LIFE Red Sea Project

Best Environmental Practices for Desalination Plants in the South Red Sea Region of Egypt

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DISCLAIMER

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ACRONYMS AND ABBREVIATIONS

cm/s	Centimeters per second
m^3/y	Cubic meters per year
BGW	Brackish Ground Water
BOO	Build–Own–Operate
BOOT	Build–Own–Operate–Transfer
CAA	Competent Administrative Authority
DO	Dissolved Oxygen
ED	Electrodialysis
EDR	Electrodialysis Reversed
EEAA	Egyptian Environmental Affairs Agency
EEPP	Egyptian Environmental Policy Project
EIAS	Environmental Impact Assessment Study
g/L	Grams per liter
IPP	Power Supply System
LIFE	Livelihood and Income from the Environment
LRS	LIFE Red Sea Project
MED	Multi – Effect Distillation
MF	Micro Filtration
MGD	Million gallons per day
MSF	Multi – Stage Flash Distillation
MVC	Model-view-controller
NF – SWRO	Nano Filtration/Sea Water Reverse Osmosis
NF	Nano Filtration
NGOs	Non-governmental Organizations
O&M	Operation and maintenance
ppm	Part per million
psia	Absolute pressure per square inch
RO	Reverse Osmosis
RSG	Red Sea Governorate
SIS	Egyptian State Information Service
SPA	Shore Protection Authority
SWRO	Sea Water Reverse Osmosis
TDS	Total Dissolved Solid Solids
TSS	Total Suspended Solids
USAID	United States Agency for International Development
UV	Ultra Violet

LIST OF CHEMICALS

$NaHSO_3$	Sodium bisulfite
Cl_2	Chlorine gas
$Al_2(SO_4)_3$	Aluminum sulfates
NaCl	Sodium chloride
Na_2CO_3	Sodium carbonate
$NaHCO_3$	Sodium bicarbonate
NH_4Cl	Ammonium chloride
$CaSO_3$	Calcium sulfite
$C_{10}H_{16}N_2O_8$	EDTA/ethyl-carboxymethyl amino acetic acid
UPVC	Ultra poly vinyl chloride
$CaCO_3$	Calcium carbonate
$Mg(OH)_2$	Magnesium hydroxide
$CaCO_3$	Calcium carbonate
Na_2SO_4	Sodium sulfate
Na_2CO_3	Sodium carbonate
KCl	Potassium chloride
$MgCl_2$	Magnesium chloride
$CaSO_4$	Calcium sulfate
$NaHCO_3$	Sodium hydrocarbonate
VOC	Volatile organic compound
SO_x	Sulfur oxides
NO	Nitrogen oxides
CO_2	Carbon dioxide

PREFACE

In Egypt, many tourism areas and activities are located on the Red Sea. Tourism in the Red Sea is a flourishing industry with increasing capacity, as the region attracts tourists with its attractive natural and climactic conditions throughout the year. Most of the tourism areas on the coast meet fresh water requirements through desalination of seawater and or brackish groundwater (beach wells).

For sustainable tourism development in the region, there is a need to establish desalination plants to provide the necessary water for the future development

In order to avoid unsustainable development, coastal area desalination activity should be integrated in management plans that regulate the use of water resources and desalination technology on a regional scale. The potential environmental impact of desalination projects needs to be evaluated. For specific developing coastal areas on the Red Sea, the desalination plant could be established in different phases, using stepped modules (expandable capacity) in accordance with the scheduled tourism development strategy to secure fresh water for tourists projects.

This report is composed of the following sections:

SECTION 1: RED SEA REGION CHARACTERISTICS

This includes a brief presentation of:

- Geomorphology
- Climatology
- Sea water salinity
- Biological diversity
- Hydrodynamic features
- Protectorates
- Aquifer
- Environmental situation

SECTION 2: DESALINATION PLANT TECHNOLOGIES

The study includes an introduction to different desalination technologies with emphasis on the most used technologies—Multi-stage Flash Distillation (MSF) and Reverse Osmosis (RO) with the new trend of using Nano Filtration (NF) to increase the percentage of water recovery.

The study compares different technologies and their limitations, cost, output, and their advantages and disadvantages.

SECTION 3: DESALINATION PLANT BRINE WATER DISPOSAL

The study presents the different disposal alternatives used for brine water disposal, with a focus on features of each method and its main applications. The advantage and disadvantage of each method are outlined, as are their design features and precautions in implementation.

The most common methods are:

- Deep well injection.
- Evaporating ponds.
- Disposal into the sea.

SECTION 4: CRITERIA FOR DESALINATION PLANT SITE LOCATION

The study presents the factors influencing location of desalination plants. The role and the importance of each factor are discussed.

SECTION 5: ENVIROMENTAL ASPECT OF DESALINATION PLANTS

An overview of the environmental impacts of desalination plants on the following are discussed:

- Air pollution
- Acoustic disturbance
- Water quality and marine life
- Brine disposal into the sea
- Brine disposal to inland bodies (deep well injection and evaporating ponds)

Mitigation measures and the environmental impact assessment study are reviewed .

SECTION 6: RECOMMENDATIONS

APPENDIX: ENVIROMENTAL SCREEN FORM B

EXECUTIVE SUMMARY

In Egypt many of the tourism areas and activities are located in the Red Sea region. Tourism is a flourishing industry with increasing capacity, as the Red Sea region attracts tourists due to its fascinating nature and climactic conditions throughout the year .

Most of the tourism areas on the coast of the Red Sea meet their fresh water requirements through the desalination of seawater and/or brackish groundwater (beach wells). In addition, most Red Sea coastal towns have desalination plants.

For sustainable tourism development in the region, there is a need to establish desalination plants to provide the necessary water demands for future development. Currently, the desalination process is becoming less costly due to the technological advances in plant design. Several desalination technologies are used worldwide to produce fresh water; the most popular among them are Reverse Osmosis (RO) technology and the Multi-stage Flash/Distillation (MSF) technology.

The RO technology is the most suitable as it is relatively less costly compared with the MSF, especially for water salt concentrations of less than 100 grams per liter (g/L). The use of Nano- Filtration (NF) with desalination technology increases the percentage recovery, especially when used with the RO system.

The environmental impact of brine water disposal is one of the major issue in operating the desalination plants. The main methods used for brine water disposals are to return the brine to the sea, to inject it into deep wells, or to pump it to evaporating ponds. Each method has its limitations of application and advantages and disadvantages.

The cost of the brine water disposal is approximately 5–33 percent of the cost of the desalination plant. The disposal cost depends on the characteristics of the reject brine, the level of treatment before disposal, the volume of the brine to be disposed, the method of disposal, and its environmental impact.

Desalination plants are viewed as factory-like construction, eliciting a negative reaction from the population, communities, and environment. The choice of desalination plant site location must be carefully studied in accordance with regional development plans.

The site selection process often results in an evaluation of two or more possible sites. The final choice can be made by performing a cost study that addresses the cost of land, availability of water, proximity to a power supply, water network connections, transportation, and proximity to the brine disposal point. Suitability of site topographical and geological features (soil investigation) has to be considered in case of brine disposal in deep injection wells and/or evaporating ponds, while in the case of seawater discharge, the environmental impact of brine water on marine life is the controlling factor.

After carrying out site selection studies for a number of sites, an environmental impact assessment study (EIAS) must be carried out for any site being considered. This study covers environmental parameters and criteria to evaluate their impact on the air, land, and marine environments and propose measures to mitigate the impact.

The procedures followed in preparing the EIAS will follow Egyptian Law No. 4 for 1994, known as the Egyptian Environmental Law. Environmental Screening Form B is used.

Desalination and the environment need not be competitive—they should complement each other in a win–win situation.

The findings of the present study can be summarized in the following points:

- Desalination of saline water is essential for the development of Red Sea coast
- Salinity of sea water and beach wells in the area is suitable for operating RO and thermal desalination technologies
- RO is considered the most suitable technology in this area due to its lower power consumption—a plant can be operated using a normal electrical supply or a generator
- It is preferred to use intake water from beach wells to minimize the treatment of the intake water
- Thermal desalination plants could be used if the chosen site for the desalination plant is located besides a power plant
- Development activities in the Red Sea area should be managed to coincide with desalination plant capacity
- Installation of centralized desalination plants to serve new developments and resorts should be considered in establishing strategic management plans for the Red Sea region; individual plants can be allowed for isolated resorts.

Centralized desalination plants to serve a group of neighboring activities in a specific zone can be configured and implemented in module form to provide flexibility in increasing desalination capacity in steps, to keep up with increasing demand for fresh water. A water distribution network from the desalination plant is necessary.

As part of the strategic plan, private investors should be encouraged to invest in desalination stations to provide the required fresh water for development. Such projects may be implemented using Build–Own–Operate–Transfer (BOOT) contracts, where the contractor carries out the whole RO project for a pre-agreed contract period (often from 10–30 years). The investor is committed the total amount of the produced fresh water. At the end of the contract the whole project is transferred back to the investor.

- It is preferable to build an independent water production project inside a tourist project using Build–Owen–Operate (BOO) type of contracts, where the contractor (or the water company) is committed to cover the investor's water needs against special reduced price without consumption limitation while the contractor is allowed to sell excess water to others at higher prices. This system is successful in most cases. BOO projects can also be established outside tourism firms by special arrangements with authorities.
- It is recommended that the investor lodge the operation and maintenance (O&M) of the desalination plant with the contractor who constructed the RO plant or with a specialist firm. The O&M service contract would include chemicals, spare parts, and membrane replacements.
- The best brine disposal method depends mainly on the nature of the sea bed and of the site. This will decide whether brine will be disposed in the sea or on land. In case of brine disposal on land, land availability could play a role in selecting evaporating ponds with recovery of the deposited salt and reuse for industrial purpose.

- A scoped EIAS for desalination plants must be carried out and approved by EEAA before starting plant construction.
- A continuous assessment program of the status of Red Sea resources and environmental quality (sediment, water, and biota) should be established and used as a baseline while investigating the status of the marine environment.

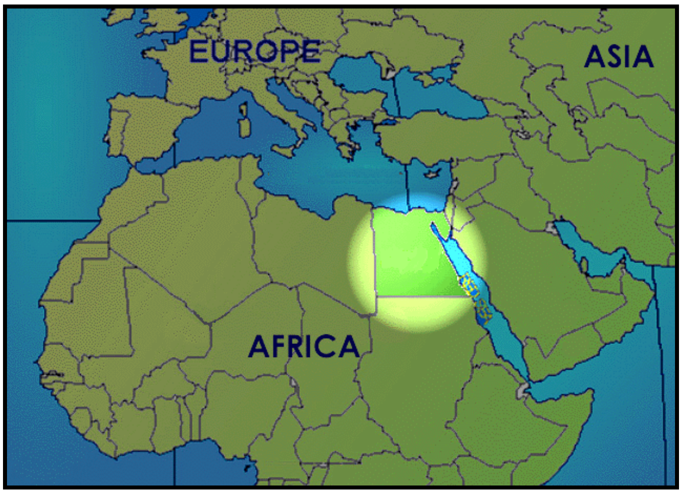
SECTION 1
CHARACTERISTICS OF THE RED SEA REGION

1.1. INTRODUCTION

Egypt lies in a semi-arid to arid region where most of its renewable fresh water is transported by the Nile River (Figure 1). The amount of deep groundwater in the sandstone aquifer is considerable, but the cost of pumping and conveyance are limiting factors. Scattered coastal winter rainfall contributes less than 1.5 billion cubic meters per year (m^3/y) on average.

Allocation of total water resources among agriculture, industry and domestic uses are within the ratio of 85, 9, and 6 percent respectively. Water per capita is about 900 m^3/y. Pollution is a serious threat to water deterioration. It is anticipated that by the year 2025, water per capita will drop to about 600m^3/y.

Figure 1 Location of Egypt

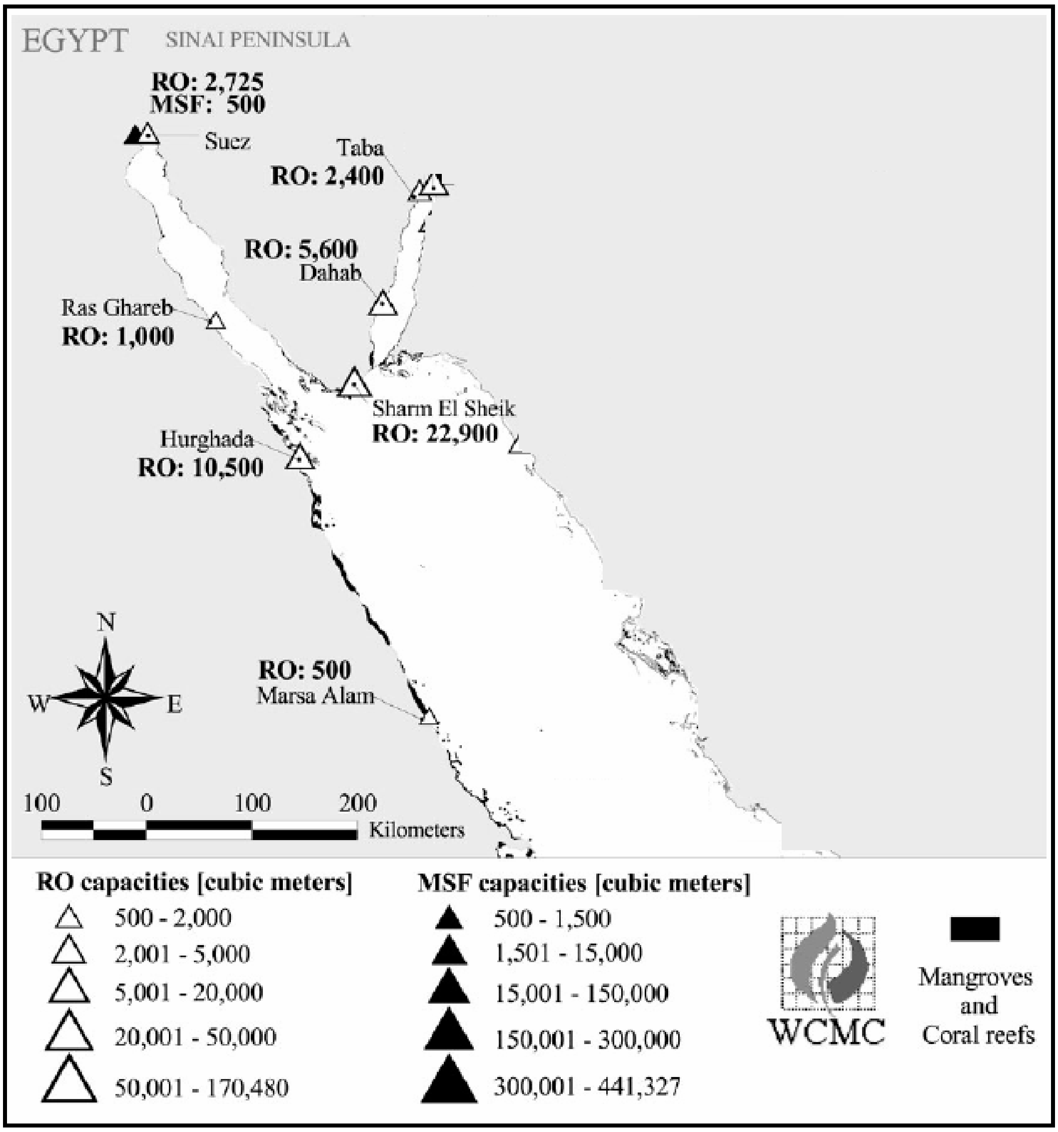


While the Upper Nile development projects are long-term plans, Egypt has to do more with a limited amount of fresh water. The immediate solution is to turn towards non-conventional sources such as water recycling, reuse of drainage water, treated industrial and sewage effluents, rainfall harvesting, and desalination.

Because of the distances between new development projects and the main sources of fresh water, together with the reduction in the cost of desalination, under site specific conditions desalination may be more feasible than water transportation. The cost of desalination, especially by RO, has moved from being expensive to competitive. For example, in 1948 the cost was more than US$1/$m^3$ total production cost, but now is about US$0.5/$m^3$ on average. Egypt's desalination experience began a with a large distillation pond for domestic uses in Helwan (South Cairo). In the mid-1970s, electrodialysis (ED) in remote areas, and recently RO became more common, attractive, and cost effective. Most of the private sector uses RO plants in resort areas located on the Red Sea (Figure 2).

Although desalination of seawater offers a range of human health, socioeconomic, and environmental benefits by providing a seemingly unlimited, constant supply of high-quality drinking water without impairing natural freshwater ecosystems, concerns are raised due to potential negative impacts.

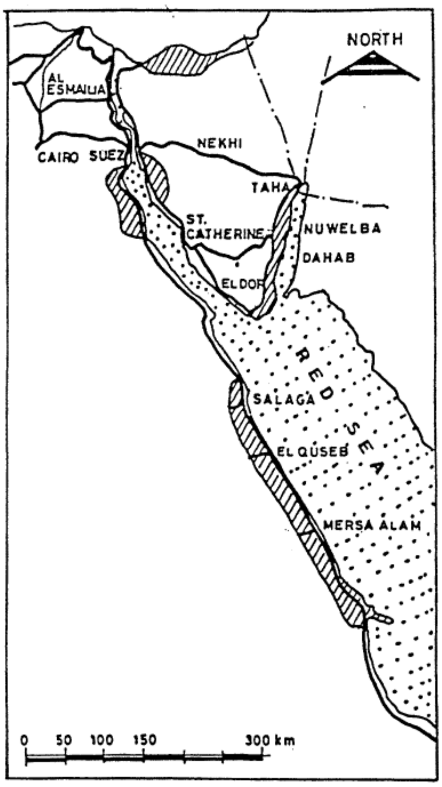
Figure 2 Locations of Multi-stage Flash Distillation (MSF) and Reverse Osmosis (RO) seawater desalination plants on the Egyptian Red Sea coast



Tourism development is considered to be one of the main development strategies for the Red Sea zone. Most tourism establishments on the coast meet their fresh water requirements through the desalination of sea water or brackish beach well ground water. In addition, most Red Sea coastal towns have their own desalination plants.

There is a great demand for fresh water in the Red Sea area to cope with planned development. The most extensive tourism development in the Red Sea has taken place in Egypt. Large sectors of the Egyptian coasts of the Red Sea, the Gulf of Aqaba and the Gulf of Suez have been developed into beach resorts. It is estimated that the Red Sea coast and the Gulf of Aqaba will attract more than one million tourists during the next years (Figure 3). Table 1 shows an estimate of the water demand in the Red Sea and South Sinai through the year 2020.

Figure 3 Expected tourist areas in Egypt



Note: Areas marked with diagonal lines (or hatches) are expected to be developed for tourist resorts.

Table 1 Assessment of fresh water demand and desalination capacity in the Red Sea and South Sinai[1]

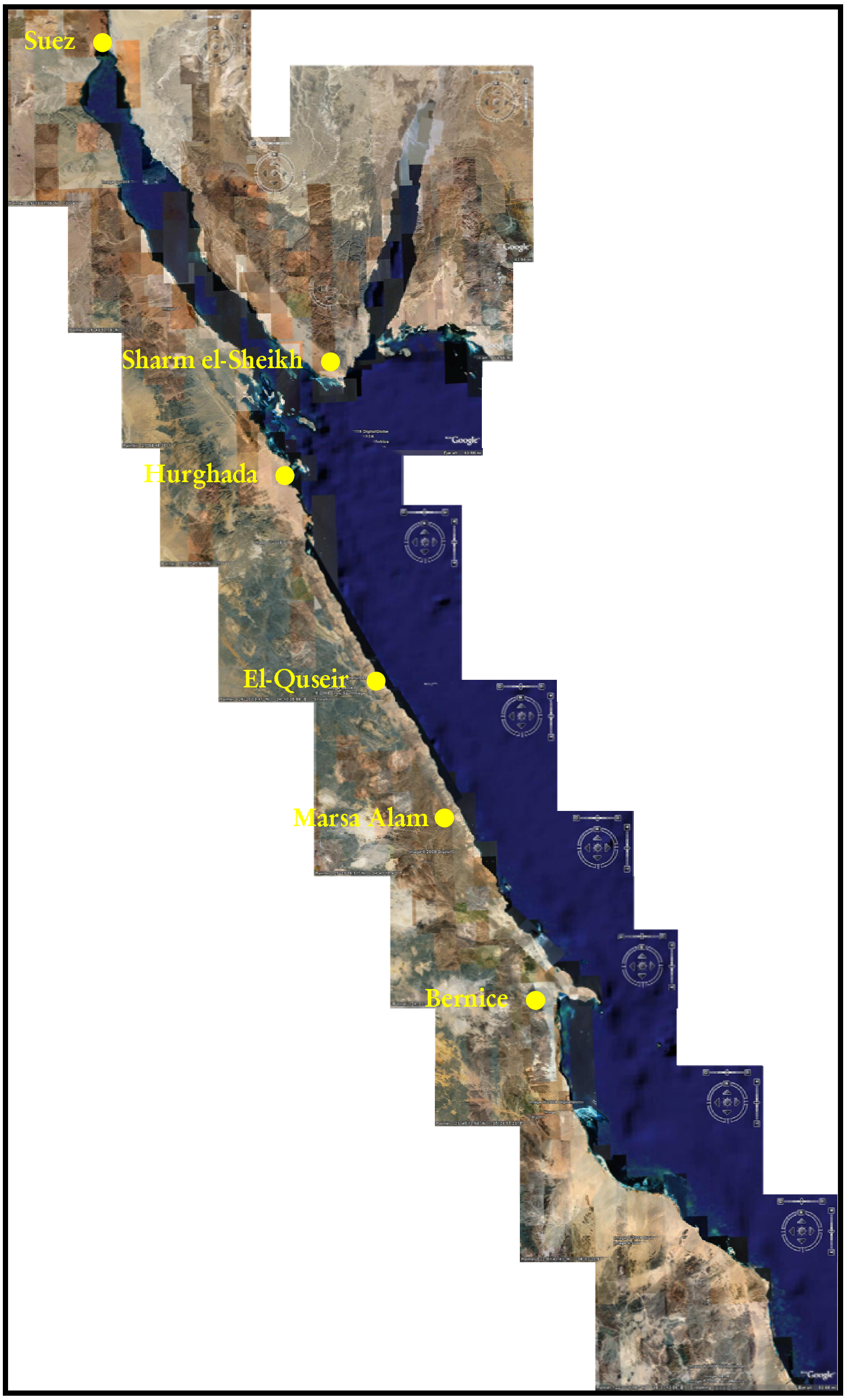
Year	2001		2020	
Fresh Water Resources	Red Sea Coast, m^3/d	South Sinai, m^3/d	Red Sea Coast, m^3/d	South Sinai, m^3/d
Nile water pipelines	80,000	0	140,000	30,000
Fresh groundwater	0	10,000	0	25,000
Seawater desalination	97,000	40,000	250,000	150,000
Estimated demand	500,000	125,000	1,000,000	600,000
Water shortage, m^3/d	323,000	75,000	610,000	395,000

Tourism in the Red Sea is a flourishing industry with ever-increasing capacity, as the Red Sea lures tourists with its fascinating nature and climatic conditions. The most extensive tourism development in the Red Sea coastal area has already taken place, with large sectors of the Egyptian coast developed into beach resorts (Figure 4).

[1] Azza, H, S. El-Manharawy, Economics of Seawater RO Desalination in the Red Sea Region, Desalination, 153 (2002) 335–347.

Tourism development may lead to a serious threat to both the marine environment and the tourism industry if not well planned and developed on a sound environmental basis with the effective enforcement of environmental regulations.

Figure 4 Red Sea Area (Google Earth Satellite Image)



Drawn by the attractive marine life and the favorable climate, a major tourist industry has evolved on the coasts of the Egyptian Red Sea. In order to manage a tourism development strategy and support the regional planning process, it is recommended that high-capacity

($>$20,000 m^3/d) Sea Water Reverse Osmosis (SWRO) desalination plants be established in phases that anticipate increasing capacity. A distribution network must also be established to allow the produced water to be transported from the desalination plant to the end user.

RED SEA REGION CHARACTERISTICS

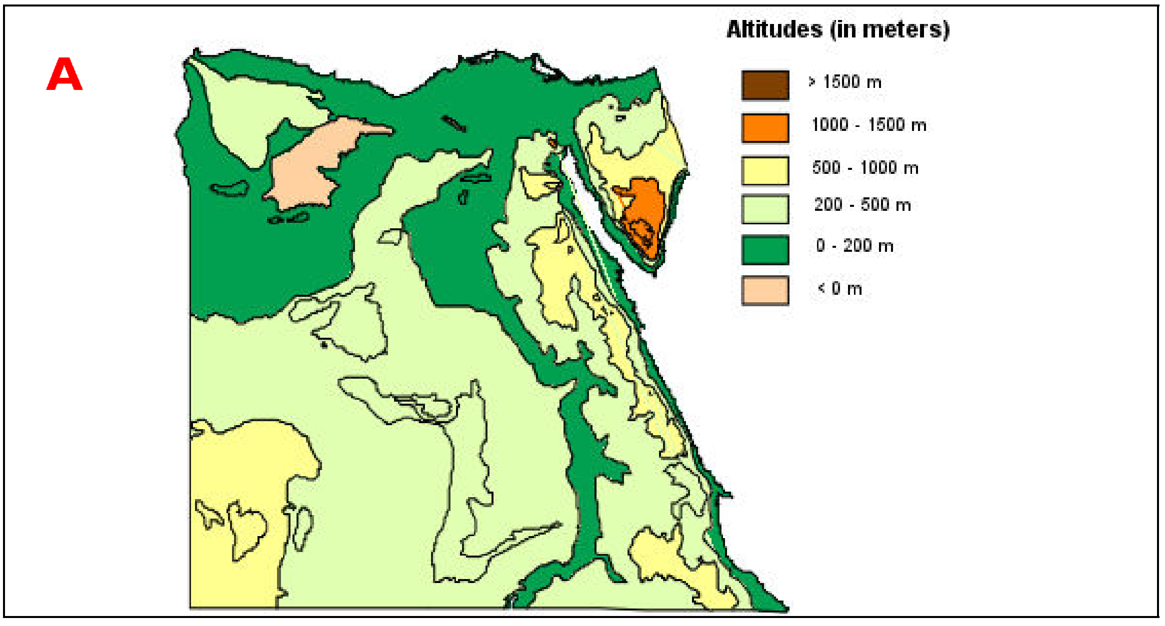
In order to design a management plan, project areas characteristics must be defined.

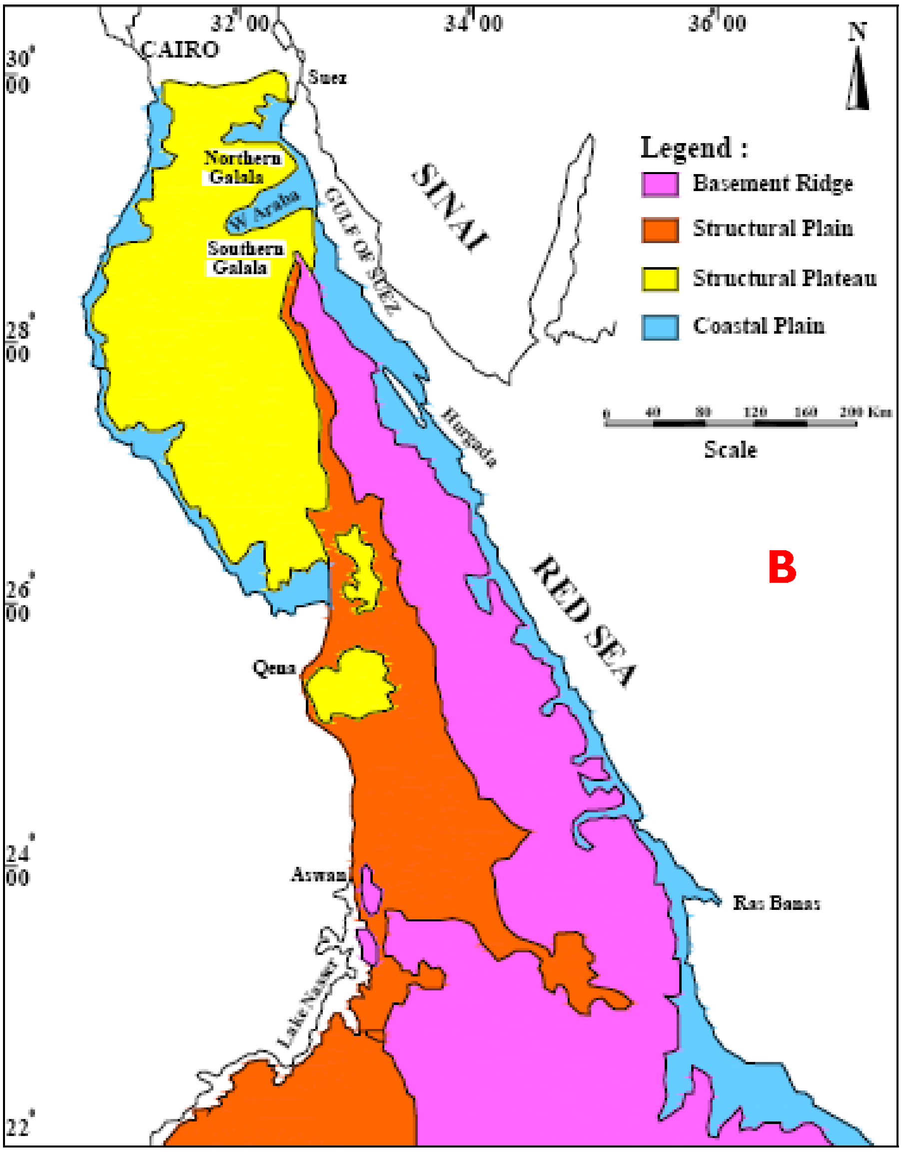
GEOMORPHOLOGY

The Red Sea is a long, narrow sea that extends from north to south over a distance of approximately 2,000 km. The northern tip of the Red Sea separates into two gulfs, the Gulf of Suez, which is connected to the Suez Canal, and the Gulf of Aqaba. The adjacent land area of the Red Sea is mostly arid, desert or semi-desert regions with no major river inflows. Further inland, the desert regions are bordered by extensive mountain ranges (Figure 5A and B).

The total length of the Egyptian Red Sea coast is about 1,705 km. Of this, 760 km is Red Sea coast and 945 km is the coastline of the Gulfs of Suez and Aqaba. Some industries are located along the Red Sea coast, in Hurghada, Safaga, and Quseir.

Figure 5 Geomorphology of Egypt (A) and the Red Sea Region (B)



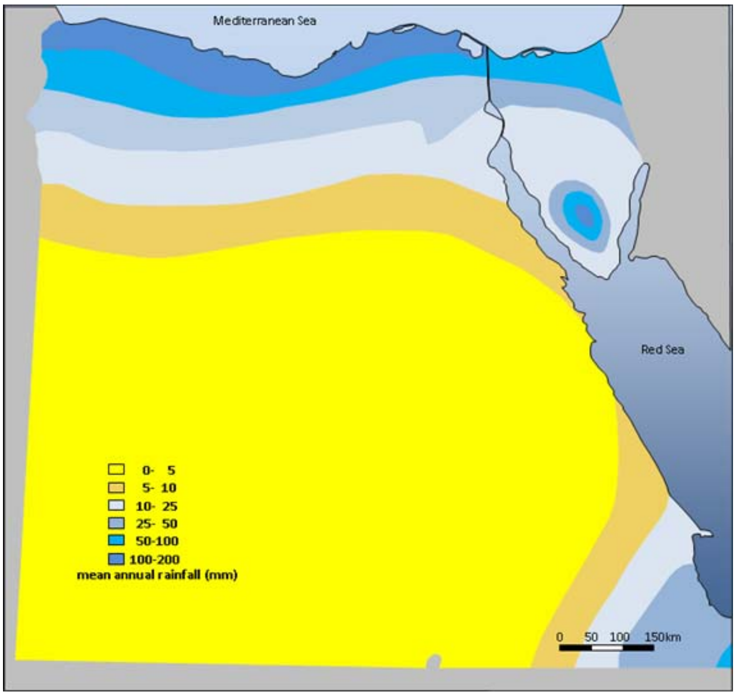


CLIMATOLOGY

The Egyptian Red Sea region is located in an arid zone with extremely hot weather in the summer. The air temperature in the northern region is in the range of 6 – 39°C at the Suez Canal and it is slightly warmer in the southern region, which has a range of 13 – 42°C along Shalateen coast.

Rainfall in the Red Sea region is extremely sparse and is usually localized in the form of short showers. The annual rainfall is in the range of 0 – 25mm (Figure 6).

Figure 6 Annual rainfall distribution in Egypt



SEAWATER SALINITY

Salinity in the Red Sea is generally high due to high evaporation, low precipitation, and the lack of a major river inflow. Salinity is usually lower in the southern region. Salinity in the north is around 41,000 parts per million (ppm) while in the south, it is 38,000 ppm.

BIOLOGICAL DIVERSITY

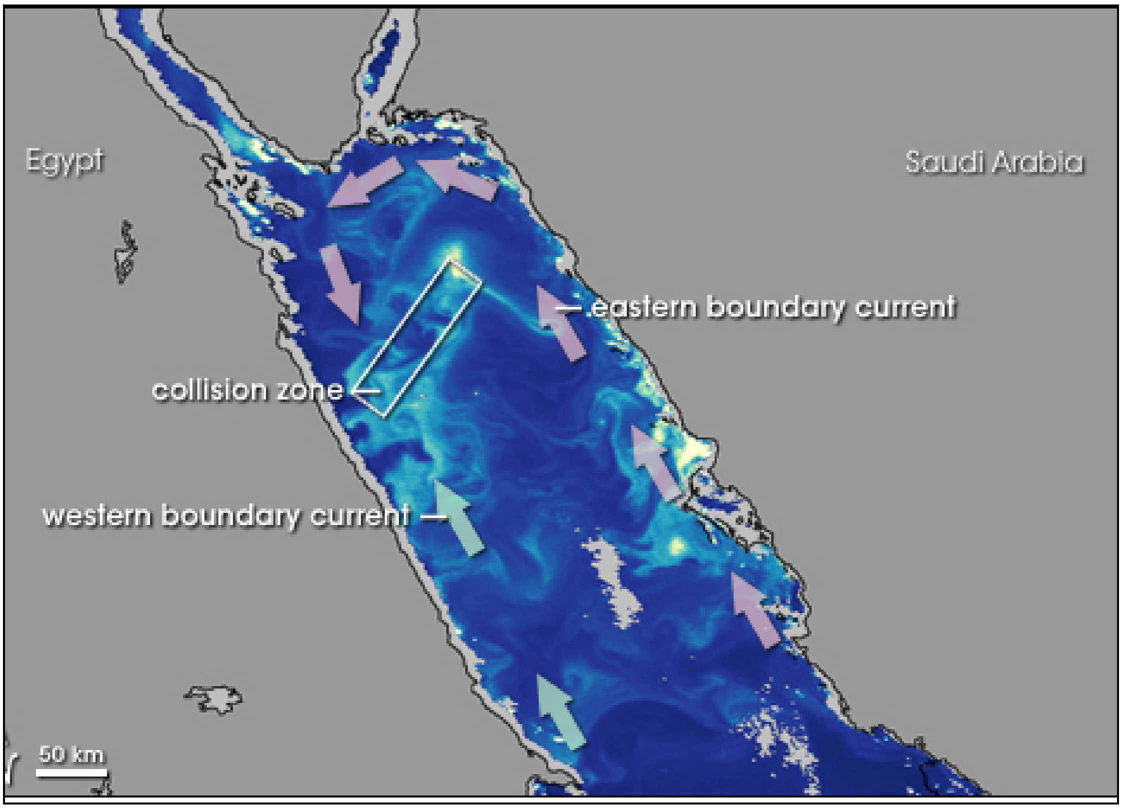
The Red Sea is characterized by coral reefs, which are mainly distributed along the tidal flats, reef slopes, and around the islands. They consist of both soft and hard corals. Corals are mainly found about 3–10 km offshore along a narrow bank, forming a large barrier reef structure that runs parallel to the coastline.

The Red Sea is blessed with natural beauty and astounding biological diversity. Beside coral reefs, there are mangrove forests, seagrass beds, salt marshes, and salt pans throughout the region. These unique habitats support a diverse range of marine life, including sea turtles, dugongs, dolphins, and many endemic fish species.

HYDRODYNAMIC FEATURES

Data about currents is lacking, partially because they are weak and variable both spatially and temporally. Temporal and spatial currents variation is as low as 0.5 m and are governed mostly by wind. In summer, northwest winds drive surface water south for about 4 months at a velocity of 15–20 centimeters per second (cm/s), whereas in winter the flow is reversed resulting in the inflow of water from the Gulf of Aden into the Red Sea. The net value of the latter predominates, resulting in an overall drift to the northern end of the Red Sea. Generally, the velocity of the tidal current is between 50–60 cm/s, with a maximum of 1 m/s at the mouth of the El-Kharrar Lagoon. However, the range of north–northeast current along the Saudi coast is 8–29 cm/s (Figure 7).

Figure 7 Red Sea Currents



PROTECTORATES

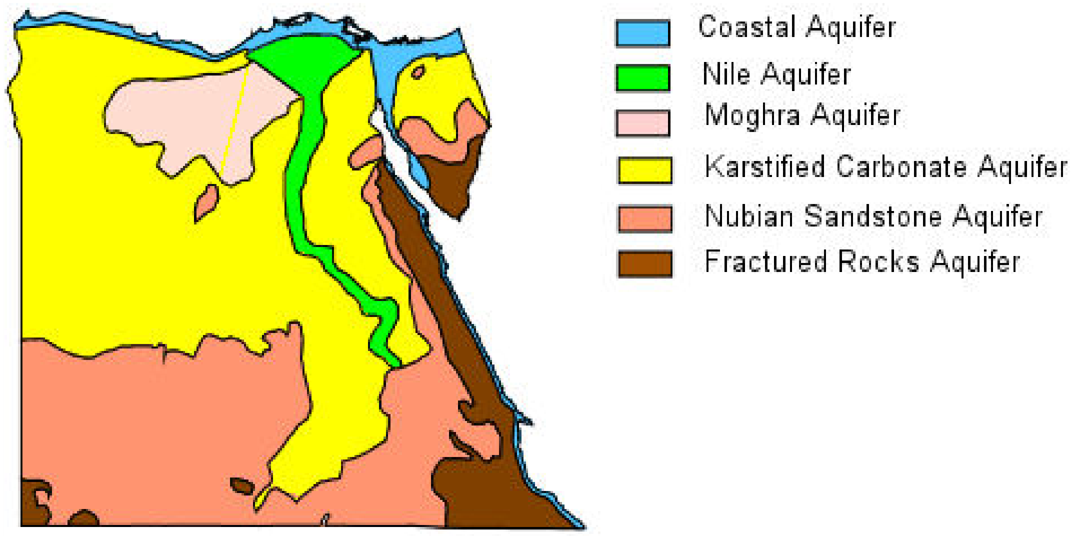
The Red Sea has several marine protected areas, the most well known being the Ras Mohammed National Park at the southern tip of Sinai Peninsula, and Hurghada and the adjacent islands.

AQUIFER

Aquifer systems are distributed throughout Egypt. The location of aquifers is shown in Figure 8. Five aquifer basin lay within the Red Sea region:

- Wadi deposits basin
- Nubian basin
- Coastal basin
- Carbonate basin
- Hard basement rocks

Figure 8 Geographic Distribution of Aquifer Systems



Nubian Sandstone

The Nubian Sandstone aquifer system is assigned to the Paleozoic–Mesozoic. It occupies a large area of the Western Desert, parts of the Eastern Desert, and Sinai. Groundwater can be found at very shallow depths, where the water bearing formation (horizon) is exposed; or at very large depths (up to 1,500 m), where the aquifer is semi-confined. The aquifer transmissivity is generally medium to low, varying from 1,000 – 4,000 m^3/day.

The Nubian Sandstone aquifer system contains a huge amount of non-renewable groundwater dating back to the rainy period that occurred from 25,000 – 40,000 years ago. Groundwater quality is generally good (< 500 ppm), except near the coastal regions and in Sinai. Groundwater recharge is limited (estimated at 500 million m^3/year) across the boundaries with Chad and Sudan.

Coastal Aquifer Systems

The Coastal aquifer systems are assigned to the Quaternary and Late Tertiary. They are found in the littoral zones along the Red Sea coasts in the form of scattered pockets.

Along the Gulf of Suez, the main formation consists of alluvial Quaternary deposits. Miocene sandstone and Nubian sandstone formations also act as local aquifers. Groundwater is generally brackish.

In the littoral area west of the Gulf of Suez, the strata of hydrogeological interest is the Miocene and the Nubian sandstone. Groundwater recharge occurs from local rainfall; while discharge takes place mainly through groundwater abstraction by wells.

In the littoral area of the Red Sea proper, the main strata of hydrogeological interest comprise the Quaternary and Late Tertiary sandstone. Locally, the fissured Upper Cretaceous and the Late Tertiary act as potential aquifers. Recharge is achieved mainly from local rainfall (Gebal Elba). Discharge, on the other hand, takes place in the form of groundwater flow (natural) and abstraction through manmade shallow wells

Fissured Carbonate Aquifer System

The Fissured Carbonate aquifer system is assigned to the Eocene and to the Upper Cretaceous. It predominates essentially in the north and middle parts of the Western Desert, covering about 50 percent of the surface area of the country. It overlies the Nubian sandstone, and underlies the Nile aquifer system.

The rocks consist of limestone, dolomite, chalk, and marl. Locally, they may include phosphate and shale intercalations. The formation of groundwater basins in the carbonate rocks is either a result of land and sea bed subsidence or a result of structural series of faults forming graben shapes favoring the deposition of other rocks and sediments.

Hard Rocks

Hard rocks are outcropping in Southern Sinai and the Eastern Desert. They consist of Precambrian igneous rocks and Mesozoic and Tertiary volcanic rocks. Very little is known about this aquifer system. However, it is expected that the occurrence of groundwater is restricted to fractures and fissures since the rock has no primary porosity. The permeability of the smaller fissures diminishes with depth. Hence, groundwater below about 100 m depth is only expected in large regional fractures. The aquifer is essentially recharged from its extension in Sudan, and, locally from rainfall in the Sinai.

Shallow groundwater is expected to be recharged either through seepage from *wadis* or by direct infiltration from rainfall. The volume of groundwater in storage is expected to be very limited, and quality is expected to show large variations.

Underground water related to the Red Sea is generally higher in salinity than sea water. This is due to the dominating underlying salt and evaporate formations. Salinity between 50,000 – 60,000 ppm is normally expected at depths more than 30 m

Groundwater Potential

Eastern Desert

Present developmental schemes are confined to shallow wells dug in *wadi* aquifer systems and desalination of groundwater. In 1984, total groundwater usage was estimated at about 5 million m^3/year; at present it is probably about 8 million m^3/year. There is potential for further development, especially based on the Nubian Sandstone aquifer, through deep wells (200–500 m) and in the large *wadis* that drain into the Nile Valley and Lake Nasser.

In addition to fresh groundwater, large amounts of brackish groundwater are expected to be available in the region. This requires proper assessment and prediction of possible changes in salinity as a result of development. One of the areas of special interest is the Red Sea coastal area, where a variety of aquifers are present. Signs of water availability are the flowing springs.

Sinai

In estimating the groundwater potential in Sinai, distinction is made between shallow groundwater in the Quaternary aquifer and deep groundwater in the Fissured Carbonate and Lower Cretaceous (Nubian Sandstone) aquifers, as summarized in Table 2.

The total present usage is about 90 million m^3/year. A large portion of the water is pumped from the Quaternary aquifer in the northern part of Sinai (El-Arish, Rafah, and Bir el-Abd). Most of the groundwater is slightly brackish and poses limitations on its use for potable supplies without further treatment. Fresh groundwater is mainly confined to the sand dunes, which are recharged from direct rainfall.

Table 2 Groundwater Potential in Sinai

Aquifer	Potential (million m^3/y)	Usage (million m^3/y)	Reserves (million m^3/y)	Development
Quaternary	81	83	0	102%
Carbonate	90	2	88	2%
Nubian Sandstone	40	5	35	12%
Total	211	90	123	42%

Groundwater salinity shows wide variations, with values often exceeding 1,000 ppm Total Dissolved Solids (TDS). At El-Arish and Rafah the usage has already exceeded the potential resulting in a continuous increase in salinity. In Bir el-Abd and Sahl el-Qaa, on the other hand, small reserves are still available provided the wells are properly sited.

Both the Carbonate and Sandstone aquifers can be developed, based on the amount of water in storage and recharge from rainfall. The major portion of available groundwater is found in middle Sinai.

1.2.8 ENVIRONMENTAL SITUATION

Although the Red Sea region has remained relatively free from pollution, the environment is currently under increasing threat from a wide range of human activities. In contrast to other regional seas around the world where most pollution comes from land-based activities, marine-based activities such as shipping and oil exploitation are becoming a significant source of marine pollution in the Red Sea.

Industrial effluents, in the form of thermal pollution from power and desalination plants, hyper saline brine water from desalination plants, particulate matter and mineral dust from fertilizer and cement factories, and chemicals and organic wastes from food processing factories have contributed to the degradation of water quality in the Red Sea.

Poorly treated or untreated sewage effluents from treatment plants, cargo vessels, tour boats, and ferries have damaged marine life in certain areas inside the Gulf of Aqaba and the Egyptian Red Sea coasts. Solid wastes such as plastics and other refuse materials are also commonly found on the beaches, reefs, and seagrass meadows of the Gulf of Aqaba.

In order to avoid unruly and unsustainable development of coastal areas, desalination activity should be integrated into management plans that regulate the use of water resources and desalination technology on a regional scale. In summary, the potential environmental impacts of desalination projects need to be evaluated, adverse effects mitigated as far as possible, and the remaining concerns balanced against the impacts of alternative water supplies and water management options, in order to safeguard a sustainable use of the technology.

SECTION 2
DESALINATION PLANT TECHNOLOGIES

Desalination systems are used to produce fresh water from saline water from the sea or brackish water from wells. The choice of the type of raw water feed for desalination plants is based on the nature of the region where the plant is installed.

As discussed in Section 1 of this report, there are beach wells in the Red Sea region that are extensively used for intake for most desalination plants in that region.

Brackish water contains much less salt than saline water or water from beach wells, as shown in Table 3. Technically, brackish water contains between 0.5–30 grams of salt per liter (part per thousand).

Table 3t Percentage of Salt in Various Types of Water

	Fresh Water	Brackish Water	Saline Water	Brine
Percentage of Salt	<0.5	0.5–35	35–50	>50
TDS(ppm)	<2500	2500–3000	3000–45000	>45000

Several desalination technologies are used worldwide to produce fresh water:

1. Reverse Osmosis (RO)
2. Multi-stage Flash Distillation (MSF)
3. Multi-effect Distillation (MED)
4. Electro-dialysis Reversed (EDR)
5. Freezing

Globally, RO and MSF technologies are the most commonly used. However, in the Red Sea region RO technology is used extensively and seems to be the most technically suitable, because of its compact modules, ease of operation and maintenance, and familiarity in the Egyptian market.

An economic comparison among the various desalination methods is shown in Table 4.

2.1 DESALINATION METHODS

2.1.1 REVERSE OSMOSIS

Stages of RO

A flowchart showing an RO-based desalination plant with energy recovery system is shown in Figure 9 and a typical assembly of the RO stage is shown in Figure 10.

Table 4 Production cost and average power consumption for different desalination technologies

Method	Specific Investment USD/m³/day	Production Cost USD/m³/day	Power Consumption KWhr/m³ (of Product Water)	Capacity (m³/d)	Percent Salinity	Percent Recovery	TDS in the Product Water (mg/l)
Brackish Water RO	500–600	0.23	1–1.3	50	0.5–35	55–60	~50
Sea Water RO	1,000–1,700	0.8–0.95	4.5–7	9,000	35–50	25–40	50–100
MSF	1,670	1.52	35	5,000–20,000	35–50	15–50	<10
MED	660–880	0.46–0.7	14	2,000–5,000	35–50	15–50	<10

Figure 9 Simplified RO System with Energy System

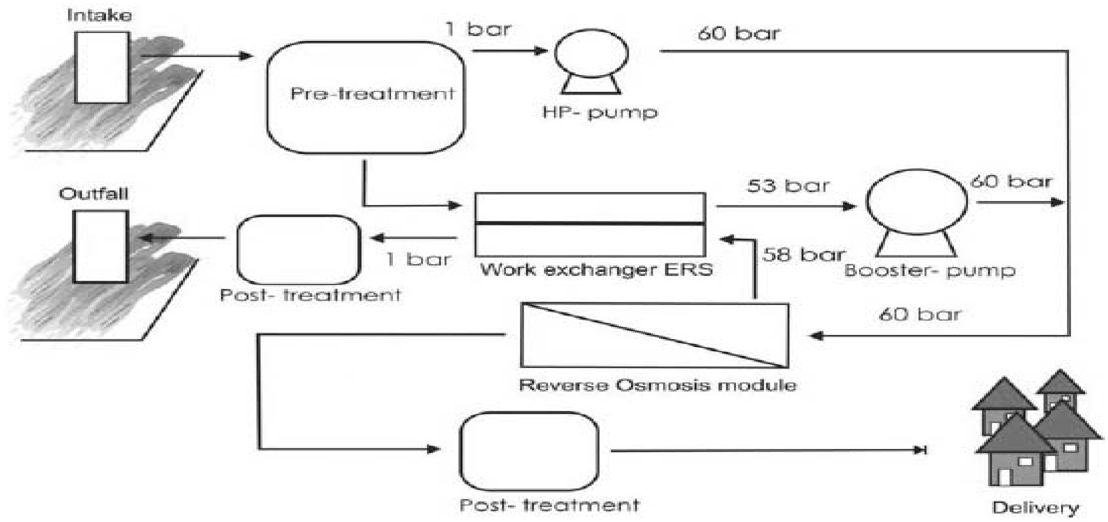
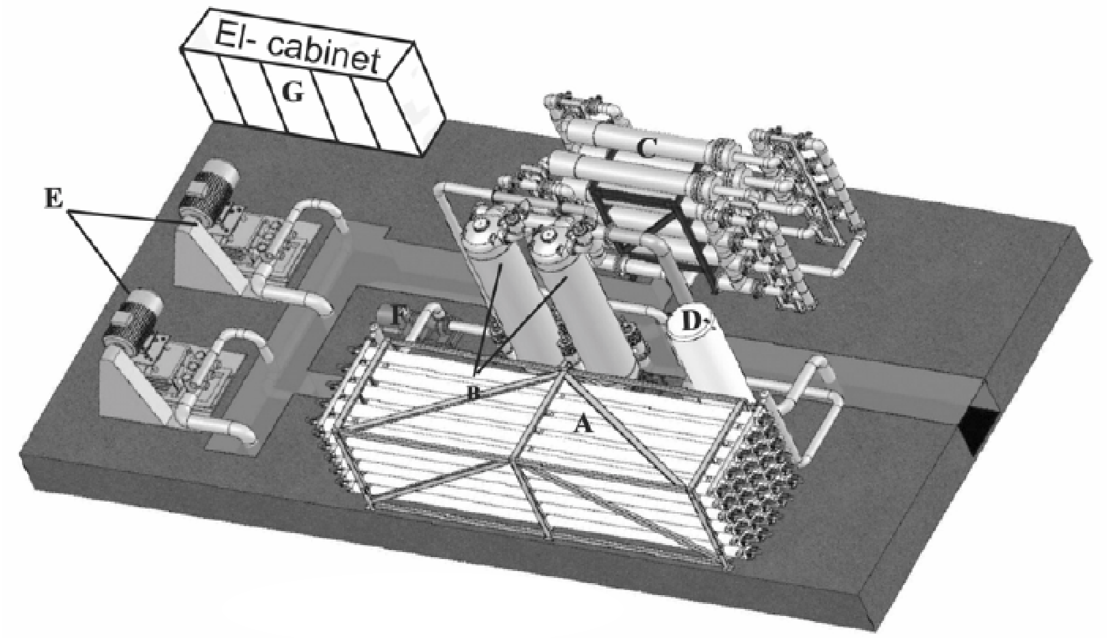


Figure 10 Typical RO Stage Installation



Key

A	Pressure vessel, membranes, and manifolds
B	Pressure recuperate towers
C	Bag filter
D	Seawater feeding tank
E	High pressure pump
F	Booster pump
G	Electro-cabinet

These stages can be described as:

Feed Water

The abstraction of feed water can be realized either through coast and beach wells or through open seawater intakes systems. Coast and beach wells provide better quality water with less turbidity (algae and TDS) than open seawater intakes, but require more space.

Pretreatment

Pretreatment is the conditioning of the feed water to make it compatible with the recommendation of the membrane manufacturer. Pretreatment is needed if certain materials in water are known to harm the membranes, whether by sticking to their surface resulting in fouling, by disintegrating them specially due to high or low values of pH, for example, or removing ozone to reduce oxidant fouling by using an oxidant scavenger such as sodium bisulfite.

Good pretreatment should protect the membranes against the bacterial growth that might take place in the feed water by using chlorine gas (C^{l2}). Another part of pretreatment is the coagulation using alum (aluminum sulfates: A^{l2} $[SO^4]^3$) and pretreatment filtration such as micro-filtration (MF) or nano-filtration (NF), where most suspended materials are removed from the feed water.

NF usually removes particles with a diameter between 0.01μm and 0.001μm, and is used for the removal of other substances from a water source as well. It is also commonly used for the desalination of water. NF pretreatment of seawater to desalination plants:

- Prevents SWRO membrane fouling by the removal of turbidity and bacteria
- Prevents scaling in both SWRO and MSF by removing up to 93 percent of scale-forming substances
- Lowers required pressure to operate an SWRO plant by reducing seawater feed TDS by 30–60 percent, depending on the type of NF membrane and the operating conditions.

The net effect of the this NF pretreatment is an increase of 50–100 percent in SWRO potable water yield by increasing percent recovery from 20–40 percent over water feed without NF pretreatment, and 60–70 percent with NF feed pretreatment. In MSF facilities, this NF pretreatment increases water yield by 30–40 percent over water that is not pretreated. By using NF pretreatment, the percent recovery increases from 60–70 percent and the maximum percent recovery is achieved by combination of SWRO and MSF, using NF pretreatment (70–90 percent) as shown in Figure 11. NF pretreatment is expected to lower water costs by about 30 percent.

In view of the positive and encouraging results obtained so far, the dual NF–SWRO desalination system is being applied to a commercial plant by adding NF and two additional types of pretreatment filtration (gravity filtration to remove coarse particles and pressure filtration to remove finer particles) to the existing SWRO unit, as shown in Figure 12.

Figure 11 Limitation in present recovery from sea water feed

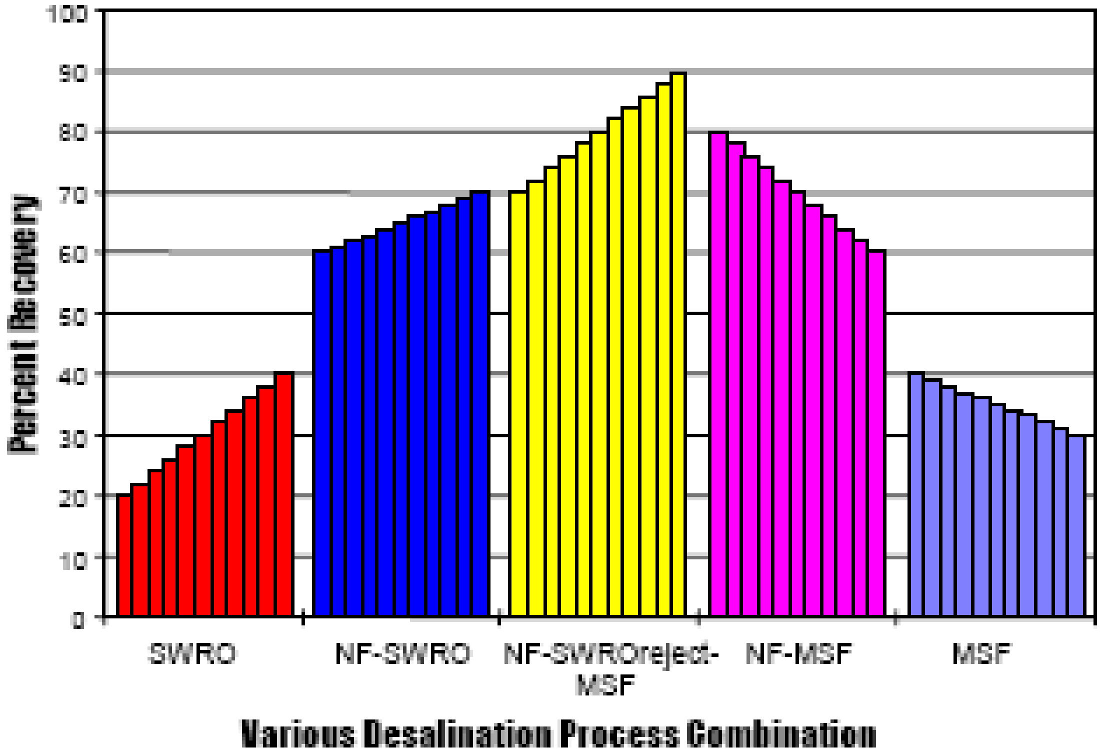
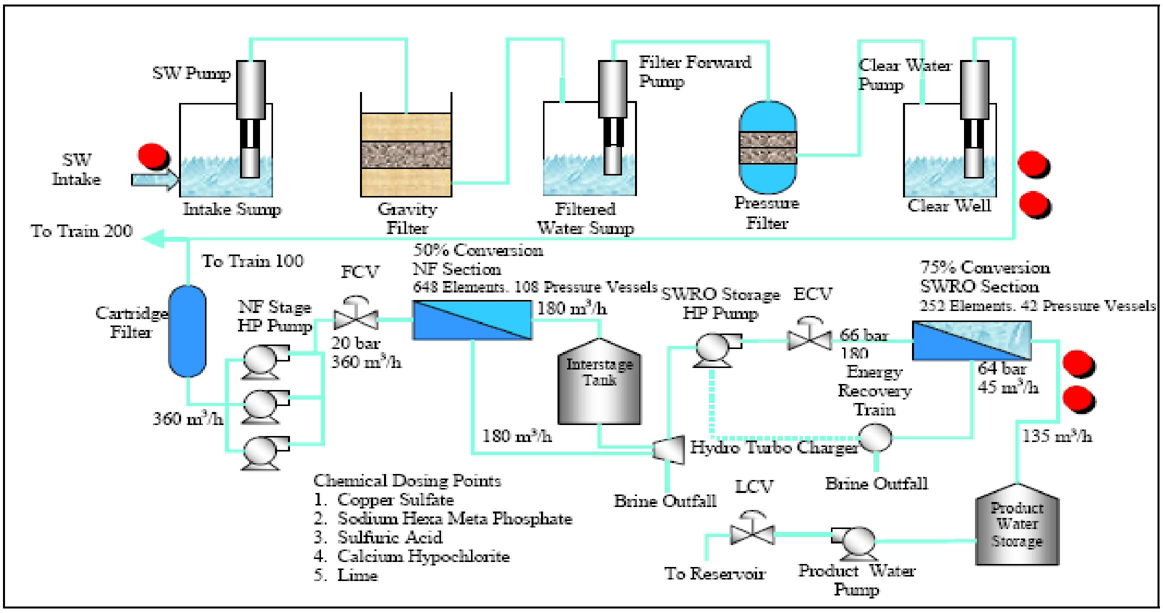


Figure 12 SWRO plant flow diagram with NF in pretreatment system



High-pressure Pumping

A high pressure pump is needed to force the feed water through the membrane, rejecting the salt. The applied pressure ranges are:

- 15–25 bar (225–375 absolute pressure per square inch [psia]) for brackish water
- 54–80 bar (800–1180 psia) for seawater

Membrane Assembly

The membrane assembly consists of a pressure vessel and a semi-permeable membrane that permits the fresh water to be pressurized against it and reject the salts. The semi-permeable membranes vary in their ability to pass fresh water and reject the passage of salts, usually rejecting particles with a diameter between 0.001μm–0.0001 μm.

The spiral-wound configuration usually used with SWRO desalination and the hollow fiber configuration is used in BWRO desalination.

Post-treatment

Post-treatment is used to achieve required product quality. It may include pH adjustment, disinfection using: C^{l2} or ozone, and the addition of calcium salts, which are deposited on pipelines to protect them from corrosion.

Energy Recovery System

The energy recovery system is responsible for the transfer of potential energy from the concentrate to the feed. Current energy recovery systems such as work exchangers operate with efficiencies of up to 96 percent.

Control System

The control system maintains continuous and reliable production.

Waste Discharge from RO

- Liquid waste containing:
  - High salt concentration
  - Defouling chemicals from equipment
- Brine disposal to:
  - Deep injection wells
  - Evaporation ponds
  - The Sea
- Small amounts of solid waste:
  - Spent chemicals from the pretreatment filters
  - Solid particles filtered in the pretreatment stage.

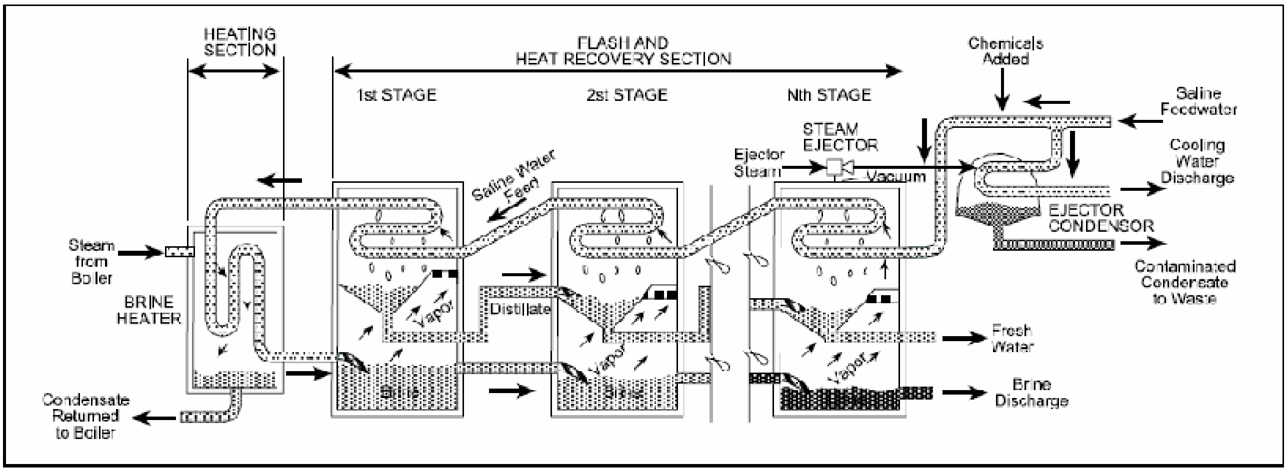
Thermal Desalination (MSF and MED)

Thermal desalination separates salt from water through evaporation and condensation. There are two concepts of distillation successful in locations around the world: MSF and MEF.

Multi-stage Flash Distillation (Seawater Feed)

The MSF process is illustrated in Figure 13. In this process, seawater is heated to the boiling point in the brine heater then introduced into a vessel at reduced pressure called stages causing the water to boil rapidly, flashing into steam. The steam vapor generated by flashing is converted to fresh water by being condensed on heat exchanger tubes that run through each stage. Tubes are cooled by the feed water going to the brine heater. MSF units are built in units from 4,000–57,000 m^3/day.

Figure 13 Multi-stage Flash Distillation (MSF) process

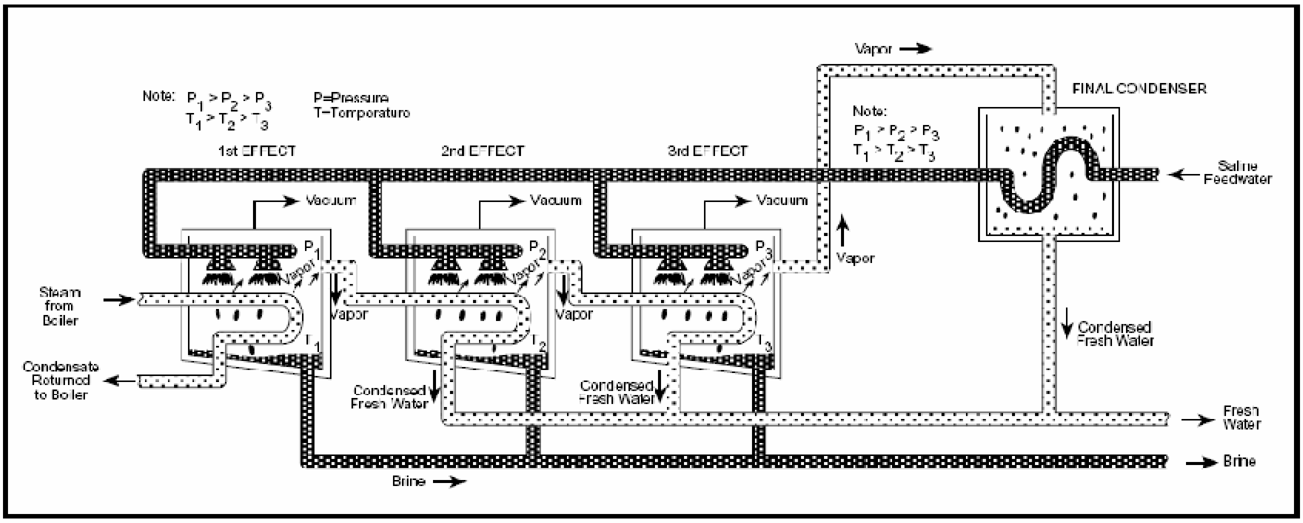


Multi-effect Distillation (Seawater Feed)

MED, as shown in Figure 13, takes place in a series of vessels (effects) and uses the principles of condensation and evaporation at reduced ambient pressure in the various effects. This permits the seawater feed to boil without the need to supply additional heat after the first effect. In general, an effect consists of a vessel, a heat exchanger, and devices for transporting the various fluids between the effects. Adding feed water in equal portions to the various effects is the most common. The feed water is sprayed onto the surface of the evaporator surface (usually tubes) in a thin film to promote rapid boiling and evaporation. All steam condensed inside the effects is the source of the fresh water product.

The ambient pressure in the various effects in the MED process is maintained by a separate vacuum system. The thermal efficiency of the process depends on the number of effects with 8–16 effects being found in a typical plant.

Figure 14 Multistage Effect Distillation (MED) process



2.2 Criteria for Desalination Selection Technologies

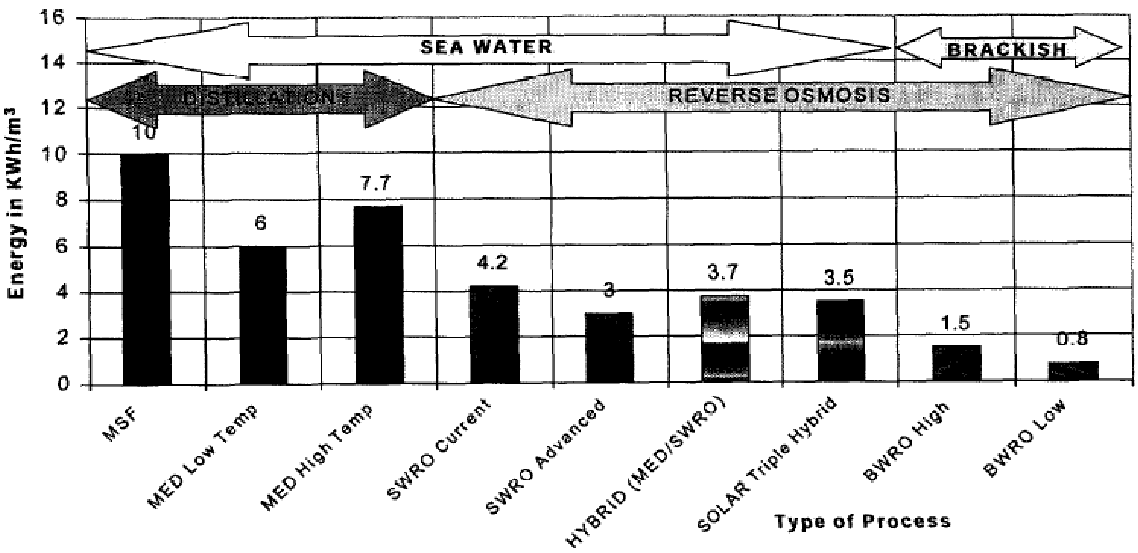
DESALINATION PROCESS EQUIPMENT

For the MSF and MED thermal processes, the equipment includes the evaporator itself as well as the directly related auxiliaries. When comparing MSF to MED, the size of each individual unit is a key issue. As far as the membrane process is concerned, it includes the RO modules, the directly-related auxiliaries, as well as the pretreatment equipment, which depend on the seawater quality. Key issues are the number of stages and the recovery factor.

Energy Network

The proximity of an electrical network is needed for the desalination plant, whatever the process. Required levels of electricity consumption vary quite significantly depending upon the process used. The RO process requires approximately 4 kWh/m^3, while the thermal processes requires 10 kWh/m^{3}for an MSF plant and 6 kWh/m^3 for a MED plant. The two latter processes need a thermal input as shown in Figure 15. This figure also shows that seawater may be desalinated by means of a wide range of desalination processes such as MSF, MED, RO, and the Solar Triple Hybrid process, with a range of energy consumption from 3–10 kW/m^3, according to the type of process used. Brackish water may be desalinated by means of the RO desalination process, with energy consumption from 0.8–1.5 kW/m^3, according to the salinity of the brackish water.

Figure 15 Energy requirements in kWh/m^3, according to process



Electromechanical Equipment

For MSF and MED thermal processes, most of efficient plants operate in combination with a steam generating plant: steam turbines behind heat recovery boilers associated with gas turbines. RO uses electrical energy to run the high-pressure pump that provides the driving force to the membrane separation.

Fuel Supply Equipment

Thermal desalination plants, either MSF or MED, operate in conjunction with a steam generating system to provide heat for distillation (boiler associated with power turbine). The fuel supply is required for that process, while RO, on the other hand, uses electromechanical energy only to operate the system.

Chemicals

Chemicals are required to operate desalination plants, whatever the process. Based on the salt-water analysis and on the desired product water quality from an MSF, MED, and/or RO plant, a comparison of cost for chemicals must be made. For thermal desalination (MSF or MED), various chemicals are used to operate the distiller itself and the post-treatment of the product water. For RO desalination, chemicals are mainly used in the pre-treatment of the raw water.

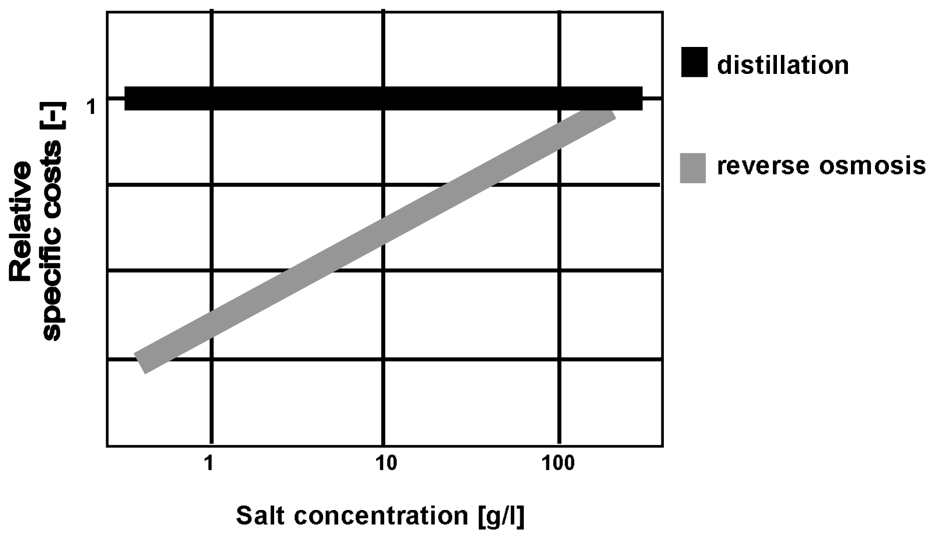
Percent Recovery

Figure 11 shows the limitation in percent recovery from seawater feed. It also indicates the increasing percent recovery with NF pretreatment, whether for RO or MSF desalination systems.

Total Process Cost

Figure 16 is a schematic of the specific total relative process cost over the feed salinity for both distillation and RO processes. Use of RO technology shows relatively less cost than desalination. The RO cost increases as the salt concentration increases (for a range of 0.5–100 g/L).

Figure 16 Relative water production cost of desalination technologies



Market Share of the Desalination Technologies

In seawater and brackish water desalination, RO makes up about three-quarters of total desalination capacity. In seawater desalination, one-quarter of total production is processed by thermal desalination technologies such as MSF distillation and MED evaporators as shown in Figure 17.

Figure 17 Market share of different desalination technologies for desalination of seawater (only plants with a capacity of at least 700 m³/d were considered)

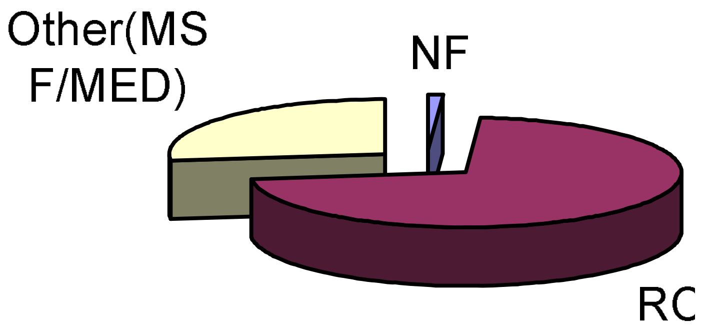


Table 5 Advantages and Disadvantages of Desalination Technologies

Advantages	Disadvantages
Reverse Osmosis	
Ease of assembly of prepackaged modules Wide range of capacity (~ 20000 m^3/day) Low installation cost Low operating labor cost Very high capacity per space production ratio ranging from 25–60 m^3/day/m^2 Low maintenance, non-metallic materials are used in construction Low corrosion problems Operates at room temperature Low energy consumption (1–3 kWh/m^3 of product water), which is 0.25–0.5 energy required for thermal distillation Negligible environment impact except for brine disposal	Membranes are sensitive and expensive Feed water must be pretreated Possible bacterial contamination of membrane
Thermal Distillation	
In most cases, distillation does not require the addition of chemicals or water softening agents to pretreated feed water Distillation has minimal environmental impacts, although brine disposal must be considered in the plant design Distillation can be combined with other processes, such as using heat energy from an electric power generating plant	Some distillation processes are energy-intensive, particularly for large-capacity plants The distillation process, particularly MSF distillation, is very costly Distillation requires a high level of technical knowledge to design and operate The technology requires the use of chemical products, such as acids, that need special handling

SECTION 3
DESALINATION PLANT BRINE WATER DISPOSAL

3.1 INTRODUCTION

Desalination plants are being used increasingly in the Red Sea area in Egypt to supply water for domestic purposes.

The characteristics of reject brine (concentrate) are directly related to the feed water, the desalination technology used, the percent recovery, and the chemical additives used.

The location of the plant is an obvious issue because selection of a plant's site should be determined by considerations of available energy supply, distance to feed water intake, disposal site, and end-user.

There are many disposal alternatives being used or investigated these days, including:

- Injection into deep saline aquifers (deep well injection)
- Disposal into evaporating ponds
- Disposal into the sea through a pipeline
- Discharge into well-engineered solar ponds.

The availability of the disposal alternative is mostly site-specific. Therefore, the most suitable disposal methods from an environmental and economic perspective have to be evaluated on a site-specific basis.

The cost of disposal ranges from 5–33 percent of the total cost of desalination for all methods. The cost of disposal depends on the characteristics of reject brine, the level of treatment before disposal, the means of disposal, the volume of brine to be disposed of, and the nature of the environment.

The major strategies for brine disposal in the Red Sea region are limited to deep well injection. However, three categories of brine disposal techniques are extensively applied worldwide:

1. Deep well injection
2. Evaporation ponds
3. Disposal into sea

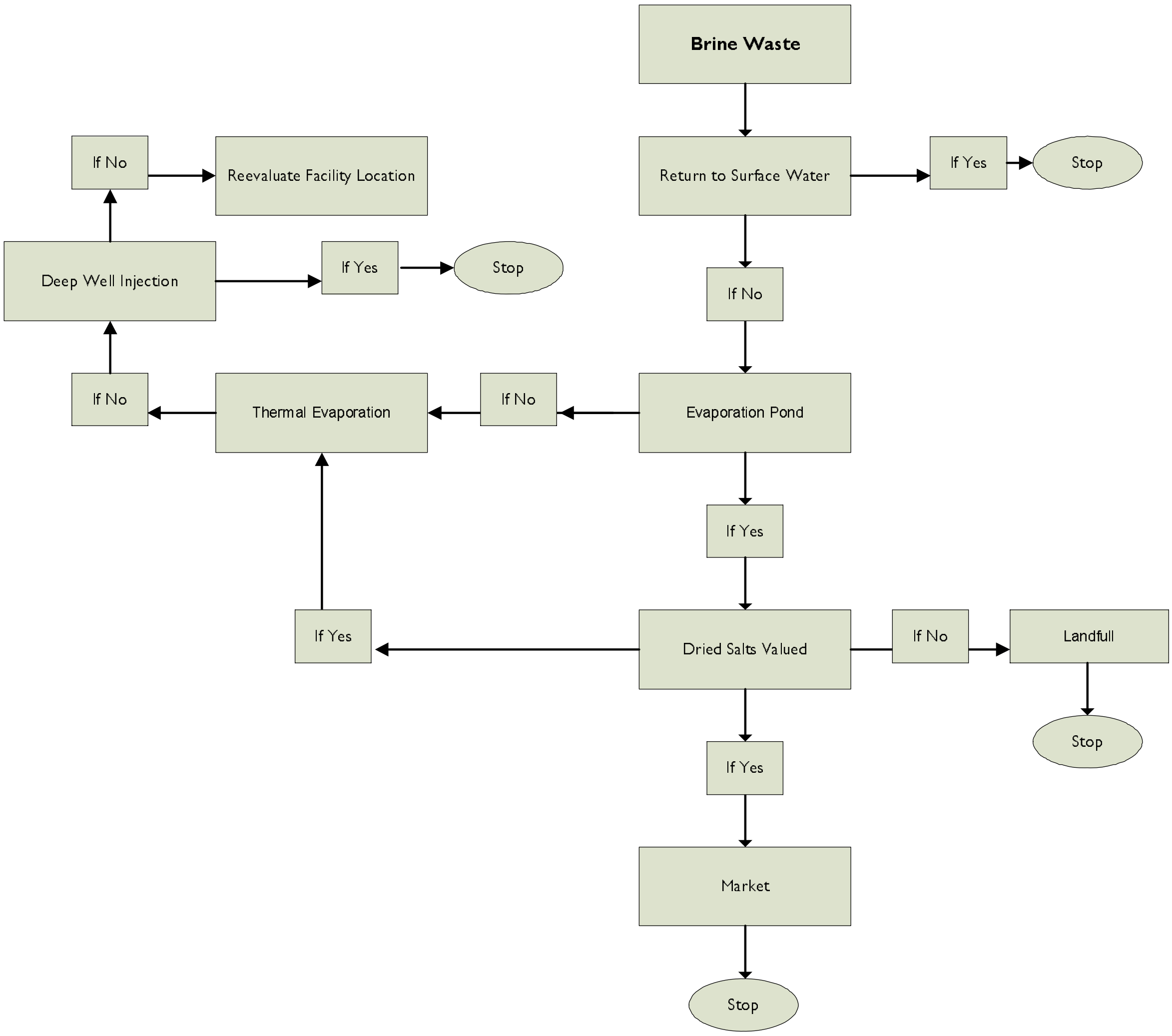
This part of the study will focus on comparing among these three major technologies for brine disposal, as shown in Figure 18, and their suitability for application in the Red Sea region.

DEEP INJECTION WELL

Deep well injection is presently the most common technique used for brine disposal in the Red Sea area in Egypt. Injection wells may vary in depth from a minimum of 100 m from sea level up to few hundred meters, depending on geological characteristics of the selected site. Deep well injection is only possible where these deep aquifers occur. The injection of brine water to deep underground formations can provide a disposal alternative where none was previously available.

To properly design and install a deep well injection facility, a complete geologic and geochemical analysis of the reservoir formation is required. Before drilling any injection well, a careful assessment of geological condition must be conducted in order to determine the depth, location, and thickness of a suitable porous aquifer reservoir, as well as determining its permeability.

Figure 18 Brine Disposal Methods



A geophysical survey could be carried out to define topographical and geological features of the investigated area (soil investigation) for selection of locations suitable for deep injection wells. The lithology, structure, and stratigraphy of the soil must be defined. In addition, hydraulic investigations must be carried out to determine the features of the water table, water quality, and the piezometric head.

An investigation to check the soil structure characteristics for a deep well should also be conducted to define the nature, thickness, and sequences of soil layers and their the hydrogeological properties. Meanwhile, the aquifer layer's thickness and properties have to be determined. The aquifer receiving formation must be separated from any water or the desalination source water (intake feed water) by an aquiclude that will ensure that the brine will not contaminate them.

Compatibility tests must be run between the brine water and a sample of the aquifer water reservoir to ensure that the two waters do not react to form precipitates that may clog the receiving formation. The injection well area must also be checked for geologic faults and any manmade penetrations of the aquiclude.

For injection deep well configurations, the Egyptian code for water resource and irrigation work has to be considered. Table 6 shows the advantages and disadvantages of injection wells.

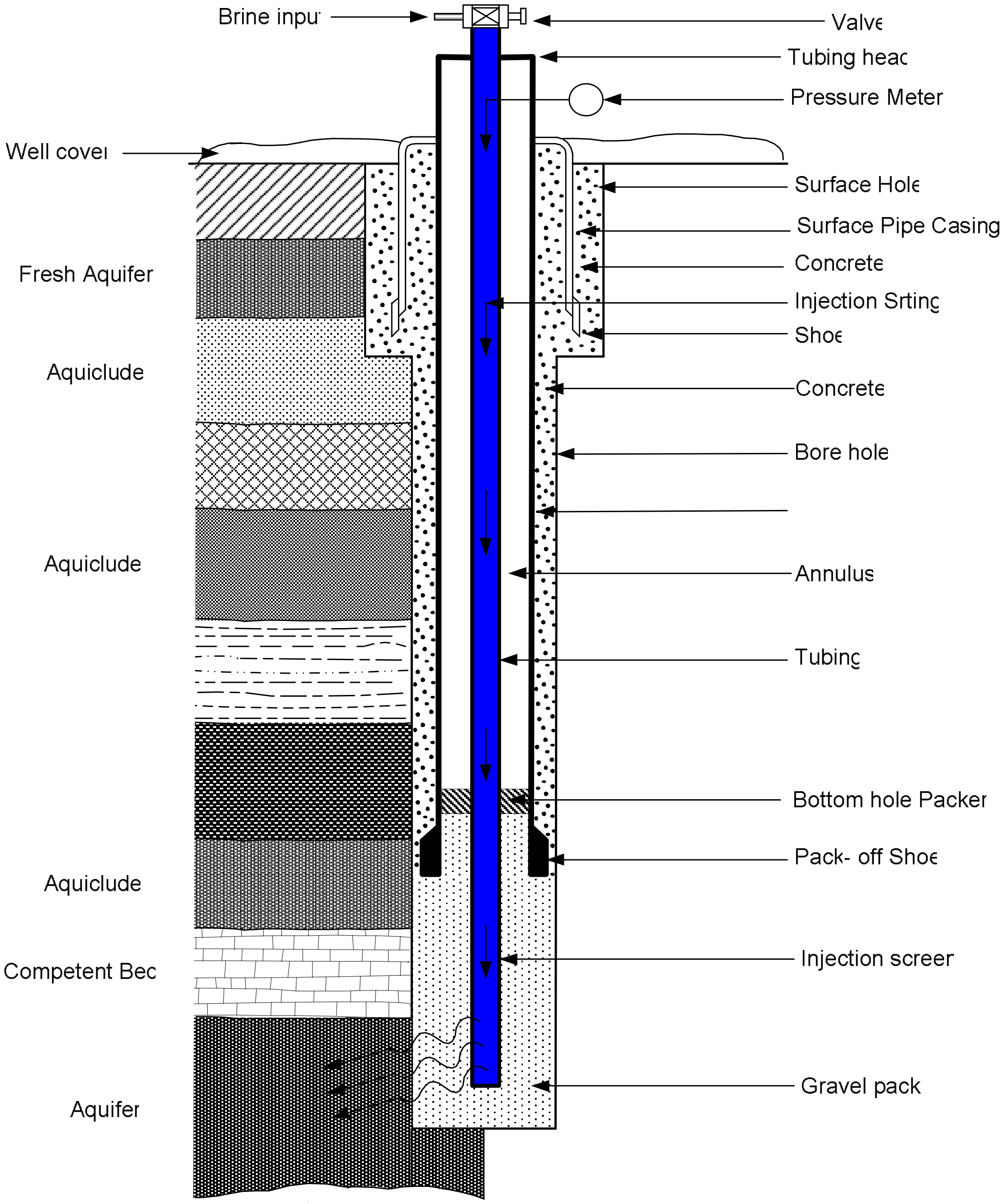
Table 6 Advantages and Disadvantages of Injection Well

Advantages	Disadvantages
Deep well injection is a reasonable method for brine disposal if long-term operation could be maintained	Selection of a specific suitable well site is costly and labor intensive High construction and operating costs and the potential for serious operations problems usually cause deep-well injection to be the last process selected Costs involved in brine conditioning and filtration are high Injection wells are limited to small capacity desalination plant (0.2–1 m^3/min); in some cases more than one deep well can be used to cope with the plant capacity Possibility of corrosion and subsequent leakage in the well casing Seismic activity could cause damage to the well and result in ground water contamination Possibility of plugging and diminished effectiveness due to high total suspended solids (TSS) and low permeability Uncertainty of the well's half-life (can only be determined with models) Environmental regulations and constraints (may face environmental legal problems)

Figure 19 shows a typical brine deep well injection configuration. The main parts of the well are:

- Pump house
- Tubing head
- Surface pipe casing
- Gravel pack
- Well casing long string
- Tubing
- Injection screen (perforated tube)

Figure 19 Deep well disposal unit



Case Studies

Case study for brine amount

- Medium-size resort village on Red Sea
- Number of guests = 1,000
- Water consumption/capita/day = 300 L
- Total consumption = 300 m^3/d
- Assume staff water consumption = 150 m^3/d

- Say overall consumption = 500 m^3/d
- Desalination plant capacity = 500 m^3/d
- Recovery = 30 percent
- Discharged brine about 1,000 m^3/d
- Total seawater 1,500 m^3/d

Case study 2

An example of one deep well injection facility with an intake from a beach well shows the following:

1. Intake water (beach well)
   - Depth of beach well intake equals 60 m (according to the site aquifer)
   - Intake water rate: 3,000 m^3/d, TDS = 42,000–45,000 ppm
2. Desalination plant SWRO
   - Recovery rate $\simeq$ 30–40%
   - SWRO capacity 1,000 m^3/d
   - Required area is 150 m^2
3. Brine disposal(deep injection well)
   - Brine discharge about 2,000 m^3/d
   - Depth of deep injection well about 100 meters
   - Distance between intake well and injection well 50–60 m according to the geological investigation of the site

Nominal sizes of SWRO units: 300 m^3/d, 500 m^3/d, 1,000 m^3/d, and modules made from above units for larger capacities.

EVAPORATING PONDS

Evaporation pond technology is practiced in arid regions in the Middle East. At this time, it is probably the most widespread method of brine disposal from inland-based desalination facilities. However, this system is rarely used in the Red Sea region in Egypt.

This disposal system is especially effective in regions with low rainfall, and where climatic conditions are favorable for steady and relatively rapid evaporation rates .In addition, desalination plants are sited often at locations where the cost of adjacent level land is relatively low.

Figures 20 and 21 represent small evaporation ponds at a farm scale. Their size does not exceed a few hectares (104 m^2). It is best if a number of smaller ponds are constructed adjacent to the one another and connected by a pipeline placed no more than 30 cm above the bed of the pond. Smaller ponds are easier to manage, especially in windy conditions where wave action can damage the levees, thereby increasing maintenance costs. The length of the pond should be placed at right angles to the predominant direction of wind to dissipate wave damage. This is particularly important if the pond is plastic-lined.

Figure 20 Generalized embankment dimensions

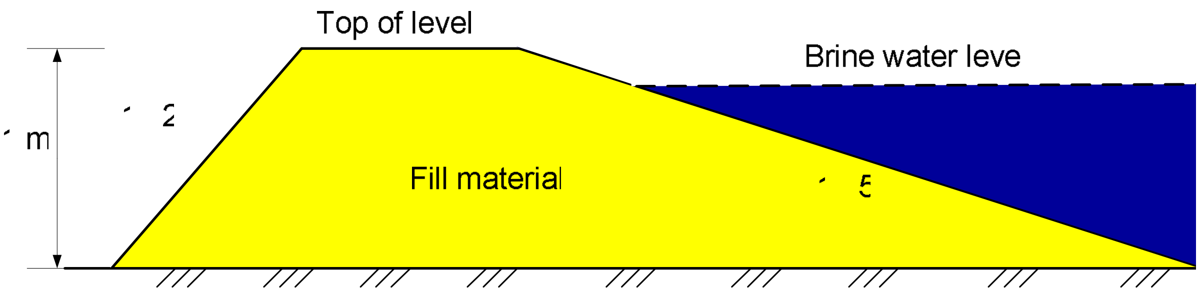
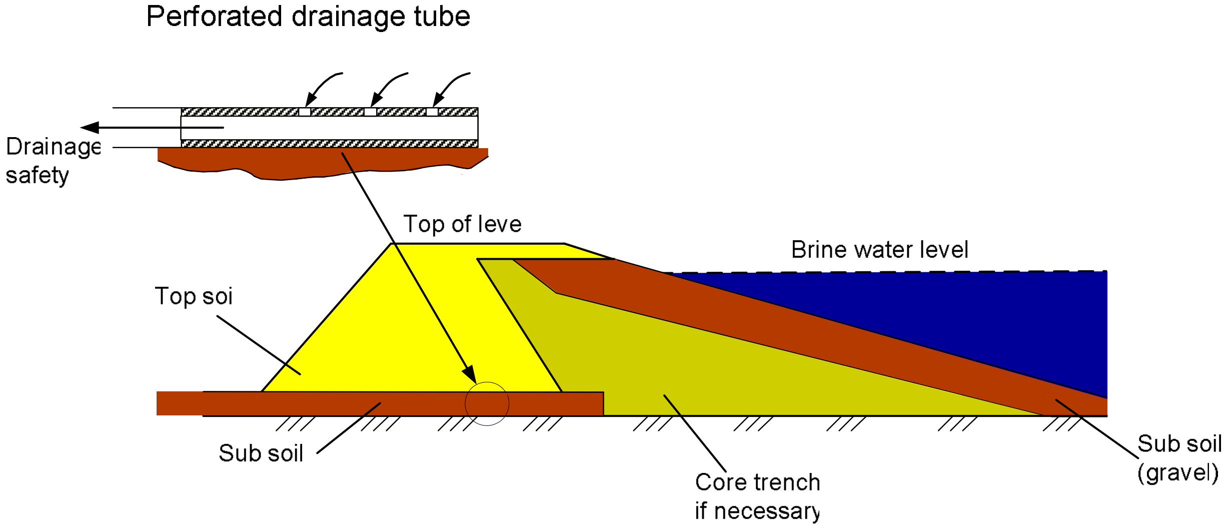


Figure 21 Cross- section of embankment



Higher evaporation rates require smaller-sized ponds. Pond sizes are influenced by two main parameters: surface area and depth.

The evaporation rate determines the surface area, whereas the calculation of depth is based on surge capacity, water storage capacity for salt, and free board for rainfall and wave action .As salinity of the disposed water increases, evaporation rate decreases

The principal environmental concern associated with evaporation pond disposal is pond leakage, which may result in subsequent aquifer contamination.

All current installations are lined with polyethylene or various other polymeric sheets. Liner installation must be carried out with care because sealing of joints is critical in order to prevent leakage, which usually takes place along the joints. Double lining is strongly recommended with leakage sensing probes installed between layers of pond lining. Liners should be mechanically strong and impermeable. All liners must be strong enough to withstand stress during salt cleaning. Sometimes sand can be placed over liners to facilitate salt removal. A subsurface drainage system should also be installed to remove the leaking wastewater, as shown in Figure 21.

In general, the walls of ponds are constructed above the ground level .A controlled spillover facility is also needed as an integral part of the evaporation ponds.

The advantages and disadvantages of evaporating ponds are shown in Table 7.

Table 7 Advantages and Disadvantages of Evaporating Ponds

Advantages	Disadvantages
Simple and straightforward method for brine disposal Satisfies legal environmental requirements Most suitable in arid climate conditions therefore, it is recommended for the Red Sea region Capital costs arise only from acquisition of land Evaporation rate could be enhanced and increased by 50 percent, reducing pond size	Limited to relatively small desalination plants(less than 5 MGD) Need for careful environmental monitoring of potential pond leakage High cost of level land

Recommendations

- It has been recommended that no salt should be removed from the pond for the first year or two of operation so that a hardpan is permitted to form on the base of the pond.
- It is recommended that both the volume of reject brine into the evaporation pond and water levels in the pond are recorded on a continuous basis, as well as the levels of groundwater and salinity adjacent to the ponds. Reporting based on monitoring data and relevant operation and maintenance information is an important step in the management of disposal systems for desalination plants.
- It is better to build a number of smaller ponds connected to each other by pipelines than one larger pond. This will minimize wave damage on the levees and they are easier to manage. Pond depths between 25–45 cm are optimal. Increasing salinity decreases the evaporation rate. Comparing evaporation from brine and distilled water, the ratio is that for each increase of 0.01 in specific gravity there is a 1 percent decrease in evaporation. A more generalized proposal to incorporate the effect of salinity on the evaporation rate is to multiply by 0.7. As evaporation ponds require large areas, this will mainly be applicable in regions with low land cost and high evaporation/precipitation ratio. High evaporation/precipitation ratio means that loss of water is quick and the pond area needed is available. A high recovery rate also reduces the pond area needed.
- Regulations and policies related to the chemical composition of reject brine and concentrate disposal must be implemented and enforced.

Options that can be adopted include:

- Zero discharge of brines from desalination plants. Industries should apply pollution reduction programs including recycling and reusing water, and developing alternative technologies. The zero discharge concept deals with reducing waste volume.
- Enhanced evaporation mechanisms. The size of the evaporation pond affects the rate at which reject brine evaporates. Different methods such as spraying of brine and creating airflow over the pond could be adopted.
- Use of reject brine from desalination plants as a growth medium for spirulina, fish, and shrimp culture. Treated reject brine water from desalination plants with high alkalinity and salinity, and the availability of solar radiation and high temperature

can provide an ideal growth medium for spirulina, i.e. *arthospira paltensis* and tilapia, which are of high commercial value. Adopting such a project could contribute to the decrease of the cost of waste disposal and reduce the impact on the environment.

Recovery of Salt from Evaporation Ponds

It may be possible to produce some chemicals from the salt concentrate remaining in evaporation ponds from brine disposal. The most likely candidates are:

Nacl as table salt	NH^4Cl
Na^2CO^3	CaSo4, which is used in the gypsum industry
$NaHCO^3$	

Using a series of batch gas bubblers and mineral extractions from desalination reject brine, extraction of minerals from desalination reject brine can represent a potentially important source of minerals, minimize disposal cost, and reduce stress on the environment.

DISPOSAL INTO THE SEA

Brine discharge is the fluid waste from a desalination plant, which contains a high percentage of salts and dissolved minerals. In the case of desalination of seawater with RO, the salt content of the brine is about 1.5–2 times that of the seawater. In the case of thermal processes, the brine is approximately 10–20 percent more saline than the sea water.

Constituents of Discharged Brine

The brine water disposal from a desalination plants has the following constituents:

- High salt concentration
- Chemicals used during pretreatment stage
- High total alkalinity (calcium carbonate, calcium sulfate, and other elements are nearly double that found in seawater)
- Higher temperature of the discharge brine due to the high temperature used in the desalination facility (in the case of thermal plants)
- Toxic metals, which might be produced if the discharge brine has contact with metallic materials used in the plant elements

Environmental Impact

The environmental impacts of sea disposal are mainly marine disturbances near the outlet due to the higher salinity and chemical constituents in the brine waste.

The high specific weight of the brine creates a plume at the outlet and this prevents mixing and makes the brine plume sink to the bottom. A "salty desert" is created in the area near the outlet affecting the benthic environment negatively. The chemicals used in desalination are also a concern for marine organisms and plants. The specific impact of the brine is a function of the ecosystem in the area and conservative estimates show that benthic environments are tolerant to salinity increases of 1,000 ppm.

Some marine disturbances that may occur near the outlet for brine disposal include:

- **A salinity gradient**—There exists an osmotic balance between marine organisms and the surrounding environment and disruptions may have negative consequences. The main effects are on marine biota, particularly benthic and plantonic organisms. Increasing salinity can have a great effect on plankton populations (mainly young individuals) as this can lead to dehydration of cells resulting ultimately in extinction.

  However, most of marine species will not survive in the case of high increases in salinity. Increased turbidity is also an effect of increasing salinity.

  The use of additives such as iron further enhances this effect, as some of these additives are dark in color. This has the effect of preventing the penetration of light and therefore disrupting photosynthesis.

- **Temperature gradient**—This will cause an increase in the seawater temperature resulting in reduction of dissolved oxygen, which is a necessity for the respiration of marine organisms.
- **Use of chemicals**—Chemicals such as chlorine and acids were used in both inland brackish water desalination and seawater desalination; however, seawater desalination uses much more.
  - **Chlorine**—Chlorine is mainly used to prevent bio-fouling. Chlorine and its compounds are toxic and affect biological and enzymatic processes of living organisms. Chlorine is a highly effective biocide, which can have detrimental effects on aquatic life even in low concentrations. In the presence of hydrocarbons in the water, chlorine has a detrimental effect on marine organisms but decays with time.
  - **Acids**—Membrane cleaning is done 3–4 times/year using weak acids and detergents such as citric acid, sodium polyphosphate, and EDTA. This rinse water usually is collected in a container and then treated in the form of titration, and neutralization is performed before discharge to authorized salt disposal sites or by releasing small quantities of the rinse water continuously together with the brine to the sea.

  Monitoring the brine impact on marine environment is important in order to assess environmental impacts. Monitoring should be carried out every 6 months for a period of 4 years to study the marine environment within a perimeter of 200 m from the outfall point.

Disposal in Coastal Locations

Discharge to the sea is the disposal method used almost exclusively for desalination plants at or near the coast. The use of seawater discharge for brine disposal requires a thorough study for the nature of the seabed, performing a hydrodynamic investigation for the sea including:

- Water current direction and speed
- Bathymetry and tidal mean and height
- Thermo-hydraulic analysis for water temperature and salinity
- Hydrodynamic modeling for the proposed zone for disposal
- Study for the diffusion to be used

An environmental impact study of brine disposal on marine life must also be conducted. According to the findings of these investigations, a suitable zone for sea disposal could be determined, as well as the depth and length of the disposal pipe to be used in the sea and the diffuser system. Proper determination must be made for a reasonable distance between the seawater intake and the brine discharge.

The problems faced for disposal of brine to the sea mainly concern disturbance of the seabed during construction and dilution of the salt concentration. They should be dealt with as follows:

- Minimize adverse effects on the seabed and marine life during construction of the sea outfall. Carefully select the route of the pipeline and installation of the pipe, minimizing disturbance to the bottom of the sea and the marine environment.
- Minimize effects on the benthos and marine life during the operation of the plant. This focuses on the concentrations of salt in the area surrounding the point of brine disposal. The location of the outfall point (depth of water, distance from the shore, elevation above the seabed, and topography and vicinity of the discharge point) and its shape play an important role in mixing the discharge with seawater and the dilution and diffusion of the salt to the large mass of seawater. Knowledge of the prevailing currents in the area and the topography of the seabed are important in selecting the most appropriate point for brine disposal.

Mathematical Models of Brine Discharge into the Sea

Mathematical modeling is the process of creating a mathematical representation of some phenomenon in order to gain a better understanding of that phenomenon. It is a process that attempts to match observation with symbolic statement. Mathematical models are used particularly in the natural sciences and engineering disciplines (such as physics, biology, meteorology, and electrical engineering) but also in the social sciences (such as economics, sociology, and political science); physicists, engineers, computer scientists, and economists use mathematical models most extensively.

A mathematical model can be defined as a representation of the essential aspects of an existing system (or a system to be constructed) that presents knowledge of that system in usable form.

Mathematical models typically contain three distinct types of quantities: output variables, input variables, and parameters (constants). Output variables give the model solution. The choice of what to specify as input variables and what to specify as parameters is somewhat arbitrary and often model dependent. Input variables characterize a single physical problem while parameters determine the context or setting of the physical problem.

Mathematical models can take many forms, including but not limited to dynamical systems, statistical models, differential equations, or game theoretic models. These and other types of models can overlap, with a given model involving a variety of abstract structures.

According to the Shore Protection Authority (SPA) and the Egyptian Environmental Affairs Agency (EEAA), the Environmental Impact Assessment for any project must contains a mathematical simulation for the impact of the proposed project structure on marine stability. The SPA require a hydrodynamic model. This model describe the impact of project construction on hydrodynamic processes (such as sediment transport, currents, and waves. In cases where the projects contain end-of-pipes, EEAA require an output result from a dispersion model. This model simulates the dispersion of effluent discharged to the water body and gives a figure of its concentrations at a certain location after an interval of time.

There are many places in Egypt where mathematical models are used in a scale; some are public and others are private. Private organizations are governed by environmental offices concerning coastal and marine projects. Gas and oil companies use mathematical models for internal proposes. Public organizations include:

- Coastal Research Institute, Alexandria
- Hydrodynamic Research Institute, El-Qanater, Cairo
- Construction Research Institute, El-Qanater, Cairo
- Oceanography Department, Faculty of Science, Alexandria University
- Civil Engineering Department, Faculty of Engineering, Alexandria University
- Oceanography Department, Faculty of Science, Suez Canal University

Brine Water Disposal into the Sea

The main feature of the disposal system is composed of a long pipeline extended on the seabed. If the seabed is sandy soil, the pipeline could be embedded in the seabed. In the case of a rocky seabed, the pipeline could be mounted on special brackets elevated from the seabed by saddles (The EEAA allows this system to be fixed only once without any extension or modifications.)

There must keep enough distance between the intake and discharge points (more than 0.2 km distance) to avoid or minimize risks of feed water deterioration. The disposal of brine by pipeline should, therefore, be sufficiently far out into the sea—about 0.5 km depending on the marine life and the coral reefs.

The outfall system includes buried ultra-polyvinyl chloride (UPVC) pipe from the desalination plant to the shore .The remaining part of the pipe from offshore to the outfall point (offshore pipe) is recommended to be high- density PE, with a special covering, laid down on/or embedded in the seabed. At the end of the outfall pipe, a distributor head (diffusers) is fitted to discharge the brine water over a wide area. Figure 22 shows the general layout of a brine disposal pipe for a small-capacity desalination plant.

A typical diffuser section used at the outfall point is illustrated in Figure 23. The normal distance between diffusers is about 30–50 m.

Figure 22 General layout of a brine disposal pipeline

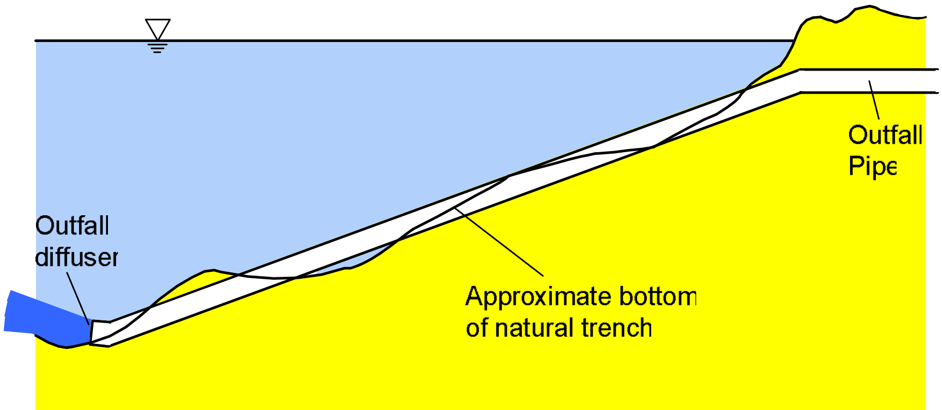
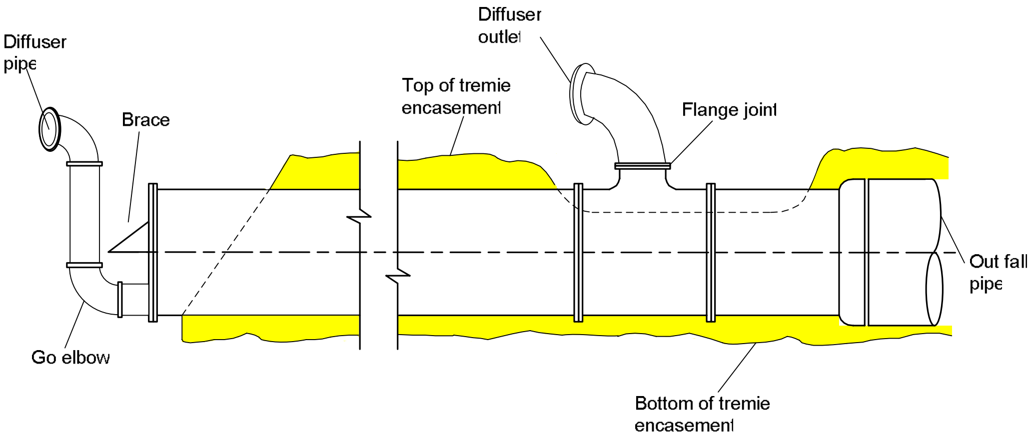
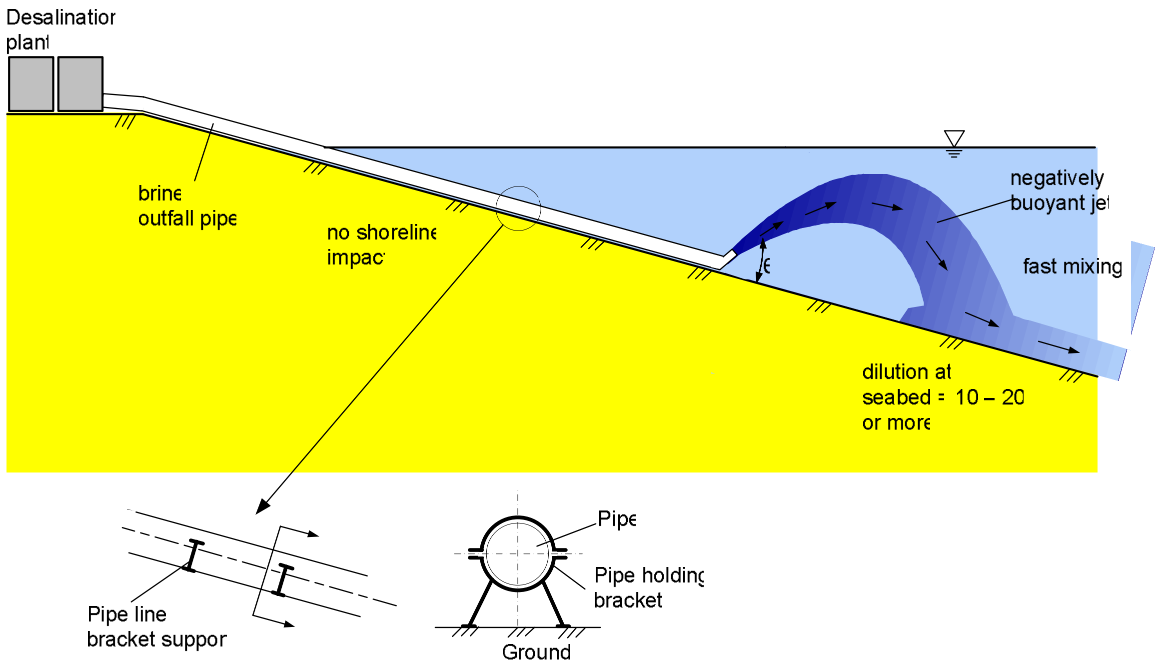


Figure 23 Typical diffusers section



Modern, large-capacity plants require submerged discharge; in the form of a negatively buoyant jet. This ensures a high rate of dilution to minimize harmful impacts on the marine environment. Figure 24 shows the discharge strategies for negatively buoyant effluent, using submerged discharge via pipeline and nozzle or diffuser.

Figure 24 Submerged discharge via pipeline and nozzle



Dilution of discharged brine

Dilution is one solution to reduce the impact of brine discharge into the sea. The process of dilution is performed either as primary or natural dilution.

Primary dilution depends on the difference in density (salt concentration and temperature gradients) between the brine and the seawater, the momentum of the brine, the velocity at the effluent pipe, the flow rate at the effluent pipe, the diameter of the pipe, and the depth at the outlet to the seafloor.

Diffusers are one of the most efficient methods of providing primary dilution of a waste in any waterway. At the end of the outfall, treated or untreated wastewater is released in a simple stream or jetted through manifold or multiple-point diffuser, as shown in Figure 24. The use of diffusers with the effluent pipe enhance natural dilution by increasing the pressure of the brine entering the seawater and allows the brine to make contact with a larger volume of seawater.

The effect of the diffusers mainly depends on how many are used and how close they are to each other. Efficiency can be enhanced by installing the diffusers (nozzles) at an angle of 30–45° to the seabed, as this will direct the brine flow upwards, increasing the volume of seawater with which it makes contact. Table 8 outlines the advantages and disadvantages of this disposal method.

Table 8 Advantages and Disadvantages of Brine Discharge into the Sea

Advantages	Disadvantages
Brine disposal into the sea is the least expensive method Rapid mixing and dilution makes it as a safe disposal option	All necessary precautions for environmental regulations must be strictly followed

SECTION 4
DESALINATION PLANT SITE SELECTION

4.1 INTRODUCTION

Desalination is becoming an important alternative water supply source in many Mediterranean and Red Sea zone countries, where the natural water resources are insufficient to satisfy the increasing demands for sustainable development. Many countries constructed and put into operation seawater desalination facilities for meeting growing water demands or to make up for reduced supplies from the decreasing natural water resources due to climate changes. With the desalination process becoming less expensive due to technological advances, it is obvious that more and more plants are likely to be constructed in the future.

Since the raw water for desalination is, in most cases, abstracted from the sea, these plants are located in coastal areas provided they are fulfilling technical, environmental, and economic requirements and they are accepted by the local population. Coastal areas in many parts of the Mediterranean and Red Sea regions are densely populated, with high-quality tourist developments and/or industries that require a lot of water such as power stations. Coastal land, therefore, is costly. Desalination plants are usually viewed as factory-like constructions, eliciting a negative reaction from nearby communities that claim that such installments cause environmental degradation and negatively affect commercial values of property, forgetting that water is a basic necessity.

4.2 FACTORS INFLUENCING SITE SELECTION

Selection criteria for choosing a site vary, depending on the process used for desalination. For example, the RO process requires a water supply that is much cleaner than a supply for a distillation process. TDS concentrations in the supply is not as important for a distillation process as it is for the membrane processes.

The site selection process often results in an evaluation of two or more possible sites. When this is the case, the final choice can be made by performing a cost study that addresses:

- Cost of land
- Location of a power supply
- Location of the connection to the water distribution network
- Proximity to the road/rail transportation networks (for chemical deliveries)
- Cost of source water supply and pretreatment
- Cost of processing water
- Location and proximity to concentrate disposal point

The key criteria that must be addressed in the selection of a desalination plant site generally can be grouped as:

- Source water
- Site location
- Land area requirements
- Concentrate disposal issues
- Data collection
- Problematic issues

Source Water

Source Water Supply

There must be enough raw feed water available at the site to sustain desired production throughout the life of the desalination plant. The quantity of water available from a surface water supply is usually easily determined.

Availability of Feed Water

Minimum quantity should be >4 times than the planned product water now. This value has to be checked depending on the desalination process. This minimum is an approximation. For example, normal operation of a RO small unit requires a feed water flow 3 times higher than produced water flow.

For a groundwater aquifer, pumping and modeling of the supply must be carried out to:

- Determine what the "safe yield" of the well field will be. The safe yield of the well field is defined as the amount of water that can safely be pumped without affecting adjacent aquifers or nearby surface water supplies. Pumping tests and modeling are carried out to determine the safe yield.
- Determine if a change in water quality over time is expected. Pumping and modeling of the aquifer are also important to determine if the water quality will change over time.

Pretreatment Considerations

Groundwater sources are usually naturally filtered, whereas open intake supplies (sea water intake) will be unfiltered.

For the RO process, water taken from an open intake will have to be pretreated by some form of filtration before the supply enters the process itself. Filtration is required to remove suspended solids as well as colloidal material.

For the distillation processes, the pretreatment requirements are generally mandated by the amount of bicarbonate in the feed water supply. Pretreatment for these processes has traditionally been acid, followed by decarbonation to prevent calcium carbonate, $CaC0_3$, and magnesium hydroxide, $Mg(OH)_2$ scale from occurring on the tubing surfaces. More recent designs use scale inhibitors in lieu of acid for scale control.

Source Water Quality

The water quality to be treated is profoundly important for design of RO plants, but has minimal importance for distillation processes. Nevertheless, a comprehensive water analysis must be preformed to have a complete understanding of the chemistry of the water to be treated. If a change in TDS or character of the water is expected over time, then the RO process will have to be designed to treat the future water quality.

The ranges of feed water salinity ordinarily handled by the various desalting processes are shown in Table 9.

Table 9 Feed Water Salinity for Desalination Processes

Process	Feed Water TDS
Thermal plants (MSF)	30, 000–60,000
Reverse osmosis (RO)	500–50,000
Non-filtration (NF)	Any

The TDS of the water to be treated has a direct bearing on the cost of water from the En- and the RO processes. If two sites with different TDS concentrations are under consideration, the site selection should include a process cost evaluation. As the TDS increases, the operating pressure increases for RO. Therefore, more energy is expended to desalinate the same amount of water.

Feed water temperature for desalination plants will influence plant capacity and plant site location as well. Thermal plants benefit from lower feed water temperatures, while membrane plants may benefit from higher water temperatures.

Physical Quality of Feed Water

Feed water to distillation facilities should be free from debris, marine flora and fauna, and any component that could interfere with pumps or process operation. In some instances, intake design will include trash racks and traveling screens.

With RO plants, special attention must be paid to the low turbidity requirements in the feed water and the potential for membrane system bio-fouling. Pretreatment selection will be predicated on the range of conditions expected at the intake site.

In general, with most brackish water systems that operate with well water feeds, bio-fouling will not present a problem. However, absence of bacteria capable of producing bio-films should be verified. Some forms of bacteria and fungi are capable of destroying cellulose acetate membranes, if used.

Well design should be predicated on a philosophy of quality, not quantity. Screens and gravel packs must be carefully selected, and wells must be properly developed before commissioning.

Heat and Electrical Energy

All desalting processes require electrical energy to operate. Most distillation processes also require heat. Analysis of the energy requirements for each major process shows that heat and electrical energy costs for each process are a significant percentage of the desalination cost. The cost of heat energy is a major factor in determining the cost of the MSF and MED processes. Cost of electricity plays an important role in the total price of the MVC and membrane processes. The choice of the heat source should be based primarily on economics. The availability of heat source (fuel) and electrical sources will play a role in site selection.

Environmental Constraints for Site Selection

Environmental constraints imposed by governmental regulations greatly influence site selection, construction, and operation of desalination plants. Although typically used for the production of municipal water supplies, these plants may often seem to resemble industrial facilities in their potential impact on the environment.

Planning and Cost Features

Depending on the type of plant, liquid and solid waste disposal, air quality, noise, and thermal issues must all be addressed in the project planning process. Some or all of these factors may have a significant impact on the cost of product water. An environmentally compatible facility may be located where land cost concentrates disposal operations, and location has a significant impact on water cost, whereas the cost of environmental compliance could rule out a more conveniently located site.

Desalination plants must be planned, designed, and operated to minimize pollution. Thermal pollution exists only with the distillation processes. Air pollution is not normally a factor in process selection. Chemical wastes generated by the desalination process generally require suitable preparation and disposal. Effluents must conform to specified local standards to prevent environmental and ecological degradation.

Solid waste disposal is becoming a more significant issue with the rapidly expanding use of membranes for desalting and pretreatment (membrane filtration).

Land Area Requirements

The total area required for the desalination facility comprises the area allocated for access, the processing facility, plus the area required for auxiliary equipment such as pretreatment, post-treatment, feed and product water storage tanks, distribution system pumps, and electrical substation. This area will vary depending on the process used and the way the source water is to be treated .The area needed for the main items of RO desalination plants is, in general, less than that for distillation processes. In the case of extending desalination plant capacity in phases, the area for future expansion must be considered.

Concentrate Disposal

Concentrate disposal can present significant engineering and economic problems. There are often environmental and legal constraints against discharging liquid wastes from a desalination plant into surface wastes or underground. This issue is important in site selection. The following are the main methods for concentrate (brine) disposal:

Disposal to Surface Waters

In general, direct discharge without treatment into a river, lake, or other watercourse cannot be made without degrading surface water quality. Water quality control laws of most political bodies prohibit such discharge. The effluent from a desalination plant located near a coast would probably be discharged into the ocean or large estuaries. Some considerations for discharge include:

- For all surface water discharge, diffusers will probably be required. Occasionally, a pipeline discharging into a high-sea energy zone may be required for adequate dispersion of the concentrate.
- Fresh and marine water biota can be harmed by corrosion byproducts, higher temperatures, or low oxygen concentrations. Effluent from distillation plant may contain copper from corrosion.
- Toxicity of the effluent stream can possibly be reduced to acceptable levels by dilution with the receiving water.

Deep-Well Injection

Injection into subsurface strata is frequently used to dispose of wastewater at inland sites. However, subsurface injection is not permitted in some jurisdictions. Such disposal is feasible only at locations where underground formations for receiving the effluent are suitable. Each potential site must be evaluated individually. The cost of concentrate disposal by injection can be a substantial part of the total cost of desalting, and must be considered in the initial design of the desalination facility. The cost of deep-well injection primarily depends on disposal volume, well depth, system design, and injection pressure. A properly designed system, based on sound engineering and geologic principles, should place wastes where groundwater will not be contaminated.

Evaporation Ponds

Evaporation from surface concentrate disposal ponds is a method suited to inland plants in hot, arid locations with inexpensive land available for the construction of such ponds. This method is subject to increasingly strict regulation to prevent pollution of both underground and surface environments and to prevent other adverse effects. Acquisition of land, earthwork for berms, and the impervious liner required in most jurisdictions make this method of disposal costly when combined with a plant of significant size. Basic rules control the design and development of concentrate disposal ponds. The use of evaporation ponds is only feasible in hot, dry climates with high net evaporation rates, relatively level terrain, and low land costs.

Evaporation to Dryness and Crystallization

Evaporation to dryness and crystallization of the effluent into disposal solid salts is probably the most expensive approach to the concentrate disposal problem. It is used only if:

- Legal or site restrictions eliminate other disposal techniques
- A valuable byproduct could be recovered
- The process is technically feasible

This method has been used for many years in the process industry. Salts produced are either sold or transported to a disposal area.

4.3 SITE LOCATION

Every plant should be reasonably close to the water distribution point, electrical supply, concentrate disposal point, and high way or rail access.

The location of the site in proximity to housing developments will depend on the process type. For example, RO can be located in buildings whose exteriors can be integrated into commercial buildings in the area. Distillation process equipment has to be located in the open and away from residential areas.

Problematic Issue

There are certain finding that may be considered "fatal flaws" to siting a desalination plant. Major items are:

- Land use constraints (e.g., site is too close to an environmental preserve)
- Distance to any of the following points may make the plant too expensive:

- Source water
    - Concentrate disposal
    - Electricity supply
    - Water distribution point
    - Highway access
- Topography presents problems (e.g., a ravine, cliffs, or potential flooding)
- Source water temperature is too high (this only applies to membrane treatments)
- Surface water supply depths are too shallow; a suitable depth for a seawater intake is 6 m or more
- Geological conditions (soil bearing characteristics) present problems.

Criteria and Procedure for Selecting a Site for a Desalination Plant

Desalination plant site selection is vital for the design, financing, construction, and operation of desalination plants under a public/private partnership or on a turnkey basis. The site, comprised of inland and offshore parts:

- Must be located where access and interconnections to the power supply grid. (or independent power production) and to the water supply networks are technically and economically feasible
- The plant's area, extent, and shape (size and geometry) must be appropriate so that the marine intake head structures, marine pipelines, inland pit, seawater pumping station, inland pipelines, main facility structures, post-treatment system, product delivery sub-system, and power supply system are adequately accommodated and optimally located so that the cost of civil, electrical, piping interconnections, and other works are minimized
- Be suitably located in a marine environment where an adequate quantity of good, uniform, and steady quality of feed seawater may be abstracted at a reasonable cost
- Be at a location where the brine, backwash wastewater, and other wastes can be disposed without adverse environmental effects
- Geologically and topographically suitable for the construction and erection of the various structures at reasonable costs
- Environmental, town planning, and rural planning regulations, laws, requirements, and restrictions are met
- The desalination plant shall have social acceptance from the neighboring communities and other authorities
- Local taxes are not prohibitive and the existing infrastructure shall make project implementation as easy and cost-effective as possible.

Select potential sites fulfilling these criteria and choose the one with the most potential. Using the site selection criteria outlined above plus any other specific criteria and requirements that the plant under consideration has, locate potential sites and mark them on a map. For each or these sites, carry out a preliminary "Site Selection Study." Based on findings, choose the three sites with the most potential, meet site selection criteria, and will be acceptable to local authorities and the client. For each of these sites carry out a detailed site selection study. An environmental impact assessment study (EIAS) should be carried out by an independent consultant acceptable to all parties.

4.4 ENVIRONMENTAL IMPACT ASSESSMENT STUDY (EIAS)

The terms of reference for the EIAS should be agreed by the client and local authorities and should cover, among others, the following topics:

- Plant geometry (area extent and height)
- Materials for construction and their conformity with the special character of the environment.
- Methods of seawater abstraction from the sea and probable location of proposed sea intake structures; and marine pipelines size, route, and installation structure
- Intake structure and intake pumping station location and general layout, including probable methods of construction
- Seawater pipeline size and route and proposed construction method
- Plant emissions (brine, chemicals used for pre-treatment, post-treatment, corrosion control, anti-scaling, anti-fouling, anti-foaming, sewage, etc.) have to be given preliminarily and included in tendering specifications
- Impacts of the above to the air, land, and sea environments should be examined, including air pollution, land pollution, marine pollution, adverse effects on marine and biotic life, noise pollution, public safety, and chemical hazards
- Estimates of the additional energy requirements and their impact on the environment because of additional gas emissions
- Benefits from the construction of the plant on the water supply balance, on the economy, and on social life
- Evaluation of the site from the point of the environmental importance of both the inland ecology and the marine seabed and marine biotic life. Impacts during construction and O&M phases of the project implementation should be considered.
- Proposed mitigation measures to minimize the adverse effects on the environment and other sectors should be studied. Such measures shall fall into two categories (1) structural measures that shall be applied during construction phases and might include the plant's architecture, materials of construction, depth and location of the sea intake and sea brine outfall, pipeline route (marine and inland), and methods of construction. (2) Operational measures that shall be applied during operation of the plant and might include prohibition for using certain chemicals; maximum noise level production; monitoring impact on the air, groundwater, marine, and biotic life; and disposal of certain special products such as anti-scalants and backwash water if specified.

4.5 SITE SELECTION

The selection of the site shall be made in consultation with local authorities, based on recommendations and with the consent of all concerned parties. Recommendations will be based on the detailed site selection studies and the environmental impact assessment studies. The recommendations include remarks and recommendations for each potential site. The sites shall be ranked according to their adverse effects on the environment with and without mitigation measures. The final step is to cost the mitigation measures for each site to determine whether the project as modified for environmental reasons is financially, economically, and technically viable.

4.6 LEGAL AND INSTITUTIONAL FRAMEWORK AND GOODWILL

The site selection criteria, the site selection studies, the environmental impact assessment studies, and the proposed mitigation measures shall be in accordance with and comply with existing national, district, and regional legislation and standards. Institutions responsible for the implementation of the legal framework shall be continuously informed or advised and requested to give their approvals and consent, and to issue permits and licenses as required. Strict compliance with the provisions of the laws and regulations creates the proper environment for smooth cooperation and coordination for resolving differences and implementation of agreeable decisions.

The site selection procedure is not an easy task, since it involves high value land and in many cases large economic interests. Politicians at the local and national level as well affected citizens may use leverage to accelerate or slow down the process and the only guidance under such conditions are the legal and institutional framework, the agreed procedures and time schedules, but above all, cooperation, coordination, and good will to resolve problems for the national and regional benefit. Those adversely affected should be generously compensated and those favorable benefited should generously contribute to the success of the process.

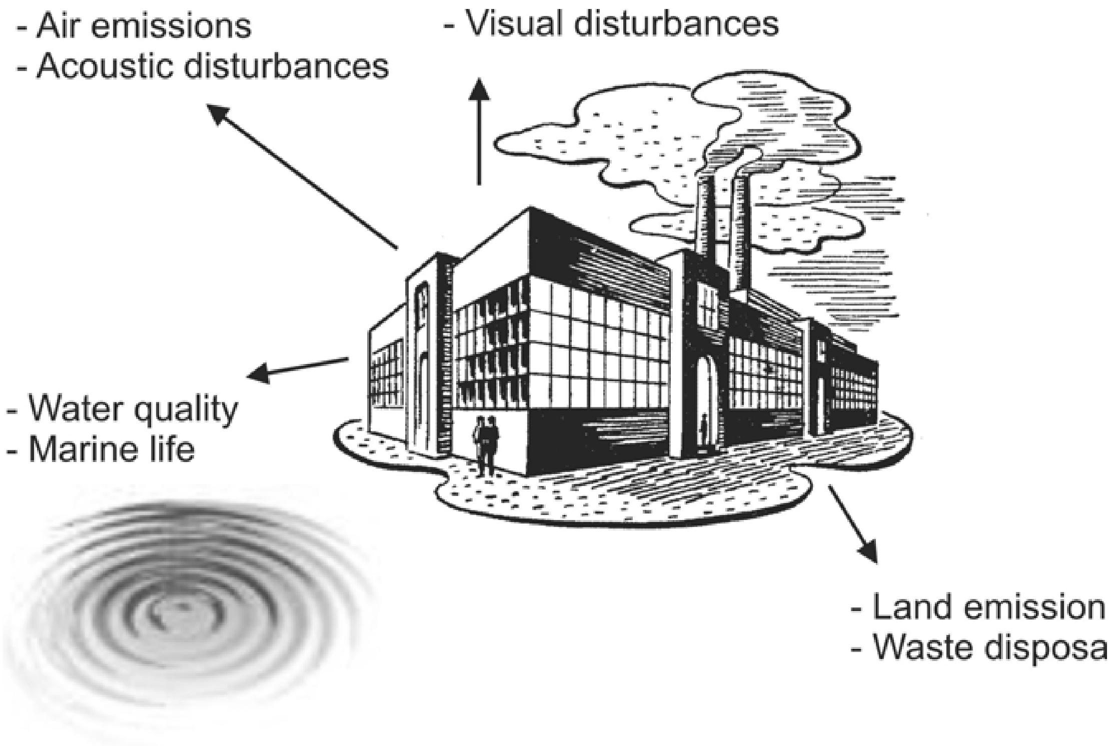
SECTION 5
ENVIRONMENTAL ASPECTS OF DESALINATION PLANTS

5.1 INTRODUCTION

With the growing market for desalinated water, environmental concerns about desalination plants have become an important issue. Introduction of desalination plants has been associated with potential impacts on the environment.

Noise is emitted, energy is consumed, and highly concentrated brine and waste membranes are discharged. Leaks in the feed water distribution system may affect aquifers, intake and outfall systems interfere with the marine environment, and the location of a desalination plant may reduce recreational values, which might adversely affect public acceptance and add to environmental damage as shown in Figure 25.

Figure 25 Environmental effects of RO desalination



Special attention must be paid to the way brine is discharged and to plant efficiency in terms of energy consumption, e.g. by using renewable energies to make a desalination project environmentally sound. Negative influences may not only damage the environment or reduce public acceptance, but can also result in financial penalties if toxicity standards are not met. In addition, tourism and the fishing industry may suffer through the installation of a desalination plant in an improper location.

To establish the relationship between desalination and the environment further, the input and output processes and their relationship to the environment must be established and evaluated. Each input and output to the desalination process has a positive or negative effect on the on the environment, and with proper mitigation measures, adverse effects may be greatly reduced.

Desalination and the environment need not be competitive, but complimentary to each other in a win–win situation.

5.2 ENVIRONMENTAL IMPACTS OF DESALINATION PLANTS

AIR EMISSIONS

Since desalination plants of any kind consume energy, every process at least indirectly emits greenhouse gases into the atmosphere. In terms of primary energy, RO requires 5–6 times less energy than thermal processes.

With the use of energy recovery systems together with high-efficiency pumps and state-of-the-art technology, energy consumption close to 3.0 kWh/m^3 of desalinated water should be the near future goal to reduce impacts on the atmosphere. Most energy for desalination processes is derived from thermo-electric power generation. The typical amount of greenhouse gases associated with the production of 1 m^3 of pure water in seawater desalination is presented in Table 10.

Table 10 Typical air emissions for desalination technologies per 1 m^3 water

Process	CO_2(kg)	NO_x(g)	So_x(g)	VOC(g)
RO	2	4	12	1.5
MSF	20	25	27	7

The production of 1 m^3 of pure water through SWRO demands about 1 kg of fuel oil/m^3 of fresh water, assuming an energy consumption of 3.0–4.5 kWh/m^3.

To mitigate the environmental influence of desalination on the atmosphere and to reduce dependency on oil as a primary energy source, the application of renewable energies should be considered in the future.

ACOUSTIC DISTURBANCES

High pressure pumps, energy recovery systems, and turbines operating in a desalination plant generate noise, as high as 90 decibels. Noise generation does not allow for operation of a desalination plant in the vicinity of population centers without the use of noise reduction technologies.

Reducing noise may require housings over pumps and other acoustical measures inside the plant. Workers must use ear protection to prevent hearing damage.

WATER QUALITY AND MARINE LIFE

Water quality and marine life are affected by desalination plants in various ways. The intake system may affect the marine environment by creating currents that can disturb marine organisms and suck them into the intake. Brine disposal has the strongest effect on water quality and marine life. The higher salt concentration and the chemical composition of the brine create disturbances in the vicinity of the outfall. The main chemicals present in the feed and in the brine include:

Calcium carbonate	Sodium sulfates

Sodium carbonate
Magnesium chloride
Sodium hydroarbonate
Potassium chloride
Calcium Sulfates

The chemical composition of brine and feed water in an SWRO plant are shown in Table 11.

Table 11 Chemical composition of brine and feed water in an SWRO plant

Analysis	Feed Water (mg/L)	Brine (mg/L)	Ratio (Feed/Brine)
Ca^{2+}	450	891.2	1.98
Mg^{2+}	1,452.3	2,877.7	1.98
Na^{+}	12,480	24,649.2	1.975
K^{+}	450	888	1.973
HCO_3	160	315.3	1.97
CO_3	0.2	0.4	2
SO_4	3,406	6,754.1	1.98
Cl	22,099	43,661.5	1.976
TDS	40,498.2	80,028.4	1.976
pH	8.1	7.8	—

Environmental effects associated with desalination processes can be classified in the categories shown in Table 12.

Table 12 Environmental Effects of the desalination process

Adverse Impact	Impact Level	Source of Impact	Mitigation Techniques
Increased salinity, may harm species less tolerant to salt	Medium	Concentrated brine	Dilute brine with sea water before discharge(see Section 3) Recover salt before discharge (see Section 3) Select outfall location for maximum mixing and dispersion
Chemical disinfectants	High	Chorine and its compounds react with organics	Use other disinfectants such as ultra violet Protect intake from pollutants
Toxic heavy metals	Medium	Plant equipment corrodes	Properly design and select plant equipment with corrosion-resistant materials
Chemicals	High	Use of anti-corrosion and anti-scalant	Reduce chemicals to minimum levels

		additives	
Adverse Impact	**Impact Level**	**Source of Impact**	**Mitigation Techniques**
Eutrophication of receiving water, toxicity, pH increase, air pollution, and acid rain Increase in greenhouse gases Dust	Medium (except dust, which has a high level of impact)	Fuel combustion	Use of environmentally friendly, non-toxic additives and clean, renewable energy wherever possible Apply co-generation and hybrid systems (RO/NF) Scrub gases before release to the atmosphere
Sediments, turbidity and limiting photosynthesis	Medium	Disturbing sand by excavation and dredging activities	Minimize and control cut and fill activities
Reduced respiration of aquatic animals	Medium	Disturbing sand by excavation and dredging activities	Proper management of runoff within the site area (see Section 4)
Noise	Low	Construction activities, pumps, and other plant operating equipment	Limit construction activities to working hours and design for and purchase plant equipment with low levels of noise

The strongest impact on the environment is expected to be from disinfectants—residual chlorine—and eutrophication of receiving waters through anti-corrosion and anti-scaling additives. The impact from thermal pollution and high loads of heavy metals is relevant for thermal desalination plants, but is not an issue in operation of membrane-based desalination plants.

5.3 ENVIRONMENTAL IMPACTS OF BRINE DISPOSAL

Brine is the process reject, and consists of water with high salt content. In case of desalination of seawater with RO, the salt content of the brine is almost double that of the seawater, where in case of thermal process the brine salt content is approximately 10 percent more than seawater.

This water also contains the membrane cleaning chemicals (SWRO) and other chemicals used for scale and corrosion control. The reject may be sent to inland aquifers, an inland water body, inland evaporating ponds, or to the sea. In all cases, the disposed water must have a minimum adverse impact on the receiving water bodies or on the land.

In general , brine water disposal has the potential to degrade the physical , chemical, and biological characteristics of the receiving water body. The degree of degradation is highly dependent on the total volume of the brine being released, its characteristics, the dilution rate prior to discharge, and the characteristics of the receiving waters.

DISPOSAL OF BRINE TO THE SEA

The reject brine contains the salts from the seawater with minor amounts of chemicals used during the process of cleaning the membranes or during scale and corrosion control. With proper disposal and dilution, no pollution or contamination problems are expected. The problems are mainly the disturbance of the seabed during construction and the dilution of the salt concentration, and may be mitigated as follows:

1. Minimize adverse effects on the seabed and marine life during construction of the sea outfall. Carefully select the route of the pipeline and install the pipe without great disturbance to the bottom of the sea and to the marine environment. Avoid use of explosives.
2. Minimize effects on the benthos and marine life during the operation of the plant. This concerns the concentration of salts in the area around the point of brine disposal. The location of the outfall (depth of water, distance from the shore, elevation above the seabed, and topography of the point) and its shape play an important role on the quick mixing of the brine with seawater and the dilution and diffusion of salts to the larger mass body.

Knowledge of the prevailing currents in the area and the area's topography are important in selecting the most appropriate point of brine disposal. A mathematical model simulating brine disposal may be used to project the salt concentration around the point of discharge using the brine concentration, the discharge rate, the seawater concentration, the sea currents, the geometry of the outfall, and the topography of the location.

Brine disposal requires a survey of fish and benthos life at the outfall area (within a perimeter of 200 m or more). The species of the benthos must be recorded and studied in conjunction with the results of the mathematical simulation model.

DISPOSAL OF BRINE TO INLAND BODIES

Disposal of the brine to inland bodies is not recommended since the adverse effects will be great. However, if this cannot be avoided, then an environmental study should be carried out and all mitigation measures taken to minimize adverse effects.

Options available for discharge are:

- Pumping brine to lined ponds
- Injecting brine to deep aquifers, providing that mixing with underground water is highly unlikely
- Spraying brine on arid land surfaces, an option that is not recommended
- Discharging brine into pipes that transport it to drainage networks or to the nearest wastewater stream
- Concentrating brine until solid salt crystals form, and disposing of them.

Risks of Inland Discharge

Risks involved in inland discharge revolve around the possibility of contaminating underground water, a risk that is always a possibility with all methods available for inland discharge except drying brine to salt crystals, which makes such contamination highly unlikely.

5.4 MITIGATION MEASURES

- Develop programs and policies to control the adverse impacts of the tourist industry and developments near the marine environment
- Establish and implement an integrated coastal zone management plan to ensure sustainable development of the coast and reduce conflicts among coastal users
- Review and update current environmental legislation to enhance its effectiveness and improve coordination among relevant sectors
- Enforce the use of Environmental Impact Assessments (EIA) coastal projects, including large-scale private and governmental development projects
- Implement and enforce existing laws, regulations, and other legislation related to the management of coastal and marine areas
- Hire and train staff to implement regulations and to ensure compliance with stated regulations both for coastal zone management and EIAs
- Encourage private parties whose activities may lead to destruction of key habitats to adjust these activities so that their impacts are reduced or avoided

5.5 ENVIRONMENTAL IMPACT ASSESSMEN STUDY

An environmental impact assessment study (EIAS) must be carried out for the most promising site. This study must consider all environmental parameters and criteria to evaluate their impact on the air, land, and marine environment and propose measures to mitigate their impact. Before carrying out this study, special studies must be carried out on selection of the site, brine disposal, and energy considerations as described earlier in this report. The EIAS should contain:

1. Selected process and plant layout (process selected, plant location, plant area, height, size, layout, raw water supply intake, pumping stations, and land pipelines)
2. Plant emissions (brine disposal; chemicals used for pretreatment, post treatment , and corrosion control, anti-scaling, anti- fouling, and anti- foaming; and heat from thermal process)
3. Environmental implications (air and noise pollution; public safety; chemical hazards; land, marine, and biotic environments)
4. Energy considerations
5. Benefits (socio-economic impact, product water, reliable supply of water)
6. Evaluation of the impact on the environment
7. Proposed mitigation measures

5.6 ENVIRONMENTAL IMPACT ASSESSMENT IN EGYPT

According to the Egyptian Environmental Law (Law No. 4/1994), new establishments and factories (including expansions) are required to carry out an EIA before embarking on construction or implementation of the project.

The main objective is to support rather than to prevent or obstruct development activities in the country, through identifying positive and negative impacts of projects, maximizing positive impacts and minimizing negative ones. Such an approach supports the concept of sustainable development of any project.

An EIA is the systematic examination of consequences of a development project or program, with the view to reduce or mitigate negative consequences and capitalize on positive ones. This means studying and analyzing the environmental feasibility of any proposed project because the implementation or operation of the project may affect the environment, natural resources, and or human health.

According to Law 4/94, projects that need to prepare EIAs are screened into three categories based on different levels of EIAs required according to severity of possible environmental impacts:

- White list projects for establishments/projects with minor environmental impacts
- Gray list projects for establishments/projects that may result in substantial environmental impacts
- Black list projects for establishments/projects that require complete EIAs due to their potential impacts

Desalination projects fall under the gray list under the Ministry of Housing and Reconstruction (the competent administrative authority) because desalination projects are categorized as water supply establishments and potable water stations.

The proponent (project owner or developer) has to fill out Environmental Screening Form B (see the annex). The procedure consists of two stages:

1. Screening (filling out Form B)
2. Preparing a scoped EIA on certain identified impacts/processes, including
   - RO projects—brine water disposal and noise
   - Other desalination projects—energy, heat, noise, and brine water disposal

5.7 PREPARING A SCOPED EIA (GRAY LIST)

If the developer is asked to conduct a scoped EIA study for certain selected impacts/processes, the developer must submit Screening Form B and a complete study for the scoped EIA to the CAA.

The CAA registers the study and checks whether the information included in the scoped EIA complies with required information according to the Terms of Reference.

The CAA checks the documents and formally submits the applicant's documents to the EEAA for review and evaluation.

The EEAA evaluates the study and submits—within 60 days of receipt of the completed documents—its possible proposals for measures to be taken in order to ensure the protection of the environment to the CAA. Failure to do so shall be considered an approval of the assessment.

The EEAA registers the documents, its opinion, and proposals in the EIA register at the EEAA.

The CAA officially notifies the developer by registered letter with an acknowledgment of receipt about the final result of the evaluation. The result can be either:

1. An approval of the project, including possible measures to be taken to ensure the protection of the environment, or
2. Disapproval of the proposed project.

The CAA forwards a copy of the decision to EEAA, which registers it in the EIA register.

The CAA ensures implementation of the decision.

The developer can appeal the decisions to the Permanent Appeals Committee in writing within 30 days of receipt.

5.8 ENVIRONMENTAL ASSESSMENT REPORT

Provide an environmental assessment report that is concise and limited to significant environmental issues. The main text should focus on findings, conclusions, and recommended actions, supported by summaries of data collected and citations for any references used in interpreting those data.

Organize the environmental assessment report according to the outline below:

1. Executive summary
2. Policy, legal, and administrative framework
3. Description of the proposed project
4. Description of the environment
5. Significant environmental impacts
6. Analysis of alternatives
7. Mitigating management plan
8. Monitoring plan
9. Non technical summary of the report for political and public use
10. List of references
11. Appendices
12. List of environmental assessments prepared
13. Data for unpublished reference documents

SECTION 6
RECOMMENDATIONS

RECOMMENDATIONS FROM THIS STUDY

1. Desalination of saline water is necessary for development of the Red Sea region.
2. The levels of salinity in sea water and beach wells in the area makes the water suitable for operating RO and thermal desalination technologies
3. RO is considered the most suitable technology in this area due to its lower power consumption; needed electrical power can be supplied by a generator
4. It is preferred to use intake water from beach wells to minimize treatment
5. Thermal desalination plants could be used if the plant is located near a power plant
6. Development of the Red Sea region should be managed together with desalination plant capacity
7. Installation of centralized desalination plants to serve new developments and resort areas should be considered as part of the region's strategic management plan
8. Individual desalination plants can be built to serve isolated resorts
9. As part of the strategic management plan, private investors should be allowed to invest in building desalination stations and providing required fresh water to developing areas; these projects may be implemented using BOOT contracts
10. It is preferable to build an independent water production project inside a tourist project using BOO contracts; BOO projects can also be established outside tourism areas by special arrangement with authorities
11. Investors should transfer O&M responsibilities to the contractor who supplies and installs an RO plant, paying for this service and for a supply of chemicals, spare parts, and membrane replacements
12. Establish centralized desalination plants that can be implemented in module form to provide flexibility in increasing the desalination capacity in steps, in accordance with the increase in demand
13. Decide on suitable brine disposal methods depending mainly on the nature of the sea bed and the geological nature of the site
14. If brine disposal is to be to evaporating ponds (land disposal), ensure that land is available at reasonable prices and that disposal methods maximize reuse of chemicals, including salt
15. A Scoped Environmental Impact Assessment Study (EIAS) for desalination plants must be carried out and approved by EEAA before starting plant construction
16. A continuous assessment program of the status of the Red Sea's resources and environmental quality (sediment, water, and biota) should be established and used as a baseline while investigating the status of the marine environment

APPENDIX: ENVIRONMENTAL SCREENING FORM B

Arab Republic of Egypt

THE CABINET OF MINISTERS
Ministry of State for Environmental Affairs
Egyptian Environmental Affairs Agency

The information required in this form should be filled in an accurate and legible way.

The administrative authority should review and stamp the form, then send it to EEAA for review and give opinion. Site visit report or any additional attachment might be submitted

Environmental Screening FORM B

1. General Information

o Project title:---

o Type of project (infrastructure, petroleum and mining, tourism, industrial, other) --
----
----

o Name of the owner (individual, company, etc) -------------

----

o Name of the person in charge (the responsible person): -
----

o Address:---
----

o Telephone No: -----------------------------Fax No-------------

o Competent Administrative Authority:-------------------------

2. Project data

o Location of the project (please attach a map that clearly shows the location of the project in relation to residential areas and neighboring activities. The map should have a suitable and clear scale and should be approved by the competent administrative authority).

Address of the project: -- -- --

A. City □, village□, accredited industrial zone□, others □ (please specify)-------

B. In a residential area□,Outside a residential area □

C. Individual building□,A multiple story building with a residence above □

Total area of the project (Square meter): ---------------------- -----------------------------

o Type of project:

New□,Extension □

Type of extension: ---

If the type of project is an extension, has an EIA study been submitted for the original project?

Yes□No□

Date of obtaining a previous approval from the EEAA: ----- ------------------

Production capacity: and/or storage capacity:

Please mention units used: -------------------------------------- ---------------------

o Main products: --

o By-product: ---

o *A general description of the area surrounding the project including a description of the different activities, historical areas, protected areas, tourist and recreational areas, etc…*

Infrastructure available:

- *Water supply (network)*: Available □ Not available □
- Electricity supply (network): Available□Not available □
- Sewers: Available□ Not available □

- Roads/railways: Available ☐ Not available ☐
- natural gas: Available ☐ Not available ☐

o Reasons for choosing the site and the degree of its safety against natural hazards and its compatibility with the neighboring communities:----------------------------------
----

----

3. **Project phases and their expected starting dates:**

Construction: ------------------------------ Actual operation: ---------------------------

4. **A brief description of the construction stages** --------
----

----

o Sources of water: --

Water use: ---

Rate of consumption: --

o Type of fuel: ---

Source of fuel: ---

Rate of consumption: --

o Expected number of workers: ------------------------------

5. **Wastes resulting from construction, control and disposal methods:**

o Solid wastes: ---

type ---

amount: ---

methods of disposal:--

o Liquid wastes: --

type ---

amount: ---

methods of disposal:--

o gaseous emissions (smoke, dust, particulate matter)------

----
methods of control: ---
----
o Noise: ------------------------------- methods of control: -----
----
----

6. Detailed description of the operation stage (*diagrams should be attached if possible*)

o Main components of the project: ------------------------------
----

----

o Description of Industrial processes (demonstrated as possible by catalogues and diagrams) --
----

----

o Electrical supply used: ---------------------------- source: ----
----

o Type of fuel (natural gas, *sular*, fuel oil): --------------------
-------------------------rate of consumption:------------------------
----

o Raw materials:

Main:--

Auxiliary:---
----

o Alternatives taken into consideration of raw materials ----
----

----

o *Reasons for choosing the technology used*-----------------
----

----

o Expected number of workers:---

----

o Source of water (public, groundwater, surface water, others):-------------------------

----

Rate of consumption: ---

7. **Wastes, treatment methods and ways of disposal** (Expected standards of

atmospheric emissions and waste water after treatment)

o Liquid wastes:

Waste water:--

Discharge rate: ( ) cubic meter/day

Methods of discharge (public sewer, boreholes, etc) -------

Industrial waste water: --

Discharge rate: ( ) cubic meter/day

Expected analysis of industrial waste water: ------------------

----

Methods of discharge (please choose one of the following options):

☐ Directly into the municipal public sewer ( )

☐ *The project has a unit for treatment of industrial wastewater which is* *discharged into the public sewer after treatment (   ) (please attach a*

catalogue or diagram for the waste water unit used and the standards of

treated waste water)

□ *It is discharged in a bore hole and then collected (   )*

□ *It is discharged into surface water (please state the standards of*

wastewater, the discharge rate and the name of the surface water body) ---

---

-----------------(   )

□ *Any other methods of discharge (please specify)--------*

-- --

(   )

o Atmospheric emissions: (the type of atmospheric emissions, and the concentrations of SOx, COx, particulate matter, etc)---

----
----

o Solid wastes: ---

Type:---

Amount: --

Methods of transport, handling and storage:------------------

----

Methods of disposal: --
----

o Hazardous wastes: --

Type:---

Amount: --

Methods of treatment::--

Methods of disposal: ---
----

8. **Preliminary analysis of environmental impacts during operation and methods of mitigation:**

o Impact of the project on the air quality: ----------------------
----
----

o Impact of the project on quality and availability of water:-
----

----

o Impact of the project on soil quality and fertility:------------
----

----

o Visual impacts:---
----

o Noise: ---
----

o Other predicted and significant impacts of the project:----
----

----

o Description of any other measures not mentioned earlier to mitigate the negative impacts of the project : --------------
----

----

o Measures undertaken to protect the health and safety of workers and fire prevention facilities:--------------------------

----

DECLARATION

Hereby I, the signer, declare that the information submitted above is accurate and true and that in

case there is any modification of the information stated above, the EEAA shall be informed

through the Competent Administrative Authority. Hereby I declare:

Name: ---

Identity Card number and address: ---

Position (in the capacity of): --

Date: ---

Form filled in with the knowledge of the competent administrative authority

Name: ---

Professional title: --

Signature: ---

Official Stamp

Arab Republic of Egypt The Cabinet of Ministries Ministry of State for Environmental Affairs Egyptian Environmental Affairs Agency	**جمهوريـــة مصـــر العربيـــة** **رئاســة مجلـــس الـــوزراء** **وزارة الدولة لشئـون البيئة** **جهـــاز شئـــون البيئـــة**

تملأ بيانات هذا النموذج بدقة وبخط واضح ويتحمل مسئولية صحة البيانات المقر بما فيه علي أن تقوم الجهة الإدارية باعتماده وإرسال نسخة من النموذج إلى الجهاز للمراجعة وإبداء الرأي ويمكن الاستعانة بأية تقارير معاينة أو مرفقات أخري إضافية

نموذج التصنيف البيئي (ب)
Environmental Screening Form (B)

١ - <u>معلـومـات عـامـة</u>

١,١ **أسم المشروع** :---

٢,١ **نوع المشروع** : (بنية أساسية - صناعي - زراعة - خلافه)

٣,١ **أسم مالك المشروع** : (شخص - شركة - ألخ ٠٠٠)

----

١. ٤ **اسم الشخص المسئول** : ---

: --- **العنوان**

------ --

: ------------------------- **رقم التليفون** : --------------------- **رقم الفاكس**

١. ٥ **الجهة المانحة للترخيص** : --

٢ - <u>بيانات المــشروع :</u>

مكان وموقع المشروع (برجاء إرفاق خريطة مفصلة ومعتمدة من الجهة الإدارية المختصة وبمقياس رسم مناسب موضحا بها حدود الموقع وموقفه بالنسبة للكتلة السكنية و الأنشطة المجاورة و طرق المواصلات والمناطق الأثرية والمحمية والسياحية إن وجدت)

٢. ١ عنـــوان المشروع : ---

مدينة ☐ قرية ☐ منطقة صناعية معتمدة ☐ أخري مع ذكره ---------- ☐

داخل الكتلة السكنية ☐ خارج الكتلة السكنية ☐

مبني مستقل ☐ يعلوه سكن ☐

المساحة الكلية للمشروع (متر^{2}) : --------------------------------------

المساحة الكلية لمبانى المشروع (متر^{2}) : ------------------------------------

طبيعة المشروع : ٢ . ٢

جديد ☐ توسعات ☐

طبيعة التوسعات : ------------------

إذا كانت طبيعة المشروع توسعات فهل تم تقديم دراسة تقييم تأثير بيئى للمشروع الأساسي؟

نعم ☐ لا ☐

تاريخ الحصول على موافقة الجهاز السابقة : ------------------------------------

٢ . ٣ **الطاقة الإنتاجية** ☐ أو **السعة التخزينية** ☐

مع ذكر الوحدات المستخدمة : --

٢ . ٤ **المنتج النهائى** :-- -----------------------------
----

٢ . ٥ **المنتج الثانوى** :---
----

٢ . ٦ وصف عام للمنطقة المحيطة بالمشروع متضمنة المناطق الأثرية والتاريخية والمحميات والمناطق السياحية والترفيهية

----

٢. ٧ البنية الأساسية المتوفرة :

- شبكة المياه: متوفر ☐ غير متوفرة ☐
- شبكة الكهرباء: متوفرة ☐ غير متوفرة ☐
- شبكة صرف صحى : متوفرة ☐ غير متوفرة ☐
- شبكة طرق / سكة حديد متوفرة ☐ غير متوفرة ☐
- مصدر للوقود : متوفرة ☐ غير متوفرة ☐

٨.٢ أسباب اختيار الموقع .I

٨,٢. **<u>مراحل المشروع و تواريخ بدايتها المتوقعة :</u>**

الإنشـــــاء : --

الـتشـغيل الفعلي : --

<u>٤. وصف موجز للمشروع أثناء مراحل الإنشاء</u>

----

٤. ١ مصادر المياه : ------- استخداماتها :-------- معدل الاستهلاك : ---------

٤. ٢ نوع الوقود : -------- مصدر الوقود :-------- معدل الاستهلاك : ---------

٤. ٣ العمالة المتوقعة وأماكن إقامتهم :------------------------------------ -----------------------------
----

٥. <u>المخلفات الناتجة عن الإنشاء وطرق التخلص منها</u> :

٥. ١ مخلفات صلبة :------------------ --- نوعيتها : --------------------

كميتها : -------------------------- طرق التخلص :----------------

٥. ٢ مخلفات سائلة :----------------------نوعيتها : -------------------

كميتها : --------------------------طرق التخلص :-------------------

٥. ٣ إنبعاثات غازية (دخان - رائحة - مواد عالقة) ---------------------------

٥. ٤ ضوضاء --

<u>٦. وصف تفصيلى لمرحلة التشغيل (ترفق أشكال أو رسومات توضيحية)</u>

٦. ١ المكونات الرئيسية للمشروع : --

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٦. ٢ وصف العمليات الصناعية (مدعما بالكتالوجات وخرائط التشغيل٠٠ الخ) -----------------------------
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٦. ٣ الطاقة الكهربائية المستخدمة ----------------مصدرها : -----------------

٦. ٤ المواد الخام : الرئيسية : --

المساعدة :--

٦. ٥ البدائل المأخوذة فى الاعتبار للمواد الخام المستخدمة --------------------------

٦. ٦ أسباب اختيار التكنولوجيا المستخدمة

----

٦. ٧ العمالة المتوقعة وأماكن إقامتهم :

----

٦. ٨ نوع ومصادر الوقود : ------------------ معدلات الإستهلاك :---------------

(كهرباء عمومية /مولدات/خلايا شمسية/٠٠٠)

٦. ٩ مصادر المياه : ------------------ معدلات الإستهلاك : --------------

(عمومية/ جوفية/مسطحات مائية/٠٠٠)

٧. **<u>المخلفات ومعالجتها وطرق التخلص منها</u>**

(توضح المعايير المتوقعة للإنبعاثات الغازية ومياه الصرف بعد المعالجة)

٧. ١ **المخلفات السائلة**

- <u>الصرف الصحي</u> : --

معدل الصرف : (   ) م٣/يوم

طرق التخلص : (شبكة عمومية - بيارت - الخ ٠٠٠) ----------------------

- <u>الصرف الصناعي</u> : --

معدل الصرف : (   ) م٣/يوم

التحليل المتوقع للصرف الصناعى : ---

طرق التخلص من الصرف : (يختار أحد البدائل التالية)

- على شبكة البلدية مباشرة (   )

- توجد وحدة معالجة للصرف الصناعى خاصة بالنشاط، ثم يصرف على الشبكة (   )

(يرفق كتالوج خاص بوحدة المعالجة المستخدمة ومعايير الصرف الناتج عن وحدة المعالجة)

- يجمع فى بيارة بدون معالجة ويتم كسحه٠   ( )

-يتم الصرف على مسطح مائى مع بيان معايير ومعدل الصرف وأسم المسطح

-- ( )

٧. ٢ ملوثات الهواء

----

٧. ٣ المخلفات الصلبة و الخطرة

طرق النقل والتداول والتخزين :

التخلص من المخلفات (مدفن آمن ـ متعهد ـ أخرى)

----

٨. <u>تحليل مبدئى للآثار البيئية أثناء مرحلة التشغيل والتخفيف من الآثار البيئية لها :</u>

٨. ١ تأثير المشروع على نوعية الهواء :

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٨. ٢ تأثير المشروع على نوعية ووفرة المياه :

----

٨. ٣ نوعية التربة

(تأثير المشروع على نوعية وخصوبة التربة)

----

٨. ٤ التلوث البصرى

----

٨. ٥ الضوضاء

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٨. ٦ أى تأثيرات أخرى محتملة أو هامة ناتجة عن هذا النشاط

----

٨. ٧ وصف لأية وسائل أخرى لتخفيف الآثار السلبية للمشروع لم يتم ذكرها سابقاً : ----------------------
----

٨. ٨ الاحتياطات المتخذة بشأن صحة بيئة العمل وأمان العاملين و تسهيلات مكافحة الحريق

إقــــــرار

أقر أنا الموقع أدناه بأن البيانات المدونة عاليه صحيحة و دقيقة طبقا للمعلومات المتوفرة لدى، و أنه فى حالة أى تعديل لاحق سيتم إخطار جهاز شئون البيئة فى حينه ،

و هذا إقرار منى بذلك ...

المقـــــــــر:............

رقم البطاقة/ الرقم القومي /جواز السفر : ----------------------------

صـــفـــــــته : -------------------------

التـــــــاريخ : -------------------- ------

بيانات تملأ بمعرفة الجهة الإدارية المختصة أو المانحة للترخيص

-

اعتمـــاد الجـهة الإداريـة :

الاسم : -------------------------

الوظيفة : ------------------------

التوقيع : -------------------------

خاتم شعار الجمهورية

Livelihood and Income from the Environment (LIFE)

Sustainable Economic Development in the Red Sea Project

in partnership with

The Egyptian Environmental Affairs Agency (EEAA),
Ministry of State for the Environment

The Tourism Development Authority (TDA),
Ministry of Tourism

and

The Red Sea Governorate (RSG)