettlement activities for public use and utility (hereafter referred to as "Law 2003-26") and decree 2003-1551 dated July 2, 2003 defining the composition, attributions and modalities of the Survey and Reconciliation Commission in charge of expropriation.

According to Article 1 (first paragraph) of Law 2003-26 "Involuntary resettlement can be made only exceptionally after exhausting all reconciliation measures stated in Article 11 (note: related to the Survey and Reconciliation Commission) of this Law, where land acquisition must first be done in an amicable way while legal methods shall be employed only as a last resort". In addition, according to Article 2 (paragraphs 2 and 3) "The expropriator can take hold of expropriated facilities only after paying or offering as a mortgage a fair compensation paid in advance. All rights held on all or part of the expropriated facility, including ENZEL leases, assets in settlement or subject to claims and any other real assets shall be transferred on the expropriation indemnity", acquisition shall be valid only after payment of a compensation to owners and to landlords. This is shown in the Figure 9.2-2.

SONEDE has conducted the land acquisition procedure through its department of juridical and real estate affairs. SONEDE manages between 60 and 100 acquisition files a year of which only two or three files are not amicably settled. These cases are handled by the MOA. The main reasons for the failure of amicable settlement are the following: 1) unidentified landlord; and 2) too low price to compensate the land. The position of transmission pipes and pumping stations can usually be adjusted so that the resettlement of people can be avoided in the majority of the cases. This is why SONEDE has no specific experience in the resettlement of people.

The land acquisition procedure implemented by SONEDE as shown in Figure 9.2-2 offers three opportunities of appeal to land rights holders. When the amicable procedure fails, the expropriation file is made public so that all different parties are able to examine it. In addition as shown in Figure 9.2-3, documents related to the procedure are drafted in Arabic and so that these can be understood by all concerned parties.



Source: JICA Survey Team

Figure 9.2–1 Land Acquisition Procedure of SONEDE

لجنة الإستقصاء والمصالحة في مادة
الانتزاع للمصلحة العامة
بولاية المنستير
=***=

محضر جلسة لجنة الاستقصاء والمصالحة في مادة الانتزاع
للمصلحة العامة بولاية المنستير يتعلق بتقرير ختم أعمال اللجنة
بخصوص ملف مشروع اقتناء قطعتي أرض لازمتين لإنجاز خزان
مياه بمنطقة زبيد من معتمدية البقالطة ولاية المنستير

محضر جلسة لجنة الاستقصاء و المصالحة في مادة الانتزاع للمصلحة العامة بولاية المنستير يتعلق بتقرير ختم أعمال اللجنة بخصوص ملف مشروع اقتناء قطعتي ارض لازمتين لانجاز خزان مياه بمنطقة زبيد من معتمدية البقالطة ولاية المنستير

في اليوم الثالث و العشرين من شهر مارس لسنة 2012 وعلى الساعة التاسعة صباحا اجتمعت لجنة الاستقصاء و المصالحة في مادة الانتزاع للمصلحة العامة بولاية المنستير المنصوص عليها في تركيبتها وسير أعمالها و مشمولاتها بالأمر عدد 1551 لسنة 2003 المؤرخ في : 02 جويلية 2003 بدعوة من رئيسها السيد منصف المرعوي و بحضور أعضاء اللجنة السادة و السيدات :

- نائلة الغندري : ممثل عن الإدارة الجهوية لأملاك الدولة والشؤون العقارية بالمنستير: مقرر اللجنة
- فاتن الماجري حرم العلويني : ممثل عن السيد والي المنستير.
- وليد البحوري : عن الإدارة الجهوية للملكية العقارية بالمنستير.
- يونس المثلوثي ومختار بن رجب : عن الإدارة الترابية للأشغال بالوسط بالشركة الوطنية لاستغلال و توزيع المياه.
- وقد تغيب كل من : عائشة رقاز الخبيرة الجهوية لأملاك الدولة ، و السيد محي الدين القربي رئيس دائرة قيس الأراضي و المسح العقاري بالمنستير.

واصلت لجنة الاستقصاء و المصالحة في مادة الانتزاع للمصلحة العامة بولاية المنستير

Survey and Reconciliation in Matters
Related to Expropriation for Public Interest
Governorate of Monastir
****

Minutes of the Meeting held by the Survey and Reconciliation Commission in charge of expropriation for public interest in the Governorate of Monastir concerning the acquisition of two land parcels required for the construction of a water tank in Zbid area, delegation of Bekalta, Governorate of Monastir.

@@@@@@

On March 23, 2012 at 10 AM, the Survey and Reconciliation Commission in charge of Expropriation for Public Interest in the Governorate of Monastir, which composition and operation are regulated by Decree n. 1551/2003 dated July 2, 2003 met at the request of its chairman Mr. Moncef Maraoui and was attended by:

- Neila Ghandri: representing the Ministry of State Domains and Real Estate Affairs in Monastir as the Commission's Reporter;
- Faten Mejri Alouini, representing the Governor of Monastir
- Walid Bhouri representing the regional real estate agency in Monastir;
- Younes Methlouthi and Mokhtar Berrjeb, representing the Center's territorial work projects department at the Tunisian water exploitation and distribution company (SONEDE);
- The following failed to join the meeting: Aicha Reguez, regional land property expert, and Mohieddine Korbi, chair of the land parceling and real estate division in Monastir.

The Expropriation Survey and Reconciliation Commission further looked into the opportunity to expropriate two land parcels required for the construction of a water tank…

Source: JICA Survey Team

Figure 9.2–2 Example of Minutes of Meeting of the Survey and Reconciliation Commission (English translation)

(2) JICA Guideline in terms of resettlement of people

According to the JICA Guideline, beneficiaries of compensations and of support to recover subsidence means related to a resettlement program are classified into three categories:

- Legal owners of buildings;
- Holders of rights and assets in buildings with no landlords;
- People with rights on buildings but depend on subject building for subsidence (workers, refugees, etc.)

On the other hand, the key principle of JICA policies on involuntary resettlement are summarized below:

Key Principle of JICA Policies on Involuntary Resettlement

I. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.

II. When, population displacement is unavoidable, effective measures to minimize the impact and to compensate for losses should be taken.

III. People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.

IV. Compensation must be based on the full replacement cost* as much as possible.

V. Compensation and other kinds of assistance must be provided prior to displacement.

VI. For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.

VII. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.

VIII. Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans

IX. Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.

X. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits.

XI. Eligibility of Benefits include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.

XII. Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based.

XIII. Provide support for the transition period (between displacement and livelihood restoration.

XIV. Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.

XV. For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared.

*: Description of "replacement cost" is as follows:

Land	Agricultural Land	The pre-project or pre-displacement, whichever is higher, market value of land of equal productive potential or use located in the vicinity of the affected land, plus the cost of preparing the land to levels similar to those of the affected land, plus the cost of any registration and transfer taxes.
	Land in Urban Areas	The pre-displacement market value of land of equal size and use, with similar or improved public infrastructure facilities and services and located in the vicinity of the affected land, plus the cost of any registration and transfer taxes.
Structure	Houses and Other Structures	The market cost of the materials to build a replacement structure with an area and quality similar or better than those of the affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labour and contractors' fees, plus the cost of any registration and transfer taxes.

Source: Environmental and Social Considerations: Points for Preparation of Report for Project in Category B, June 2011, JICA

(3) Comparison between JICA directives and the Tunisian Law

Comparison shows that the Tunisian procedures and the JICA Guideline are similar in terms of land acquisition but when it comes to resettlement of people, the Tunisian procedure is insufficient. A framework must be set up for the resettlement of people to comply with the JICA Guideline.

There will be no resettlement of people in the Project. Compensation, however, must be provided for the agricultural lands that will be used for the passage of transmission pipelines, for surge tanks, and other facilities.

Table 9.2-1 Comparison between JICA Guideline and the Tunisian Law

JICA Guideline	Tunisian legal framework	Gaps	Policy for this Project
1. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives	Article 1 (paragraph 1) of Law 2003-26 states that "Involuntary resettlement can be made only exceptionally after exhausting all reconciliation measures stated in Article 11 (note: related to the Survey and Reconciliation of this Law"	Similar approaches	In the Project, there will be no involuntary resettlement of people and loss of means of livelihood
2. When, population displacement is unavoidable, effective measures to minimize the impact and to compensate for losses should be taken	Article 2 (paragraph 2) of Law n. 2003-26 states that "The expropriator can take hold of expropriated facilities only after paying or offering as a mortgage a fair compensation paid in advance."	Similar approaches	Not applicable in the Project
3. People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels	Article 2 (paragraph 3) of Law 2003-26 states the following : "All rights held on all or part of the expropriated facility, including ENZEL leases, assets in settlement or subject to claims and any other real assets shall be transferred on the expropriation indemnity"	Similar approaches	Not applicable in the Project
4. Compensation must be based on the full replacement cost as much as possible.	Article 4 of Law 2003-26 states the following :"The expropriation indemnity is set	Similar approaches	Not applicable in the Project

JICA Guideline	Tunisian legal framework	Gaps	Policy for this Project
	based on the value of the building assessed according to its consistency and the effective and assigned use"		
5. Compensation and other kinds of assistance must be provided prior to displacement.	Article 2 (paragraph 2) of Law 2003-26 "The expropriator can take hold of expropriated buildings only after payment or mortgage of a fair indemnity paid in advance"	Similar approaches	Not applicable in the Project
6. For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.	In case of large-scale involuntary resettlement, procedure of Law 2003-26 must be applied for each specific case	The absence of a general resettlement plan endangers community preservation	In the Project, there will be no resettlement of people.
7. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.	-	There is no resettlement plan hence no consultation with people	Not applicable in the Project
8. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.	Files are drafted in Arabic. (As Arabic is the language spoken by the people.)	Similar approaches	Files are drafted in Arabic
9. Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.	-	There is no follow up of the resettlement plan hence no consultation with people.	Not applicable in the Project
10. Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.	The Survey and Reconciliation Commission is set up by Article 10 of Law 2003-26.	Concerns land acquisitions only. Nothing is planned for other impacts	Concerning land acquisition, the law is suitable. For other impacts, specific mechanisms must be set up.
11. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferably at the 0 identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits.	The acquisition procedure starts with a real estate survey. The starting date of the survey represents the cut-off date for non-right holders. As for right holders, the cut-off date is the publication of the expropriation decree as per Article 11 of Law 2003-26.	The cut-off date for compensation procedures of other impacts is not defined.	Regarding the acquisition of lands, the cut-off dates are the expropriation decree or the real estate survey. For other impacts, the cut-off date is when public consultations start about subject impact.
12. Eligibility of Benefits include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized	Article 2 (paragraph 3) of Law 2003-26 states the following : "All rights held on all or part of the expropriated facility,	Non-right holders are not recognized.	Regarding right holders, Law n. 2003-26 is suitable. A compensation

JICA Guideline	Tunisian legal framework	Gaps	Policy for this Project
under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying	including ENZEL leases, assets in settlement or subject to claims and any other real assets shall be transferred on the expropriation indemnity"		procedure must also be set up for non-right holders.
13. Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based.	Law 2003-26 provides only for financial compensations	No in-kind compensation is planned (agricultural lands)	When implementing the resettlement plan, compensations based on lands will eventually be preferred.
14. Provide support for the transition period (between displacement and livelihood restoration..	Law 2003-26 provides only for financial compensations	No compensation during transition periods	Compensations will be granted for transition periods
15. Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.	-	No special care is made to vulnerable populations	The resettlement plan must include special provisions for vulnerable people.
16. For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared..	-	There is no resettlement plan	In the Project, there will be no involuntary resettlement of people.

Source: JICA Study Team

(4) Policies for Land Acquisition and Resettlement of People for this Project

Based on the comparison stated above, the Tunisian legal framework does not entirely comply with guideline of JICA and World Bank regarding the planning the resettlement of people, therefore the resettlement policy suggested for this Project is given below:

Resettlement Policy for the Seawater Desalination Plant Construction Project in Sfax

1. The Government of the Republic of Tunisia will use the following resettlement policy (project strategy) for the construction project of the Sfax seawater desalination plant (Tunisia), particularly because national laws and regulations in force were not designed to reply to involuntary resettlement as provided for by international practices including JICA Guideline. The project policy aims at compensating shortfalls in local laws and regulations in order to ensure that PAP (People Affected by the Project) are able to recover at least their pre-project situations. This section describes principles of the project policy and PAP's rights according to the type and degree of their loss. Whenever there is a gap between the Tunisian legal framework in terms of PAP resettlement and JICA Guideline regarding involuntary resettlement, mutually acceptable approaches are suggested in compliance with the government practices and JICA Guideline.

2. The acquisition of land and involuntary resettlement will be avoided as much as possible or reduced to the best extent, by identifying other possible outlines that would have less negative impacts on the project area's communities.

3. In case the displacement of households is inevitable, all PAPs (including communities) losing their means of subsidence or their resources shall be entirely compensated and supported in order to be able to improve or at least restore their previous social and economic conditions.

4. Compensations and support to reintegration will be provided to all PAPs, people, households or companies, who because of the Project would:

- See their living standards deteriorate;
- Lose assets, securities or interests, or the right to use lands including premises, farming lands, pasturages, commercial facilities, leased premises, or the right in crops, annual or perennial trees, or any other fixed or variable assets, acquired or owned, whether temporarily or permanently;
- Lose possibilities to make additional profits, companies, jobs, worksite or site of residence, or which housing may be temporarily or permanently affected;
- Lose social and cultural activities and relations or any other loss that may be identified during the planning and reinstallation process.

5. All impacted people shall be eligible for compensations and support to reintegration, regardless of their occupation status, social and economic conditions, and other factors that may determine the achievement of objectives stated above. The absence of legal rights on lost properties or the affected occupation status and the social and economic conditions shall not constitute a reason to prevent PAPs from enjoying compensation, reintegration and resettlement measures. Any PAP who is residing, working, making business and / or cultivating lands in project areas affected on the date of the last census and inventory of lost properties shall be liable for due compensation against lost properties (lands and / or real estate properties), replacement costs, and when needed the restoration of revenues and companies, in addition to sufficient rehabilitation measures to help them improve or at least maintain their pre-project living standards, the capacity to earn revenues and their production standards.

6. PAPs who lose only one part of their physical assets shall not be left with a part that would be insufficient to maintain their current living standard. The minimal size of remaining lands and structures shall be agreed upon during the resettlement planning process.

7. People temporarily affected must be considered as PAPs and resettlement plans shall include the temporary acquisition issue.

8. If a hosting community is affected by the development of a reinstallation site within the community, it shall be involved in all resettlement planning and decision making processes. All efforts must be made to minimize the negative impacts of the passage of vehicles on the local community.

9. Resettlement plans shall be designed according to the Tunisian policy and procedures pertaining to land acquisition and compensations and to JICA Guideline related to involuntary resettlement.

10. The resettlement plan shall be translated in the local languages and forwarded to PAPs and to other concerned parties and groups;

11. The payment of real estate and / or non-land properties shall be based on the principle of the replacement cost.

12. The compensation of PAPs depending on agricultural activities will be in the form of land exchange whenever possible. “land” strategies may include the supply of replacement land parcels, offer much larger employment safety, and improve the means of subsidence for people not holding legal real estate property certificates. In the absence of replacement land parcels, other strategies may be built around re-training possibilities, capacity building, waged employment or self-employment, including access to credits. The only option that should be avoided is cash compensations, as this can never indemnify losses that cannot be easily quantified, such as access to services and to customary rights, and may induce situations that are worse than before the Project;

13. Replacement lands, if this is the preferred option for PAPs shall be made whenever possible in the close vicinity of impacted lands and with comparable production capacities. As a second option, sites must be identified so as to reduce as much as possible social troubles for people affected; land parcels must also have access to services and facilities that are similar to those in affected areas;

14. Support to resettlement must be provided not only for the immediate loss but also for a transition period required to restore means of subsidence and PAP’s living standards. Such support can be short term employment, support for

subsidence, keeping the payment of salaries or similar measures;

15. The resettlement plan must take in consideration needs of the most vulnerable people to displacement negative impacts (including the poor, people with no property certificates, ethnic minorities, women, children, old people, and the handicapped) and must ensure they are properly accounted for in resettlement planning and mitigation measures. Assistance must be offered to help these groups improve their socioeconomic status;

16. PAPs will be involved in resettlement plans' development and implementation processes;

17. PAPs and their communities will be consulted about the Project, informed about their rights and options open to them, in addition to measures to reduce negative effects, and they will be as much as possible involved in decisions that will be taken regarding their resettlement;

18. An appropriate budget support will be fully engaged and provided to cover costs for land acquisition (including compensation measures and restoration of revenues) within agreed implementation period. Funds for resettlement activities will be covered by the Tunisian Government;

19. Displacement shall not take place before providing compensation and other forms of assistance required for resettlement. A sufficient civil infrastructure must be provided in the resettlement site before this operation is made. The acquisition of assets, payment of allowances, resettlement and the launch of rehabilitation activities for PAPs means of subsidies must be complete before the start of construction works, only in the case of an expropriation order issued by the court. (subsidence means' restoration measures must also be set up but not necessarily complete before the beginning of construction works, as they may be ongoing activities).

20. The administrative organization and provisions for the preparation and effective implementation of the resettlement plan will be identified and set up before starting the process. This includes supply of appropriate supervision human resources, consultation and follow up of land acquisition, and re-adaptation activities;

21. Appropriate reports (including audit and appeal reports), supervision and evaluation mechanisms, shall be identified and implemented in the framework of the resettlement management system. An external follow up team will also work on the project to assess the resettlement plan and final results. This team may include qualified NGOs, research institutions or universities. Follow up reports will be directly sent to JICA.

CUT-OFF-DATE OF ELIGIBILITY

The cut-off-date of eligibility refers to the date prior to which the occupation or use of the project area makes residents/users of the same eligible to be categorized as PAPs and be eligible to Project entitlements. In this Project, cut-off dates for holders of real estate certificates is the notification date as per the real Estate Acquisition Law (expropriation decree for public use/Law n. 85 dated August 11, 1976 modified by Law n.26 dated April 14, 2003 related to land acquisition for public interest works); as for holders not having property certificates, the cut-off date is the beginning of the field study (social and real estate survey and preliminary works), carried out by SONEDE in 2015). This date has been disclosed to each affected village by the relevant local governments and the villages have disclosed to their populations. The establishment of the eligibility cut-off date is intended to prevent the influx of ineligible non-residents who might take advantage of Project entitlements

PRINCIPLE OF REPLACEMENT COST

All compensation for land and non-land assets owned by households/shop owners who meet the cut-off-date will be based on the principle of replacement cost. Replacement cost is the amount calculated before displacement which is needed to replace an affected asset without depreciation and without deduction for taxes and/or costs of transaction as follows:

a. Productive lands (agriculture, orchards, gardens) based on the current market real prices, reflecting recent land sales in the region, and in the absence of these recent sales, they shall be based on recent sales in comparable areas with other similar attributes such as charges and taxes, and in the absence of these sales, based on their productive value;

b. Residential land parcel based on based on the current market real prices, reflecting recent land sales in the region, and in the absence of these recent sales, they shall be based on recent sales in comparable areas with other similar attributes such as charges and taxes,

c. The Government's current regulations and the Law on real estate acquisitions to calculate compensations on constructions, cultures and trees whenever possible;

d. Houses and other related facilities based on the current market real prices of subject materials;

e. Annual crops equivalent to the market's current value of crops at the time of compensation;

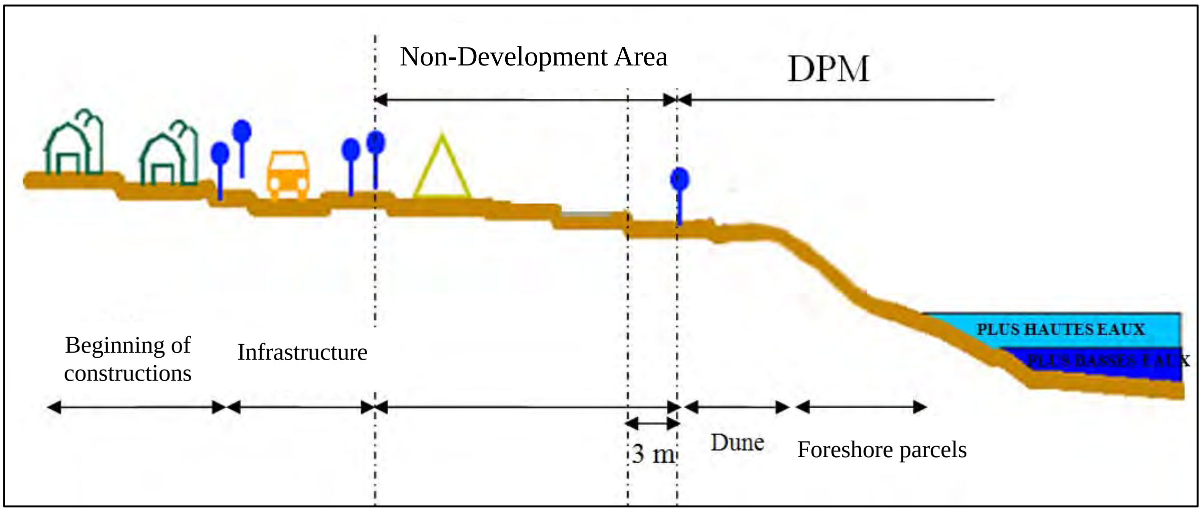
f. For sustainable cultures, cash compensation for the replacement cost which shall be in line with local regulations when available, is equivalent to the market's current value with regard to the type and age at the time of compensation.

g. Regarding wood and fruit trees such as olive trees, cost of compensation for the replacement value which shall be in line with the Government's local regulations when available, is equivalent to the market's current value for each type, age and the appropriate productive value at the time of compensation based on the diameter at every tree's chest height.

Source: Environmental and Social Considerations: Points for Preparation of Report for Project in Category B, June 2011, JICA

(5) Public maritime domain

The public maritime domain is regulated by Law No. 95-72 dated July 24, 1995 providing for the creation of APAL and Law No. 95-73 dated July 24 related to the Public Maritime Domain (DPM). The following figure shows the scope of the public maritime domain:



Source：APAL 2003

Figure 9.2–3 Public Maritime Domain

When the public maritime domain is specifically demarcated and when there is an urban development plan, the radius of the non-development area is 25 m. In the absence of an urban development plan, the radius of this area increases to 100 metres. When the public maritime domain is simply not demarcated, a building is not allowed within a radius of 200 metres from the highest sea water level.

Since the site of the desalination plant is entirely located within DPM which is already subject to an urban development plan. The construction of the desalination plant is planned at least 25 metres from the limits of DPM. As the desalination plant is not a structure that can be dismantled, a special authorization is required before starting construction works so far scheduled for the beginning in

October 2019. The concession procedure shall be completed by January 2019 to secure preparation work period of SONEDE. As shown in Figure 9.2-4, there will be enough time to complete the required procedure even if it starts from 2017.

Item	Authority in charge	2017									2018							
		-.	Apr	May.	Jun	Jul	Aug	Sep	Oct	-	Feb	Mar	Apr	May	Jun	Jul	—	Dec
DPM concession request	SONEDE																	
Analysis of request and report to PM	APAL																	
Approval of PM about the choice of SONEDE as Franchisee	Prime Minister																	
Preparation of the concession contract (Approved EIA must be included)	SONEDE + APAL																	
Examination of contract by 3 Ministries	Ministry of Env. & Sustainable Development Ministry of Justice Ministry of State Properties																	
Approval of contract by the Prime Minister	Prime Minister																	
Concession Decree	APAL																	

Source : APAL DPM management Department; JICA Survey Team

Figure 9.2–4 Execution Schedule of DPM Concession Procedure

The agency in charge of evaluating the request file is the DPM management department, APAL. The DPM management department is in charge of; 1) Checking the use of DPM (management of beach); 2) Managing DPM usage concession files; and 3) Monitoring the environment and its cleaning operations.

The DPM usage fee will be defined during negotiations between SONEDE and the Ministry of State Domains and Land Affairs. Fees may amount to nothing, but in general, the following formulas are used (annually):

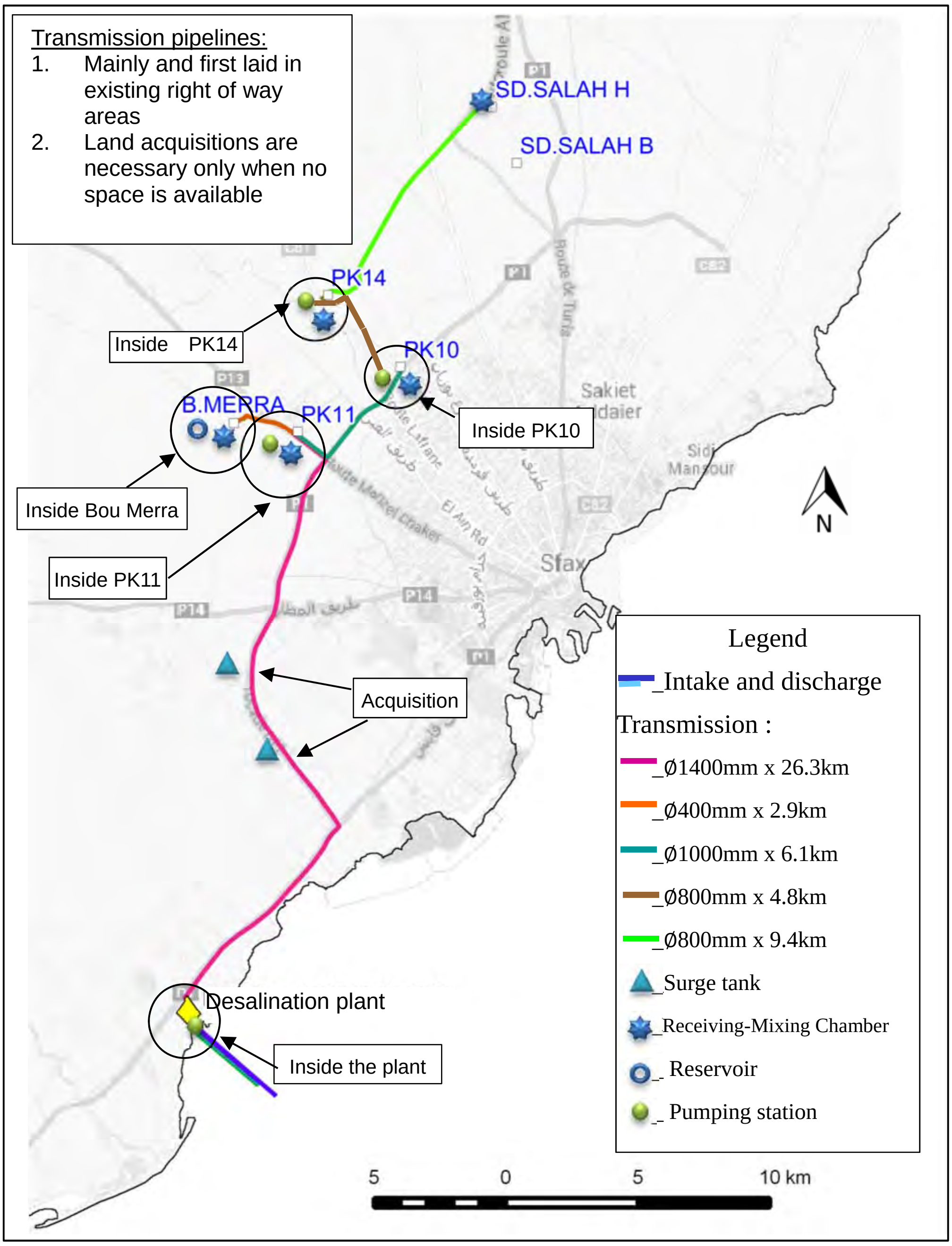
- Non-covered areas: 0.3TND/m^2+30TND
- Covered areas: 3 times the price of non-covered areas
- Pipelines: 0.072TND/m+10TND

Regarding this Project, the covered area is estimated at about 10 ha, the non-covered area at 10 ha, and the pipeline's total linear at about 9000 m. This would reflect an annual fee of; 4 x (100 000 x 0.3 + 30) + 9000 x 0.072 + 10 ~ 120,800 TND/year to be paid to the Public Treasurer.

9.3 Scale and Scope of Land Acquisitions and Resettlement

(1) Summary of acquisitions and concerned population

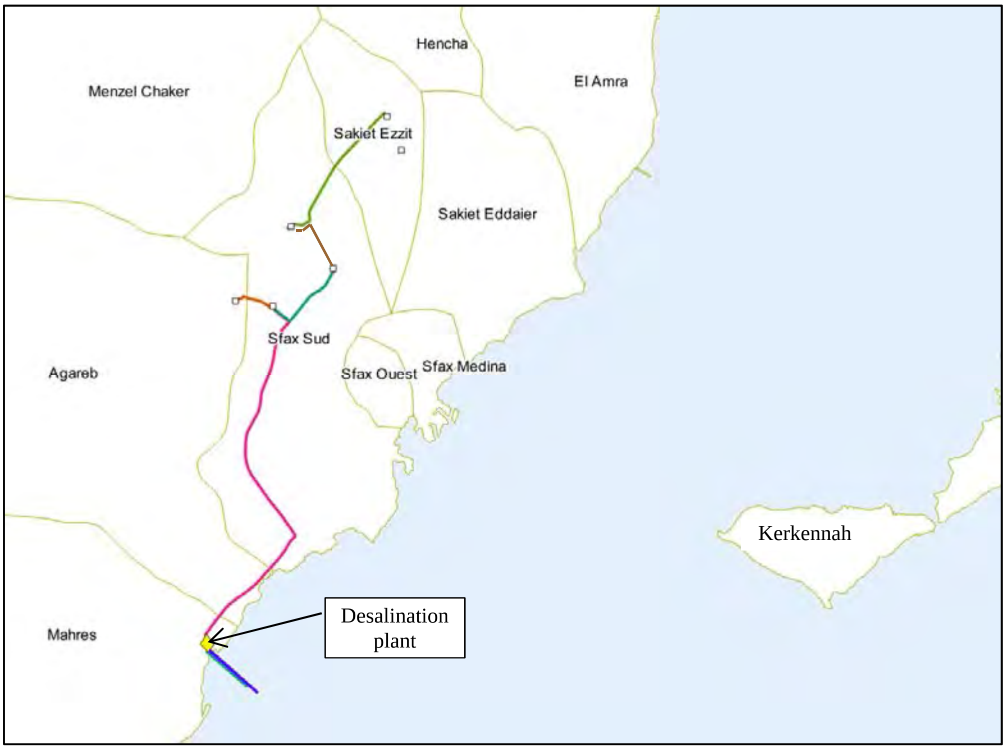
This Project's policy is to avoid resettling people by making all appropriate design modifications, consequently, no resettlement is expected. As shown in Figure 9.3-1, however, land acquisitions will be made only for some sections of the transmission pipelines and surge tanks..



Source: JICA Survey Team

Figure 9.3-1 Scope of Land Acquisitions

As shown on the following map, villages and delegations (counties) crossed by the transmission pipeline are; Mahres, Agareb, Sfax South, and Sakiet Ezzit.



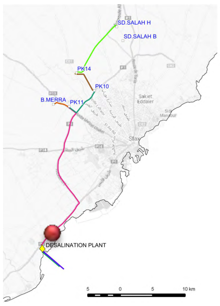
Source: JICA Survey Team

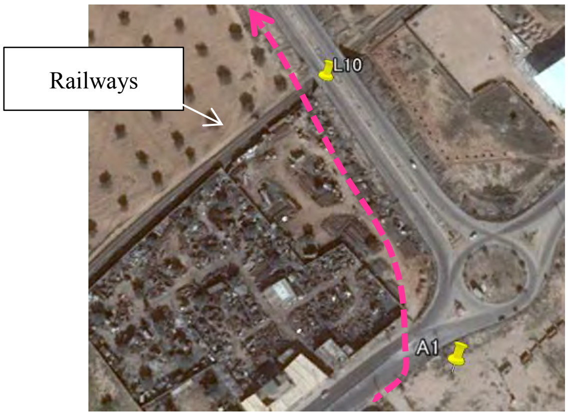
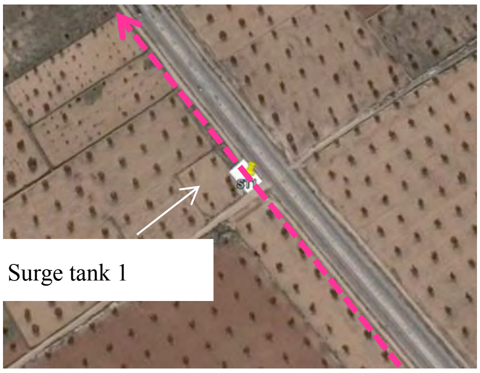
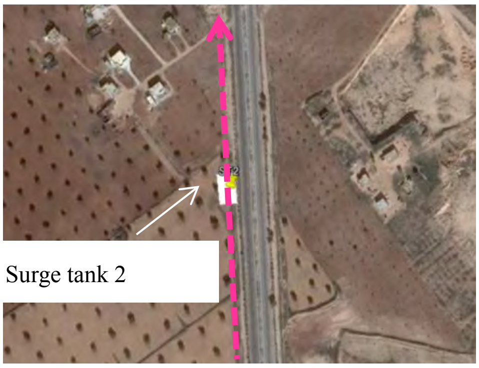
Figure 9.3-2 Villages crossed by the Project

A field study conducted along the transmission pipeline showed that lands that will be crossed are mainly olive groves, while few sections cross buildings or housing areas.

Table 9.3-1 Current Conditions along the Outline of the Transmission Pipeline

No	Section	Localization	Current conditions
1			
		Note The industrial fence on the right of the roadway may be affected by the works. Community: Mahres Outline in dotted pink: φ1,400mm	

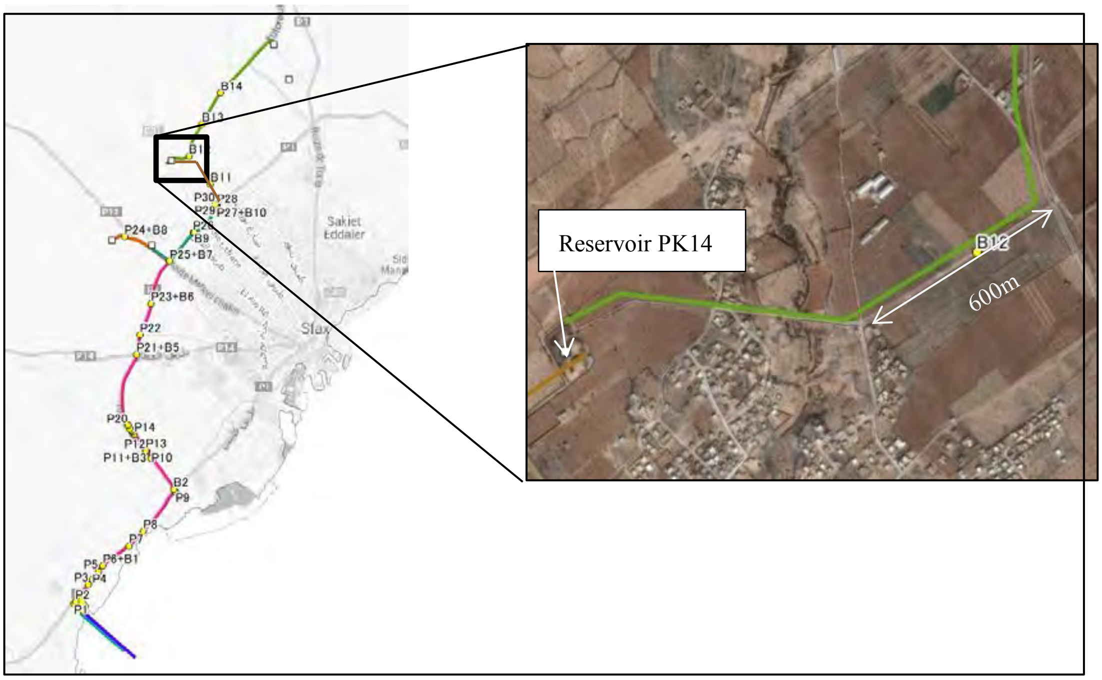
No	Section	Localization	Current conditions
2			
		Note The agricultural fence on the right of the roadway may be affected by the works. Community: Agareb Outline in dotted pink: φ1,400mm	
3			
		Note The industrial fence on the right of the roadway may be affected by the works. Community: Sfax South Outline in dotted pink: φ1,400mm	
4			
		Note The industrial fence on the right of the roadway may be affected by the works. Community: Sfax South Outline in dotted pink: φ1,400mm	
5			
		Note The agricultural fence on the right of the roadway may be affected by the works. Community: Sfax South Outline in dotted pink: φ1,400mm	

<table>
<tr><th>No</th><th>Section</th><th>Localization</th><th>Current conditions</th></tr>
<tr><td rowspan="2">6</td><td rowspan="2"></td><td colspan="2">
</td></tr>
<tr><td colspan="2">Note
The pipeline crosses the roadway and the railways. The industrial fence on the left of the roadway may be affected by the works.
Community: Sfax South
Outline in dotted pink : φ1,400mm</td></tr>
<tr><td rowspan="2">7</td><td rowspan="2"></td><td colspan="2">
</td></tr>
<tr><td colspan="2">Note
The acquisition of a land parcel covering about 17m x 31 m for the surge tank will be required. This will also require the logging down of two olive trees.
Community : Sfax South
Outline in dotted pink: φ1,400mm</td></tr>
<tr><td rowspan="2">8</td><td rowspan="2"></td><td colspan="2">
</td></tr>
<tr><td colspan="2">Note
The acquisition of a land parcel covering about 17m x 31 m for the surge tank will be required. This will also require the logging down of 2 olive trees.
Community: Sfax South
Outline in dotted pink: φ1,400mm</td></tr>
</table>

No	Section	Localization	Current conditions
9			
		Note Laying of pipes in the road's right of way area. Community: Sfax South Outline in dotted pink: φ1,400mm, in green :φ1,000mm	
10			
		Note Laying of pipes in the road's right of way area. Community: Sfax South Outline in dotted orange : φ400mm	

Source : GOOGLE satellite images, Photos : JICA Survey Team

In addition, when test boring was made along the pipeline as shown in the following Figure 9.3-3, the local people claimed ownership of lands at the level of boring point B12 (an unpaved road of about 600 metres).



Source: JICA Survey Team

Figure 9.3-3 Sites of Test Boring and Situation of Boring Point B12

Besides transmission pipelines, the main component which will require land acquisition is the work for the power transmission line. Although SONEDE will pay STEG the required amount as the cost for power supply, STEG will plan, design, construct and maintain the facilities. Ownership of the power transmission line will be held by STEG. However, the power transmission towers and their sites will be owned by SONEDE.

Since the area around the Seawater Desalination Plant is almost flat farmland, the power transmission line will be installed above ground in the air in principle because of the non-necessity of resettlement of residents.

SONEDE initially stated that the length of the transmission line will be 15.5km from the desalination plant, but presently, this has not yet been defined in detail, because STEG has not started the examination on the transmission route. Assuming that the required transmission towers will be 40 in number with an average interval of 400m, and size of the tower base will be 10 m x 10m, requiring an area of land acquisition of approximately 4,000m^2. It is also assumed that compensation will be needed for the land under the power transmission lines because high height structures cannot be constructed under the power line. STEG, however, has no experience of payment for such compensation so far. Land use under the power line, however, will be olive field and unused land. Therefore, the required compensation cost will not be a large amount. As a result of discussion between SONEDE and STEG, the cost for land acquisition and compensation shall be paid for by SONEDE, not by STEG who will have ownership of the power transmission towers and lines. SONEDE, therefore, shall take part in the study for selection of the power line route by STEG, so that such cost for land acquisition and compensation is at a minimum.

The results of the survey mentioned above show that the population affected by acquisitions is as follows:

Table 9.3-2 Population affected by Acquisitions

Item	Population	Observations
Resettlement		
Total	0	Based on the Project's policy
Land acquisitions		
Landlords	9 people (+transmission tower affected persons: 40 at maximum)	Table 9.3-1 ; Items 1 to 8 and are nearby B12

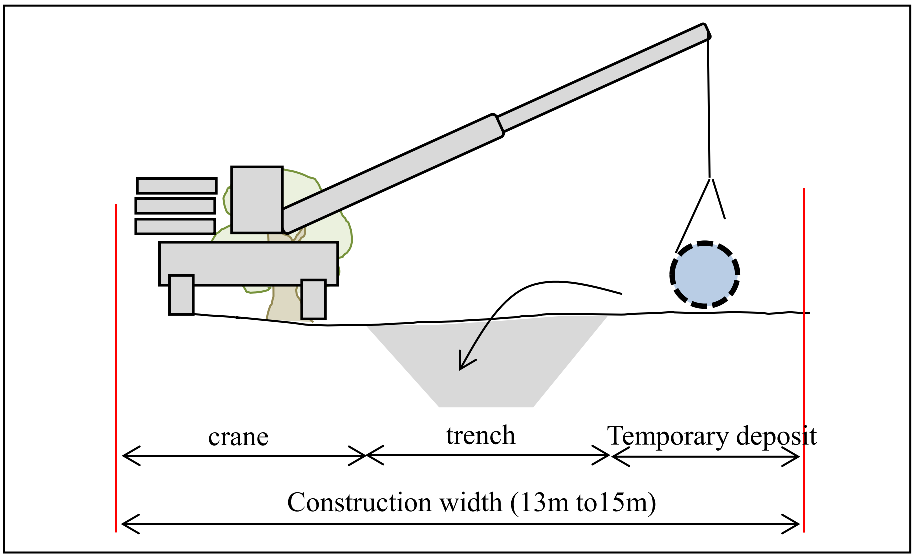
Source: JICA Survey Team

Except for the lands relating to the power transmission line, the real estate survey can be started by SONEDE once the detailed outline of transmission pipes is designed in 2018. STEG will also conduct the real estate survey for the power transmission line upon completion of its detailed design in 2018.

This survey will show the precise area of land acquisitions, the number of landlords, right-holders, and others holding other rights to land parcels, which will be useful to update the Table 9.3-2. The cut-off date to submit claims on lands is the publication date of the expropriation decree for landlords and rights-holders and the date when the real estate survey starts for non-rights holders.

(2) Real estate and patrimony

The acquisition of land for the laying of the pipe will be done based on a total width of 8 metres. However, since the project plans the use of pipes with a diameter of 1400 mm, it will be necessary to log down some olive trees along the width required for pipe laying. The distance between olive trees in Sfax averages 24 metres.



Source : JICA Survey Team

Figure 9.3-4 Construction Width

Consequently, the acquisition and compensation widths for this Project will be determined as follows:

- Acquisition width = Maximum 8m
- Compensation width = width of construction work

Table 9.3-3 Construction and Compensation Widths for Transmission Pipelines

<table>
<tr><th>Diameters</th><th>Width of trench</th><th>Temporary deposit</th><th>Crane (including margin)</th><th>Construction width = compensation width</th><th>Acquisition width</th></tr>
<tr><td>-</td><td>A</td><td>B</td><td>C</td><td>A+B+C</td><td>Maximum 8 (or A)</td></tr>
<tr><td>1400mm</td><td rowspan="2">4m</td><td rowspan="2">3m</td><td rowspan="5">6m
(crane 16t)
+2m
(margin)
=8m</td><td rowspan="2">15m</td><td rowspan="5">8m</td></tr>
<tr><td>1000mm</td></tr>
<tr><td>800mm</td><td rowspan="3">3m</td><td rowspan="3">2m</td><td rowspan="3">13m</td></tr>
<tr><td>700mm</td></tr>
<tr><td>400mm</td></tr>
</table>

Source: JICA Survey Team

As it would be possible to partly use the existing roadway for construction works and since olive trees are usually distant from roadways, the following table should be adapted for each specific case.

However, in this study, land parcels to acquire and the impacted agricultural patrimony (olive trees) are estimated in the following table:

Table 9.3-4 Property and Patrimony Damage related to Water Transmission Pipelines

Real estate property

Item	Community	Type	Area: Length (m)	Area: Width(m)	Area: Area (m^2)	Total (m^2)
Table 9.3-1,No.1	Mahres	Industry	275	8	2,200	2,200
Table 9.3-1,No.2	Agareb	Farming	1,320	8	10,560	10,560
Table 9.3-1,No.3	Sfax South	Industry	155	8	1,240	17,394
Table 9.3-1,No.4		Industry	100	8	800	
Table 9.3-1,No.5		Farming	970	8	7,760	
Table 9.3-1,No.6		Industry	205	8	1,640	
Table 9.3-1,No.7		Farming	31	17	527	
Table 9.3-1,No.8		Farming	31	17	527	
Table 9.3-1 No.11		Farming	10	10	100	
Figure 9.3-3 (B12)		Farming	600	8	4,800	

Structures

Item	Community	Type	Length (m)	Total (m)
Table 9.3-1,No.1	Mahres	Wall	275	275
Table 9.3-1,No.2	Agareb	Wall	150	150
Table 9.3-1,No.3	Sfax South	Wall	155	810
Table 9.3-1,No.4		Wall	100	
Table 9.3-1,No.5		Wall	350	
Table 9.3-1,No.6		Wall	205	

Farming Patrimony

Item	Community	Type	Length(m)	Width(m)	Area(m^2)	Number	Total
Table 9.3-1,No.2	Agareb	Olive trees (25/ha)	1,320	15	19,800	50	50
Table 9.3-1,No.5	Sfax South		970	15	14,550	37	61
Table 9.3-1,No.7			31	17	527	2	
Table 9.3-1,No.8			31	17	527	2	
Figure 9.3-3 (B12)			600	13	7,800	20	

Source: JICA Survey team

The required land for 40 power transmission towers is about 4,000 m^2. For construction work to be carried out, however, an area of 20 m x 20 m is required on a temporary basis. Therefore, compensation shall cover the area of 10 m × 10 m + 20 m × 20 m = 500 m^2 for each transmission tower. For total of 40 towers, 40 towers × 500 m^2/tower = 20,000 m^2, and therefore, 2 ha × 25 tree/ha = 50 olive trees logged will be the subject of compensation. Regarding compensation for the land under the power line, its subject area will be 10 m x 15 km = 15 ha, and 375 olive trees. Compensation for it will be quite small because farming activities can be continued. As stated previously, the cost for land acquisition and compensation will be shouldered by SONEDE.

As stated above, the land acquisition area is 3.41ha at maximum including those for power transmission line, and compensation is necessary for the fence of 1,235metres, and 536 olive trees as shown in Table 9.3-5.

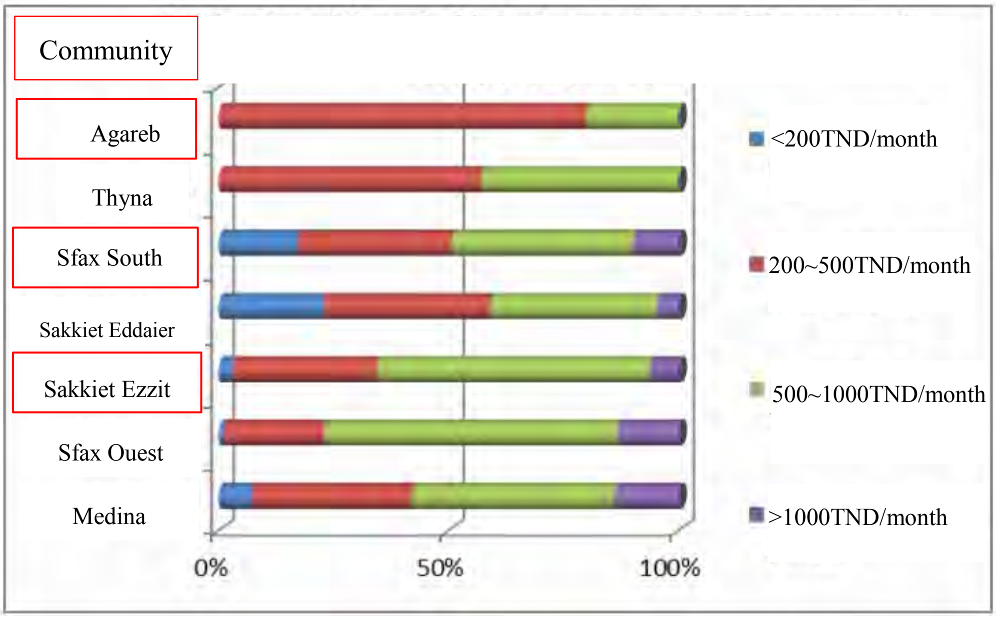
Table 9.3-5 Summary of Land Acquisition and Compensation for Water and Power Transmission Facilities

Subject	Water Transmission Pipeline			Power Line	Total
	Mahres	Agareb	Sfax South		
Land (m^2)	2,200	10,560	17,294	4,000	**34,054**
Structures (fence, m)	275	150	810	-	**1,235**
Olive Trees (tree)	-	50	61	50+375	**536**

Source: JICA Survey team

(3) Households survey

A socioeconomic study was also conducted in the framework of this survey. Results show that the average household includes 4.3 people and that households are made up of one person or more than six people represent 21% of the population (of which 12% represent households with more than six individuals). Finally the average revenue amounts to 650 TD/month among communities concerned by the Project, the smallest revenues are in Agareb. Expenditure for water is 45 TND/3months in average and equivalent to 2% of average income.



Source: JICA Survey Team

Figure 9.3–5 Households' Average Revenue around Sfax

9.4 Implementing the Compensations System

(1) Compensations

Unanticipated expenses related to the Project are land acquisitions (loss of real estate) and sea shore constructions (temporary loss incurred by fishing activities). There will be no resettlement of people.

As already mentioned in Section 9.2 (1), cut-off dates for claims related to real estate acquisitions are determined on the publication date of the expropriation decree (scheduled in 2016) for rights holders in compliance with Law 2003-26 ; while the date set for the beginning of the real estate survey will be the cut-off date for non-rights-holders (scheduled in 2016).

On the other hand, the cut-off date for claims or to request the compensation of interrupted fishing activities, the starting date is set when information meetings on site about planning and sea shore construction methods take place.

All cut-off dates must be notified for all sites concerned at least one month prior to the dates. Compensation for the land where people is earning his living by utilization of it will be made by land with similar value as far as possible. In other cases, financial compensations will be granted.

(2) Rights allocation matrix

Based on the previous, the matrix used to allocate rights for compensations is as follows:

Table 9.4-1 Matrix for the Allocation of Compensation Rights

<table>
<tr><th>N</th><th>Incurred losses</th><th>People concerned</th><th>Compensation method</th><th>Implementation</th><th>Party in charge</th></tr>
<tr><td>1</td><td>Land losses,</td><td>People holding rights over subject land parcels</td><td rowspan="2">a) Equivalent land parcels for people living from lands, whenever possible.
b) Compensation determined based on the evaluation of losses</td><td>i) According to Law 2003-26.</td><td rowspan="2">i) SONEDE Department of juridical and real estate affairs, Ministry of State Properties.
ii) SONEDE
iii) Land acquisition and compensation will be done by SONEDE</td></tr>
<tr><td>2</td><td>Constructed or agricultural assets</td><td>People holding rights over subject land parcels; non-rights holders living from subject land parcels</td><td>i) According to Law 2003-26.
ii) Regardless of ownership, people receiving impacts are subject to compensation.
iii) To be compensated in accordance with national law and JICA guideline.</td></tr>
<tr><td>3</td><td>Loss of fishing activities due to non-access to fishing areas because of pipes laying works</td><td>Fishing boats registered at the port of Mahrès</td><td>Evaluation of the period concerned by the loss of fishing activities, financial compensation based on that period.</td><td rowspan="2">a) Organization of information meetings planning and construction methods
b) Identify concerned boats and women collectors
c) Calculate compensation amounts and payment</td><td rowspan="2">a) SONEDE and UTAP
b) DGPA or local representation
c) SONEDE</td></tr>
<tr><td>4</td><td>Loss of fishing activities due to sea water high turbidity because of excavation works in the sea</td><td>Walking fishermen (including women collectors) registered at the competent authority (UTAP)</td><td>Evaluation of the period for collection activities, financial compensation based on this period</td></tr>
</table>

Source : JICA Survey Team

9.5 Claim Management Mechanisms

Appropriate mechanisms to manage claims must be implemented in order to maximize social acceptance of the Project and avoid problems during construction or operation.

The mechanism for land acquisition is provided for by Law No. 2003-26 as it concerns the Survey and Reconciliation Commission. Expropriation files must be published to the public (posting at the municipality, radio spots, etc.) one month at least before their final confirmation. Plaintiffs may appeal this decision before the Survey and Reconciliation Commission which composition is given below (as per Decree 2003-1551):

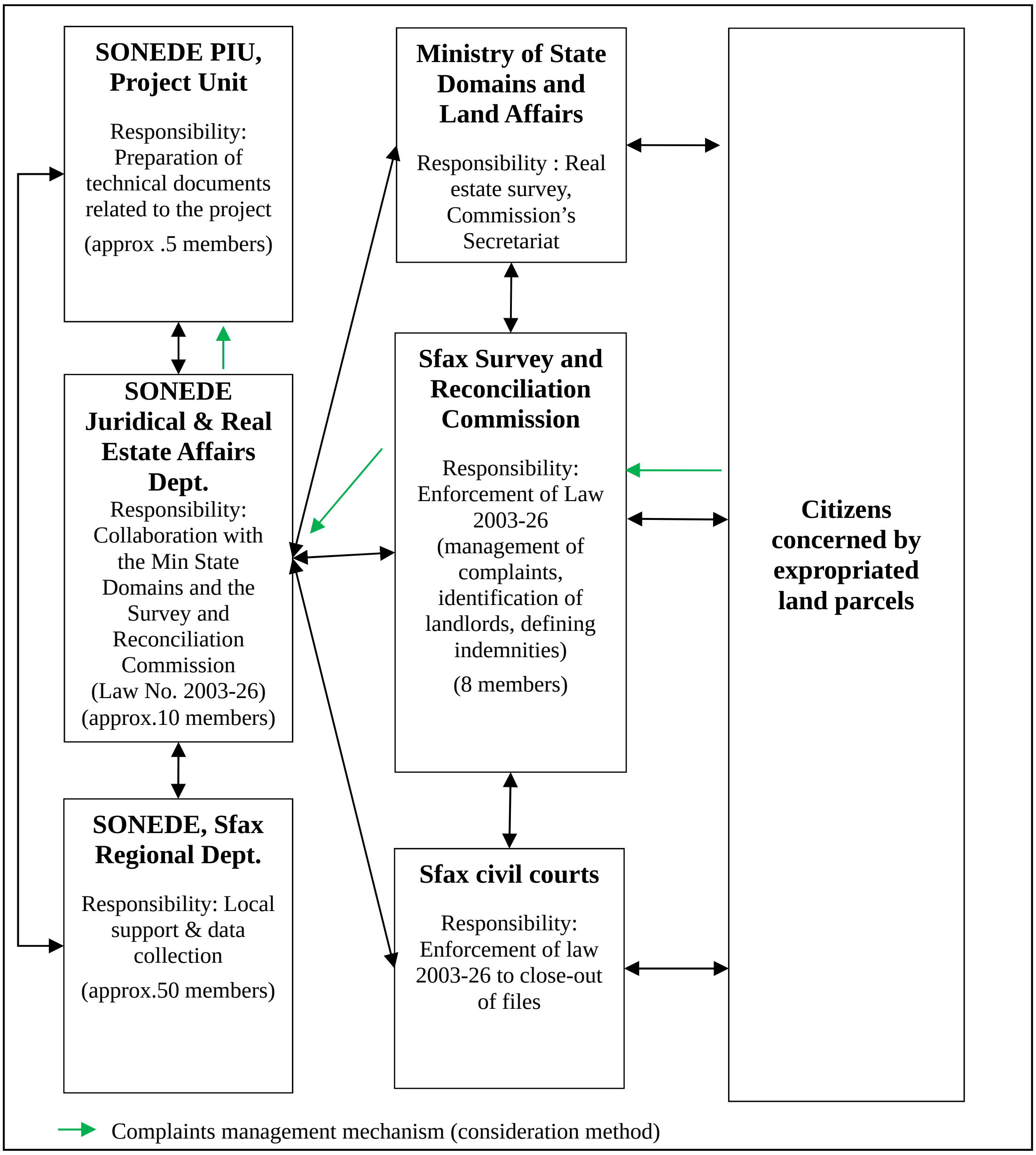
- A magistrate : Chair,
- Representative of the Governor: member,
- Regional Director of the State Domain and Real Estate Affairs of his/her representative: member
- Regional Director of the Topography and Cartography Office (OTC) or his/her representative: member;
- A representative of the Ministry or the company gaining from expropriation (in this case the Director of juridical and real estate affairs at SONEDE or STEG): member;
- Expert in State properties: member;
- Representative of the real estate conservation and properties: member;
- A representative of the municipality or municipalities where the expropriated property is expropriated: member.

As for unanticipated losses in fishing activities, the complaints management mechanism may be made through UTAP (Tunisian Agriculture and Fishing Union). UTAP is a nation-wide union bringing together small producers and cooperatives. UTAP can be the appropriate interlocutor to defend fishermen’s rights and interests.

9.6 Organization for the Implementation of Social Considerations

This Project will be implemented by a project implementation unit (hereafter referred to as PIU). Land acquisitions will be implemented by PIU and the juridical and real estate affairs department in SONEDE. Contributors shall be the Ministry of State Domains and Land Affairs (including its local representations), the Survey and Reconciliation Commission of the Sfax Governorate as well as civil courts.

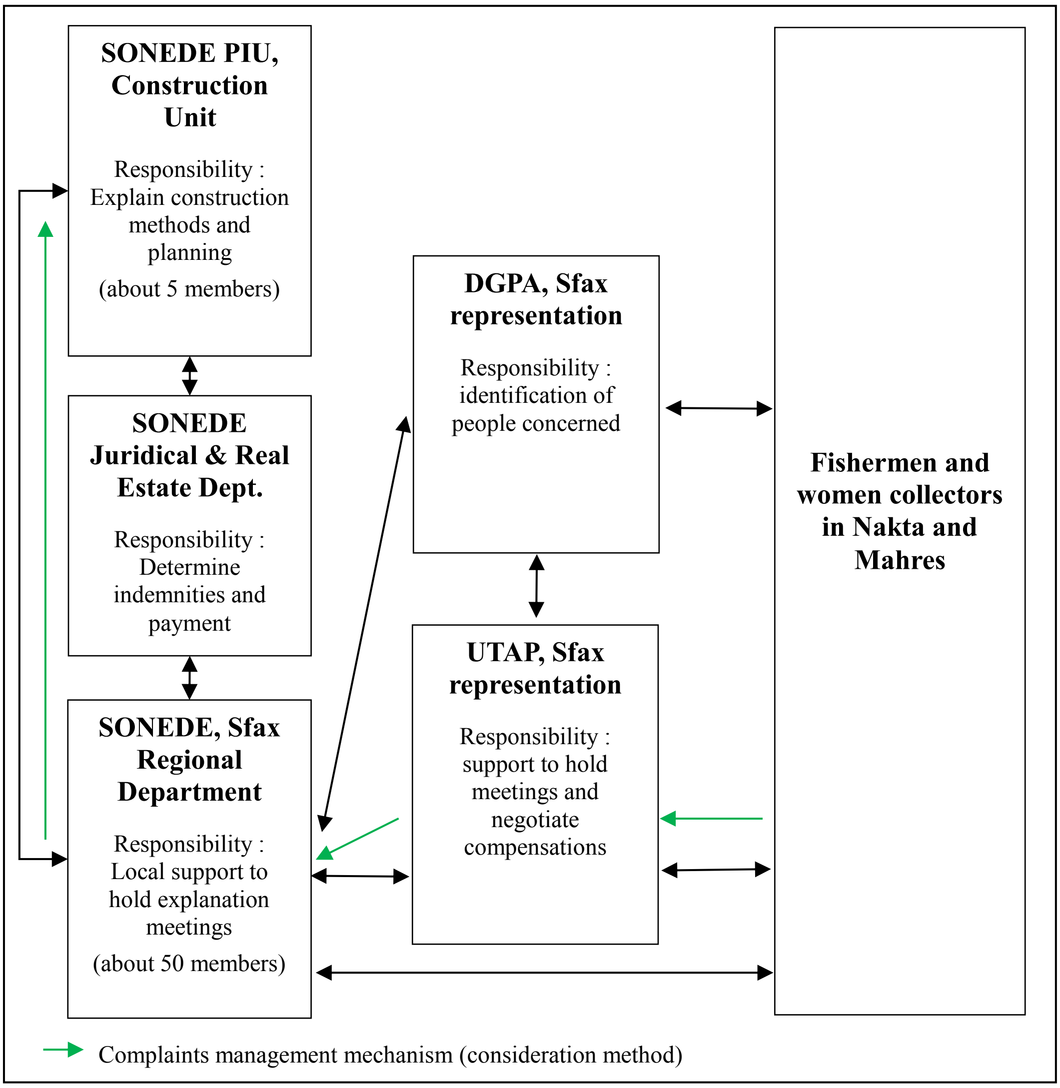
Social considerations will therefore be implemented based on the following plan:



Source : JICA Survey team

Figure 9.6–1 Organization and Implementation of Land Acquisition Operations

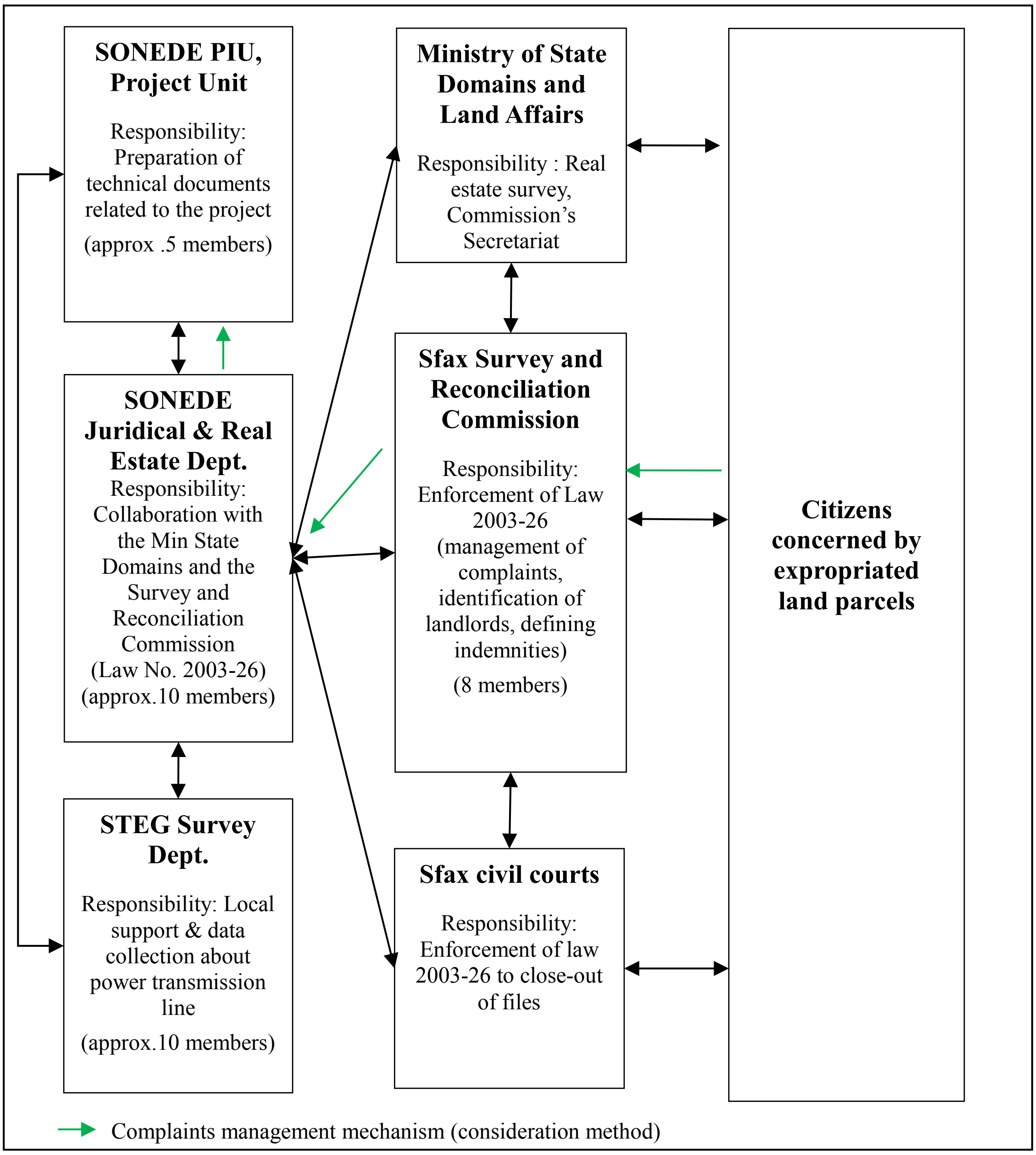
The Juridical and Real Estate Affairs Department and the Sfax Regional Department will work together on complaints regarding fishing activities PIU's Construction unit. The main interlocutor will be UTAP and its branch in Sfax.



Source : JICA Survey team

Figure 9.6–2 Organization and Implementation of Compensations to Fishing Activities

The power transmission line will be constructed and maintained by STEG, however, land acquisition and compensation will be performed by SONEDE. Therefore, social considerations will be implemented based on the following plan.



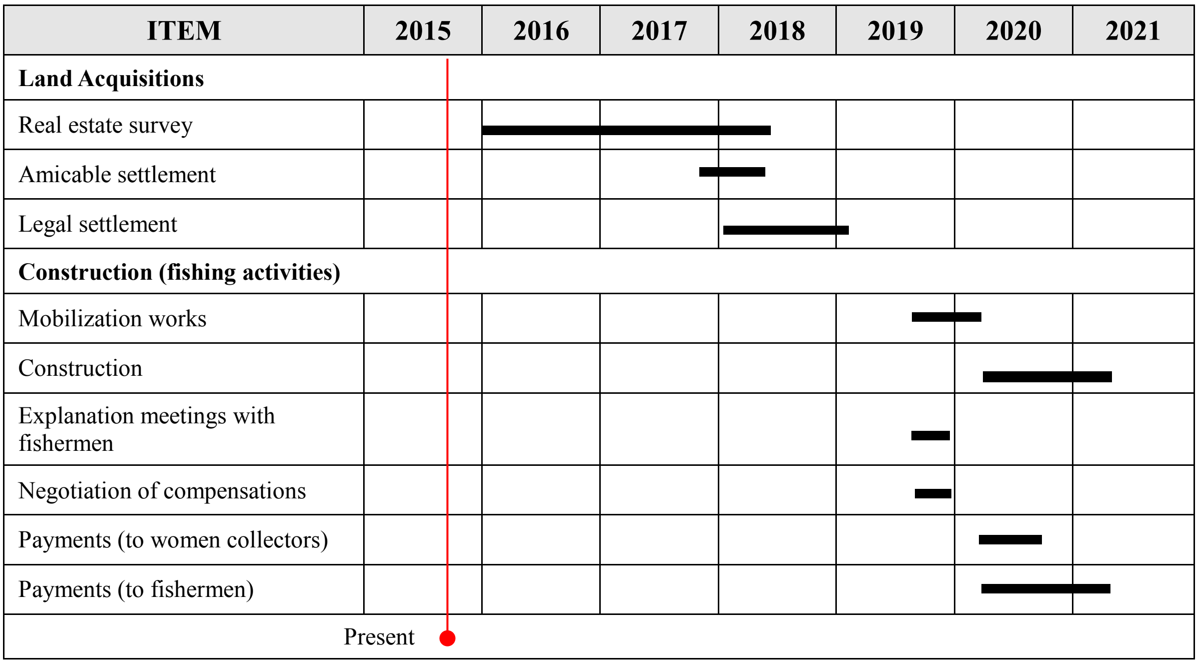
Source : JICA Survey team

Figure 9.6–3 Organization and Implementation of Compensations for Land Acquisition for Power Transmission Line

9.7 Implementation Schedule

When the detailed pre-project concerning transmission pipes is finalized (planned in July 2017), the real estate survey may then start and amicable settlements may be finalized by the end of 2017, legal procedures will need to be finalized by the end of 2018.

Information meetings about the schedule and construction methods will start in the autumn of 2019 when the Contractor is selected. The procedure must be finalized towards end of 2019 and compensations will be disbursed during construction works, for six months for issues related to turbidity and one year for issues related to access to fishing areas, with the disbursement made on a monthly basis. Based on the preceding, the schedule may be displayed as follows:



Source : JICA Survey Team

Figure 9.7–1 Social Considerations Implementation Schedule

9.8 Costs and Funding

In order to define an appropriate budget for social considerations, costs and findings are planned as follows:

(1) Costs related to acquisitions

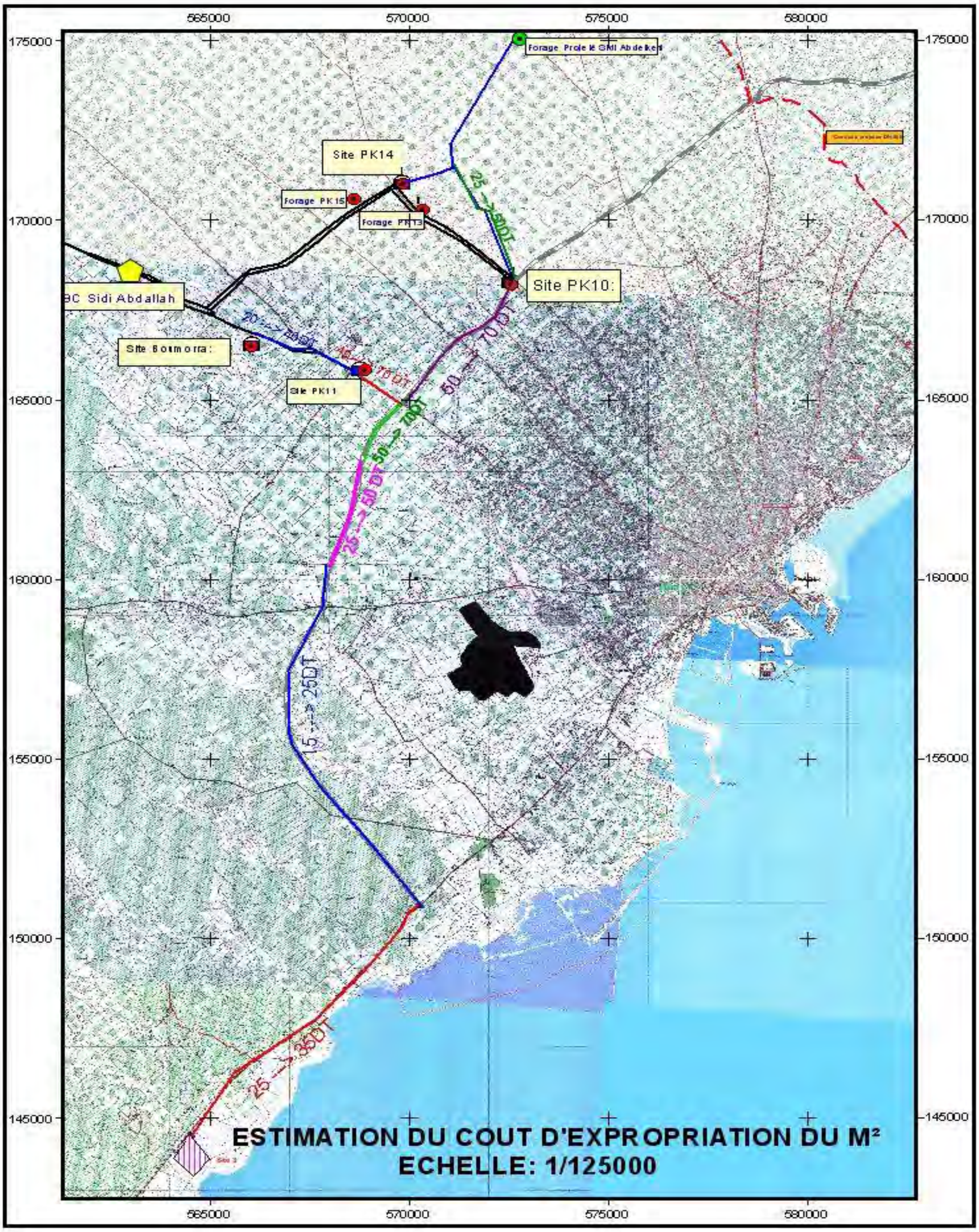
Costs related to acquisitions are evaluated based on Table 9.3-4. Unitary costs for olive trees and other fruit trees are estimated based on another expropriation file submitted by the Juridical and Real Estate Affairs Department of SONEDE. Close out is estimated at 50TND/m.

Table 9.8-1 Unit Price of Olive Trees and Other Fruit Trees

Size	Olive trees	Fruit trees (almonds)
Big	120	100
Medium	80	70
Small	50	40

Source : SONEDE Juridical and Real Estate Affairs Department, Unit : TND

Square meter costs of lands along the transmission pipeline were provided by SONEDE's General Department in Sfax.



Source : SONEDE, Sfax Regional Department, May 2014

Figure 9.8–1 Unit Price of Lands for Acquisition in Sfax

Based on the information shown in Table 9.3-4, the costs for land acquisition are estimated in Table 9.8-2:

Table 9.8-2 Land Acquisition and Compensation Costs for Transmission Facilities

Land						
Item	**Community**	**Type**	**Area (m^2)**	**U. Price[1] (TND)**	**Total (TND)**	**Total (TND)**
Table 9.3.1,No.1	Mahres	Industry	2,200	25	55,000	55,000
Table 9.3.1,No.2	Agareb	Farming	10,560	30	316,800	316,800
Table 9.3.1,No.3	Sfax South	Industry	1,240	35	43,400	549,250
Table 9.3.1,No.4		Industry	800	35	28,000	
Table 9.3.1,No.5		Farming	7,760	35	271,600	
Table 9.3.1,No.6		Industry	1,640	35	57,400	
Table 9.3.1,No.7		Farming	527	25	13,175	
Table 9.3.1,No.8		Farming	527	25	13,175	
Figure 9.3.3 (B12)		Farming	4,800	25	120,000	
Power Transmission Tower	Based on STEG's Plan[2]	Farming	4,000	30	120,000	120,000
Structures						
Item	**Community**	**Type**	**Length(m)**	**Price**	**Total**	**Total**
Table 9.3.1,No.1	Mahres	Wall	275	50	13,750	13,750
Table 9.3.1,No.2	Agareb	Wall	150		7,500	7,500
Table 9.3.1,No.3	Sfax South	Wall	155		7,750	40,500
Table 9.3.1,No.4		Wall	100		5,000	
Table 9.3.1,No.5		Wall	350		17,500	
Table 9.3.1,No.6		Wall	205		10,250	
Agricultural assets						
Item	**Community**	**Type**	**Number**	**Price**	**Total**	**Total**
Table 9.3.1,No.2	Agareb	Olive trees (25/ha)	50	120	6,000	6,000
Table 9.3.1,No.5	Sfax South		37		4,440	7,320
Table 9.3.1,No.7			2		240	
Table 9.3.1,No.8			2		240	
Figure 9.3.3 (B12)			20		2,400	
Power Transmission Tower	Based on STEG's Plan		425		51,000	51,000

Note 1): price in 2014
Note 2): Mahres, Agareb, Sfax South
Source: JICA Survey team

The total costs amount to 68,750TND in Mahres, 330,300TND in Agareb, 597,190TND in Sfax South, with the overall amount totalling 996,240TND. The above includes the costs for land asset, structure and crops assets, based on market prices in the region. This cost can be considered as full replacement costs.

SONEDE will also shoulder the following costs for land acquisition and compensation for power transmission line; TND 120,000 (land acquisition) + TND 51,000 (olive) = TND 171,000.

(2) Compensations to fishing activities

As described in Table 8.10-2, the compensation cost for fishing activities amounts to 162,000TND.

(3) Budget and funding for social considerations

The total budget necessary for compensations on expropriation and for fishing activities amounts to 993,620+171,000+162,000=1,326,620TND. Since this Project is being implemented by SONEDE, funding will be provided by SONEDE and may be charged to the budget of the Juridical and Real Estate Affairs Department.

The current budget devoted to expropriation at the Juridical and Real Estate Affairs Department amounts to about 1,000.000 TND. According to the implementation schedule (Figure 9.7-1), the budget for land acquisition and compensation of 1,326,620 TND shall be secured in the four years from 2018 to 2021 besides of usual budget. Therefore, the annual budget for land acquisition and compensation of SONEDE shall be TND 1,340,000 (=1,326,620/4+1,000,000) per year. Assuming that 25% for unanticipated expenses is taken, the total budget will amount to 1.7 million TND.

9.9 Monitoring Implementation Follow-up Form

The Project's overall schedule depends on the enforcement of social considerations including land acquisition and compensation relating to power transmission line, therefore, follow up must be conducted by PIU by means of the follow up form presented in Table 9.9-1. This form shall be modified in accordance with the result of EIA study being conducted by SONEDE.

Table 9.9-1 Follow-Up Form of Social Considerations

Meetings with stakeholders and information during EIA			
No.	Date	Community	Content and Comments
1			
2			

Land acquisition							
Activities	Item	Mahres		Agareb		Sfax South	
		Water pipe	Power line	Water pipe	Powe r line	Water pipe	Power line
Real estate survey	Starting date						
	Publication date and site						
	Progress 1 month after the starting date (% of transmission line length surveyed)						
	Progress 3 months after the starting date						
	Main results : ➢ Area to acquire ➢ Length of fence ➢ Number of olive trees ➢ Number of landlords ➢ Number of right-holders ➢ Non-right holders						

Amicable settlement	Number of cases						
	Compensations amount						
	Planned disbursement date						
	Effective disbursement date						
	Progress 1 month after the starting date (% of cases completed)						
	Progress 3 months after the starting date						
Legal settlements	Number of cases						
	Reasons for rejecting amicable settlement						
	Commission meetings dates						
	Date of expropriation decree						
	Compensations amount						
	Planned disbursement date						
	Effective disbursement date						
	Progress 3 month after the starting date (% of cases completed)						
	Progress 6 months after the starting date						

Compensations to fishing activities	
Activities	Content
Meetings about schedule information and construction methods	Dates : Communities : List of participants :
Identification of people concerned and compensations amount	Number of people concerned: Selection method of people: Compensations calculation method:
Payment of compensations	Compensation amount: Compensation period: Disbursement method:

Source: JICA Survey Team

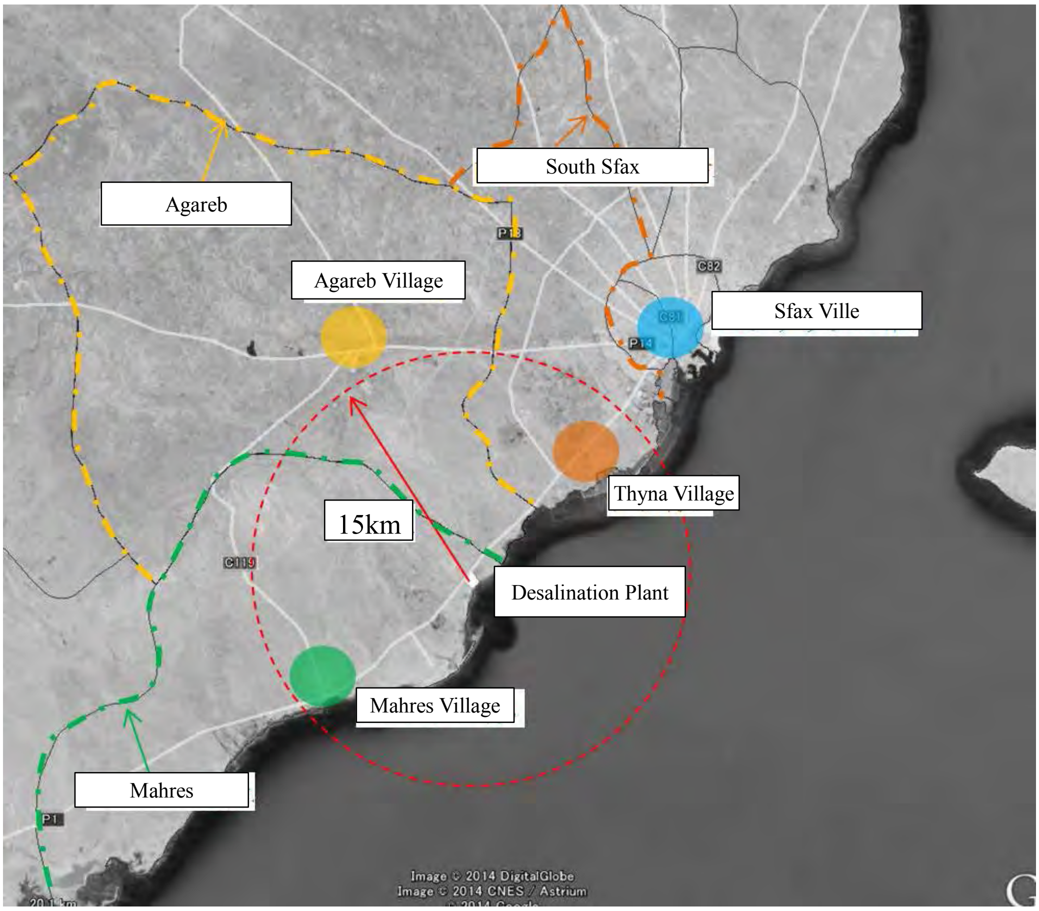
9.10 Explanation to Residents about Power Transmission Line

In addition to the support for the stakeholders meeting, the JICA Survey Team also supported SONEDE to explain and collect the opinions of residents about power transmission line for the desalination plant. Collection of residents' opinions was carried out by distribution of explanation papers and questionnaire survey. Outlines of activities are as follows:

(1) Subject area

Subject area where receive influence by construction work of power transmission line is presented in the Figure 9.10-1. The route of 15km[1] long transmission line has not been identified yet by STEG.

[1] STEG changed the planned distance of the power transmission line to 15km from initially planned 15.5km.



Source: JICA Survey Team

Figure 9.10–1 15kmLong Power Transmission Line Construction Site

Subject area is supposed to be Mahres, Agareb, and Thyna. Since STEG has not identified the route of the power line in detail yet, the questionnaires were sent to representative people in each region. Contents of the distributed papers are as shown in Figure 9.10-2, i.e. general map, questionnaire, outlines of the Project, policies of land acquisition and compensation relating to construction of the power transmission line.

الشركة الوطنية لاستغلال وتوزيع المياه
SOCIETE NATIONALE D'EXPLOITATION ET DE DISTRIBUTION DES EAUX

تونس في 12 2014

29036 إلى السيد والي صفاقس

الموضوع: - مشروع انجاز محطة تحلية مياه البحر بسعة 200 ألف متر مكعب في اليوم بصفاقس الكبرى
- حول ربط المحطة بالكهرباء

المصاحيب: - ملحق عدد1 حول المسار الأولي لخط الجهد العالي،
- ملحق عدد2 حول وثيقة استشارة (للملاحظات و التساؤلات حول المشروع)
- ملحق عدد3 حول العناصر الأساسية للمشروع؛

تحية طيبة وبعد،

في إطار تدعيم تزويد صفاقس الكبرى بالماء الصالح للشرب، كما تعلمون برمجت الشركة الوطنية لاستغلال وتوزيع المياه انجاز محطة لتحلية مياه البحر بسعة 100 ألف متر مكعب في اليوم كمرحلة اولى، وتبعا لذلك ستقوم الشركة التونسية للكهرباء و الغاز بجلب الطاقة الكهربائية اللازمة لكافة المنشآت التابعة للمشروع عن طريق مد خط كهربائي جهد عالي.

كما نفيد سيدتكم علما بأن الشركة التونسية للكهرباء و الغاز تقوم حاليا بإعداد الدراسات الضرورية لتحديد مسار خط الجهد العالي لربط محطة التحلية بالكهرباء، وعند الانتهاء من هذه الدراسة و تحديد المسار النهائي، سيتم انجاز دراسة المؤثرات البيئية التي ستشمل منشآت محطة التحلية وخط الكهرباء ذات الجهد العالي من قبل مكتب دراسات مختص. وخلال الدراسة البيئية سيتم تنظيم يوم إعلامي للعموم قصد شرح كل تفاصيل المشروع و خاصة الجزء المتعلق بربط المحطة بالكهرباء.

وبهدف الإعلام المسبق للسكان المعنيين بهذا المشروع، تجدون صحبة هذا ملخصا للعناصر الأساسية للمشروع (ملحق عدد3). كما نطلب من سيادتكم مدنا بملاحظاتكم و تساؤلاتكم بخصوص عناصر المشروع وذلك طبقا لوثيقة الاستشارة المصاحبة (ملحق عدد2).

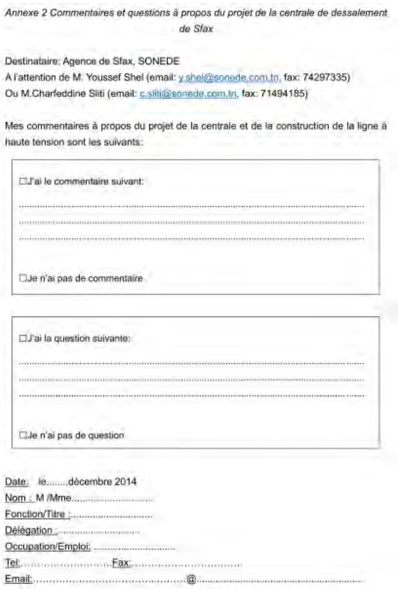
وحتى نتمكن من إدراج ملاحظاتكم في الدراسة البيئية للمشروع، الرجاء موافاتنا بإجاباتكم في أقرب الآجال.

تقبلوا سيدي الوالي فائق عبارات التقدير و الاحترام.

المدير المركزي للدراسات
عدنان بوبكر

Explanation about Papers - cover

General map (annex 1)



Annexe 2 Commentaires et questions à propos du projet de la centrale de dessalement de Sfax

Destinataire: Agence de Sfax, SONEDE
A l'attention de M. Youssef Shel (email: y.shel@sonede.com.tn, fax: 74297335)
Ou M.Charfeddine Sliti (email: c.sliti@sonede.com.tn, fax: 71494185)

Mes commentaires à propos du projet de la centrale et de la construction de la ligne à haute tension sont les suivants:

☐J'ai le commentaire suivant:
....
....
....

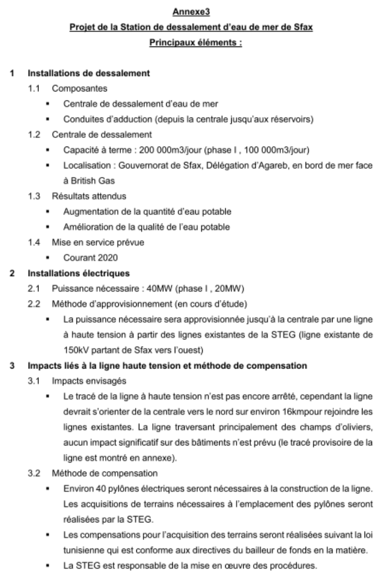
☐Je n'ai pas de commentaire

☐J'ai la question suivante:
....
....
....

☐Je n'ai pas de question

Date: le........décembre 2014
Nom : M /Mme...............................
Fonction/Titre :...............................
Délégation :...............................
Occupation/Emploi: ....
Tel:...............................Fax:...............................
Email:...............................@...............................

Questionnaire (annex 2)



Annexe3
Projet de la Station de dessalement d'eau de mer de Sfax
Principaux éléments :

1 **Installations de dessalement**
1.1 Composantes
- Centrale de dessalement d'eau de mer
- Conduites d'adduction (depuis la centrale jusqu'aux réservoirs)

1.2 Centrale de dessalement
- Capacité à terme : 200 000m3/jour (phase I , 100 000m3/jour)
- Localisation : Gouvernorat de Sfax, Délégation d'Agareb, en bord de mer face à British Gas

1.3 Résultats attendus
- Augmentation de la quantité d'eau potable
- Amélioration de la qualité de l'eau potable

1.4 Mise en service prévue
- Courant 2020

2 **Installations électriques**
2.1 Puissance nécessaire : 40MW (phase I , 20MW)
2.2 Méthode d'approvisionnement (en cours d'étude)
- La puissance nécessaire sera approvisionnée jusqu'à la centrale par une ligne à haute tension à partir des lignes existantes de la STEG (ligne existante de 150kV partant de Sfax vers l'ouest)

3 **Impacts liés à la ligne haute tension et méthode de compensation**
3.1 Impacts envisagés
- Le tracé de la ligne à haute tension n'est pas encore arrêté, cependant la ligne devrait s'orienter de la centrale vers le nord sur environ 16kmpour rejoindre les lignes existantes. La ligne traversant principalement des champs d'oliviers, aucun impact significatif sur des bâtiments n'est prévu (le tracé provisoire de la ligne est montré en annexe).

3.2 Méthode de compensation
- Environ 40 pylônes électriques seront nécessaires à la construction de la ligne. Les acquisitions de terrains nécessaires à l'emplacement des pylônes seront réalisées par la STEG.
- Les compensations pour l'acquisition des terrains seront réalisées suivant la loi tunisienne qui est conforme aux directives du bailleur de fonds en la matière.
- La STEG est responsable de la mise en œuvre des procédures.

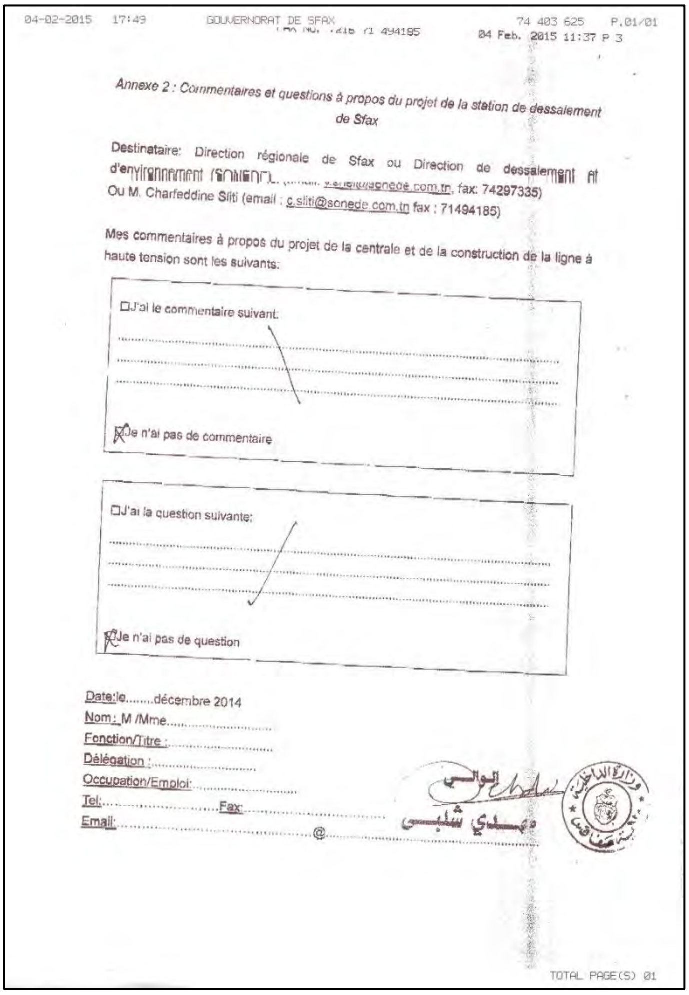
Outlines of the Project , policies about land acquisition and compensation (annex 3)

Source: SONEDE

Figure 9.10–2 Questionnaire distributed for Explanation about Power Transmission Line

(2) Results of the Survey

The Sfax Governorate office is the sole responsible authority for administrative issues in the Sfax Governorate under Ministry of Interior of Tunisia. SONEDE cannot contact each region directly, but through the governorate office. SONEDE sent the said questionnaire to the governorate office on 12 December 2014, and requested the office to deliver the questionnaire to representatives of each region. As a result, the governor of the Sfax Governorate answered on 14 February 2015 with the letter shown in Figure 9.10-3. The answer was that there had been no objection from Sfax Ville, West Sfax, and Thyna, and the governor also had no objection about the Project. It may be considered that no objection to construction work of the power transmission line at present.



04-02-2015 17:49 GOUVERNORAT DE SFAX 74 403 625 P.01/01
04 Feb. 2015 11:37 P 3

Annexe 2 : Commentaires et questions à propos du projet de la station de dessalement de Sfax

Destinataire: Direction régionale de Sfax ou Direction de dessalement et d'environnement (SONEDE) ([illegible]@sonede.com.tn, fax: 74297335)
Ou M. Charfeddine Sliti (email : c.sliti@sonede.com.tn fax : 71494185)

Mes commentaires à propos du projet de la centrale et de la construction de la ligne à haute tension sont les suivants:

☐J'ai le commentaire suivant:
………………………………………
☒Je n'ai pas de commentaire

☐J'ai la question suivante:
………………………………………
☒Je n'ai pas de question

Date:le........décembre 2014
Nom: M /Mme..........................
Fonction/Titre :.........................
Délégation :.........................
Occupation/Emploi:.........................
Tel:.........................Fax:.........................
Email:.........................@.........................

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Source: SONEDE

Figure 9.10–3 Answer to the Questionnaire from the Governor

Social survey will be conducted by SONEDE at the time of detailed design of the power transmission line by STEG. Subject area and residents will be identified through the survey, and then, the land required to be acquired and amount of compensation will be identified. Furthermore, SONEDE will hold explanation meetings with residents in the subject areas to explain about policies for land acquisition and compensation and to confirm that there is no opposition to the Project.

CHAPTER 10

IMPLEMENTATION PLAN

CHAPTER 10 IMPLEMENTATION PLAN

10.1 Project Purpose

The purpose of the Project is to improve and enhance the living condition of Tunisia, particularly for the residents of Greater Sfax by increasing and stabilizing water supply capacity and improving water quality through the construction, installation and operation of a seawater desalination plant.

10.2 Project Area

The project area is the Greater Sfax located in the middle of Tunisia.

10.3 Project Outline

In the Project, the facilities to be installed are i) a sea water desalination plant with a capacity of 200,000 m^3/d and facilities required for the operation, ii) transmission pipes from the sea water desalination plant to the existing reservoirs, iii) transmission and intermediate pump stations, and appurtenant facilities for the operation, iv) reservoirs, v) electricity facilities which will receive power from the distribution network of STEG.

The outline of the overall plan and Phase 1 project is as follows:

Table 10.3-1 Outline of the Project

Facilities	Overall plan	Phase I project (for Yen loan project)
Lot 1 Sea water intake pipe (Procurement/Construction)	Intake: 444,400m^3/d, length: 3.6 km (buried pipe in sea bed), diameter of pipe: 2,000 mm x 2 lines, HDPE pipe	(Construction of overall plan) Intake: 222,200m^3/d, length 3.6 km (Buried, off-shore; 3.2km, on-shore; 0.4km), pipe diameter 2,000mm x 2 lines, HDPE pipe
Sea water desalination plant (Procurement/Construction)	Production amount: 200,000 m^3/d, RO membrane, recovery: 45%, production water: TDS < 500mg/L, transmission pump facilities	(Facility construction for production of 100,000m^3/d) Production: 100,000m^3/d, RO membrane, recovery: 45%, TDS concentration of produced water: less than 500mg/L, transmission pump facility
Brine discharge pipe (Procurement/Construction)	Discharge: 244,400m^3/d, length: 4.4 km (buried pipe in sea bed), diameter: 1,800 mm, HDPE pipe, brine of TDS: about 73,000mg/L	(Construction of overall plan) Discharge: 122,200m^3/d, length: 4.4km (Buried, off-shore; 4.0km, on-shore;0.4km), diameter: 1,800mm, HDPE pipe, concentrated water of TDS: about 73,000mg/L
Lot 2 Transmission pipeline materials (Procurement) Note: divided to 2 lots depends on pipe diameters	Necessary pipes for transmission pipe of Lot 4	(Procurement for overall plan) Pipes necessary for transmission pipeline of Lot 4, ductile cast iron pipe, diameter: 400 - 1,400 mm, length: about 49.5km Sub-lot: 2-1 ：dia. 1400mm and 1000mm 32.5km Sub-lot: 2-2 ：dia. Less than 1000mm 17.0km

Facilities	Overall plan	Phase I project (for Yen loan project)
Lot 3 Valves and other equipment materials (Procurement)	Necessary valves and other equipment for transmission pipe of Lot 4	(Procurement for overall plan) Valves necessary for transmission pipeline of Lot 4 of diameter 400 - 1400 mm and length about 49.5km
Lot 4 Transmission pipelines (Construction) Water hammer prevention facilities (Procurement/Construction)	Ductile cast iron pipe, diameter: 400 - 1400 mm, length: 49.5 km Construction of one-way surge tanks at 2 locations along transmission pipelines, and installation of flywheels and other devices at pump stations	(Construction of overall plan) Ductile cast iron pipe, diameter: 400 - 1400mm, length: 49.5km (Construction of overall plan) Construction of one-way surge tanks at 2 locations along transmission pipelines, and installation of flywheels and other devices at all pump stations
Lot 5 Reservoirs (Procurement/Construction)	New reservoirs with a capacity of 45,000 m^3 in total at existing reservoirs' site, receiving water and mixing chambers at 5 locations	(Construction of facilities necessary for Phase 1) New reservoir of 5,000 m^3 at existing reservoir (Bou Merra), and receiving and mixing chambers at 5 locations PK11: 9.0W x 15.0L x 5.0D Bou Merra : 4.0W x 3.0L x 5.0D PK10: 7.0W x 10.0L x 5.0D PK14: 7.0W x 7.0L x5.0D Sidi Salah EH: 6.0W x 5.0L x 5.0D m, W:width, L:length, D: water depth
Lot 6 Intermediate pump stations (Procurement/Construction)	Three locations at the existing reservoirs' site	(Civil and Architectural works: construction of overall plan, Mechanical and Electrical woks: installation of facility necessary for Phase 1) Three locations at existing reservoirs' site
Lot 7 Power receiving line (Procurement/Construction)	Power receiving line from power line of STEG to sea water desalination plant	(Construction of overall plan) Power receiving line from power line of STEG to sea water desalination plant

10.4 Consulting Services

Serious water shortage is expected to occur in Greater Sfax from 2017, which requires the immediate construction and operation of a Seawater Desalination Plant. Considering the scale of the Project, it is important to have a proper head start to guarantee that the plant operates as planned and as scheduled. Bearing in mind the type of facilities to be constructed, the appropriate contract type for the contractors is the design-build contract for Lots 1 and 6, and BoQ (unit price) contract for Lots 2 to 5. The role of consultants is in providing critical assistance in the documentation and approval process. Therefore, it is recommended that the consulting services be provided for detailed design including preparation of tender documents (Lots 1 to 6), tender assistance, and construction supervision. The following is a summary of the consulting services.

(1) Subject for Consulting Services
All lots (Lot 1 to Lot 7)

(2) Period of consulting services

- Detailed design stage: 12 months
- Tender assistance stage: 15 months
- Construction supervision stage: 60 months for Lot 1 (36 months for construction work 12 months for performance test, and 12 months for defect liability period)
- Total: 87 months (including defect liability period)

(3) Required Man-months of consultants

Required man-months for the consulting services are as follows:

Table 10.4-1 Required Man-Months for the Consulting Services

unit: man-months

Type	Detailed Design	Tender Assistance	Construction Supervision	Total
Foreign Professional	77.0	36.0	190.5	303.5
Local Professional	84.0	16.0	406.5	506.5
Local Supporting Staff	149.0	61.0	491.0	701.0
Total	310.0	113.0	1,088.0	1,511.0

Table 10.4-2 Required Man-Months for the Consulting Services（breakdown）

No	**Position**	**Man-Month**			
		DD[1)]	**TA[2)]**	**CS[3)]**	**Total**
Foreign Professional Staff					
1	Team Leader	12.0	10.0	35.5	57.5
2	Desalination Plant Process Engineer	9.0	4.0	18.5	31.5
3	Civil Engineer	12.0	4.0	33.0	49.0
4	Pipeline Engineer	12.0	1.5	28.0	41.5
5	Mechanical Engineer (Desalination Plant)	4.0	3.5	9.5	17.0
6	Mechanical Engineer (Transmission Pumps)	3.0	2.0	7.0	12.0
7	Electrical Engineer	3.0	3.5	9.0	15.5
8	Instrumentation Engineer	3.0	2.0	9.0	14.0
9	Structural Engineer	6.0	0.0	2.0	8.0
10	Contract Specialist	5.0	5.5	5.0	15.5
11	Quantity Surveyor	4.0	0.0	34.0	38.0
12	Specification specialist	4.0	0.0	0.0	4.0
Subtotal: Foreign Professional Staff		**77.0**	**36.0**	**190.5**	**303.5**
Local Professional Staff					
1	Deputy Team Leader	12.0	15.0	36.5	63.5
2	Environmental Specialist	2.0	1.0	38.0	41.0
3	Geo-technical Engineer	3.0	0.0	3.0	6.0
Lot 1. Construction of Sea Water Desalination Plant					
4	Resident Engineer 1 / Civil Engineer (1) for Lot 1	9.0	0.0	48.0	57.0
5	Civil Engineer (2) for Lot 1	0.0	0.0	29.0	29.0
6	Mechanical Engineer for Lot 1, 6	4.0	0.0	9.0	13.0
7	Electrical Engineer for Lot 1, 6, 7	3.0	0.0	9.0	12.0
8	Structural Engineer for Lot 1, 4, 5, 6	4.0	0.0	3.0	7.0
9	Architect	4.0	0.0	4.0	8.0
10	Building Utilities Engineer	3.0	0.0	4.0	7.0
11	Quantity Surveyor for Lot 1	0.0	0.0	33.0	33.0
Lot 2 & 3 Procurement of Pipes / Valves and Other					

No	Position	Man-Month			
		DD[1)]	TA[2)]	CS[3)]	Total
Equipment Lot 4. Construction of Pipeline					
12	Resident Engineer 2 / Civil Engineer (1) for Lot 2, 3, 4	12.0	0.0	33.0	45.0
13	Civil Engineer (2) for Lot 2, 3, 4	10.0	0.0	32.0	42.0
14	Procurement Specialist	4.0	0.0	0.0	4.0
15	Quantity Surveyor for Lot 2, 3, 4	0.0	0.0	32.0	32.0
Lot 5 & 6. Reservoirs/Pump Facility Construction					
16	Resident Engineer 3 / Civil Engineer (1) for Lot 5, 6	8.0	0.0	33.0	41.0
17	Civil Engineer (2) for Lot 5, 6	6.0	0.0	30.0	36.0
18	Quantity Surveyor for Lot 5, 6	0.0	0.0	30.0	30.0
Subtotal: Local Professional Staff		**84.0**	**16.0**	**406.5**	**506.5**
Local Supporting Staff					
1	Assistant Engineer	12.0	15.0	69.0	96.0
2	Inspector/Surveyor	0.0	0.0	156.0	156.0
3	CAD Operator	60.0	0.0	36.0	96.0
4	Interpreter/Translator	29.0	16.0	86.0	131.0
5	Office Manager	12.0	15.0	36.0	63.0
6	Accountant	12.0	0.0	36.0	48.0
7	Clerk	12.0	0.0	36.0	48.0
8	Office Boy	12.0	15.0	36.0	63.0
Subtotal: Local Supporting Staff		**149.0**	**61.0**	**491.0**	**701.0**
Total		**310.0**	**113.0**	**1088.0**	**1511.0**

1) Detailed/Conceptual Design
2) Tendering Assistance
3) Construction Supervision

(4) Cost of consulting services

The cost of consulting services is Japanese Yen 2,486 million that consists of foreign currency of Japanese Yen 951 million and local currency of TND 25 million, and base cost. The details are indicated in Table 10.4-3.

Table 10.4-3 Cost of Consulting Services

USD = JPY 119.6
TND = JPY 61.02

	Unit	Qty.	Foreign Portion (JPY) Rate	Foreign Portion (JPY) Amount ('000)	Local Portion TND Rate	Local Portion TND Amount ('000)	Combined Total ('000) JPY
A Remuneration							
1 Professional (A)	M/M	303.5	2,895,000	878,633	0	0	878,633
2 Professional (B)	M/M	506.5	0	0	16,000	8,104	494,506
3 Supporting Staffs	M/M	701.0	0	0	12,000	8,412	513,300
Subtotal of A		1511.0		878,633		16,516	1,886,439
B Direct Cost							
1 International Airfare	Trip	103	650,000	66,950			66,950
2 Domestic Airfare	Trip	0					0
3 Domestic Travel	Trip	103			250	26	1,571
4 International Travel Expenses	Trip	103	50,000	5,150			5,150
5 Accommodation / Per Diem for A	Month	304			8,000	2,428	148,157
6 Accommodation / Per Diem for B	Month	507			4,800	2,431	148,352
7 Accommodation / Per Diem for C	Month	0					0
8 Vehicle Rental w/Driver and Fuel	Month	297			10,000	2,970	181,229
9 Office Rental	Month	63			4,000	252	15,377
10 International Communications	Month	77			1,000	77	4,699
11 Domestic Communications	Month	75			500	38	2,288
12 Office Supply	Month	75			1,000	75	4,577
13 Office Furniture and Equipment	LS	1			40,000	40	2,441
14 Report Preparation	Month	77			2,000	154	9,397
15 Topographic Survey	LS	1			100,000	100	6,102
16 Soil Investigation	LS	1			50,000	50	3,051
17 Water Quality Analysis	LS	1			3,000	3	183
Subtotal of B				72,100		8,643	599,523
Total				950,733		25,159	2,485,962

10.5 Project Cost and Financial Plan

The total project cost is JPY 52,587 million, JPY 26,696 million is foreign currency portion and TND 424 million is local currency portion. The eligible cost in the total project cost is JPY 44,013 million.

The Japanese ODA loan lending scheme of the Project is that; i) JICA provides a loan to the Tunisian government, ii) Tunisian government finances the cost for the Project including consulting services, and iii) the completed facilities become the asset of SONEDE. Therefore the foreign exchange risk and interest rate of loan will be shouldered by the government, and not by SONEDE. The asset granted to SONEDE will be recorded as a normal asset of SONEDE and be depreciated, and the resultant depreciation cost shall be accumulated. SONEDE will not incur any serious financial risk because there will be no cash expenditure for depreciation. Non-eligible portion for the Japanese ODA loan, such as administration cost, land acquisition cost compensation cost, and etc. shall be shouldered by SONEDE with its own fund.

The procurement items and the breakdown of foreign currency portion and local currency portion are shown in Table 10.5-1.

Table 10.5-1 Project Cost (Phase 1)

unit: FC,Total; million JPY, LC: million TND

	Item	FC	LC	Total
A. ELIGIBLE PORTION				
Ⅰ)	Procurement / Construction	22,165	312	41,174
	Lot1: Construction of Sea Water Desalination Plant (ICB) *PQ, Design Build	14,163	191	25,826
	Lot2-1: Procurement of Pipes 1000mm & 1400mm (ICB)	2,189	4	2,432
	Lot2-2: Procurement of Pipes less than 1000mm (ICB)	436	1	484
	Lot3: Procurement of Valves & Other Equipment (LCB)	511	1	568
	Lot4: Construction of Transmission Pipeline (ICB)	40	48	2,940
	Lot5: Construction of Reservoir (LCB)	0	5	307
	Lot6: Construction of Pumping Stations (ICB) *Design Build	1,565	14	2,405
	Lot7: Construction of Power Supply Line (STEG)	0	7	444
	Base cost for JICA financing	18,904	270	35,406
	Price escalation	2,206	26	3,807
	Physical contingency	1,055	15	1,961
Ⅱ)	Consulting services	1,095	29	2,839
	Base cost	951	25	2,486
	Price escalation	82	2	196
	Physical contingency	49	1	128
Total A (Ⅰ+Ⅱ)		23,260	340	44,013
B. NON ELIGIBLE PORTION				
a	Procurement / Construction	0	0	0
	Base cost for JICA financing	0	0	0
	Price escalation	0	0	0
	Physical contingency	0	0	0
b	Land Acquisition	0	1	88
	Base cost	0	1	81
	Price escalation	0	0	3
	Physical contingency	0	0	4
c	Administration cost	0	22	1,323
d	VAT	0	60	3,647
e	Import Tax	0	1	80
f	Interest during Construction	3,348	0	3,348
	Interest during Construction (Construction)	3,347	0	3,347
	Interest during Construction (Consultant)	2	0	2
g	Front End Fee	88	0	88
Total B (a+b+c+d+e+f+g)		3,436	84	8,574
C. GRAND TOTAL (A+B)		26,696	424	52,587
D. JICA finance portion (A)		23,260	340	44,013

TND1.000 = JPY61.02, USD 1.00 = JPY119.6

Notes: Total may not equal to summation of each item due to rounding off.

Source: JICA survey team

The conditions of project cost calculation are as follows.

1) Unit Prices Basis: May 2015
2) Exchange Rate: TND1.000 = JPY61.02, USD 1.00 = JPY119.6 (as of May 2015)
3) Physical Contingency: Project cost 5%, Consultant Fee 5%
   Set the lowest level of general scope (5% ~ 10%) because the size of the Project is large
4) Price Escalation: Project cost LC: 1.5% FC: 1.8%
   Consultant Fee LC: 1.5% FC: 1.8%
   LC is considered CPI inflation rate and foreign currency exchange rate.
5) Tax: VAT 18% (Construction/procurement), 12% (Consultant)
6) Import Tax: Imports from EU, EFTA and neighbouring countries are 0%. From other countries, customs values are different for each item, and various procedures fees and taxes associated with customs clearance are charged. It is tax-free if it is certified as public works. SONEDE plans to carry out this procedure. It is set at 0.36% in this survey.
7) Administration cost: 3% of the total project cost from experience with similar project
8) Interest during Construction (IDC): Project Cost 1.7%, Consultant Fee 0.01% (interest of the loan)
   It is expected that the Tunisian government prefer cash payment; therefore, IDC is not included in the loan amount but the total project cost.
9) Front End Fee: 0.2% of loan
   (0.1% will retroactively be applied instead of 0.2% in the event that all disbursements are completed within the original disbursement period)
10) Categorization of Local Currency Portion (LCP) and Foreign Currency Portion (FCP)
   Unit costs of construction work and procurement are based on the information and data obtained from local contractors, SONEDE's experiences, and quotation from manufactures. In principle, the costs are categorized into LCP and FCP in accordance with the policies presented in Table 10.5-2.

Table 10.5-2 Policies for Categorization of LCP and FCP

Item	LCP	FCP	Remarks
General Civil Work on ground	100%	0%	Possible with local materials and labour forces
Marine civil work	100%	0%	Possible with local materials and labour forces except pipe materials
Pipeline installation work	100%	0%	Same as above
Marine pipe materials	0%	100%	All materials shall be imported. Inland transportation cost is not needed because of sea transportation and marine work. Intake head and discharge head are considered as local portion because these can be made in Tunisia.
Pipe materials and valves	10%	90%	All materials shall be imported. Inland transportation cost and local materials are considered as LCP at 10%.
Buildings for Desalination Plant	75%	25%	High grade imported materials and equipment are assumed to be used at 25% because of main structure of the Project.
Other Buildings	100%	0%	Possible with local materials and labour forces
Equipment for Desalination Plant	5%	95%	All materials shall be imported. Inland transportation cost and local materials are

Item	LCP	FCP	Remarks
			assumed to be LCP at 5%. Installation cost is assumed to be LCP.
Other Equipment (including installation)	15%	85%	LCP at 15% is assumed for inland transportation, installation, and local materials.

The total amount of the JICA ODA loan eligible items is JPY 44,013 million which is 83.7% of total project cost JPY 52,587 million. Since the ceiling ratio of the coverage of a loan over total cost of the Project for Tunisia is 85%, all eligible items shall be covered by the JICA ODA loan. Loan ratio and yearly financial plan are shown below.

Table 10.5-3 Loan Coverage Ratio

Unit: million JPY

Total Project Cost	ODA Loan	Own Fund	Loan Ratio
52,587	44,013	8,574	83.7%

Table 10.5-4 Yearly Disbursement

Unit: million JPY

Year	Project Cost	ODA Loan	Own Fund
2015	88	0	88
2016	0	0	0
2017	725	610	115
2018	364	283	80
2019	6,238	5,571	667
2020	10,976	9,579	1,397
2021	10,769	9,292	1,477
2022	10,082	8,541	1,541
2023	9,668	8,083	1,584
2024	2,809	1,900	909
2025	869	153	716
Total	52,587	44,013	8,574
Ratio	100.0%	83.7%	16.3%

Source: JICA survey team

Table 10.5-5 Yearly Project Cost Breakdown

Unit: Million JPY for FC, Total, Million TND for LC

Item	2015			2016			2017			2018		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
Procure./Construction	0	0	0	0	0	0	0	0	0	0	0	0
Consulting Services	0	0	0	0	0	0	251	6	610	133	2	283
Land Acquisition	0	0	0	0	0	0	0	1	44	0	1	45
Administration Cost	0	0	0	0	0	0	0	0	20	0	0	10
VAT / Import Tax	0	0	0	0	0	0	0	1	51	0	0	26
ID C*	0	0	0	0	0	0	0	0	0	0	0	0
Front End Fee	88	0	88	0	0	0	0	0	0	0	0	0
TOTAL	88	0	88	0	0	0	251	8	725	133	4	364

Item	2019			2020			2021			2022		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
Procure./Construction	3,261	35	5,396	4,637	74	9,140	4,716	68	8,867	4,264	64	8,179
Consulting Services	76	2	175	144	5	440	127	5	425	133	4	363
Land Acquisition	0	0	0	0	0	0	0	0	0	0	0	0

Item	2023			2024			2025			Total		
Administration Cost	0	3	167	0	5	287	0	5	279	0	4	256
VAT / Import Tax	0	7	408	0	14	863	0	13	800	0	12	748
ID C*	92	0	92	247	0	247	398	0	398	537	0	537
Front End Fee	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3,429	46	6,238	5,028	97	10,976	5,241	91	10,769	4,934	84	10,082
Item	2023			2024			2025			Total		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
Procure./Construction	4,414	59	8,020	873	11	1,573	0	0	0	22,165	312	41,174
Consulting Services	35	0	63	137	3	327	60	2	153	1,095	29	2,839
Land Acquisition	0	0	0	0	0	0	0	0	0	0	1	88
Administration Cost	0	4	242	0	1	57	0	0	5	0	22	1,323
VAT / Import Tax	0	11	668	0	2	152	0	0	11	0	61	3,727
ID C*	673	0	673	700	0	700	700	0	700	3,348	0	3,348
Front End Fee	0	0	0	0	0	0	0	0	0	88	0	88
TOTAL	5,123	74	9,668	1,710	18	2,809	760	2	869	26,696	424	52,587

*:It is expected that Government of Tunisia prefers to pay by cash for IDC. Therefore, IDC is included for the total project cost, but not included for the loan amount.
Source: JICA survey team

10.6 Procurement Process

10.6.1 Selection of Consultants

The consultants employed for the ODA loan project will be selected through the shortlist method with processes in accordance with the guidelines of JICA as follows:

1) Preparation of Shortlist
2) Request for Proposals
3) Submission of proposals
4) Opening and evaluation of technical proposal
5) Opening and evaluation of financial proposal
6) Contract negotiation, award of contract

The concurrence of JICA is required for the request for proposals including shortlist, evaluation results of tenders, and contract. The evaluation results are also required to be approved by the High Authority of Public Procurement (HAICOP, French: Hauts instance de la commande publique). The JICA Procurement Guideline does not require invitation of Expressions of Interest (EOI) in the shortlist procedure. Consequently, it is highly recommended to select the consultants through shortlisting without EOI process because the Project is strongly requested to be implemented without delay. SONEDE, however, intends to make shortlist upon EOI. Because of this reason, the implementation schedule is assumed that EOI will be conducted.

10.6.2 Procurement of Contractors

The Phase 1 of the Project is composed of seven lots in consideration of facilities' component and a category of procured items. Regarding construction projects, the design-build contact is appropriate for Lot 1 and Lot 6, and BoQ contract or unit price contract is appropriate for Lot 2 to Lot 5.

1) Lot 1: Seawater desalination plant

- Procurement and construction of seawater intake, seawater desalination plant, discharge pipe for concentrated seawater, and transmission pump facilities.
- Selection of contractors by the design-build contract through International Competition Bidding (ICB).
- After construction work, the contractor shall conduct a Guarantee Test for 12 months.

2) Lot 2: Procurement of transmission pipeline material

- Procurement of pipe materials for transmission pipeline
- Selection of a supplier for the material's procurement through ICB
- This lot is divided to two sub-lots in order to keep the competiveness as follows:
  Sub-lot 2-1; dia. 1400 mm and 1000 mm
  Sub-lot 2-2; dia. less than 1000 mm
- Tender for Sub-lot 2-1 and Sub-lot 2-2 will be conducted at same time. Tenderer can submit the tender for one of two sub-lots or both.

3) Lot 3: Procurement of valves and the other equipment for transmission pipeline

- Procurement of valves and related equipment regarding transmission pipelines
- Selection of a supplier for the material's procurement through Local Competition Bidding (LCB)

4) Lot 4: Construction of transmission pipe

- Construction of transmission pipe at a length of 49.5 km, and water hammer prevention facilities at two locations
- Selection of a contractor by the BoQ contract through ICB

5) Lot 5: Construction of reservoirs

- Construction of a reservoir, and five receiving/mixing chambers at existing five reservoir sites
- Selection of a contractor by the BoQ contract through LCB

6) Lot 6: Construction of pump facility

- Construction of pump facility at three locations
- Selection of a contractor by the design-build contract through ICB

7) Lot 7: Construction of receiving power line

- Construction of receiving power line from power distribution network of STEG for supplying power to sea water desalination plant.
- Construction will be executed under the direct contracting between SONEDE and STEG, who will take charge of construction. The cosnstruction cost is considered as the project cost and is eligible to the Japanese ODA loan.
- SONEDE is willing to include the cost of STEG's technical support into Lot 7. The said support will be for the work of power receiving and transformation in Lot 1 and for power connection work of facilities in Lot 6. The required cost for said support for Lot 1 is counted in Lot 7. The cost for said support for Lot 6, however, is not counted in the project cost because the work for Lot 6 will be the one for relatively low tension voltage, which is unlike

the one for the desalination plant, and SONEDE has carried out such work for many construction works in the past. Even though SONEDE shall consult with STEG about said work, it was judged that the cost for said support will not be that large to be counted as a part of the project cost.

10.6.3 Summary of Procurement Process

Selection method of consultants, procurement method of construction works, and project costs of each lot are presented in Table 10.6-1.

Table 10.6-1 Selection Method of Consultants and Type of Bid

Lot	Contents	Type of Bid	Type of Contract	Base Cost*		Employment of Consultant				Type of SBD#
				TND (1000TND)	equiv. Yen (1000Yen)	Detailed Design	Preliminary Design	Tender Assistance	Construction Supervision	
Lot 1:	Seawater Desalination Plant Construction Work	PQ-ICB	Design-Build	423,245	25,826,438	-	JICA Loan	JICA Loan	JICA Loan	1. 2
Lot 2-1:	Pipe Materials Procurement (1400 & 1000)	ICB	BOQ	39,860	2,432,246	JICA Loan	-	JICA Loan	JICA Loan	3
Lot 2-2:	Pipe Materials Procurement (Less than 1000)	ICB	BOQ	7,931	483,946	JICA Loan	-	JICA Loan	JICA Loan	3
Lot 3:	Valve and Other Materials Procurement	LCB	BOQ	9,301	567,541	JICA Loan	-	JICA Loan	JICA Loan	-
Lot 4:	Transmission Pipeline Installation	ICB	BOQ	48,179	2,939,856	JICA Loan	-	JICA Loan	JICA Loan	4
Lot 5:	Reservoir Construction Work	LCB	BOQ	5,023	306,503	JICA Loan	-	JICA Loan	JICA Loan	-
Lot 6:	Pump Facility Construction Work	ICB	Design-Build	39,420	2,405,399	-	JICA Loan	JICA Loan	JICA Loan	2
Lot 7:	Power Supply Service Line Construction Work	Direct Contracting w/ STEG		7,283	444,409	STEG	-	-	STEG**	4
CS:	Consulting Services	Short-List	Time-based	40,740	2,485,962	JICA Loan		JICA Loan	JICA Loan	5
	Total			620,982	37,892,300					

Notes. * : Price Escalation and Physical Contingency are excluded . Exchange Rate: 61.02 Yen/TND

**: Watched by Consultant

SBD#: Standard Bidding Documents of JICA to be applied

1: Standard Prequalification Documents, JICA

2: Standard Bidding Documents-EQUIPMENTS (Plant), JICA

3: Standard Bidding Documents-BIENS (Goods), JICA

4: Standard Bidding Documents-TRAVAUX（Works）, JICA

5: Standard Request for Proposals、JICA

Source: Minutes of Discussion of Sfax Sea Water Desalination Plant Construction Project between JICA, Government of Tunisia and SONEDE, 6 February 2015

10.7 Project Implementation Schedule

Table 10.7-1 and Figure 10.7-1 present the process of the loan project with time schedule. The stage of the Project is separated as before construction and during construction. Table 10.7-1 indicates the schedule of Lot 1 as a critical path of the Project.

Table 10.7-1 Outline of Project Implementation Schedule

Project activity	Required period (month)	Expected time
1. Pledge of a loan project (possible to commence the document process between implementation organization and JICA)		2015.12
2. Exchange of Notes for a Loan Project		2016.3
3. Loan Agreement		2016.3
4. EIA Study	12	2015.6 - 2016.5
5. Approval of EIA		2016.9
6. Selection of Consultants	24	2015.7 – 2017.6
7. Consulting Services (for Lots 1 to 7)	87	2017.7 – 2024.9
7.1 Detailed (conceptual) Design (Lots 1 to 6)*	(12)	2017.7 – 2018.6
7.2 Tender Assistance (Lots 1 to 6)	(15)	2018.7 – 2019.9
7.3 Construction Supervision (Lots 1 to 7)	(60)	2019.10 – 2024.9
8. Selection of Contractor (Lot 1)	23	2017.11 – 2019.9
9. Construction Work (Lot 1) (including Performance Test**)	48	2019.10 – 2023.9
10. Handing-over, Commissioning (Lot 1)		2023.10
11. Defect Liability Period (Lot 1)	12	2023.10 – 2024.9

*: For Lots 1 and 6, conceptual or basic design and preparation of bidding documents which correspond to design-build contract. For Lots 2 and 3, preparation of bidding documents for procurement of equipment and materials. For Lots 4 and 5, detailed design and preparation of bidding documents which correspond to construction work contract. Preparation of prequalification documents and evaluation of submitted PQ documents will also be conducted during this period for Lot 1.

**: The Performance Test to be conducted by the Contractor after completion of construction work. Tentative hand-over to SONEDE will be done before the start of the test. Costs required for power, chemicals and remuneration will be included in the construction cost. Power cost and chemicals cost, however, will be treated as provisional sum which shall be put in tender under the fixed conditions specified in the tender documents and be settled during the test based on the actual expenditure. Duration of the test will be 12 months and the facilities will be handed over to SONEDE after completion of the test. Defect liability period shall be extended 12 months after handing-over to SONEDE.

Each lot has different construction period. Lot 1 for sea water desalination plant construction has the longest period, and is the main facility for the entire operation. Therefore, the critical path of the Project is set for Lot 1. The schedule of each lot is planned so as to avoid any delay of Lot 1 as follows:

1) Lot 1: Seawater desalination plant. Construction period: 48 months. A guarantee test for 12 months is included.

Implementation Schedule

Item	Month
Feasibility Study by JICA team	20
Fact Finding / Appraisal	14
Pledge	1
Signing of Exchange Notes (E/N)	1
Signing of Loan Agreement (L/A)	1
EIA Procedure (24) by SONEDE	24
Preparation of TOR and tendering document (4)	4
Bidding and submission of proposal (1)	1
Evaluation and approval by committee (2)	2
Comment by contract committee and preparation of contract (1)	1
Execution of EIA study and submission of report (12)	12
Implementation of stakeholder meeting (1)	1
Evaluation and approval of EIA report by SONEDE (1)	1
Evaluation and approval of EIA report by ANPE (3)	3
Selection of Consultant (24) (Common)	24
Preparation of documents, expression of interest, S/L ,HAICOP approval (8)	8
Preparation of RFP and Invitation Letter, S/L (3)	3
・JICA concurrence on Invitation Letter, RFP, S/L (1)	1
Bidding(2)	2
Technical Evaluation (2)	2
・JICA Comment (1)	1
・HAICOP approval (1)	1
・JICA concurrence (1)	1
Financial Evaluation (2)	2
・JICA Comment (1)	1
・HAICOP approval (1)	1
・JICA concurrence (1)	1
Contract Elaboration , Approval (board meeting) and Signing of Contract (2)	2
・JICA concurrence (1)	1
Execution of Consulting Services (87) (Common)	87
Preparation of Design (Lot, Lot6) (12)	12
Preparation of Design (Pipe & others) (12)	12
Execution of Tendering Assistance (15) (Common)	15
Execution of Construction Supervision (60) (Common)	60

Figure 10.7-1 Implementation Schedule (1/4)

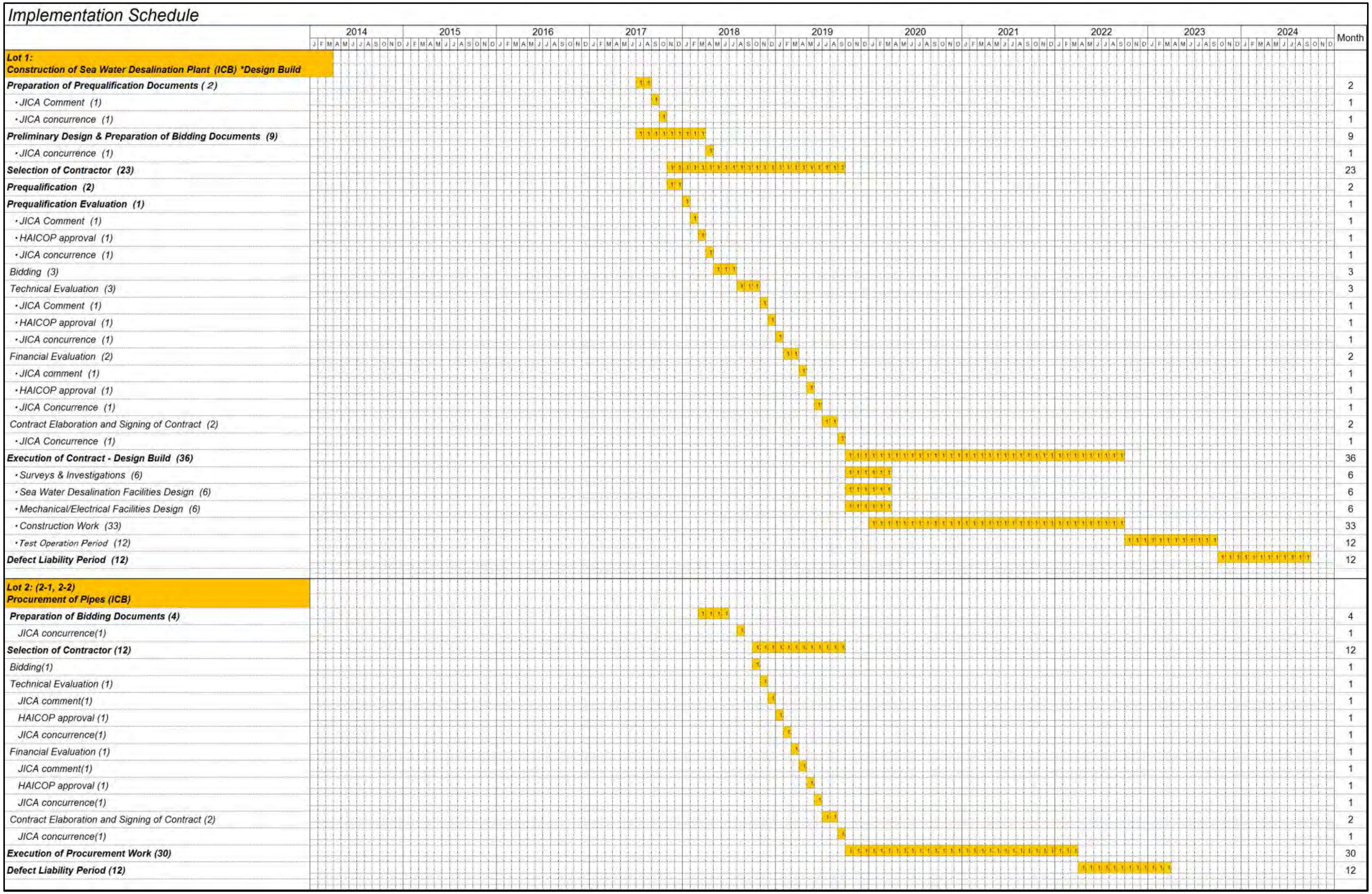


Figure 10.7-1 Implementation Schedule (2/4)

Implementation Schedule

Task	Month
Lot 3: Procurement of Valves and Other Equipment (LCB)	
Preparation of Bidding Documents (4)	6
Selection of Contractor(7)	7
Bidding(1)	1
Technical Evaluation (1)	1
・HAICOP Approval (1)	1
Financial Evaluation (1)	1
・HAICOP Approval (1)	1
Contract Elaboration and Signing of Contract(2)	2
・JICA Concurrence (1)	1
Execution of Procurement Work(30)	30
Defect Liability Period (12)	12
Lot 4: Construction of Pipeline (ICB)	
Detailed Design & Preparation of Bidding Documents (12)	12
JICA concurrence(1)	1
Selection of Contractor (14)	14
Bidding(3)	3
Technical Evaluation (1)	1
・JICA Comment (1)	1
・HAICOP Approval (1)	1
・JICA Concurrence (1)	1
Financial Evaluation (1)	1
・JICA Comment (1)	1
・HAICOP Approval (1)	1
・JICA Concurrence (1)	1
Contract Elaboration and Signing of Contract (2)	2
・JICA Concurrence (1)	1
Execution of Construction Work (30)	30
Defect Liability Period (12)	12
Lot 5: Construction of Reservoir (LCB)	
Detailed Design & Preparation of Bidding Documents (8)	8
Selection of Contractor (8)	8
Bidding(2)	2
Technical Evaluation (1)	1
・HAICOP Approval (1)	1
Financial Evaluation (1)	1
・HAICOP Approval (1)	1
Contract Elaboration and Signing of Contract(2)	2
・Notice to JICA about Contract	0
Execution of Construction Work (30)	30
Defect Liability Period (12)	12

Figure 10.7-1 Implementation Schedule (3/4)

Implementation Schedule

Task	Month
Lot 6: Construction of Pumping Stations - Design Build (ICB)	
Preliminary Design & Preparation of Bidding Documents (8)	8
JICA concurrence(1)	1
Selection of Contractor (15)	15
Bidding(3)	3
Technical Evaluation (2)	2
JICA comment(1)	1
HAICOP approval(1)	1
JICA concurrence(1)	1
Financial Evaluation (1)	1
JICA comment(1)	1
HAICOP approval(1)	1
JICA concurrence(1)	1
Contract Elaboration and Signing of Contract(2)	2
JICA concurrence(1)	1
Execution of Contract (33)	33
Surveys & Investigations(3)	3
Detailed Design (5)	5
Mechanical/Electrical Facilities Design(6)	6
Execution of Construction Work (30)	30
Defect Liability Period (12)	12
Lot 7: Construction of Power Supply Line (by STEG, Negotiation)	
Prior-arrangement with STEG (12)	12
Preparation of Contract Documents by STEG & SONEDE(3)	3
HAICOP approval(1)	1
JICA concurrence(1)	1
Contract Elaboration and Signing of Contract(2)	2
JICA concurrence with the Contract (1)	1
Execution of Construction Work (30)	30

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Month
Land Acquisition	0	0	12	12	12	0	0	0	0	0	0	36
Lot 1: Construction of Sea Water Desalination Plant (ICB) *Design Build	0	0	0	0	0	3	12	12	12	9	0	48
Lot 2-1: Procurement of Pipes 1000mm, 1400mm (ICB)	0	0	0	0	0	3	12	12	3	0	0	30
Lot 2-2: Procurement of Pipes less than 1000mm (ICB)	0	0	0	0	0	3	12	12	3	0	0	30
Lot 3: Procurement of Valves & other Equipments (LCB)	0	0	0	0	0	3	12	12	3	0	0	30
Lot 4: Construction of Transmission Pipeline (ICB)	0	0	0	0	0	0	12	12	6	0	0	30
Lot 5: Construction of Reservoir (LCB)	0	0	0	0	0	0	12	12	6	0	0	30
Lot 6: Construction of Pumping Stations (ICB) *Design Build	0	0	0	0	0	3	12	12	6	0	0	33
Lot 7: Construction of Power Supply Line (STEG)	0	0	0	0	0	0	12	12	6	0	0	30

Figure 10.7-1 Implementation Schedule (4/4)

2) Lot 2 (Sub-Lot 2-1, and Sub-Lot 2-2): Procurement of transmission pipe material. Completion of the procurement in three months before the construction of the transmission pipe commences. Procurement period: 30 months.
3) Lot 3: Procurement of valves and other equipment. Completion of the procurement in three months before the construction of the transmission pipe commences. Procurement period: 30 months.
4) Lot 4: Construction of transmission pipe. Completion of the construction in three months before completion of Lot 1. Construction period: 30 months.
5) Lot 5: Construction of reservoirs. Completion of the construction in three months before the completion of the sea water desalination plant, and before the completion of transmission pipe construction. Construction period: 30 months.
6) Lot 6: Construction of pump facility. Completion of the construction in three months before the completion of sea water desalination plant, and before the completion of transmission pipe construction. Construction period: 33 months.
7) Lot 7: Construction of receiving power line. Completion of the construction in three 3 months before the completion of seawater desalination plant. Construction period: 30 months.

10.8 Operation and Maintenance Cost

The estimate of the operation and maintenance cost includes all necessary costs for the operation and maintenance of the seawater desalination plant based on the existing desalination plants. Depreciation is not included because there is no cash involved.

The operation and maintenance cost of this seawater desalination plant and the related water supply systems is 36,990,400 TND/yr. or 1.013 TND/m^3 for desalinated water production of 100,000 m^3/day as shown in Table 10.8-1 and 10.8-2.

Table 10.8-1 Annual Cost for Operation and Maintenance

Unit: TND/yr.

Facility	Power	Chemical	RO Membrane	Personnel	Other	TOTAL
Seawater desalination plant	24,893,400	2,717,000	2,898,000	570,000	1,703,000	32,781,400
Water supply facility	1,840,000	0	0	75,000	195,000	2,110,000
Intermediate pump facility	1,438,00	0	0	195,000	466,000	2,099,000
TOTAL	28,171,400	2,717,000	2,898,000	840,000	2,364,000	36,990,400

Source: JICA Survey Team

Table 10.8-2 Detail of Operation and Maintenance Cost

O&M for seawater desalination							
1	Production		100,000	m^3/d =	36,500,000	m^3/year	
2	Electricity		4.2	kWh/m^3			
			420,000	kWh/d	153,300,000 kWh/yr.		Power consumption
			10.50	TND/kW/month	Demand Charge		
			0.148	TND/kWh	Energy Charge		
			2,205,000	**TND/yr.**	Demand Charge		
			22,688,400	**TND/yr.**	Energy Charge		
			24,893,400	**TND/yr.**	Total		
3	Chemicals	Item		usage (kg)/day	TND/kg	TND/day	TND/yr.
		12%NaClO		4,575	0.347	1,585	551,059
		38%$FeCl_3$		1,772	0.630	1,116	388,068
		$Na_2S_2O_5$		667	1.260	840	292,146
		Anti-Scalant		889	3.297	2,931	1,018,883
		33%NaOH		1,212	0.801	971	337,536
		Total				7,444	**2,717,000 TND/yr.**
4	RO membrane	Total number of membrane	8,624	nos			
		Number of replacement	1,725	nos/yr.	Replacement: 20%/yr.		
		Unit price	1,680	TND/nos	Japanese manufactures		
		Replacement cost	**2,898,000**	**TND/yr.**			
5	Personnel	O&M staff	38	persons			
		Salary per person	15,000	TND/yr./person			
		Annual salary for all staff	**570,000**	**TND/yr.**			
6	Maintenance cost for equipment	3% / year to 50% of desalination related equipment					
			1,703,000	**TND/yr.**			
7	**O&M for seawater desalination plant Total**		**32,781,400**	**TND/yr.**			
O&M for Transmission facilities							
1	Transmission		100,000	m^3/day	Head	72m	
2	Electricity		31,048	kWh/day =	11,332,520	kWh/yr	Consumption
			10.50	TND/kW/month	Demand Charge		
			0.148	TND/kWh	Energy Charge		
			163,002	**TND/yr.**	Demand Charge		
			1,677,213	**TND/yr.**	Energy Charge		
			1,840,000	**TND/yr.**	Total		
3	Personnel	O&M staff	5	persons			
		Salary per person	15,000	TND/yr./person			
		Annual salary for all staff	**75,000**	**TND/yr.**			
4	Maintenance cost for equipment	3% / year to 50% of equipment					
			195,000	**TND/yr.**			
5	**O&M for Transmission facilities Total**		**2,110,000**	**TND/yr.**			
O&M for intermediate pump facilities							
1	Transmission (year 2025)	PK11- Bou Merra	12,200	m^3/day	Head	49m	
		PK11- PK10	95,286	m^3/day	Head	21m	
		PK10 - PK14	55,586	m^3/day	Head	39m	
		PK14- Sidi Salah EH	35,786	m^3/day	Head	24m	
2	Electricity (year 2025)		2,578	kWh/day	Consumption	PK11 - Bou Merra	
			8,629	kWh/day	Consumption	PK11 - PK10	
			9,348	kWh/day	Consumption	PK10 - PK14	
			3,704	kWh/day	Consumption	PK14 - Sidi Salah EH	
			24,259	kWh/day =	8,854,535	kWh/yr	
			10.50	TND/kW/month	Demand Charge		
			0.148	TND/kWh	Energy Charge		
			127,360	**TND/yr.**	Demand Charge		
			1,310,471	**TND/yr.**	Energy Charge		
			1,438,0000	**TND/yr.**	Total		
3	Personnel	O&M staff	13	Persons			
		Salary per person	15,000	TND/yr./person			
		Annual salary for all staff	**195,000**	**TND/yr.**			

4	Maintenance cost for equipment	3% / year to 50% of equipment			
		466,000	**TND/yr.**		
5	**O&M for intermediate pump facilities Total**	**2,099,000**	**TND/yr.**		
O&M for all facilities of the Project Total		**36,990,400**	**TND/yr.**	➔	1.013 TND/m^3
		2,257,154,000	Yen/year	➔	62 Yen/m^3
					(61.02 Yen/TND)

10.9 Project Implementation Structure

10.9.1 Borrower

The borrower of the loan project is the Government of Tunisia, represented by the Ministry of Foreign Affairs, the Ministry of Finance, and the Ministry of Development, Investment and International Cooperation.

10.9.2 Implementing Entity of the Project

Implementing entity of the Project will be SONEDE. The Research Central Department will be in charge of planning and designing. The New Project Central Department will be in charge of construction. In addition, some experts of other departments will participate in the Project in the field of finance as supporting staff.

During the planning and designing stages, both the headquarters divisions and the Central-South Branch of the Research Central Department will participate in implementing the Project. The headquarters divisions are the Water Treatment Process Division, the Civil Engineering Division, the Hydrology Division, the Topography Division, the Division of Bidding Preparation and Monitoring, and the Department of Desalination and Environmental Impact (hereinafter referred to as “DDEI”). The divisions of the Research Central Department Central-South Branch are the South-East Hydrology Division, the Equipment Division of Central and South Region, and the Civil Engineering Division. The DDEI shall participate in the Project from the beginning for pre-negotiation with the fishery organization and supervising EIA. The DDEI has had experience in negotiation with stakeholders demanding compensations. When the British Gas Company installed the gas intake pipeline, just along the planned water pipeline route of the Project in 1994 and 2008, the stakeholders protested strongly against the work. As a result, the work was temporary stopped and the DDEI contributed to the solution by payment of compensation to the affected stakeholders.

At the construction stage, both the headquarters division and the South Branch of the New Project Central Department will participate in the project implementation. The headquarters division is the Division of Project Monitoring and Market. The divisions of the South Branch are the Hydrogeology Division, the Technical Division, the Land Division, the Site Management Division, and the Evaluation and Survey Division.

It is the common practice in large-scale projects to establish the Project Implementation Unit (PIU) inside SONEDE for the project coordination to facilitate the smooth implementation. It has been internally agreed upon that the PIU organized in the construction project of Djerba desalination plant funded by

AFD and KfW will be in charge of both the Project and the project of Gabes desalination plant expected to be financed by KfW. The specific positions and names of the members will be approved by the Ministry of Agriculture after the approval by the Board of SONEDE. According to the guideline approved by the Ministry of Agriculture in December 2013, this PIU is comprised of one manager and five engineers as shown in Table 10.9-1.

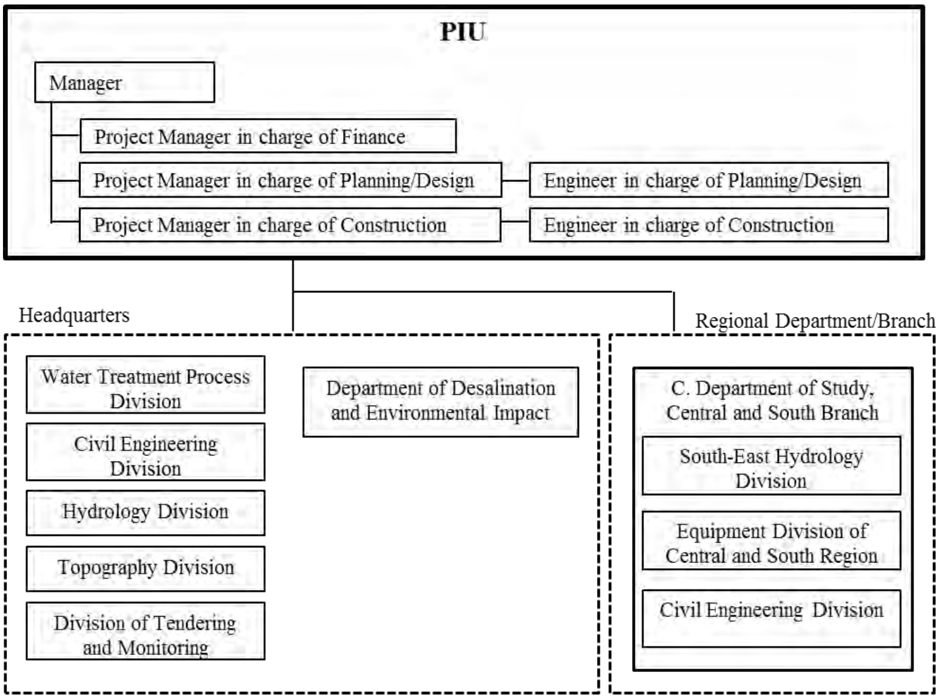
Table 10.9-1 Members of PIU

No.	Member	Position	Remarks
1	Manager	Central Director of HQ level	All members are concurrent with the existing jobs.
2	Project Manager in charge of Finance	Director level	
3	Project Manager in charge of Planning/Design	Director level	
4	Project Manager in charge of Construction	Director level	
5	Engineer in charge of Planning/Design	Head of Division level	
6	Engineer in charge of Construction	Director of Regional Dept. level	

Source: JICA Survey Team

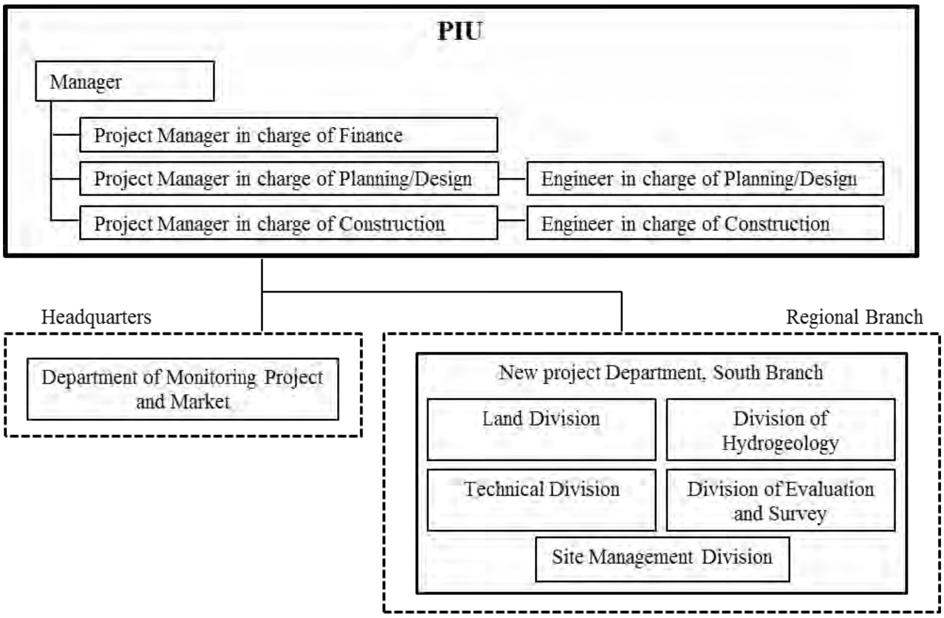
The approval by the SONEDE's Board is necessary for the establishment of PIU and the appointment of its members. Usually, the approval by the SONEDE Board and the Ministry of Agriculture takes 1-2 months and one month, respectively. A total of three months is required to obtain both approvals. In actuality, the period for the member nomination has to be taken into consideration and the reality is that it takes about six months for the entire process. The Board of SONEDE has a regular meeting every three months, i.e. March, June, September, and December. If JICA requests the establishment of PIU, the written agreement between SONEDE and JICA about establishment of PIU is deemed necessary at the time of appraisal. The approval of the board should be obtained for both the establishment of PIU and member nomination prior to the conclusion of the L/A, and this should be explicitly written by the M/D prior to the loan pledge statement. To date, the conclusion of the E/N and the L/A is planned in March 2016. Accordingly, a request for the approval for the establishment of PIU and the nominations of the members should be submitted to the Board of SONEDE by December 2015.

The project implementation structures in the planning/designing phase and the construction phase are summarized in Figures 10.9-1 and 10.9-2.



Source: JICA Survey Team

Figure 10.9-1 Project Implementation Structure during the Planning/Designing Phase



Source: JICA Survey Team

Figure 10.9-2 Project Implementation Structure during the Construction Phase

10.9.3 Operation and Maintenance Entity

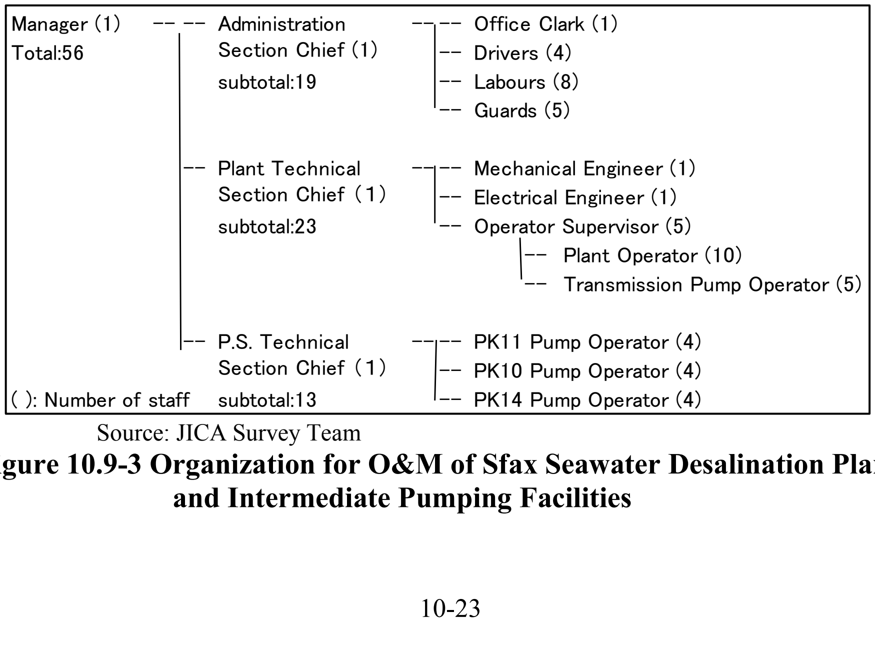
Regarding the implementation structure for the operation and maintenance, the Production Department of SONEDE will be in charge of the water intake, aqueduct, treatment plant, transmission pipeline and reservoir. The Operation Department of SONEDE will be in charge of distribution network.

The Production Department currently has three branches, namely, the North-Tunis Branch, the Central-Sfax-South West Branch, and the South-East Branch. With the new facilities to be operated the Production Department will be reorganized into four branches as follows: the North Branch, the Tunis Branch, the Central Branch, and the South Branch. The reorganization process will take at least two years, because any change of organization structure and/or the numbers of staff to be assigned should be approved by the cabinet after the approval by the MOA. There will be enough time to complete the required process before starting commercial operation of the plant. After the reorganization, the operation and maintenance of all existing desalination plants and the plant planned in this survey will be integrated into the reorganized South Branch of the Production Department from current Central-Sfax-South West Branch and the South-East Branch, resulting into a more streamlined, efficient and effective operation and maintenance.

SONEDE has confidence in operating and maintaining the desalination plant by the transfer and recruitment of necessary staff. The reason is that i) SONEDE has accumulated thirty years of experience in operating and maintaining desalination plants with fully experienced staff including engineers dispatched to provide technical assistance for desalination projects in Algeria and Qatar, ii) SONEDE has its own training centre, and iii) there is enough time for the organizational setup before the start of desalination plant operations. The JICA experts confirmed by site inspection and interview survey that the existing desalination plants are operated and maintained at satisfactory levels.

The need for additional training is expected for the O&M staff in charge of the desalination plant because the technical features are different from the existing plants such as water source of sea water instead of brackish groundwater, and an installation of high-voltage power receiving/transforming apparatus. Therefore, as stated in 10.9.2, it is recommended that SONEDE allocate the main engineers/technicians and administrative manager for the desalination plant from the construction stage, when the mechanical and electrical equipment are being installed as this will be the best time for actual on-the-job training (OJT) which includes the monitoring of the setting up process. It is also recommended that a series of training programs and activities be completed before commissioning.

Figure 10.9-3 presents the organization plan of operation and maintenance group for the project facilities.



Source: JICA Survey Team

Figure 10.9-3 Organization for O&M of Sfax Seawater Desalination Plant and Intermediate Pumping Facilities

10.10 Financial Status of SONEDE

Table 10.10-1 and 10.10-2 show the financial situation of SONEDE from 2008 to 2012. The operating income has been negative consistently from 2008, pointing to a severe financial situation. The main reason given is the high operating expenses such as electricity and personnel. SONEDE, which manages and operates the water supply for entire country, cannot easily raise the water tariff because the tariff is applicable for all. Therefore, the revision of the tariff based on the water balance between demand and supply in the regions, and electricity charges is not recommended at this instance.

There had been a deficit from 2008 to 2009, but this has been reduced from 2010 by a combination of factors - increasing water supply volume and raising the tariff. SONEDE, however, needs to continue to improve its fiscal position as the deficit is covered with the borrowing. In addition, specific projects such as rural water supply are financed by the government subsidy or donors. One of the ways to achieve financial independence is efficiently implementing the project implementation system and in increasing water tariff.

Table 10.10-1 Balance Sheet (Year 2008-2012)

unit: TND

	2008	2009	2010	2011	2012
Asset					
Cash and cash equivalents	30,448,861	21,295,783	11,886,071	6,711,982	7,111,387
Accounts receivable	155,423,239	148,715,473	158,033,635	198,196,846	237,912,129
Allowance for doubtful accounts	▲29,855,558	▲34,372,878	▲39,254,359	▲51,434,081	▲61,617,956
Other financial assets and investment*1	14,336,011	14,505,842	13,201,333	13,795,694	54,205,544
Shares hold	26,582,131	28,599,250	21,979,555	22,372,835	29,634,133
Stock valuation loss	▲6,524,897	▲7,071,266	▲6,030,017	▲4,291,767	▲4,254,047
Other current Asset	-	36,837,344	52,247,001	47,258,756	78,957,767
Other current Asset valuation loss	-	▲8,164,197	▲10,782,957	▲6,935,933	▲8,336,662
Total Current Asset	**217,035,815**	**200,345,352**	**201,281,262**	**225,674,332**	**333,612,295**
Tangible fixed assets	1,826,506,304	1,912,401,289	1,997,098,490	2,076,475,470	2,145,873,762
Tangible fixed assets accumulated depreciation	▲711,303,949	▲759,891,771	▲817,199,925	▲875,316,347	▲930,666,412
Intangible fixed assets	1,011,962	1,103,528	1,132,378	1,298,725	1,380,680
Intangible fixed assets accumulated depreciation	▲997,640	▲1,012,903	▲1,026,117	▲1,167,055	▲1,262,123
Financial Asset	46,270,108	48,786,033	52,952,636	58,007,691	59,867,106
Financial asset impairment allowance	▲1,663,683	▲786,329	▲786,329	▲1,433,321	▲1,699,121
Total Fived Asset	**1,159,823,102**	**1,200,599,847**	**1,232,171,132**	**1,257,865,162**	**1,273,493,892**
Other non-current Asset	23,807,657	24,721,736	26,060,935	24,895,501	29,194,080
Total non-current Asset	**1,183,630,758**	**1,225,321,583**	**1,258,232,067**	**1,282,760,663**	**1,302,687,972**
Total Asset	**1,400,666,573**	**1,425,666,935**	**1,459,513,329**	**1,508,434,995**	**1,636,300,267**
	2008	2009	2010	2011	2012
Debt					
Account Payable	48,980,194	58,103,532	53,736,320	50,470,867	49,010,015
Other current liabilities*2	115,593,872	113,778,495	128,803,677	155,919,194	213,647,299
Other financial liabilities and bank loans	31,182,313	68,781,320	77,321,471	76,013,107	53,660,179
Total current liabilities	**195,756,379**	**240,663,347**	**259,861,469**	**282,403,167**	**316,317,493**
Debt	282,074,583	268,438,188	262,100,422	284,302,160	314,421,581
Other non-current liabilities	848,408	2,231,210	1,464	—	—
Guarantees allowance	12,146,794	14,256,488	13,247,435	11,603,416	12,024,685
Total fixed liabilities	**295,069,785**	**284,925,886**	**275,349,321**	**295,905,576**	**326,446,266**

Total liabilities	**490,826,164**	**525,589,233**	**535,210,789**	**578,308,743**	**642,763,759**
Net Asset					
Donations, Subsidies*3	432,670,549	458,637,498	487,092,470	497,501,871	562,475,072
Reserves and capital paid	107,915,614	81,864,252	29,190,352	106,894,766	106,935,874
Retained earnings	—	—	—	**▲113,773,207**	**▲150,731,268**
Effects of accounting changes	—	—	—	▲952,667	2,242,493
Other Assets	394,603,688	411,563,148	444,456,287	477,413,551	502,171,792
Total Net Asset	**935,189,851**	**952,064,898**	**960,739,108**	**967,084,314**	**1,023,093,963**
Net profit or loss for the period	▲25,349,443	▲51,987,196	▲36,436,568	▲36,958,061	▲29,557,455
Total capital before disposal	**909,840,409**	**900,077,702**	**924,302,540**	**930,126,252**	**993,536,508**
Total liabilities and net assets	**1,400,666,573**	**1,425,666,935**	**1,459,513,329**	**1,508,434,995**	**1,636,300,267**

*1: "Other financial assets and investment" includes homes and bike loans to employees and loans of less than one year to customers.
*2: "Other current liabilities" includes sundry debtors, employee loans and value added tax reduction.
*3: Assets contributed to SONEDE's projects by private persons and companies, and funds of governorates and foreign governments for local water supply and foreign are included.
Source: SONEDE Financial audit report 2009, 2010, 2012

Table 10.10-2 Profit-and-Loss Statement (Year 2008-2012)

unit: TND

	2008	2009	2010	2011	2012
Revenue	209,964,549	213,590,163	236,682,955	247,132,837	271,016,392
Income from fixed assets	1,586,329	2,149,984	1,235,216	673,657	719,577
Other operating income	22,772,255	23,940,211	26,717,923	29,607,337	31,649,647
Total revenue	**234,323,134**	**239,680,358**	**264,636,095**	**277,413,831**	**303,385,616**
Operating expenses	66,779,125	67,626,620	75,004,579	76,173,275	85,006,343
Personnel expenses	107,989,077	121,143,237	126,753,955	140,496,449	147,568,945
Depreciation and provisions	55,833,564	67,278,779	63,347,805	63,308,624	67,675,673
Other operating expenses	26,924,988	28,005,145	27,672,805	27,561,497	24,913,507
Total expenses	**257,526,755**	**284,053,781**	**292,778,593**	**307,539,845**	**325,164,468**
Operating income	**▲23,203,621**	**▲44,373,423**	**▲28,142,498**	**▲30,126,014**	**▲21,778,852**
Investment income	6,643,019	5,372,964	5,729,174	6,758,856	7,793,013
Financial cost	8,243,094	9,976,667	10,394,862	10,592,580	11,426,414
Exchange loss *1	1,748,995	5,566,193	4,980,845	5,435,237	5,865,407
Other profit	1,496,948	2,988,806	3,344,708	2,803,736	2,260,223
Other loss	48,010	182,686	1,715,465	88,563	236,146
Pre-tax ordinary income	**▲25,103,753**	**▲51,737,199**	**▲36,159,787**	**▲36,679,801**	**▲29,253,583**
Income Tax	245,689	249,997	276,781	278,261	303,872
Net income after taxes	**▲25,349,443**	**▲51,987,196**	**▲36,436,568**	**▲36,958,061**	**▲29,557,455**
Effects of accounting changes *2	-	-	-	▲952,667	3,195,160
Net income after changes in a ccounting policies	**▲25,349,443**	**▲51,987,196**	**▲36,436,568**	**▲37,910,728**	**▲26,362,295**

*1: "Exchange loss" occurs against loan that is made directly to the account of SONEDE from overseas donors. Exchange loss occurs each year because TND is relatively weak in recent years.
*2: "Effects of accounting changes" is change with the calculation method change of loan repayment from the Islamic Development Bank (request from Islamic Development Bank side).
Source: SONEDE Financial Audit Report 2009, 2010, 2012

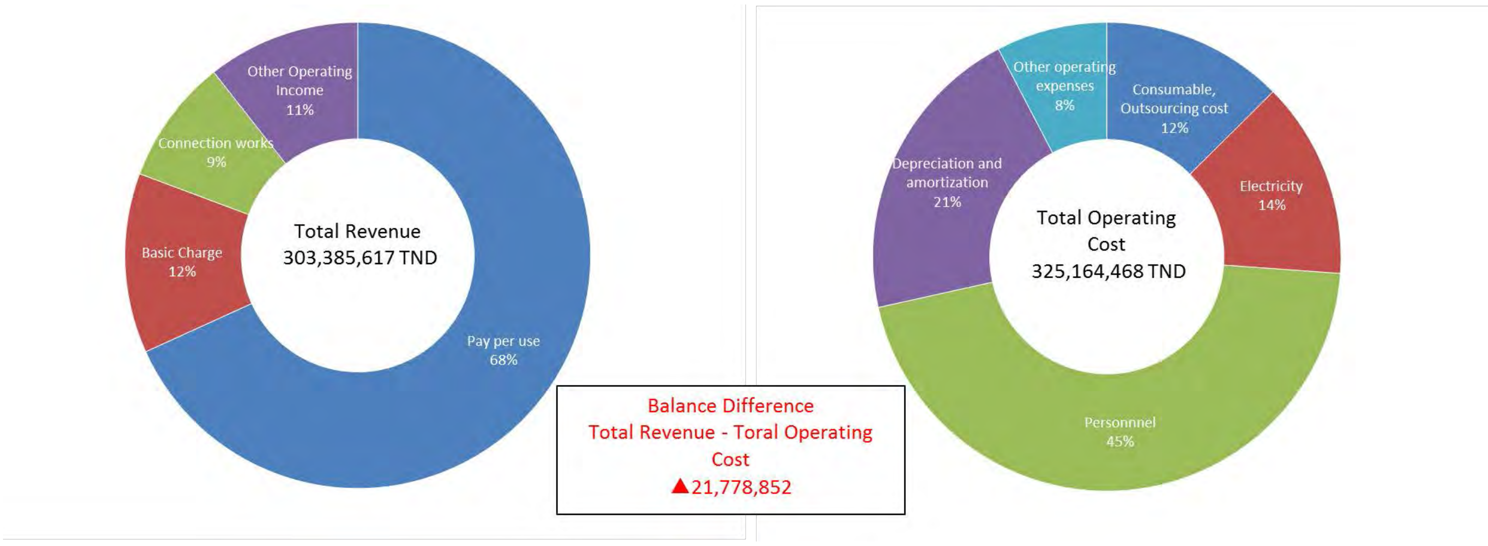
The main financial indicators of profitability and safety are shown below. The shareholders' equity includes funding for a rural centre from overseas donors and Tunisian government. Therefore, the safety net is high. The problem lies with profitability due to the negative operating income. This occurred since 2008, caused by high electricity rates as a result of high oil prices, and the deferment of tariff increase. But with the tariff having been increased since 2010, it is expected that SONEDE will see profitability in 2015. There are no special subsidies for the negative result of revenue to compensate deficit from bank loans.

a) Safety

- Current Ratio in 2012: 105%
  (Total Current Asset: 333,612,295 ÷ Total Current Liabilities: 316,317,493 = 1.054)
- Capital adequacy ratio in 2012: 63%
  (Total Net Asset: 1,023,093,963 ÷ Total Liabilities and Net Asset: 1,636,300,267 = 0.625)

b) Profitability

- Operating Margin in 2012: ▲8%
  (Operating Income of 2012: ▲21,778,852 ÷ Total Revenue of 2012:271,016,392 = ▲0.08)
- Total capital profit ratio: ▲2%
  (Net Income after Taxes of 2012: ▲29,557,455 ÷ Total Liabilities and Net Asset of 2012: 1,636,300,267 = ▲0.018)



Source: SONEDE Financial audit report 2009, 2010, 2012

Figure 10.10-1 Operating Profit/Loss Breakdown in 2012

As described above, 80% of operating revenue is water tariff, which increased by about 10% from 2011 to 2012. The personnel cost is the largest among the operating expenses. Depreciation and power are the second and the third largest expenses, respectively.

10.11 Water Tariff

10.11.1 Water Tariff System

The water tariff in Tunisia is determined by the government after the tariff section and the financial section of SONEDE reviews and submits the proposal to the government. The proposal is not approved at every instance. Therefore, SONEDE recognizes that the tariff is not reflected for the financial condition of SONEDE.

Water tariff is consumption-based and is measured by use of water meter. Customers also pay for the equipment expenses necessary for obtaining water service up to eight years. Water tariff is charged by the basic charge and the pay-per-use fee. The basic charge has 7 categories based on a diameter of water meter. The pay-per-use fee is charged according to the amount of water consumption. The water tariff is charged at every three months. The same rate of the pay-per-use fee is applied to all sectors except tourism. The pay-per-use fee for tourism is applied to "501 +", the highest rate. Table 10.11-1 presents the water tariff rate in 2014.

Table 10.11-1 Water Tariff in 2014

Basic Charge/3months	
Diameter	Tariff (TND)
15	4,400
20	8,160
30	15,080
40	27,700
60-80	70,400
100	113,250
150	295,000

Pay-per-use/3months	
Water Use m^3/3months	Tariff (TND)/m^3
0-20	0.155
21-40	0.270
41-70	0.365
71-100	0.665
101-150	0.815
151-500	1.135
501+	1.190

Source: Drinking Water Tariff 2014

Sewage tariff is managed and operated by ONAS. The tariff for water and sewerage is billed and collected by SONEDE. Collected sewerage tariff is paid to ONAS after subtracting the service fee of SONEDE.

10.11.2 Increase in Water Tariff

To increase in water tariff, SONEDE first reviews the financial condition, and, if necessary, proposes to and gets the approval from the Administration Board of SONEDE to increase water tariff. After the approval from the board is received, the proposal is then submitted to the Ministerial Board of State organized by the MOA, Minister of Finance, and the others. With the approval of the Ministerial Board, the new tariff is published in the Federal Register bearing the presidential name. Tariff was increased almost every year in 2010, 2011, 2013 and 2014, and the latest increase at 7%. Consumer price index (CPI, 100 in 2010) of Tunisia rose from 96 in 2009 to 121 in 2014. The increase rate in the period is calculated at 26%. On the other hand, in case of the category (41 – 70m^3), an increased rate of pay-per-use from 2009 to 2014 is approximately 22%, which is lower than CPI of 4%. Further, the pay-per-use fee for water consumption of 0-20 m^3 has not been raised in consideration of low-income people. SONEDE, however, recognizes the need of the raising tariff even for the low consumption rate in the near future.

Table 10.11-2 Basic Charge Raise

Unit: TND/3months

Diameter	2001－09 Tariff (3 months)	2010			2011			2013			2014		
		Tariff (3months)	Increase amount	Increase rate	Tariff (3months)	Increase amount	Increase rate	Tariff (3months)	Increase amount	Increase rate	Tariff (3months)	Increase amount	Increase rate
15	3.300	3.500	0.200	6.10%	3.800	0.300	8.60%	4.100	0.300	7.90%	4.400	0.300	7.32%
20	5.830	6.500	0.670	11.50%	7.050	0.550	8.50%	7.600	0.550	7.80%	8.160	0.560	7.37%
30	10.740	12.000	1.260	11.70%	13.030	1.030	8.60%	14.050	1.020	7.80%	15.080	1.030	7.33%
40	20.570	22.000	1.430	7.00%	23.900	1.900	8.60%	25.800	1.900	7.90%	27.700	1.900	7.36%
60	53.460	56.000	2.540	4.80%	60.800	4.800	8.60%	65.600	4.800	7.90%	70.400	4.800	7.32%
80	53.460	56.000	2.540	4.80%	60.800	4.800	8.60%	65.600	4.800	7.90%	70.400	4.800	7.32%
100	82.810	90.000	7.190	8.70%	97.700	7.700	8.60%	105.500	7.800	8.00%	113.250	7.750	7.35%
150	220.670	235.000	14.330	6.50%	255.000	20.000	8.50%	275.000	20.000	7.80%	295.000	20.000	7.27%

Source: SONEDE

Table 10.11-3 Consumption Charge Raise

unit: millimes (0.001TND) /m^3

Water use (m^3/3months)	2005 — 2009 Tariff	2010			2011			2013			2014		
		Tariff	Increase amount	Rate hike	Tariff	Increase amount	Rate hike	Tariff	Increase amount	Rate hike	Tariff	Increase amount	Rate hike
0-20	140	145	5	3.60%	145	0	0.00%	145	0	0.00%	155	10	6.90%
21-40	240	250	10	4.20%	250	0	0.00%	250	0	0.00%	270	20	8.00%
41-70	300	315	15	5.00%	315	0	0.00%	340	25	7.90%	365	25	7.35%
71-100	545	575	30	5.50%	575	0	0.00%	620	45	7.80%	665	45	7.26%
101-150	545	575	30	5.50%	700	125	21.70%	760	60	8.60%	815	55	7.24%
151-500	840	890	50	6.00%	975	85	9.60%	1060	85	8.70%	1135	75	7.08%
501 +	840	890	50	6.00%	1025	135	15.20%	1110	85	8.30%	1190	80	7.21%
Standpipe	140	145	5	3.60%	145	0	0.00%	145	0	0.00%	155	10	6.90%
Tourism	840	890	50	6.00%	1025	135	15.20%	1110	85	8.30%	1190	80	7.21%

Source: SONEDE

According to the tariff section of SONEDE, an annual increase of the tariff at 7% for next three years (2014 - 2016) has been planned, and the increase at 7% was made in 2014 and the increase at 8% is scheduled in 2015. SONEDE estimates that the operating income will result in a surplus in 2014 when the annual increase at 7% is applied. The following is the result of the calculation by SONEDE. (Details are not disclosed.)

Table 10.11-4 Tariff Raise and Forecasted Operating Profit

		2012	2013	2014	2015	2016
With Tariff Increase	Increase Rate	Base	7.0%	7.0%	0.0%	0.0%
	Operating Income	-22	-3	8	-8	-30
Without Tariff Increase	Increase Rate	Base	7.0%	7.0%	7.0%	7.0%
	Operating Income	-22	-3	8	14	16

Note: The calculation was made with consideration about increase of Electric Charge.
Source: SONEDE

The calculation presented in Table 10.11-4 does not consider the seawater desalination plant planned in this survey, thus a review is required to set the appropriate tariff. SONEDE has requested to the World Bank on the water tariff, and the study is on-going. A kick-off meeting was held on 3 February 2015 and the study will be completed in January 2016.

10.12 Economic and Financial Analysis

For economic and financial analysis, the Internal Rate of Return (IRR), widely used as an evaluation index of ODA loan projects, is applied for measuring the quantitative effect of the Project. By using this indicator, the objective evaluation is made to ensure uniformity and identity. The Financial Internal Rate of Return (FIRR) calculated by financial data, presents the validity of the investment as compared to the opportunity cost of capital. Economical Internal Rate of Return (EIRR) calculated by social benefit, presents the validity of the investment compared to the social discount rate. As a result, FIRR is 0.02% when water rate of SONEDE is increased to 0.418 TND/m^3 and EIRR is 12.08%. The pre-conditions are described below for IRR analysis.

(1) Project period

The project implementation period is nine years, i.e. 2017 to 2025, in which the 4-year construction period is included. The amortization period from the start of operation is 30 years, i.e. 2023 to 2052. Total period is 36 years, in which three years overlap. Phase 2 project is not considered.

(2) Project cost

In the Project, the initial investment cost is covered by the government[a]. When the construction is completed, the ownership of the desalination plant will be transferred to SONEDE as a donation. Then the plant is amortized in the account of SONEDE. Therefore, two types of IRR are analysed. One is the ordinal analysis including project and operation cost with normal calculation. The other is the same as the first one except eliminating the project cost at the completion of the construction.

(3) Cash flow analysis

In order to use the value of the cash flow, items for no movement of cash such as accounts receivable, accounts payable, and depreciation are excluded.

(4) Use of present price

In order to use the actual price, the price at the time of the survey is applied and inflation is not considered.

(5) FIRR of total capital

For calculating IRR without distinguishing loans and own funds, the Interest during Construction (IDC) is not included in the finance costs.

[a] The Tunisian government will shoulder the cost eligible to Japanese ODA loan, and non-eligible cost will be shouldered by SONEDE.

(6) Exclusion of sunk costs

For calculating IRR from the financial benefit and the financial cost from a start of the Project, investments made before the Project are excluded.

(7) Residual value

Due to a long life span of the facility, the residual value becomes small. In addition, it is difficult to use it for another purpose or transfer it to another place. Therefore, the residual value is not considered.

(8) Sensitivity analysis

In general, the sensitivity is analysed i) for an excess of the initial investment cost at 10%, ii) for reducing benefit value at 10%, and iii) for delay of occurring benefits using one year as a bench mark. However, it is not practical to ensure financial benefit according to the nature of the Project. The tariff to cover the operation and maintenance costs is analysed.

The results of financial analysis (FIRR) and economic analysis (EIRR) are discussed below.

10.12.1 FIRR

FIRR is calculated based on the project cost, operation and maintenance costs, and benefit in the evaluation period. In this survey, two cases of FIRR were calculated - one that considers the project cost in order to evaluate the entire project, and the other considers only the operation and maintenance cost in order to evaluate the cost covered by SONEDE.

It should be noted that the water tariff system of Tunisia covers all the costs, and from this standpoint, it is difficult to increase the tariff. But the Project will be implemented for its social benefits, not only for financial gain. Therefore, sensitivity is analysed for the tariff level, which can cover the operation and maintenance costs.

Calculating the financial benefit and the financial cost considers the following:

(1) Project Cost

The project cost is the entire project cost excluding price escalation and IDC.

(2) Operation and Maintenance Cost

The operation and maintenance cost is estimated with a reference on the existing sea water desalination facilities of SONEDE. The evaluation period of the operation and maintenance costs is 30 years after the start of the operation. In order to use the real price as well as the project cost, the inflation rate is not considered. The depreciation without movement of cash is excluded. Accounts payable and accounts receivable are not considered because there is no significant delay in the settlement and no significant impact on cash flow.

As presented in Table 10.8-1, the operation and maintenance cost is 36,990,400 TND/year or

1.013TND/m^3 for desalination water production of 36,500,000 m^3/year.

(3) Sales volume

Sales are calculated by multiplying the selling price by the expected production volume at the desalination plant. The selling price is applied by dividing the annual sales of the pay-per use in 2012 by the annual water distribution volume by SONEDE. SONEDE is scheduled to increase the tariff at 7% in annually for next two years. The annual increase at 7% is equivalent to the inflation rate. Therefore, the tariff increase is not considered in the analysis. In sensitivity analysis, an impact on the financial benefit is analysed for an appropriate tariff without consideration of an increase at 7%.

The annual sales are calculated as 13,943,000 TND/year based on the current average water tariff of 0.382 TND/m^3 as of 2013.

Average water tariff	303,585,617 TND x 68% (water supply rate in invoice) / 540,000,000m^3/year = 0.382 TND/m^3

(4) Opportunity cost of capital

Opportunity cost of capital is set at 4.77% based on the average interest rate of the Tunisian Central Bank in May 2015.

(5) Calculation of FIRR

Net income becomes negative by calculating the current water tariff and the operation and maintenance cost of sea water desalination plants based on the above-mentioned conditions. If negative, FIRR cannot be calculated. However, the current tariff in Tunisia is relatively lower than the disposable income of 4%, a reference rate of international organizations. Since the tariff is planned to be increased continuously, sensitive analysis is made for several patterns of the tariff. The following is the table of cash flow and the result of the FIRR calculation.

<u>Project Cost</u>

Use of following costs is presented in Table 10.5-1

- I) Procurement / Construction, and II) Consulting Services with Physical Contingency of 5% (not counted in case of no burden of CAPEX)
- Administration Cost (counted even in case of no burden of CAPEX)
- Land Acquisition (counted even in case of no burden of CAPEX)
- VAT (counted even in case of no burden of CAPEX)
- Price Escalation and IDC are not counted.

<u>Operation & Maintenance Cost</u>

Use of the amount is presented in Table 10.8-1 and 10.8-2. Considered as fixed cost is 10%, and 90% of it is adjusted in proportion to water volume produced.

Operation and Maintenance Cost =36,990,400 x (0.1+0.9x (annual water production / (100,000 x 365)))

O&M cost for the period of the performance test, i.e. one year from October 2022, is included in the construction cost. Therefore, O&M cost for 2023 is accounted for three months, from October to December.

<u>Sales (Revenue)</u>

Sales amount is calculated by multiplying water production[b] by assumed water tariff. Annual desalinated water production is calculated as 365 days of average daily production, which is derived from the maximum daily production divided by 1.4, the peak ratio. Water production during the one-year performance test from October 2022 was counted as sales. The water tariff increase is planned to be increased gradually in five years from 2022. After year 2026, it is assumed that the facilities of the first phase are fully operational. However, the production volume was calculated based on the average daily production at 26,071,429 m^3/year. Gradual water tariff increase for five years from 2022 was assumed for the cases with tariff increase.

Table 10.12-1 presents the cash-flow for FIRR calculation in case of 1.154 TND/m^3[c] as increased tariff, which makes FIRR positive. In this case, costs non-eligible for the Japanese ODA loan is assumed to be shouldered by SONEE. If CAPEX is shouldered by SONEDE, FIRR is -10.54%.

[b] Average daily water production (maximum daily production / 1.4) x 365 days

[c] Assuming tariff increase is for all water distributed by SONED, it is equivalent to 0.418 TND/m^3

Table 10.12-1 Cash Flow for FIRR

Unit: JPY

1.154	YEAR	Project Cost	Non-eligible Cost to be financed by SONEDE	Operartion & Maintenance Cost	Revenue	Net Benefit With CAPEX	Net Benefit Without CAPEX
		a	b (included in a)	c	d	d-a-c	d-b-c
Construction	2015	0	0	0	0	0	0
	2016	0	0	0	0	0	0
	2017	701,738,436	111,086,679	0	0	-701,738,436	-111,086,679
	2018	346,429,763	76,845,491	0	0	-346,429,763	-76,845,491
	2019	5,752,699,567	540,549,751	0	0	-5,752,699,567	-540,549,751
	2020	9,892,306,518	1,065,375,471	0	0	-9,892,306,518	-1,065,375,471
	2021	9,403,934,920	983,924,237	0	0	-9,403,934,920	-983,924,237
	2022	8,516,748,025	901,726,138	0	192,003,135	-8,324,744,890	-709,723,003
Operartion & Maintenance	2023	7,888,928,826	805,443,700	391,979,012	1,016,555,498	-7,264,352,340	-180,867,214
	2024	1,820,589,502	182,022,124	1,676,743,126	1,344,610,569	-2,152,722,059	-514,154,682
	2025	144,100,349	13,587,337	1,676,743,126	1,590,242,220	-230,601,255	-100,088,243
	2026	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2027	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2028	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2029	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2030	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2031	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2032	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2033	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2034	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2035	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2036	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2037	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2038	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2039	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2040	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2041	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2042	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2043	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2044	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2045	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2046	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2047	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2048	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2049	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2050	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2051	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
	2052	0	0	1,676,743,126	1,835,873,871	159,130,745	159,130,745
TOTAL		44,467,475,906	4,680,560,928	49,017,529,664	53,712,005,950	-39,772,999,620	13,915,358
FIRR						-10.54%	0.02%

Source: JICA Survey Team

(6) Sensitivity analysis

The sensitivity is analysed for two cases. One case includes the project cost (FIRR with CAPEX). The other is a case that excludes the project cost (without CAPEX). In actual, SONEDE will cover only operation and maintenance costs. Therefore, a result of FIRR without CAPEX is the practical value. The calculation results are presented in Table 10.12-2 and 10.12-3.

Table 10.12-2 Calculation of FIRR

Unit: JPY

Tariff Level (Project)*1	0.382TND/m^3	1.154TND/m^3	1.258TND/m^3	2.022TND/m^3	3.035TND/m^3
Tariff Level (SONEDE)*2	0.382TND/m^3	0.418TND/m^3	0.423TND/m^3	0.458TND/m^3	0.505TND/m^3
Calculation Base	Without CAPEX	Without CAPEX	Without CAPEX	With CAPEX	With CAPEX
Project Cost	4,680,560,928	4,680,560,928	4,680,560,928	44,467,475,906	44,467,475,906
Operation & Maintenance*3	49,017,529,664	49,017,529,664	49,017,529,664	49,017,529,664	49,017,529,664
Sales*4	18,322,625,771	53,712,005,950	58,479,487,218	93,456,296,903	139,939,239,263
Gross profit*3	▲35,375,464,822	13,915,358	4,781,396,625	17,132,499	46,454,233,693
FIRR (%)	—	0.02%	4.79%	0.00%	4.77%

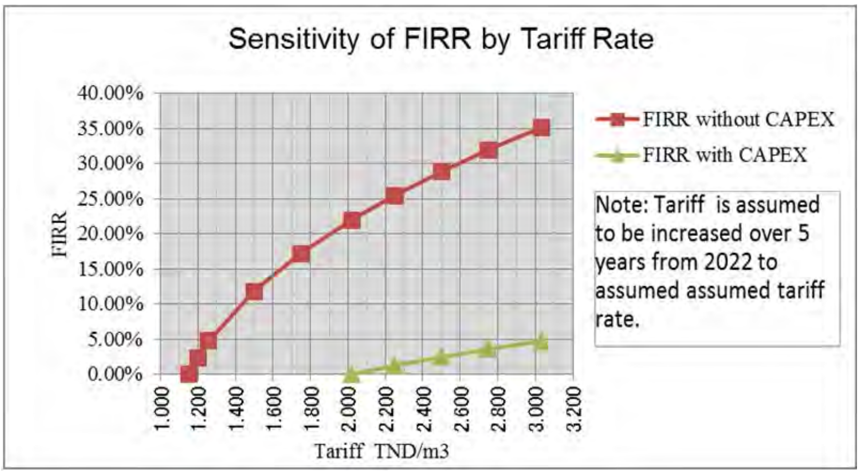
*1: In case tariff increase for water supplied by desalinated water.
*2: In case tariff increase on all water supplied by SONEDE. Refer to 10.12.1 (7)
*3: Total for 36 years
*4: Water sales for production water for project life of 36 years.
Source: JICA Survey Team

FIRR is negative when the water tariff is 0.382TND/m^3. However, FIRR becomes 0.02% when the tariff is 1.154 TND/m^3. If the tariff is raised to 1.258 TND/m^3, FIRR becomes 4.79%, which exceeds the opportunity cost of capital. In case of including CAPEX, if the tariff is raised to around 3.035 TND/m^3, FIRR equals to the capital opportunity cost.

Table 10.12-3 Sensitivity Analysis of FIRR (Tariff Level)

Tariff (TND/m^3)	1.154	1.200	1.258	1.500	1.750	2.022	2.250	2.500	2.750	3.035
FIRR without CAPEX	0.02%	2.41%	4.79%	11.85%	17.18%	21.96%	25.44%	28.86%	31.95%	35.16%
FIRR with CAPEX	-10.54%	-9.05%	-7.67%	-4.14%	-1.86%	0.00%	1.29%	2.53%	3.63%	4.77%

Source: JICA Survey Team



Source: JICA Survey Team

Figure 10.12-1 Sensitivity Analysis of FIRR (Tariff Level)

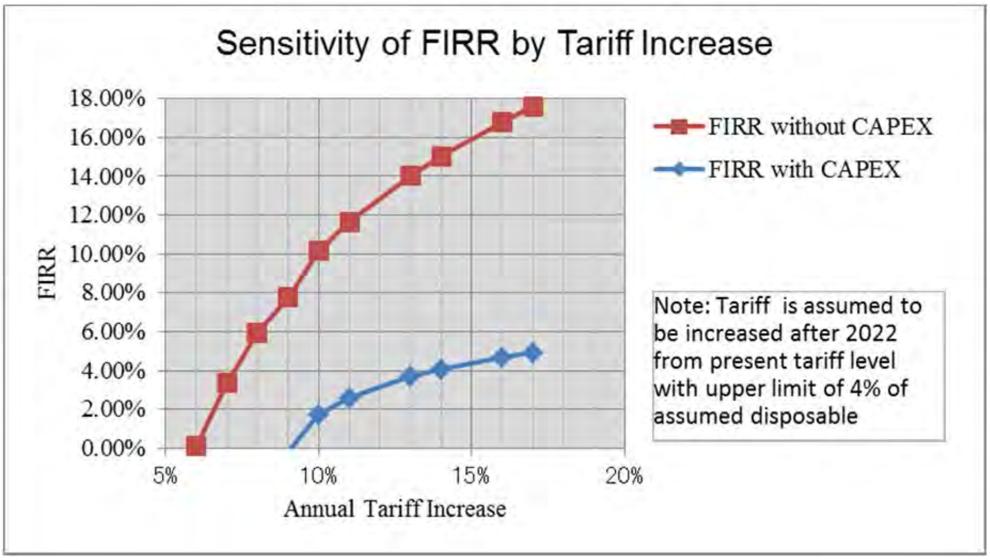
The sensitivity is also analysed based on an increase rate of the tariff. Currently, SONEDE has a plan to increase the tariff at 7%, the same as inflation rate. The following is the analysis on an actual increase rate of the tariff without considering inflation for obtaining sufficient FIRR.

Without CAPEX, when an annual increase of the tariff is 6%, FIRR becomes 0.13%, exceeding ODA loan interest rate. When an annual increase of the tariff is 8%, FIRR reaches at 5.96%, exceeding the opportunity cost of capital. In case it is without CAPEX, when an annual increase of the tariff is 10%, FIRR becomes 1.71%. It is required to raise the tariff with an annual increase rate of 17% in order to make FIRR exceed the opportunity cost of capital.

Table 10.12-4 Sensitivity Analysis of FIRR (Tariff Increase Rate)

Annual Tariff Increase Rate	6%	7%	8%	9%	10%	11%	13%	14%	16%	17%
FIRR without CAPEX	0.13%	3.36%	5.96%	7.74%	10.14%	11.65%	14.01%	15.00%	16.77%	17.59%
FIRR with CAPEX	-5.28%	-3.02%	-1.19%	-0.19%	1.71%	2.57%	3.67%	4.06%	4.65%	4.92%

Source: JICA Survey Team



Source: JICA Survey Team

Figure 10.12-2 Sensitivity Analysis of FIRR (Tariff Increase Rate)

As described above, it is possible to expect a sufficient FIRR if the water tariff is continuously raised. As a result, it is expected that this is not only done for profit of the Project but also to improve the financial situation of SONEDE.

On the other hand, it is necessary to consider the affordability of the customer. Generally the upper limit of the water tariff level is about 4% of disposable income. GNI of Tunisia in 2013 is about 6,826 TND per capita per year[d]. Considering the disposable income as 70% of the GNI, the disposable income is about

[d] 4,200 US$/capita (http://data.worldbank.org/country/tunisia)
US$=TND1.6253 (2013)(http://www.bct.gov.tn/bct/siteprod/tableau_statistique_a1.jsp?params=PL212010&la=AN)

4,478 TND per capita per year. If water consumption per capita is assumed at 200 L/day, which is a sufficient amount in general, the annual consumption per capita is 73m^3. When the tariff is applied at 1.154 TND/m^3, one customer pays 84.242 TND/year. This amount is about 1.9% against disposable income of 4,478 TND, which is considered as the affordable rate.

The financial analysis for the Project is concluded that the sufficient investment effect is expected if SONEDE could increase the tariff within a generally acceptable level.

The result of sensitivity analysis for the cases of increase and decrease of initial cost, operation and maintenance cost and revenue by 10% CAPEX is presented in Table 10.12-5 as a reference.

Table 10.12-5 FIRR Sensitivity Analysis (by fluctuation of cost)

Initial cost (CAPEX)	O&M cost	Revenue	FIRR	
		1.154TND/m^3	With CAPEX	Without CAPEX
+10%	+10%	+1%	-20.2%	-13.0%
+10%	+10%	+5%	-13.3%	-4.0%
+10%	+10%	+10%	-10.5%	0.0%
0%	0%	-8%	-19.3%	-11.8%
0%	0%	0%	-10.5%	0.0%
0%	0%	+10%	-7.4%	5.3%
-10%	-10%	-10%	-10.5%	0.0%
-10%	-10%	0%	-7.2%	5.8%
-10%	-10%	+10%	-5.2%	9.9%

(7) Impact to the entire business of SONEDE

As one single project as described above, it is difficult to expect the return from the investment with the current tariff level. However, the annual production by the desalination plant constructed in the Project is 26,071,000 m^3 [e] that is considered about 4.8% against the annual production of 540,000,000 m^3 by SONEDE. It is a small amount, and the impact of the Project on the entire business of SONEDE is considered to be limited.

The annual sales volume with the current tariff level (water charges income) is about 206,438,219 TND. The annual operation and maintenance cost of the desalination plant in the Project will be 27,478,219 TND[f]. The average tariff is calculated by adding the annual sales and the annual operation and maintenance cost, and then dividing the sum with the annual production of 566,071,000 m^3 (=540,000,000 +26,071,000). As a result, the tariff becomes about 0.413 TND/m^3, which is additional 0.031 TND/m^3 (= 0.413 - 0.382) to the current tariff. If this increase is made possible, the operation and maintenance cost of the plant in the Project is covered. This is an increase of 8.1% against the current tariff. However, against disposable income of 4,478 TND/year, the water tariff is only 0.67% (=

[e] Daily Maximum/Daily Average=1.4. (100,000m^3/day) / (1.4) x 365 days＝26,071,000m^3

[f] A 10% of O&M cost presented in Table 10.8-1 is considered as fixed cost and remaining 90% of it is considered as variable cost in proportion to water production volume.
36,990,400 TND/year x (0.1+0.9x(26,071,000/36,500,000)) ＝ 27,478,189 TND/year

(73m^3/year/person x 0.413TND/m^3) / 4,478TND/year/person). Therefore, tariff level is within the acceptable range. This tariff level, however, is not sufficient to amortize the cost not financed by ODA loan, which shall be shouldered by SONEDE

For achieving positive FIRR without CAPEX[g], the required tariff level is 1.154 TND/m^3. The analysis is made to distribute the required tariff to all SONEDE's customers. Since the annual production at the desalination plant is 26,071,000 m^3, total sales amount to 30,085,934 TND (= 1.154TND/m^3 x 26,071,000 m^3). When a sum of the current annual sales and the total sales is divided by the total production of the plant, the tariff level becomes 0.418 TND/m^3 (= (206,438,219 TND + 30,085,934 TND) / 566,071,000 m^3), or an increase of 9.4% from the current tariff. Even in this case, the tariff is about 0.68% of the disposable income per capita per year.

For achieving positive FIRR with CAPEX, the required tariff level is 2.022 TND/m^3. The analysis is made to distribute the required tariff to all SONEDE's customers. The total sales amounts to 52,715,562 TND (= 2.022 TND/m^3 x 26,071,000 m^3). The tariff level becomes 0.458 TND/m^3 (= (206,438,219TND + 52,715,562 TND) / 566,071,000 m^3), or increase of about 20% from the current tariff. Even in this case, the tariff is about 0.75% of the disposable income per capita.

For exceeding the opportunity cost of capital (4.77%) with CAPEX, the required tariff level is 3.035 TND/m^3. When this required tariff is distributed to all customers, the tariff level becomes 0.505TND/m^3. This rate is a 32% increase against the current tariff levels, and is considered large, which the customers may not easily accept. However, the tariff is equivalent to about 0.82% of the disposable income. Therefore, it falls under an acceptable tariff level.

Table 10.12-6 presents comparison of water tariff in case tariff increase is only for the water of produced at the Sfax Seawater Desalination Plant and the one in case tariff increase covers the whole water distributed by SONEDE. For example, in order to cover O&M cost and make FIRR positive without CAPEX, water tariff shall be increased to 0.418TND/m^3 by 2026 from 0.382 TND/m^3 at present. For exceeding the opportunity cost of capital (4.77%) without CAPEX, the tariff level shall be increased to 0.423 TND/m^3 by 2026.

In calculating the FIRR, it is assumed that water tariff is increased to the required level gradually for five years from present level as presented in Table 10.12-6.

[g] The cost not financed by ODA loan shall be shouldered by SONEDE.

Table 10.12-6 Comparison of Water Tariff between the Cases of Desalinated Water and SONEDE's Distributed Water

Unit:TND/m^3

Water Tariff	Condition	Year	2021	2022	2023	2024	2025	2026
0.413	No Initial Cost Covering O&M cost FIRR＞0	Tariff*	0.382	0.388	0.394	0.401	0.407	0.413
		I. Rate**	8.1%（1.57%/p.a.）					
0.418	Without CAPEX Covering O&M cost FIRR＞0	Tariff*	0.382	0.389	0.397	0.404	0.411	0.418
		I. Rate**	9.4%（1.81%/p.a.）					
0.423	Without CAPEX Covering O&M cost FIRR＞Opportunity Cost of capital 4.77%	Tariff*	0.382	0.390	0.398	0.406	0.415	0.423
		I. Rate**	10.7%（2.05%/p.a.）					
0.458	With CAPEX Covering O&M cost FIRR＞0	Tariff*	0.382	0.397	0.412	0.428	0.443	0.458
		I. Rate**	19.9%（3.69%/p.a.）					
0.505	With CAPEX Covering O&M cost FIRR＞Opportunity Cost of capital 4.77%	Tariff*	0.382	0.407	0.431	0.456	0.480	0.505
		I. Rate**	32.2%（5.72%/p.a.）					

*: Average water tariff for water newly produced by the Project plus whole water distributed by SONEDE, 1,551,000 m^3/day (566,071,000 m^3/year) is the subject.
**: Increase Rate between the tariff in 2021 and the one in 2026.

10.12.2 EIRR

EIRR is calculated with a factor of economic costs and economic benefits converted into the monetary value of social benefits. In FIRR, financial balance is evaluated including financial benefits and financial expense. In EIRR, economic value is evaluated by the broader effects from, the implementation of the Project. The validity of the Project is discussed with a comparison of the social discount rate and EIRR.

Social Discount Rate (SDR)

This project is applied the SDR of 10% referred from the value of 10% to 12% described in the economic analysis guideline of the World Bank, the Inter-American Development Bank and the Asian Development.
(JBIC 2002 "Guideline on the calculation of Internal Rate of Return for ODA Loans")

Standard Conversion Factor (SCF)

The simple method used in the Asian Development Bank is applied. The standard conversion factor is calculated from trade statistics.

SCF = (Total import amount ＋ Total export amount) /
((Total import amount ＋ Total import tax) ＋ (Total export amount － Total export tax))
= (38,178 +26,548) / ((38,178 ＋ 1,313.2) + (26,548 － 20.3)) = 0.98

Total export tax and total import tax are referred from the following published by the World Bank.

- Total import tax: Customs and other import duties (current LCU)
  (http://data.worldbank.org/indicator/GC.TAX.IMPT.CN)
- Total export tax: Taxes on exports (current LCU)
  (http://data.worldbank.org/indicator/GC.TAX.EXPT.CN)

Data in 2012 for above calculations are used.

The conversion factor for unskilled workers is generally 0.6 to 0.8. However, the conversion factor is applied to SCF of 0.98 for all items because Tunisia is a middle-income country, and the skill level of workers is relatively high.

(1) Economic benefit

The main elements of the economic benefits in the water supply project are generally considered as follows.

(i) Price of alternative water sources
(ii) Willingness to pay for the additional benefits
(iii) Improvement of health conditions associated with water quality improvement
(iv) Reduction of labour to fetch water

"(iv) Reduction of labour to fetch water" is not suitable as a benefit because the coverage of the water supply system in Tunisia is high. Therefore, the benefit is analysed for "(i) Price of alternative water sources", "(ii) Willingness to pay for the additional benefits", and "(iii) Improvement of health conditions associated with water quality improvement". In addition to the existing data, the interview survey was conducted to collect data on willingness to pay. As a result, "(i) Price of alternative water sources" is included as non-additional supply portion. In addition, "(ii) Willingness to pay for the additional benefit" is also included as an additional supply portion. "(iii) Improvement of health conditions associated with water quality improvement" is not included for the economic benefit because it is difficult to quantify the mitigation of the diseases by the water quality improvement. Details are as follows.

(i) Price of alternative water sources

Damage to commerce, industry and life during water shortage has been avoided at the present time by transmitting water from other water sources. Therefore, the amount of damage due to water shortage is equivalent to the cost of the water transmission from an alternative water source. In considering the accuracy and availability of data, the water transmission from the cost of the alternative water sources during times when water shortages occur is included in the analysis.

The expenses related to water transmission from other water sources are calculated based on the past data of construction, and operation and maintenance cost for other water sources (new wells), which have direct effects on the Project. The details are discussed as follows.

<u>Construction cost of new wells</u>

When water shortage occurred in the summer 2012, SONEDE installed wells at nine locations in 2013 as additional water sources of Sfax. These wells have been utilized at full capacity. Therefore, these wells will be fully utilized unless new water sources are developed such as the seawater desalination plant. When the desalination plant is installed, the operation and maintenance cost for the wells will be reduced. This reduction is included in the benefit. The six wells - confirmed for the supplied amount and the installation cost – are the following:

Table 10.12-7 Construction Cost of Newly Constructed Wells in Sidi Bouzid

UNIT: TND

Well	Year	Water Supply	Construction Cost
Garaat Hadid2	2013	15 L/s x 75%	92,548.526
Garaat Hadid3	2013	25 L/s x 125%	93,101.574
Ouled Asker 2	2013	40 L/s x 100%	220,036.037

Source: JICA Survey Team

Table 10.12-8 Construction Cost of Newly Constructed Wells in Sfax

UNIT: TND

Well	Year	Water Supply	Construction Cost
Mahrouga	2013	30 L/s x 100%	327,991.401
PK15	2013	50 L/s x 125%	350,352.787
Agareb	2013	15 L/s x 50%	266,204.032

Source: JICA Survey Team

From Table 10.12-7 and Table 10.12-8, the cost of the well construction is about 225,039TND per well. If amortized over 30 years, the cost per year is estimated at 7,500 TND/year. Nine wells (total water production: 8,632,980 m^3/year (23,652m^3/day)) were installed in 2013, and the cost amounted to 67,500TND/year.

Therefore, the installation cost of the alternate sources per m^3 is;

(67,500 TND/year) / (23,652 m^3/day x 365 day/year) = 0.008 TND/m^3

This cost may be counted as the revenue of the alternative water source’s construction cost for water production volume of the seawater desalination plant. However, it was not counted in the calculation of EIRR because its amount is small.

Water production cost of alternative source

If total head of groundwater pumping is assumed at 150m, the power cost for the pumping is about 0.100 TND/m^3. The removal of iron and other costs are estimated at 20% of the power cost. The unit cost of the production is the sum of the power and removal of iron and other costs, which is about 0.120 TND/m^3. This cost may be counted as the revenue of water production cost of alternative water source for water production volume of the seawater desalination plant. However, it was not counted in the calculation of EIRR because its amount is small.

Depletion Premium

Regarding construction of new wells, the concerns are cost and groundwater conservation. Currently pumping of groundwater is regulated in order to ensure sustainability of groundwater resource. If groundwater is pumped at 200,000 m^3/day instead of the seawater desalination plant, it is difficult to conserve groundwater. As a result, groundwater resources in the future may be depleted. In the

"Handbook for the Economic Analysis of Water Supply Project", March 1999 published by ADB, the depletion of groundwater is considered as "Depletion Premium" due to a loss of a national property. This is an additional cost to the cost of developing new groundwater wells. Conversely, applying this approach, an additional cost can be considered as the benefit if new well developments are avoided by the Project.

The water reduction volume from groundwater exploitation attained by the Project is the seawater desalination plant production water and 20% of produced water volume from the existing wells. It is obvious that groundwater depletion will slow down by implementing the Project. Since the degree of effect on the groundwater resource conservation, however, is not definite, this premium is not counted in the EIRR calculation.

Water transferred from agricultural dam or the purchase of water from SECADENORD is implemented by SONEDE to ensure continuous water service. However, these are measured against chronic water shortages in Tunisia. The utilized volume of these alternative water resources will not be reduced significantly by the construction of the seawater desalination plant alone. Therefore, these alternatives are not considered in this analysis.

(ii) Willingness to pay for additional benefit

The willingness to pay is calculated from the results of the questionnaire survey, and included as an additional economic benefit. The Contingent Valuation Method (CVM), sometimes used in the environmental assessment, was applied for the questionnaire survey by directly interviewing the residents' willingness to pay. There are many methodologies to ask the willingness to pay such as i) free answer format, ii) bid game method, and iii) selection from two choices. However, in this survey, SONEDE was against using the question format, as it will lead to the indication of an amount to be used for tariff increase at a very sensitive time after the revolution. As a result, the choice was to choose the tariff increase ratio (%) from the current against the additional benefits from the seawater desalination plant.

a) General information of questionnaire survey

Survey period:	March 24 - April 5, 2014
Survey Team:	Team leader and 10 members (including 5 female), university degree or higher Survey members were trained before a start of the survey.
Target:	Households, public facilities, commerce and industry, tourism Households are selected from 10 regions that are expected to benefit directly from the sea water desalination plant. The 10 regions include rural and urban areas. The numbers of samples were proportional to the regional population.
Valid responses:	1,027 (Households 902, Public facilities 34, Commerce and Industry 74 Tourism 17)

Table 10.12-9 Sampling Plan of Household by Region

Delegations	Housing: Census Results INS 2004			Number of Households by Delegated For our Sample: Urban Area	Number of Households by Delegated For our Sample: Non-Urban Area	Number of Households by Delegated For our Sample: Urban and non-Area
	Urban Area	Non Urban Area	Total			
Sfax City	34 872		34 872	167		167
Sfax West	30 495		30 495	146		146
Sakiet Ezzit	19 249	1 017	20 266	92	5	97
Sakiet Eddaïer	26 182	1 037	27 219	125	5	130
Sfax South	20 505	6 921	27 426	98	33	131
Tina	6 858	4 769	11 627	33	23	56
Agareb	2 262	6 363	8 625	11	30	41
Djebeniana	1 801	8 950	10 751	9	43	52
El Amra		7 116	7 116		34	34
El Hencha	1 665	8 161	9 826	8	39	47

Source: JICA Survey Team

Sample Extraction Method:

- Households as subscribers were randomly selected from the data of SONEDE.
- Households as non-subscribers were randomly selected from the regions.
- Public facilities, commerce and industries, and tourism were randomly selected in the regions.

Table 10.12-10 Number of Actual Samples by Region

Location	Data	Share in the total: %	Share for valid data: %	cumulative percentage: %
Sfax City	277	27,0	27,0	27,0
El Hencha	47	4,6	4,6	31,5
Sfax West	149	14,5	14,5	46,1
Sakiet Ezzit	97	9,4	9,4	55,5
Sakiet Eddaïer	131	12,8	12,8	68,3
Sfax South	133	13,0	13,0	81,2
Tina	57	5,6	5,6	86,8
Agareb	52	5,1	5,1	91,8
Jebeniana	52	5,1	5,1	96,9
El Amra	32	3,1	3,1	100,0
Total	1027	100,0	100,0	

Source: JICA Survey Team

Table 10.12-11 Subscribers and Non-Subscribers

Area / Type	already a subscriber	Not subscriber	Total Sample
Urban	816	3	819
Rural	190	18	208
Total	1006	21	1027

Source: JICA Survey Team

b) Income distribution

Many people refused to answer the questions about income. As a result, the answer to the question is only 45% among the total valid responses. Since low-income people tend to refuse this type of the survey, better answers were obtained from the seven regions with high urban population. The results show that the average income per capita is 650 TND/month or 7,800 TND/year, which is higher than 6,324 TND/year, GNI of Tunisia in 2012. For others sectors, income per capita is 3,1546,636 TND/month for industrial offices, 4,500 TND/month for hotels, and 48,738 TND/month for other sectors.

Table 10.12-12 Average Monthly Income by Sector

	Number	Minimum TND / Month	Maximum TND / Month	Moyenne TND / Month s	Standard deviation
Average Monthly Income for Gouseholds : TND/Month	406	10	2 000	650	354
Average Monthly Income for Industrial firms : TND/Month	11	1 000	10 000 000	3 154 636	3 066 900
Average Monthly Income for Hotels : TND/Month	3	1 500	10 000	4 500	4 770
Average Monthly Income for Sector « Others » : TND/Month	8	450	350 000	48 738	121 993

Source: JICA Survey Team

Table 10.12-13 Regional Income Distribution

	Sfax City	Sfax West	Sakiet Ezzit	Sakiet Eddaïer	Sfax South	Tina	Agareb	Total
Up to 200 TND / Month	11	1	1	5	14			32
From 201 to 500 TND / Month	53	18	10	8	27	12	12	140
From 501 to 1 000 TND / Month	67	53	19	8	32	9	3	191
More than 1 000 TND / Month	21	11	2	1	8			43
Total Valid Respondents	152	83	32	22	81	21	15	406

Source: JICA Survey Team

c) Water Tariff

The average payment of water tariff is 45TND/3months for households, 6,426TND/3months for industrial offices, 831TND/3months for hotels, and 499TND/3months for other sectors.

Table 10.12-14 Average Payment of Water Tariff by Sector

	Number	Minimum	Maximum	Average Size	Standard deviation
Households	875	4	600	45	39
Industry Firms	11	510	24 000	6 426	7 443
Hotels	15	20	4 000	831	1 128
Others (Exept households – Industry and Hotels)	103	5	12 000	499	1 443
Total Valid Respondents	1004				
Did not respond	23				
Total Sample	1027				

Source: JICA Survey Team

d) Source of drinking water and domestic water

Sources of drinking water and domestic water are as follows: 96.6% from separate connection of SONEDE, 13.3% from wells, 33.2% from Majel, and 33.2% from mineral water. Majel is an old rainwater collection system installed at home. It seems that Majel water is used as domestic water after being boiled. The volume and the purpose of utilizing Majel were not confirmed in this survey. However, it was confirmed people are using Majel and mineral water in addition to water from SONEDE.

Table 10.12-15 Source of Drinking Water and Domestic Water (Multiple Answers)

	Data (Number)	Share in the Total %
Individual connection	992	96,6
Public Tap	7	0,7
individual well	137	13,3
Mineral Water	341	33,2
Majel (Rainwater Collection)	386	37,6
Others	41	4,0
Total Sample	1027	100,0

Source: JICA Survey Team

e) Satisfaction with the current water supply services

The survey shows that 11% of customers are “satisfied” with the service of SONEDE, and the remainder, or 89% was "dissatisfied" with the current service. Reasons for dissatisfaction with current service are shown in the following table.

Among unsatisfied items, the answer of water quality is highest at 88.2% (820). The subscribers do not know the data of salinity or TDS. They just feel the quality from the taste. Water pressure, water tariff, and water cuts follow in the order of dissatisfaction.

Table 10.12-16 Dissatisfaction to Water Service (Multiple Answers)

	Price of drinking water (3)	Water cuts (4)	Water quality (1)[2]	Water pressure (2)	Area served by the drinking water (5)	Others (Quantity) (5)	Share (%) Quality / Total Sample
Sfax City	110	81	222	76	2	12	80,1
El Hencha	10	7	34	15			72,3
Sfax West	57	21	120	62	2	2	80,5
Sakiet Ezzit	46	42	86	32			88,7
Sakiet Eddaïer	40	39	115	53	1	2	87,8
Sfax South	64	5	106	36	4	41	79,7
Tina	11	12	40	44	2	7	70,2
Agareb	29	16	41	30	7	3	78,8
Jebeniana	9	7	33	28		4	63,5
El Amra	2	5	23	17	1		71,9
Total	378	235	820	393	19	71	79,8

Source: JICA Survey Team

f) Expectation regarding water supply service

The question was made as a follow up on the dissatisfaction of the customers. Improvement of the water quality is the highest as 85%. Reducing water tariff, reduction of water cuts, and improving the pressure of the water supply follow. It was found out that the customers are most dissatisfied with water quality, and want to see improvement in this area.

Table 10.12-17 Services Wished to Improve (Multiple Answers)

	Reducing water rate : %	Reduction of water cuts : %	Improvement of water quality : %	Improving the pressure of the water supplied: %	Expansion of the area water supply: %	% Improvement of quality / Total of Simple
Sfax City	150	120	236	80	9	85,2
El Hencha	9	24	33	17		70,2
Sfax West	66	55	117	56	1	78,5
Sakiet Ezzit	47	61	89	35		91,8
Sakiet Eddaïer	43	64	120	46	1	91,6
Sfax South	80	73	122	28	1	91,7
Tina	46	34	50	14	4	87,7
Agareb	34	8	42	28	18	80,8
Jebeniana	8	24	32	21	3	61,5
El Amra	10	16	28	15	1	87,5
Total	493	479	869	340	38	84,6

Source: JICA Survey Team

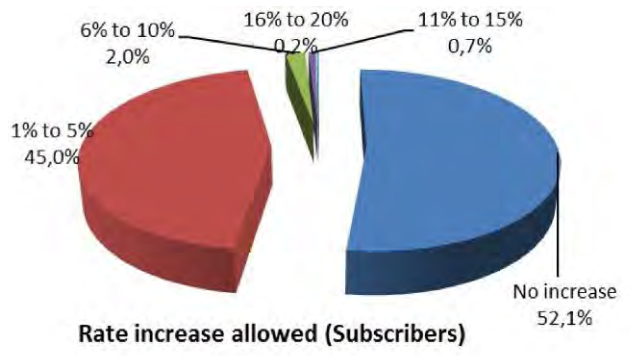
g) Willingness to pay

In order to identify the willingness to pay (WTP), users were asked to select a tariff increase ratio (%) against the current water tariff when the services are improved. The most common answer was "no increase". The second most common answer was "lowest level of tariff increase". The increase rate among answers of acceptance of tariff increase averages 2.8%. The question format had a strong bias against wanting an increase; however, it also gave a good indication that tariff increase is acceptable if the services are improved since the same percentage of answers was obtained on the non-acceptance for an increase in water tariff with those that accept tariff increase.

Table 10.12-18 Willingness to Pay if Water Service is improved (water tariff increase rate)

Ranges of increase	Data	Share in the total: %	Share for valid data: %	cumulative percentage: %
No increase	518	51,5	52,1	52,1
1% to 5%	448	44,5	45,0	97,1
6% to 10%	20	2,0	2,0	99,1
11% to 15%	7	,7	,7	99,8
16% to 20%	2	,2	,2	100,0
Total valides	995	98,9	100,0	
Not responding	11	1,1		
Totalsubscribed	1006	100,0		
Total Not Subscribed	21			
Total Sample	1027			

Source: JICA Survey Team



Source: JICA Survey Team

Figure 10.12-3 Willingness to Pay if Water Service is improved (Water Tariff Increase Rate)

The amount that the unconnected residents are willing to pay was directly asked to them assuming they can connect to the service of SONEDE. The survey shows that the average amount of the unconnected residents are willing to pay is 8.583 TND/m^3 [h]. Some non-subscribers even gave higher values than the subscribers, because they buy water at a higher price from current water sellers. In Tunisia, official water sellers are only SONEDE and bottled water selling companies. However, unconnected residents purchase water from unofficial water sellers, who get water from private wells or from SONEDE and sell without permission. The price is about 1.5 TND/20 L or 75 TND/m^3, which is relatively higher than SONEDE's water. Water bought from private water re-sellers is stored in plastic buckets and hygiene conditions are relatively poor. Bottled water sold in Tunisia, is clean natural water from northern Tunisia and the retail price is about 0.5 TND/1.5 L or 333 TND/m^3, which is very expensive as compared to SONEDE’s water. Therefore, 8.583 TND/m^3 is judged reasonable as willingness to pay for the unconnected residents.

[h] Arithmetic average of answers excluding abnormally high value of 15 TND/m^3

Table 10.12-19 Willingness to Pay of Unconnected Residents

TND / m^3	Data	Share in the total: %	Share for valid data: %	cumulative percentage: %
5	1	7,7	7,7	7,7
6	1	7,7	7,7	15,4
7	2	15,4	15,4	30,8
8	1	7,7	7,7	38,5
10	7	53,8	53,8	92,3
15	1	7,7	7,7	100,0
Total	13	100,0	100,0	
No-responding	8			
Total	21			

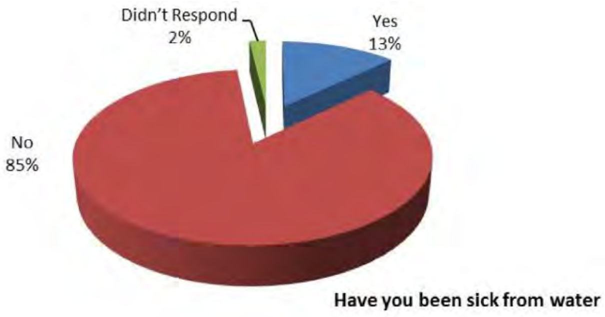
Source: JICA Survey Team

The average rate of increase acceptable to the subscribers is 2.8%. If this increase is added to the current tariff of 0.382 TND/m^3, rate comes up to 0.393 TND/m^3. This is almost the same level with the current tariff. The willingness to pay by non-subscribers, on the other hand, is 8.583 TND/m^3. This could be considered as the price of the alternative water source when bottled water or water from private seller is purchased when there is a water shortage. The difference of the willingness to pay between subscribers and non-subscribers is the intermediate economic price of water, which is 4.488 TND/m^3. This intermediate price is used and applied in this survey as an economic price to include the economic benefit for the economic analysis as it also reasonable when referred to the income level.

Willingness to pay: (8.583TND/m^3 ＋ 0.393TND/m^3) / 2 ＝ 4.488 TND/m^3
Production of sea water desalination facility 71,428 m^3/day (annual average)
Economic price of water:
71,428m^3/day x 365 day/year x 4.488 TND/m^3 ＝ 117.007,635 TND/year

(iii) Reduction of water borne diseases by improvement of water quality

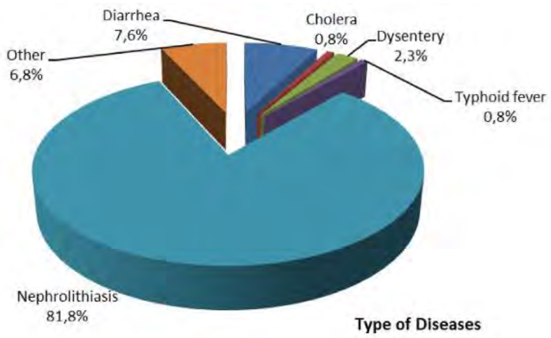
One of the economic benefits in any water supply project is a reduction of water borne diseases which comes as a result of the improvement in water quality. This is especially significant for Sfax since groundwater in the project area has been found to have a high concentration of salinity. The answers on the impact to health from water quality improvement were obtained from questionnaire survey. The first question was whether the customers have had waterborne diseases. If yes, the name of the disease was asked. The results show that 13% (132) have had bouts with waterborne diseases.



Source: JICA Survey Team

Figure 10.12-4 Experiences on Water Borne Disease

Of the 132 people who experienced water borne diseases, 108 identified the disease as "Nephrolithiasis" caused by an excessive intake of carbohydrates and animal protein, and lack of water intake. In the opinion of the Sfax Health Department, it is difficult to directly link Nephrolithiasis on the quality of tap water to the disease. However, there is a possibility of low water intake because of low water quality particularly on the issue salinity. In addition, the cause of the disease cannot be blamed on water alone. Under these conditions, it is difficult to quantify the reduction of water borne disease by the Project, thus it will be excluded from economic benefit.



Source: JICA Survey Team

Figure 10.12-5 Name of Disease Suspected as Water Borne

(2) EIRR

EIRR, which is calculated based on the benefit determined above, is 12.08%. This value is higher than the social discount rate of 10%. Sufficient economic benefits can be expected from the Project. The results of calculation and cash flow statement are shown in Tables 10.12-20 and 10.12-21.

Table 10.12-20 Calculation of EIRR

UNIT: JPY

Total Cost	Project Cost	40,983,078,860
	Operation and Maintenance Cost	49,017,529,664
Total Benefit	Benefit (Economical benefit)	215,266,870,311
Gross Profit		125,266,261,787
EIRR (%)		12.08%

Source: JICA Survey Team

Table 10.12-21 Cash Flow for EIRR

UNIT: JPY

Stage	Year	Cost		Benefit	Net Benefit	Sensitivity Analysis		
		Project Cost*1	Operation & Maintenance Cost*2	Economic Price of Water*3		CAPEX +10%	Benefit -10%	Delay of 1 year
Construction	2015	0	0	0	0	0	0	0
	2016	0	0	0	0	0	0	0
	2017	609,649,526	0	0	-609,649,526	-670,614,478	-609,649,526	-609,649,526
	2018	278,950,017	0	0	-278,950,017	-306,845,018	-278,950,017	-278,950,017
	2019	5,368,514,311	0	0	-5,368,514,311	-5,905,365,742	-5,368,514,311	-5,368,514,311
	2020	9,091,738,979	0	0	-9,091,738,979	-10,000,912,876	-9,091,738,979	-9,091,738,979
	2021	8,672,611,004	0	0	-8,672,611,004	-9,539,872,104	-8,672,611,004	-8,672,611,004
	2022	7,843,472,543	0	1,606,469,181	-6,237,003,362	-7,021,350,616	-6,397,650,280	-7,843,472,543
Operation & Maintenance	2023	7,295,989,680	391,979,012	6,604,373,301	-1,083,595,390	-1,813,194,358	-1,744,032,720	-5,689,520,498
	2024	1,687,724,398	1,676,743,126	7,139,863,029	3,775,395,504	3,606,623,064	3,061,409,201	4,524,669,891
	2025	134,428,403	1,676,743,126	7,139,863,029	5,328,691,500	5,315,248,660	4,614,705,197	5,328,691,500
	2026	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2027	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2028	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2029	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2030	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2031	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2032	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2033	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2034	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2035	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2036	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2037	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2038	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2039	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2040	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2041	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2042	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2043	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2044	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2045	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2046	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2047	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2048	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2049	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2050	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2051	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
	2052	0	1,676,743,126	7,139,863,029	5,463,119,903	5,463,119,903	4,749,133,600	5,463,119,903
TOTAL		40,983,078,860	49,017,529,664	215,266,870,311	125,266,261,787	121,167,953,901	103,739,574,756	119,803,141,884
Exchange Rate:		61.02 Yen/TND		EIRR	12.08%	10.93%	10.47%	10.79%

*1: Project Cost - (Price Escalation Cost + Land Acquisition Cost + VAT + IDC). The SCF at 0.98 is applied for Local Currency Portion

*2: A 10% of O&M cost for full capacity operation presented in Table 10.8-1 and Table 10.8-2 is fixed. Remaining 90% of it is varied in proportion to production volume.

O&M cost = 36,990,400 x (0.1 + 0.9 x (annual water production / (100,000 x 365)))

O&M cost for one year from October 2022 is included in the project cost, because it is included in the cost for the Guarantee Test by the Contractor.

*3: The economic water price is assumed at 4.488TND/m^3 for distributed desalinated water. That is intermediate value between WTP of unconnected residents at 8.583TND/m^3 and allowable increased water rate at 0.393 (=0.382x1.028) TND/m^3 which is considered allowable by connected users based on the Social Survey.

4.488 TND/m^3 (Economic Vale) x 100,000 m^3/day / 1.4 (Desalination production water) x 365 days x 61.02 TND/JPY = 7,139,863,029 JPY

Source: JICA Survey Team

The cash flow was made based on the following:

Project Cost

Use of following items from Table 10.5-1

- Applied with Physical Contingency of 5% to (I) Procurement / Construction and (II) Consulting services
- Administration Cost
- excluding Price escalation, Land Acquisition, VAT and IDC
- use of SCF of 0.98 for Foreign Currency

Operation & Maintenance Cost

- The amount in Table 10.8-1 converted to JPY is used. It is assumed that 10% of it is fixed cost and 90% of it varies in proportion to water production volume.

Benefit (Economic Price of water)

- Based on the social survey, 4.488 TND/m^3 is assumed as the benefit of economic water price for water volume produced by the seawater desalination plant[i].

(3) Sensitivity analysis

The sensitivity is analysed for an increase of the project cost at 10%, a decrease of the economic benefit at 10 %, and a delay of the benefit by one year. EIRR becomes 12.08% in the base case, which exceeds the social discount rate of 10%. As a result, the sufficient economic benefits are expected. EIRR in other conditions also exceeds the social discount rate of 10%. For the other conditions, sufficient economic benefits are also expected.

Table 10.12-22 Sensitivity Analysis of EIRR

Case	BASE	CAPEX +10%	Benefit -10%	1 year Delay
EIRR	12.08%	10.93%	10.47%	10.79%

Source: JICA Survey Team

10.13 Operation and Effect Indicators

As performance indicators of outcome level, operational and effect indicators are applied for the main sector in the ODA loan projects. The definition of each indicator is as follows.

- Operation Indicator: Indicators to quantify the status of the operation
- Effect Indicator: Indicators to quantify the status of the effect expression

Specifically, the following indicators are set as the operation and effect indicators for water supply project. The population served and the percentage of population served are defined as basic item. However, these items are not suitable for performance indicators because the percentage of population served in Sfax Prefecture is as high as 98.1%. In addition, the non-revenue water rate / revenue water rate is not suitable for an operation indicator because it is not expected with the construction of desalination facilities.

[i] Annual water production = Daily Average Water Production x 365 days, Daily Average Water Production = Daily Maximum Water Production / 1.4

Therefore, as an operation indicator, water supply volume, rate of facility utilization, and the water quality are selected. In addition, the operation of the desalination plant will be effective in reducing TDS concentration of distributed water. SONEDE is willing to reduce it lower than 1500 mg/L, which is possible, and will be set as the operation indicator. This indicator, however, is affected by external conditions such like progress of water resources' development. If SONEDE will reduce water production by the operation of the desalination plant, it will save on water production cost from other water sources with surplus water quantity, but will raise the TDS concentration of distributed water because of high TDS concentration of water from other water sources. The target value is applied only to Sfax sea water desalination plant, and eliminates external factors such as the development status of other water sources.

Table 10.13-1 Operation and Effect Indicators of Water Supply Project

Category	Area	Section	Indicator	This Project
Operation Indicator	Project Area	Basic	Population Served (Persons)	—
		Basic	**Water Supply Volume (m^3/Day)**	○
			Rate of Facility Utilization (%)	○
		Basic	Non-revenue Water Rate(%) Revenue Water Rate (%)	—
		Supplement	Leakage Rate (%)	—
		Supplement	Water Intake Volume (m^3/Day)	—
		Supplement	**Water Quality**	○
Effect Indicator	Project Area	Basic	Percentage of Population Served (%)	—
		Supplement	Water Supply per Capita (L/c/d)	—
		Supplement	Land Subsidence (cm/year)	—
		Supplement	Revenue on Water Tariff	—
	Entire Province	Supplement	Percentage of Population Served (%)	—

Source: JICA Survey Team based on Operation and Effect Indicators Reference (2nd edition)

Table 10.13-2 Monitoring Indicators of the Project

Indicator	Method of establishing the indicator	Timing	Baseline (2013)	Target (2025*)
Water Supply Volume (m^3/d)	Maximum daily water supply volume = (the maximum volume among daily water supply volume in a year)	Yearly		100,000m^3/d (maximum capacity of the seawater desalination plant)
Rate of Facility Utilization (%)	Rate of Facility Utilization (maximum) = (maximum daily water supply volume)/ (capacity of the facility) × 100	Yearly		100% (maximum utilization rate)
Water Quality	TDS Concentration of each Reservoir	Yearly	1,852 -2,257 mg/L	Less than 1,500 mg/L

* : 2 years after completion of facilities in 2023.
Source: JICA survey team

10.14 Application of Japanese Technology

10.14.1 Components of Seawater Desalination Plant

To be constructed in the Project are the following as shown below. The potential for participation and winning the bid by Japanese companies are evaluated and are shown in italics and are also described:

(1) Sea water desalination plant

1) Pre-treatment facility

2) RO membrane

3) High pressure pump

4) Energy recovery equipment

5) Control system

6) Desalination system design and construction

(2) Sea water intake, discharge facility

1) Pipe material

2) Construction of marine facilities

(3) Produced water distribution system

1) Transmission pump

2) Transmission pipe material, installation works

3) Construction of reservoir

4) Transmission pipe management system

(4) Power receiving system

10.14.2 RO Membrane

Until the 1990s, RO membranes of the hollow fibre and spiral types were competitive in the RO membrane market of the world. Thereafter, the shape of the spiral was unified, providing better safety features to the users. In Tunisia, existing desalination plants operated by SONEDE are all polyamide-based spiral type.

A 90% of RO membrane market is controlled by Japanese companies, such as Toray and Nitto Denko Corporation, and U.S. companies, such as Dow and Hydranautics, a subsidiary of Nitto Denko Corporation. Recently, Korean and Chinese companies have entered the business but their market share is not significant.

Sorek seawater desalination plant (514,000 m^3/d) in Israel is the largest in the world. In this plant, the product of Dow and Hydranautics has been installed. Before construction of this plant, Magta sea water desalination plant (500,000 m^3/d) in Algeria was the largest in the world. In the Magta plant, the RO membrane of Toray was also installed. Toray's product was installed at sea water desalination plant of TIFERT (fertilizer company) located at Skhira, south of the project site. This is only plant in Tunisia, which uses seawater for desalination, and Toray's RO membrane is functioning very well.

As mentioned above, Japanese-made RO membranes have been used out of Japan including Tunisia, and have been installed in large-scale plants. The potential of using Japanese-made RO membranes is huge.

10.14.3 High Pressure Pump

There are three well-known high pressure pump manufacturers - KSB (Germany), Sulzer (Germany), and

Torishima Pump Mfg. (Japan). In addition, Ebara Corporation (Japan), Grundfos (Denmark), and Calder (England) also have global market share, although to a lesser degree.

Torishima Pump Mfg. manufactures highly reliable products and has a dependable support system and is ranked as one of the top 10 plant manufactures in the world since the year 2000. Among large plants with capacities of more than 100,000 m^3/d, Torishima Pump Mfg. has 20 % share in the world market. In the Project, a capacity of one line is planned at 25,000 m^3/d. Therefore, a large high pressure pump should be selected based on the actual past operational experiences in such large plants.

10.14.4 Energy Recovery Equipment

A well-known type of the energy recovery equipment is the Pelton wheel method and the turbocharger method that is connected to high pressure pump axis. Recently the pressure exchange (PX) method has become popular due to higher efficiency. At the seawater desalination plant of TIFERT mentioned in section 5.1.2, the pressure exchange method was employed. As to manufacturers, ERI (USA, PX), Calder (USA, PX), and FEDCO (USA, turbocharger) have more experience than the others. Recently, Torishima Pump Mfg. cooperated with FEDCO and is now in the business field of energy recovery equipment. Also, Kubota Corporation (Japan) and DMW Corporation (Dengyosha, Japan) have been developing the PX method energy recovery equipment. Thus Japanese manufacturers have the competitive recovery equipment products.

The following is a newsletter of GWI (Global Water Intelligence) which introduces the world's top suppliers objectively in above three fields. As for Japanese manufacturers, Toray and Torishima Pump Mfg. are mentioned (Figure 10.14-1).

Published 10th June 2010

Insight from Christopher Gasson, GWI publisher

Should desalination plant suppliers concentrate more on differentiating their product offerings? It is a question I raised in yesterday's Global Water Market 2011 webinar, and one which deserves closer investigation.

The theory is that the market may take a couple of years to regain its 2007 peak, during which time there will be too many contractors looking for too little work. The problem for most of them is that they all use the same equipment suppliers: membranes from Dow, Hydranautics or Toray, energy recovery devices from ERI, Fedco or Calder, pumps from KSB, Sulzer, or Torishima. The scope for differentiation is limited.

The market leaders – Degrémont, Veolia, Befesa, Acciona and IDE – all build great plants, but how different are the plants that each of them builds? My guess is that in order to increase their market share, desalters are going to have to

Source: News letter of GWI

Figure 10.14-1 Main Manufactures in Market of Desalination Plant

10.14.5 Plant Manufacturers

The following plant manufacturers can design and construct the desalination system using RO membrane, and have experience in the surrounding area.

i) IDE (Israel): construction of Sorek seawater desalination plant in Israel, the largest desalination plant in the world
ii) Hyflux (Singapore): construction of Magta seawater desalination plant in Algeria, similar to the Sorek seawater desalination plant
iii) GE (USA, former INONICS): construction of seawater desalination plant of TIFERT by JV with EPPM, an engineering company of Tunisia
iv) Veolia (France), Degremont (France), Acciona (Spain), Befesa (Spain): experience in the Mediterranean region

The following is a summary of Japanese manufacturers.

i) Mitsubishi Heavy Industries
Mitsubishi Heavy Industries has experience in desalination plant in Saudi Arabia. Metito (Dubai) is also constructing desalination plants in Medenin province and Gabes province, whose client is SONEDE. Metito is currently a subsidiary company of Mitsubishi Heavy Industries. This network and experience can be applied to the Project.
ii) Hitachi
Construction of seawater desalination plant at a production capacity of over 300,000m^3/d in India in the recent year.
iii) Suido Kiko Kaisha
Installation of small-scale desalination plant at Medenin province and Ben Guerdane province.
iv) Others
Kobelco Eco-Solutions, Toyo Engineering Corporation, Swing Corporation, and Hitachi Zosen Corporation have excellent technology for installation of desalination plant. However, they do not have comprehensive capacity to compete in terms of a desalination plant project.

10.14.6 Other Facilities

(1) Facilities at desalination plant

Pre-treatment facilities such as filters, tanks, low pressure pumps are produced without special technology. Therefore, Japanese manufacturers will not have a chance to participate the Project due to few advantages on pre-treatment facilities.

Toshiba Corporation and Yokogawa Electric Corporation install the operation control system of the plants. At the seawater desalination plant at Chatan, Okinawa (southern province of Japan), which is the first large scale desalination plant in Japan, the product of Toshiba Corporation was installed. Therefore, Toshiba Corporation can provide excellent control system under the plant manufacturers mentioned in section 10.14.5.

(2) Facility and construction of seawater intake and discharge

This field can be separated into pipe materials and construction. For pipe materials, HDPE pipe with a diameter of about 2,000 mm is recommended for installation in the seabed. There is no Japanese manufacturer which can produce such pipes.

For construction, contractors which have offices in Tunisia are competitive. There is a possibility of participation in the Project by Japanese major marine construction companies, such like Penta-Ocean Construction and Toa Corporation, and major general contractors, such like Taisei Corporation and Maeda Corporation. However, they do not have any experience in Tunisia. Therefore, it may be considered that Japanese contractors may decide to participate depending on the timing of bid and contents of bidding documents.

(3) Produced water transmission system

With regard to large capacity transmission pumps, in addition to manufacturers listed in 10.14.3, Japanese manufacturers, such like Kubota Corporation, Hitachi Corporation, and DMW Corporation have many experiences in Japan and abroad.

Ductile cast iron pipe is used for transmission pipes in the Project. Kubota Corporation is considered as one of the three top companies in the world. However, it is difficult to participate in the Project due to the estimated cost in Tunisia. In addition, manufacturers in EU have better advantage because the transportation cost is much lower than that from Japan. Therefore, it may be considered that Japanese companies may decide to participate if the bidding depending on the contents of bidding documents.

(4) Power receiving system

Japanese companies do not have an advantage for power receiving system due to the transportation cost. Therefore, Japanese companies have less possibility to participate in the Project.

CHAPTER 11

CONFIRMATION OF VIABILITY AND RISK ANALYSIS

CHAPTER 11 CONFIRMATION OF VIABILITY AND RISK ANALYSIS

The necessity for installing a seawater desalination plant installation was examined in Chapter 4. In constructing the plant, there are some issues on finance, the environment, and power supply. This chapter discusses these issues as well as mitigation of risks associated with the issues presented.

11.1 Concern about Financial Aspect

The initial costs in the construction of seawater desalination plant will be shouldered by the government of Tunisia. SONEDE is not required to consider the payment of the initial cost from its account, but the operation and maintenance cost shall be borne by SONEDE from its own revenue. The O&M cost of the desalination plant is higher compared with other common water treatment process. Without implementing measures to increase revenue, SONEDE will not able to shoulder the increased expenditure for operation and maintenance of the desalination plant.

Measures to increase revenue are; 1) increasing water tariff; 2) reducing non-revenue water ratio; and 3) increasing subsidy. Among these measures, it is only the first that is feasible at this time. For example the present NRW ratio is relatively low comparing with the one in developing countries so further reduction will entail continuous investment. Subsidy at this time is also not advisable as;

i) the government will shoulder the construction cost, and

ii) SONEDE has a responsibility to continue being a self-supporting and autonomous authority.

Therefore, the most applicable practical measure is to increase water tariff.

As described in the FIRR analysis, the water production cost from the seawater desalination plant is estimated at 1.013 TND/m^3. This is based on the water production cost of four existing desalination plants at Kerkennah Gabes, Djerba and Zarzis, as well as the investigated cost found out in this survey. The annual water production volume by this project is 36,500,000m^3/year or only about 6.7% of SONEDE's present production volume at 540,000,000m^3/year. SONEDE has applied the uniform water tariff rate to all users in the entire country. If all the customers of SONEDE cover the increased cost brought by this project, the required water tariff is 0.413 TND/m^3. The required increase will be approximately 0.031TND/m^3 or 8.1% of the present tariff. The percentage of the water tariff against the disposable income is 0.67% after the increase.

In 2014, SONEDE increased the tariff by 7%. There were, however, no serious complaints from customers. SONEDE has a plan to increase the tariff using the same rate annually in the next two years. With these increases, the operation and maintenance cost of the desalination plant constructed in this project can be covered by the net increase at 7% in next two years.

Generally it is said that the acceptable water tariff level is 4% of disposable income, which is 179TND/person/year based on the disposable income of 4,478TND/person/year in 2013. As shown in Table 11.1-1, 87% or more among the connections belongs to the category of 41-70 m^3/3 months. These customers pay less than 20 TND/3months or around 80TND/year, that is 45% of the acceptable tariff level mentioned above. Therefore, the increase falls under the acceptable level.

Table 11.1-1 Water and Sewerage Bills in Category

unit: TND

Category		No of connection (%)	Water consumption (%)	Average water consumption (m^3/3 months)	Tariff (TND)	Water tariff (%)	Sewerage tariff (%)	VAT (%)
Domestic	(0-20) m^3 /3 months	37.3%	8.0%	9	7.5	68.2%	19.5%	12.3%
	(21-40) m^3 /3 months	29.9%	21.0%	30	16.9	66.8%	21.1%	12.0%
	(41-70) m^3 /3 months	20.0%	23.6%	50	38.4	50.9%	39.9%	9.2%
	(71-100) m^3 /3 months	5.2%	10.1%	82	91.9	55.4%	34.6%	10.0%
	(101-150) m^3 /3 months	1.9%	5.3%	119	153.4	56.8%	33.0%	10.2%
	(151-500) m^3 /3 months	0.8%	4.1%	222	374.8	58.8%	30.7%	10.6%
	(501-+) m^3 /3 months	0.1%	2.3%	1264	2,244.2	57.9%	31.7%	10.4%
Central government		1.3%	6.2%	207	407.4	50.5%	40.4%	9.1%
Commerce + Local Government + others		2.9%	5.3%	78	119.0	40.9%	51.7%	7.4%
Industry		0.58%	7.6%	4995	9,841.3	52.2%	38.5%	9.4%
Tourism		0.06%	3.8%	2749	6,174.5	45.8%	45.9%	8.3%
Domestic, not connected		0.04%	2.7%	3154	555.0	84.7%	-	15.3%

Sources: RAPPORT DES STATISTIQUES ANNEE 2012

Note: Tariff is charged every three months.

11.2 Concern about Social and Environmental Aspect

There are two categories of environmental issues caused by the implementation of the project, i.e. concerns under the sea and on ground.

Since intake and discharge pipelines will be installed under the seabed, the pipe installation will directly impact the aquatic environment. Seagrasses are observed to grow by the seafront of the proposed site for the desalination plant, which means that other marine creatures inhabit the area. In the field investigation, no other remarkable sea creatures were observed except for the presence of seagrasses.

In the interview survey, the environmental authority responded there would be no particular concern, but the issue will still be clarified when the EIA will be implemented. Since the intake and the discharge pipelines will be installed under the seabed, the seagrasses' habitat will temporary be disturbed during the construction period. It is necessary to reduce the impacts during the construction work, and if required, transplanting of the seagrasses from the construction site will be done. After construction, the area will be restored to its original state.

The seawater desalination plant is to be installed at non-utilized open space facing the coast, so a big impact to the environment will not be expected. However, there will be vehicles for construction plying the roads. The transmission pipelines are to be installed along main roads for long distance, thus pipeline construction work will affect traffic conditions. Efforts will be taken to minimize the effect on traffic.

With the identification of impacts of the project and measures by the EIA, appropriate mitigation measures will be undertaken to lessen its adverse impacts.

11.3 Concern about Power Supply Aspect

Power demand of the proposed sea water desalination plant is assumed at 40MW in the final stage of the project. SONEDE inquired of STEG's availability to provide 40MW power supply, which requires the payment for a new power distribution system including a substation. STEG, however, orally answered to the JICA Survey team that 40 MW (150kV) power supply will be possible. It is expected that STEG will be able to supply the required power based on the following:

- Generating capacity: an increase at 1.51 times from 2007 to 2013
- Power sales: an increase at 1.28 times from 2007 to 2013
- Securing of power receiving capacity: reliable enough to secure the power receiving capacity due to the high voltage power receiving.
- Record of power failure: few records of power failure according to the investigation at the existing sea water desalination plants

As shown in Figure 2.2-6, the average increase in the power generation from 2007 to 2013 is 370MW. This increase exceeds 40MW or the power demand of the proposed seawater desalination plant. When an average rate of power demand (an annual average for hourly maximum power demand) is assumed at 90%, the annual power consumption of the proposed plant will approximately be 158 GWh. Compared to the present power sales of 563GWh in 2013 to water supply and sewage sector, it indicates that the project requires an unprecedented increase of power supply. It, however, can be seen in Figure 2.2-7 that the average power sales increase from 2007 to 2013 was 530 GWh, three times more than compared the power consumption of the proposed plant. The power demand of 40 MW is for the plant in final stage. Water production in Phase 1 is half of the production in final stage, so the power demand will be approximately half as well.

According to the reasons mentioned above, it is considered that STEG has the power supply capacity to meet the requirement of the proposed seawater desalination plant.

11.4 Concern about Delay of the Project

The implementation schedule of the project is prepared as follows:

- Pledge of the JICA ODA loan for the project: December 2015
- Loan Agreement: March 2016
- Start of Construction work after selection of consultants and contractors: October 2019
- Start of Operation: October 2022

If this schedule is delayed, water shortage in the Greater Sfax anticipated to occur from 2017 will be reality until the completion of the project. Furthermore, if completion is delayed by one year, it will affect the project by a decrease of the EIRR by 1.34%.

Besides the Saida Seawater Desalination Plant Construction Project, the first phase of the Saida Reservoir and Kalaa Kebira Reservoir & Water Treatment Plant projects is expected to be completed by 2020, while completion of the second phase will be by 2024. If these projects are delayed, water shortage in the Greater Sfax will be more serious because water to be supplied by the said project is more than that of the Sfax Seawater Desalination Plant.

11.5 Risks and Mitigation Measures

11.5.1 Financial Risks and Mitigation Measures

At present, Government of Tunisia is responsible for paying the initial investment cost of the project, while SONEDE will cover the operation and maintenance cost from its own revenue. Power, chemicals, and personnel, the major O&M costs, should be properly calculated and covered by the projected increase in the water tariff. Together with the tariff increase, there is also a need to review the operation and maintenance costs and operating expenses including outsourcing, enhancement of water-saving awareness, and the study on mitigation measures.

The risks are analysed on the financial and water tariff impacts by its resultant increase in the operation and maintenance cost when the project is implemented. Together with the risks, the mitigation measures are shown below, which make it necessary to:

i) Conduct a review of the costs involved in construction work, in having an effective organization structure and in the procurement for operation and maintenance, and

ii) Promote and gain public understanding for the tariff increase. According to the result of social survey, the customers showed dissatisfaction with the water supply service. The improvement of the value-added service, particularly water quality is the future challenge to obtain better customer satisfaction.

Table 11.5-1 Financial Risks and Mitigation Measures

Financial Risks	Cause of Risks	Mitigation Measures
Initial cost of sea water desalination facility	• Increase in construction cost	• Increase the burden of the government • Review of construction work
Operation and maintenance cost of sea water desalination facility	• Increase the amount of water supply due to the high unit cost production process	• Consideration of tariff increase • Review of the supplies and personnel expenses • Reduction of operating expenses, including the use of outsourcing • Decrease in the utilization rate of the high unit cost production process with water-saving[1]
Opposition of residents to the tariff increase	• Rapid rate increase	• Explanation to residents and public relations on a review on water tariff • Information to residents about the benefit on sea water desalination plant • Information to residents about water-saving

11.5.2 Socio-Environmental Risks and Mitigation Measures

The socio-environmental risks are those that have impact on the lives of residents during construction, and citizens' movements or legal actions if the construction of the desalination plant is opposed. Therefore, it is necessary to give proper and advance information on the project to the stakeholders and the local residents during the construction period. Regarding land acquisition, SONEDE has not had any serious problems in the past project. However, it is necessary to confirm the land ownership when the site for this project is selected.

The other risks related to environment are the approval process of EIA required by Tunisia, whether approval is delayed or is not given. Employing local consultants to study the EIA will be indispensable. In addition, the impact of the construction of the intake and the discharge pipeline to undersea environment should be fully studied during the detailed design to minimize effects during construction. It is also necessary to investigate the effect of the project on fishery activities especially on changes in the surrounding natural environment. If expected, the risk of these effects has to be eliminated at the earliest time.

The socio-environmental risks and mitigation measures are summarized in Table 11.5-2.

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[1] The operation rate of the Chatan Sea Water Desalination Plant in Okinawa, Japan with a capacity of 40,000 m^3/day was 25% on average for 10 years from when it started operation in 1997 to 2006. In 2011 it was 12.3%. The reasons of its low operation rate are; high power consumption at 6.17 kWh/m^3, and other water resource development after its completion.
Umi-no-nakamichi Nata Sea Water Desalination Plant in Fukuoka, Japan with a capacity of 50,000 m^3/day was 78% in 2011 due to drought of surface water and water shortage caused by other works. However, not only that year but also other years, the plant had high operation rate of 60% to 83%/ since the start of its operation in 2005. Though the high power consumption at 5.87 kWh/m^3,is much higher than that of the nearby Ushikubi Water Treatment Plant at 0.18 kWh/m^3, this plant keeps high operation rate because of lack of water supply capacity originated from surface water.

Table 11.5-2 Socio-Environmental Risks and Mitigation Measures

Socio-Environmental Risks	Cause of Risks	Mitigation Measures
Social impact • Impact on life of residents during construction • Legal action if the residents do not agree with the construction of the desalination plant	• Lack of social awareness for water supply development plan • Lack of public relations • Failure of negotiation • Impact on economic activities (For instance: impact of intake/discharge pipes to fishery activities, noise at pump station, traffic congestion caused by construction)	• Verification of the necessity of the project • Explanation to residents and public relations • Installation of transmission pipes or pump stations along roads, or public land avoiding residential areas, and technical and economic applicability • Securing sufficient budget for land acquisition
Impact on the natural environment • Non-approval of the EIA • Impact on the economic activities	• Impact of intake and discharge pipes on marine environment (change in salinity, change in current, excavation for pipe installation, etc.) • An increase in sewage by an increase in water supply, and pollution expansion at public waters	• Selection of the site with less or insignificant impact to marine environment • Optimization of design by simulating intake/discharge pipe operation • Verification of impact on economic activities with change in the natural environment • Promotion of sewerage development plan

11.5.3 Power Supply Risks and Mitigation Measures

As mentioned previously in Section 11.3, a sufficient power capacity must be secured. The risk next to the power capacity is power failures due to accidents. It is desirable not to have power failures in order to provide continuous water supply and to conserve the equipment at the desalination plant. Actually, there is hardly a record of power failures at the existing seawater desalination plants with two power receiving systems. Once there was an eight-hour power failure at Ben Guerdane plant due to single incoming power line. Although power failures depend on the season and time, these will not cause a complete shut-down of water supply because there are alternative water transmissions from different water sources. In addition, the reservoir has enough capacity in case of power failure. The capacity of the water tank at the desalination plant is designed for a hydraulic retention time of six hours in order to secure the transmission of water for a certain period. There are also emergency power generators installed at the transmission pump stations at the desalination plant, and reservoirs of PK11, PK10, and PK14. However, the emergency power generators are not installed for the desalination process equipment for the following reasons:

- As mentioned above, water is supplied continuously at a certain period if the transmission facilities are operated during the power failure.
- Large amount of investment for generators is required for operation of the desalination process because the desalination plant consumes a large amount of power.

Table 11.5-3 Power Supply Risks and Mitigation Measures

Power Supply Risks	Cause of Risks	Mitigation Measures
Power failure	• Lack of emergency generators • Accidents	• To intensify generating facilities (below: measures at the plant) • Two-line power receiving system • To receive power from high voltage line • To secure large capacity of production water tanks • To install standby generators for the transmission pumps.

11.5.4 Project Delay Risks and Mitigation Measures

There will be various causes for delay risk. Most probable case is the delays in processing various procedures shown in Table 10.7-1 and Figure 10.7-1. Furthermore, delays in getting approval from related authorities for the implementation of works, such as permission of road authorities for works in road premises can cause delay of the works. The project shall be implemented under the control of the PIU which will be established in SONEDE together with cooperation with related authorities. The PIU is expected to have strong leadership and approaches with related authorities for implementing the project without delay.

The risks and mitigation measures are summarized in Table 11.5-4.

Table 11.5-4 Project Delay Risks and Mitigation Measures

Risks of Delay of Implementation	Cause of Risks	Mitigation Measures
Delay in implementation of the Project	• Delay in establishment of PIU • Delay in making Loan Agreement • Delay in preparing Tender Documents • Delay in the approval of various procedures by HAICOP • Delay in Tender evaluations • Rupture of Tender • Delay in the concurrence in various procedures by JICA • Delay in land acquisition • Delay in the approval of implementation of works by related authorities • Delay in marine works due to bad weather.	• Strong leadership and approach to related authorities by PIU. • Secure sufficient number of PIU staff • Hire consultants • Preparation of appropriate and easily understandable tender documents. • Preparation of flexible construction plan.