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AAWDC Project: Executive Summary of the ESIA

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This technical assistance operation is financed under the EIB's Economic Resilience Initiative (ERI). The ERI is EIB's response to the European Council's call to intensify its support for the EU's neighbourhood, in pursuit of economic growth and the achievement of the sustainable development goals (SDGs). The objective of this initiative is to rapidly mobilise additional financing in support of sustainable growth, vital infrastructure and social cohesion in Southern neighbourhood and Western Balkans countries. The Economic Resilience Initiative focuses on both the public and the private sectors, in support of EIB activities during different stages of the project cycle. The EIB is contributing to the ERI TA window with an envelope amounting to EUR 90 million from its own budget resources.

Table of Contents

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List of Figures

List of Tables

1. Introduction

Jordan has limited surface and groundwater resources, which are significantly less than the international threshold of 500 cubic meters per capita, which is considered "absolute scarcity". As a result, the only remaining option that can provide an entirely in-country and Jordan-controlled new water supply source is the desalination of Red Sea seawater, leading the the Ministry of Water and Irrigation (MWI) to launch the Aqaba-Amman Water Desalination and Conveyance National (AAWDC) Project. The Project will generate 300 million cubic meters (MCM)/year of drinking water after commissioning. The Project will be implemented through a build-operate-transfer (BOT) scheme.

The AAWDC Project aims to reduce the deficit in the country's crucial water resources by providing a safe and reliable freshwater supply for Amman and other governorates in Jordan and areas along the Project pipeline route.

The ERI ITA Consortium, with Tetratech in the lead and Engicon as local subconsultant, was contracted by the European Investment Bank (EIB) for conducting the Environmental and Social Impact Assessment (ESIA) Study for this project. This report was prepared in line with national requirements for ESIA, as well as EIB and the United States Agency for International Development (USAID) standards, who are considering providing financing for the AAWDC Project.

2. Project Description

A summary of the Project scope of facilities are shown in Table 2-1 below. The detailed Project description is provided in Chapter 2 of the ESIA study.

Table 2-1: Scope of Facilities

Item	Type of Facilities	Description
1	Seawater Intake System and Conveyance Pipeline to the Intake Pump Station	Sized to meet the set production capacity of 300 MCM/year of fresh water at a set plant availability of 97%. The RO plant overall recovery rate was set between 42% and 45%.
2	Seawater Intake Pump Station	
3	Seawater Pipeline from IPS to Desalination Plant	
4	Desalination Plant	
5	Brine Line	Sized to discharge generated brine
6	Conveyance Pipeline from Desalination Plant to Amman PS ADC	250 MCM/year
7	Pump Stations along Conveyance Pipeline from Desal Plant to Amman 1. BPS 1 to 4 2. Mudawarra PS 3. PS ADC	BPS 1 is sized for 300 MCM/year while all other pumping stations are sized for 250 MCM/year
8a	Conveyance Pipeline from PS ADC to Abu Alanda Reservoir	180 MCM/year
8b	Conveyance Pipeline from PS ADC to Al Muntazah Reservoir	70 MCM/year
9	Regulating Tanks on Conveyance Pipeline	250 MCM/year for the tanks that are a part of the conveyance system

Project Location

A general layout of AAWDC Project along with its key technical components is presented in Figure 2-1. The figure illustrates the general alignment of the water conveyance system along with the location of the IPS and Sea Water Reverse Osmosis (SWRO) Desalination Plant, Abu Alanda Reservoir and Al Muntazah Reservoir.

Figure 2-1: Overall Location of AAWDC Project

Description of Project Components

Table 2-2 summarizes the project's two main groups of components, which are the Water Desalination Components and the Water Conveyance Components.

Table 2-2: Summary of Project Components

Water Desalination Components		Water Conveyance Components
Offshore Facilities	**Onshore Facilities**	
• Intake pipeline and towers • Brine outfall pipeline and diffusers	• Intake Pumping station • Sea water conveyance pipeline from the IPS to the SWRO desalination plant • SWRO desalination plant • Domestic Wastewater Treatment System • Brine conveyance pipeline from the SWRO desalination plant to the IPS • BPS 1 • Aqaba Res. 2	• Conveyance Pipeline • BPS2 • Aqaba Res. 1 • BPS3 • RGT1 • BPS4 • RGT2 • MUS2/BPS5 • RGT3 • BPT • ADC • Al Muntazah branch • Abu Alanda branch

Offshore Facilities

Intake pipeline and towers

According to the preliminary Project design, seawater will enter the intake system via submerged offshore intake towers that will be installed at the seabed. Four (4) intake towers are envisaged to accommodate the ultimate plant capacity of 300 MCM/year. Screen arrangements will be provided at the intake towers to prevent solid objects from flowing to the onshore Intake Pumping Station (IPS). The intake towers will be designed as typical 'velocity cap' type structures that enable the change of abstracted seawater flow from horizontal to vertical and thus minimise the entrainment of marine species; they shall be constructed from reinforced concrete. The intake towers will be designed to achieve a 'through-screen' velocity of less than or equal to 0.15 m/s at ultimate capacity, with clean screens and all intake towers in operation.

The intake system will have a strategy for macrofouling control (i.e., the removal of mussels and barnacles from the towers and the pipelines) in order to maintain the intake capacity at the set plant availability. The use of chlorination for macrofouling control of the intake system shall be avoided unless it is proven that there is no other technical solution to maintain the intake capacity (i.e., through manual cleaning by divers or mechanical pigging). However, should chlorination be used for the intake system fouling control, the chlorination dosing pipelines will be double-contained and equipped with a leak detection system. Further, a means to prevent scaling of the chlorination dosing lines will be needed if hypochlorite is used.

Based on relevant preliminary design calculations, the intake arrangement will comprise four (4) No. DN2300 intake pipelines, each connected to the relevant intake tower below the seabed level.

Brine outfall pipeline and diffusers

The desalination process will result in a significant amount of brine concentrate which will be discharged back into the sea. According to the preliminary Project design, an outfall configuration comprising two (2) outfall pipelines of nominal diameter DN2300 will accommodate brine flow in either 50% or 100% plant operating capacity and provides a potentially wider choice of suppliers by maintaining the pipe size common to that of the intake pipelines.

Based on near-field modelling, the outfall will be designed to comprise a diffusers' section. The concept design for the diffusers was based on a nominal diffuser port exit velocity of approx. 6.4 m/s. For a 100% operating capacity, there will be two outfall pipelines in operation, each terminating in a diffuser arrangement around 86 m long, and each discharging nominally around half the total reject brine flow. The two 86 m long diffuser sections are perpendicular to the shore and arranged in a staggered manner – one further offshore than the other – such that the total combined diffuser length with both pipelines in operation will be just under 200 m. Based on the preliminary design calculations, each diffuser section will indicatively consist of 8 sets of twin-port risers (or twin-riser pairs) of nominal diameter of 300 mm, which will be equally spaced along the 86 m long diffuser section. The first riser will be located in around 25 m water depth. Consideration will be given so that the diffuser risers/ports be shrouded with a protective cowl to guard against being snagged by nets/cables, etc. from unauthorised vessels that may encroach into the diffuser area, while the diffuser area can be determined to be a restricted area and marked with buoys to be an exclusion area.

Onshore Facilities

Intake pumping station

The intake pumping and screening systems will be designed to deliver sufficient raw seawater to the Desalination Plant to allow continuous operation. The raw seawater pumping, and screening system will comprise bar screens, traveling screens with wash pumps, intake seawater pumps, and biofouling control in order to deliver seawater that is sufficiently free of solid materials. Seawater pumps will be designed to deliver sufficient raw seawater to the Desalination Plant even with one unit out of service. They will be capable of stable operation over the expected range of desalinated water production from 150 MCM/year to 300 MCM/year and expected sea level conditions.

There will be suitable provision for ease of operation, maintenance, and cleaning of the intake pipelines from the intake towers to IPS, including the provision for a chlorination system and a pig-launching and receiving system. A chlorination system will only be only provided if manual cleaning by divers and/or mechanical cleaning through pigging are proven not to be technically feasible. The pig receiving station will be installed at the Desalination Plant for the pigging of the intake pipelines connecting the IPS to the Desalination Plant site.

Sea water conveyance pipeline from the IPS to the SWRO desalination plant

According to the preliminary design, there will be two seawater pipelines from the IPS to the Desalination Plant of 2,700mm outside diameter (OD) each, which will be placed on the same trench of an average depth of 5 m. A width of approximately 10 m is required for the installation of these seawater pipelines.

Brine conveyance pipeline from the SWRO desalination plant to the IPS and brine outfall system

According to the preliminary design, there will be one (1) brine conveyance pipeline from the Desalination Plant to the IPS of 2,700mm outside diameter (OD), which will be placed on the same trench as the seawater pipelines at an average depth of 5 m. A width of approximately 5 m is required for the brine pipeline. A 40 m right of way (ROW) is foreseen for the installation of both seawater and brine pipelines. However, this will need to be further verified during the detailed design. Should there be traffic restrictions within the industrial area, consideration will be given so that every pipe is installed in a single trench, which will need only 5 m width so that a 25 m road corridor is maintained.

SWRO desalination plant

The desalination plant will be designed to produce 300 MCM/year of treated water in one phase. The system will be designed to achieve 97% availability and an overall plant recovery efficiency to product water ranging from 42% to 45% and will be based on the reverse osmosis (RO) process. The key water treatment process steps consist of seawater pre-treatment, single pass RO including energy recovery system, water post-treatment stabilization, and finally product water disinfection to provide a disinfectant residual in the distribution system for protection against pathogens. The desalination plant will also include an on-site Solids Treatment System for the processing of process waste effluent streams (i.e., filters backwash effluents, neutralized effluents from the cleaning of membranes, and post-treatment backwash effluents). Neutralized organic membrane cleaning waste will be conveyed to onsite evaporation ponds. Generated wastewater of domestic origin will be conveyed to an on-site Wastewater Treatment System. Figure 2-2 presents a simplified process flow diagram of the water desalination component starting from the intake system (at the Gulf of Aqaba), continuing to the desalination plant, reaching the freshwater booster pump station (BPS1), and ending at the brine discharge outfall.

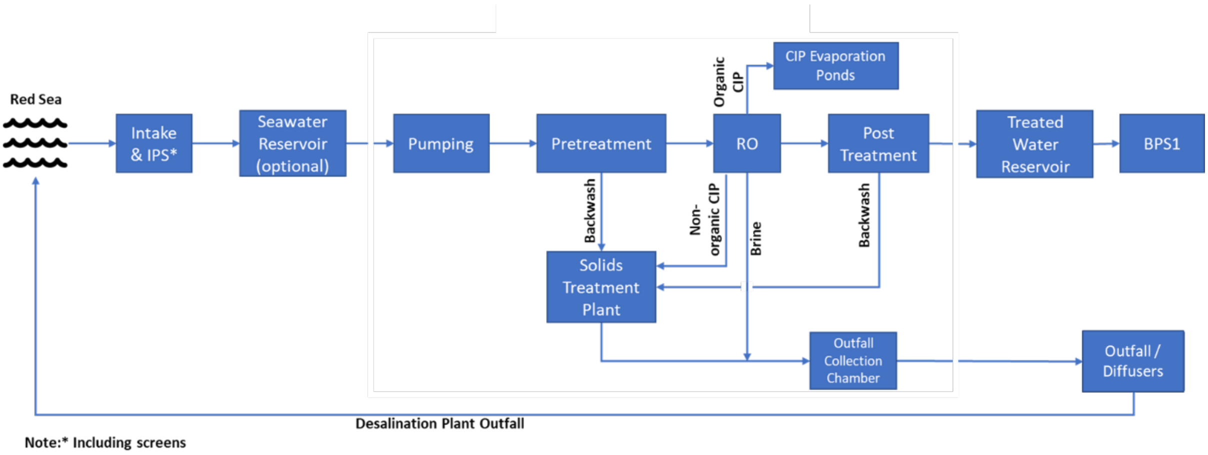

Figure 2-2: Process Flow of the Entire Desalination Plant. [1]

Based on the preliminary design, the Desalination Plant is divided into two identical halves each with 150 MCM/year capacity, one located at the north side of the platform and the other at the south side. Both plants are independent, but the process train is the same for both including pre-treatment, RO treatment, post-treatment and treated water pumping to the Treated Water Storage. The Chemical Storage Building,the Solids Treatment System, and the domestic Wastewater Treatment System are common for both plants.

The domestic Wastewater Treatment System will be sized to treat the expected wastewater flows to be generated by the employees assigned to the operational period of the Desalination Plant. A per capita wastewater flowrate of 150 l/capita/day shall be used to estimate the wastewater flow to be treated. Based on the preliminary design, a conventional packaged activated sludge WWTP will be provided including the following process treatment steps: pretreatment, aeration, sedimentation, sludge treatment, and treated effluent disinfection.

Figure 2-3 shows the loation of the onshore facilities including intake pumping station (IPS), the desalination plant, the feed seawater pipeline and the brine pipeline.

Figure 2-3: Location of Intake Pumping Station, RO Plant, Feed Water Pipeline and Brine Pipeline

Capacity and Flow

In order to meet the capacity target and provide the required flexibility in the system, the conveyance system from the Desalination Plant to Abu Alanda Reservoir is designed at the ultimate development capacity of 300 MCM/year for 97% of availability. A total of 250 MCM/year of fresh water will be conveyed from the SWRO plant through the conveyance pipeline to Amman and other governorates. The destination of the remaining 50 MCM/year of fresh water is still to be decided and is out of the scope of this ESIA study.

Moreover, two reservoirs associated with this scheme will be constructed under this project: a 6,000 m^3 reservoir (Res-1) near PS2 and a 9,000 m^3 reservoir (Res-2) near PS1 (see Figure 2-1 for locations of PS1 at the RO site and PS2), each serving different zones in the Aqaba distribution system. From Res-1, a 6 km long, 500mm diameter, pipeline (Line A) will be constructed to serve "Zone-1" of the Aqaba distribution zones. Similarly, from Res-2, a 2 km long, 500mm diameter, pipeline (Line B) will be constructed to serve "Zone-2" of the Aqaba distribution zone.

Diversion of flows to Ma'an, Tafileh, Karak and Madaba Governorates are understood to be under consideration. However, since these concepts have not yet been sufficiently developed to enable incorporating them in the analysis, and given the relatively small impact on the overall project, the ESIA team did not look at the impacts of these changes to the Project.

Power Demand

The estimate of power demand relative to the AAWDC Project facilities is summarized in the Table 2-3 and Table 2-4 for the SWRO plant. The power demand was based on a system production capacity of 300 MCM/year. However, the BOT Developer will be requested to consider options related to renewable energy supply to compensate for consumed power and prepare the necessary studies including the Environmental Impact Assessment for the needed infrastructure.

Table 2-3: Power Demand Estimates at AAWDC Facilities (Except for SWRO Plant)

AAWDC Facilities	Assumed Provider	Total Connected Load		Total Demand Load		Estimated Energy Consumption
		MW	MVA¹	MW	MVA¹	GWh/y
IPS	Electricity Distribution Company (EDCO)	30.3	33.7	27.4	30.4	238
BPS1	EDCO	39.3	43.7	35	38.9	282
BPS2	EDCO	33.3	37	28.4	31.6	230
BPS3	EDCO	43.8	48.7	31.8	35.3	250
BPS4	EDCO	32.3	35.9	25.7	28.5	217
MUS2/BPS5	Jordanian Electric Power Company (JEPCO)	43.8	48.7	31.8	35.3	258
PS ADC[4]	JEPCO	36.7	40.8	30.4	33.8	215
Total		259.7	288.5	210.4	233.8	1,699

Notes:

1) **Based on Power Factor of 0.9**
2) **Based on 300 MCM/y desalinated water production**
3) **Considaring Abu Alanda and Al Muntazah Delivery porints**
4) **Based on average operating conditions**

Table 2-4: Power Demand Estimates at SWRO Plant

AAWDC Facilities	Assumed Provider	Total Connected Load (MVA)	Total Demand Load (MVA)	Estimated Energy Consumption[1] (GWh/y)
Desalinaton Plant	EDCO	235.2	202.8	980.3

1) **Based on 300 MCM/y desalinated water production and average seawater quality conditions.**

Schedule of Works

The Project BOT scheme execution is expected to take place at the end of 2021 and last for six (6) years, until the end of 2027. This will include two (2) years for tendering, negotiation, and financial close in addition to four (4) years for the construction activites.

Milestone	Targeted Date
RFP distribution to qualified bidders	Q4 2021
Bid preparation by bidders	Q2 2022
Bid evaluation and selection	Q3 2022
Negotiation with preferred bidders	Q4 2022
Financial close	Q2 2023
Construction commencement	Q2 2023
Operation	Q2 2027

3. Legal and Administrative Framework

An outline of the legal and administrative framework underlying the Project is provided below. The detailed analysis can be found in Chapter 3 of the ESIA study.

Authorities and Institutions

The main identified authorities and insitutions relevant to the AAWDC project are the Ministry of Water and Irrigation (MWI), the Ministry of Environment (MoEnv), the Aqaba Special Economic Zone Authority (ASEZA), the Water Authority of Jordan (WAJ), Miyahuna, the Ministry of Local Administration (MoLA), the Aqaba Development Corporation (ADC), the Jordan Maritime Authority (JMA), the Royal Jordanian Navy and municipalities along the pipeline route.

National Policies and Legislation

Key relevant national policies and strategies identified include the National Water Strategy (2016-2025) and Jordan's Climate Change Policy. The legal framework for the AAWDC project is defined based on the following main legislation:

- Environmental Protection Law 6 of 2017
- Aqaba Special Economic Zone Law No. 32 of 2000
- Water Authority of Jordan (WAJ) Law No. 18 of 1988
- Public Health Law No. 47 of 2008
- Agriculture Law No. 13 of 2015
- Antiquities Law No. 20 of 2004.
- Labour Laws and Regulations including Labour Law No. 8 of 1996 and its amendments
- Real Estate Law No. 13 of 2019
- Law on Guarantee of Access to Information No. 47 of 2007
- Environmental Classification and Licensing Regulation No. 69 for 2020 and its amendment No. 97 for 2020
- Regulation No 21 for 2001 for the Protection of the Environment in the Aqaba Special Economic Zone
- Regulation for the Protection of Air No. 28 of 2005
- Regulation for the Prevention of Health Nuisances within Municipal Areas, Regulation No. 1 of 1978 and its amendments
- Noise Prevention - Instruction for Reduction and Prevention of Noise for 2003
- Drinking Water Standards (JS 286/2015)
- Water – Reclaimed domestic wastewater (JS893/2021)

International Standards and Commitments

In addition to multilateral international agreeements that Jordan has signed, the AAWDC is required to abide by the following:

- EIB Environmental and Social Standards
- USAID Requirements
- Relevant EU Directives including the EIA Directive, the Drinking Water Directive, and Directives related to Labour and Working Conditions.

Gaps in Relevant Environmental Legislations

A gap analysis was undertaken between the national environmental requirements in Jordan and the EIB environmental and social standards particularly as they relate to the following key aspects: Environmental Permitting, Environmental Management, Land Acquisition, and Public Consultations and Disclosure and subsequently was presented in the ESIA report.

Project Ownership

The AAWDC Project will be owned by the Government of Jordan through MWI, the Project Promoter. Since the Project is planned to be implemented through a BOT scheme, the BOT contractor will operate the project for an agreed duration, most likely 25 - 35 years, after which it will be transferred to the Jordanian government.

Project Categorization and Permitting

The Jordanian regulators MoEnv and ASEZA both reviewed the project documentation submitted and concluded that the AAWDC Project requires conducting a comprehensive EIA as per Jordanian law. In addition, based on the types of projects listed in Annex II of the EU EIA Directive 2011/92/EU, the proposed AAWDC Project would require a full EIA process if it was located in an EU member country.

4. Project Alternatives

Various alternatives were considered for the AAWDC Project components. The No-Project alternative was also assessed. The detailed analysis of Project alternatives is provided in Chapter 4 of the ESIA study.

In outline, the assessed alternatives were as follows:

- Site (location) alternatives
- Technology / process alternatives
- Construction materials alternatives

For the water desalination component, site alternatives were examined for the intake pumping station as well as for the water intake and brine outfall systems. In addition, three locations for the desalination plant siting were investigated. As for the conveyance components, four alternative alignments were considered and subsequently assessed.

Moreover, an assessment of potential technology options was conducted for the intake system comprising examination of the following alternative options:

- Seawater Abstraction Type
- Intake Fouling Control
- Intake and Outfall Material
- Intake Abstraction Depth

Technology options were also assessed for the outfall system.

As for the desalination plant itself, the examined process alternatives per key process stage involved the following:

Pre-treatment

Clarification process

- Sedimentation
- Dissolved Air Flotation (DAF)

Filtration process step

- Microfiltration/ultrafiltration (MF/UF) membrane filtration
- Granular media filtration (gravity and pressurised filters).

RO system

RO units

- Single pass RO
- Two pass RO

Energy recovery system

- Isobaric ERD Systems
- Centrifugal ERD Systems (Turbocharger)

Post-treatment

Remineralization and pH adjustment alternatives

- CO2 + Lime slurry dosing

- CO_2 + Calcite contactors

Disinfection

- Use of chlorine gas
- Use of sodium hypochlorite

Several pipe materials namely Steel, Ductile Iron, Glass Reinforced Plastic and Pre-stressed Concrete Cylinder were analyzed based on various environmental categories to the extent possible, such as Global Warming Potential, ozone layer depletion, ecotoxicity, and energy consumption during production, transportation, and installation phases. The assessment was mainly based on a review of the scientific literature that used the Life Cycle Assessment method.

5. Environmental and Social Baseline

An outline of the Project related environmental and social baseline conditions per key attribute is presented below; whereas the detailed descriptions based on collected data and information as well as field surveys undertaken to this effect are provided in Chapter 6 of the ESIA study.

Topography: The project topography varies between the different components; starting at sea level where the IPS is located it varies along the transfer pipeline section to reach Amman at an elevation of around 1,000 m, where the existing Abu Alanda reservoir and the existing Al Muntazah Reservoir are located (Section 6.1.1 of the ESIA study refers).

Geology and soils: The Project area is situated to the east of the Dead Sea rift. It is dominated mostly by sedimentary rocks and igneous rocks exposed at limited areas, while quaternary and recent deposits are also present covering the older geologic formations. As for soils, detritus material of alluvium and colluvium is derived from the weathering of the older formations as presented at the end of the route (Amman Silicified Limestone and the Muwaqqar Chalk Marl formations), soils are overlying any of the above-described formations. They range in thickness from a few centimetres when the bedrock is exposed to several metres (Section 6.1.2 of the ESIA study).

Water resources: Several groundwater basins are included within the project area. One of the groundwater basins is Wadi Araba. Another main aquifer within the project area is the Disi aquifer in southern Jordan. The quality of these aquifers is described in the ESIA report. As for the surface water, about 37% of the total water supply from 16 basins and the Yarmouk River is the main tributary of the Jordan River. During the site visits, no major streams were observed. However, the desalination plant will be surrounded by two wadis in the east-west direction (Section 6.1.3 of the ESIA study).

Weather Parameters: Jordan is considered as having a hot, dry climate characterized by long, hot, dry summers and short, cold winters. January is the coldest month, with temperatures from 5°C to 10°C, and August is the hottest month at 20°C to 35°C. About 70% of the average rainfall in the country falls between November and March; June through August are often dry. Total annual rainfall ranges between 250 and 450 mm in the north-western area, and it decreases to a desert level, below 100 mm per year in the rest of the country. The temperature, precipitation, and wind direction of different governorates within the the project area are provided in Section 6.1.4 of the ESIA study.

Air Quality: The average daily air quality data was obtained from ASEZA's New Port Air Quality Station for the year of 2020 in order to establish an indicative baseline for air quality in the area. It was noted that PM10 levels exceeded the Jordanian Standards for air quality (JS 1140/2006) for all available months except for January. NH_3 concentrations were above the standard limits (JS 1140/2006) during several months of the measuring period. In addition, air quality data for the year 2019 were obtained from MoEnv and the Royal Scientific Society monitoring stations in order to develop the air quality baseline condition along the conveyance route. The monitoring stations that are in close proximity to the pipeline are located in Ma'an, Husaineyah, Qatraneh, Sultani and Sahab. It was noticed that all tested parameters by MoEnv were within the national standards except for H_2S, for which concentrations were slightly above the standards for all locations. As for the station located in the industrial area in Sahab, the results showed that SO_2 and CO concentrations were within the air quality standard limits while NO_2 and $PM_{2.5}$ concentrations exceeded the set air quality standard limits (Section 6.1.5 of the ESIA study).

Marine Characteristics: The coastal area where the IPS is located is mainly a rocky reef structure extending to the 45 m depth contour. It is a well-developed coral reef with relatively high live percentage cover in the centre down to 25 m. Beyond 45 m, the reef structure disappears and the bottom drops rapidly to 50 m after which a gently sloping consolidated sand area exists (Section 6.2.1 and Annex 9 of the ESIA study). As for the seismic activity, the Gulf of Aqaba is situated along the southern part of the Dead Sea Rift Area, which extends for about 1,000 km forming the boundary between the African plate and the Arabian plate. It is one of the joints interfacing the Asian and African landmasses. The rift area is tectonically active. In 1995, a large 7.2 magnitude earthquake struck at a depth of 10 km centred near Nuweiba on the Gulf of Aqaba (54 km from the project site). Although the project area appears to have the potential for destructive earthquakes, such an earthquake has never been witnessed in recent history (Section 6.2.2 of the ESIA study). In terms of seawater hydrology, the Gulf of Aqaba forms with the Gulf of Suez the two northern terminal basins of the Red Sea. The Gulf of Aqaba is connected to the Red Sea through the shallow strait of Tiran. Exchange between the Gulf of Aqaba and the Red Sea through the Strait of Tiran defines most of the hydrology of the Gulf of Aqaba. Seawater level and tides in the Gulf of Aqaba along with wave heights and current conditions are provided in Sections 6.2.3 to 6.2.6 of the ESIA study. ESIA field investigations showed that the average daily current speed profile along the 25m water column depth varied between 3-4 cm/s from the surface down to 22 m depth and then increased at the end of the water column at 25 m to 10 cm/s at the bottom. While along the 50 m water column, the average daily current speed showed a gradual increase from 2 cm/s to 4 cm/s with changing direction clockwise (Section 6.2.6.2 and Annex 12 of the ESIA study).

Seawater Density / Thermohaline Structure: Seawater column characteristics in the Gulf of Aqaba was studied extensively. One of the studies discussed the water column characteristics down to 450 m based on six years of observations. According to this study, the annual water column cycle exhibited pronounced seasonal variations where thermal stratification dominated during summer (May-November) and water mixing dominated during winter (January-April). The strongest stratification occurred during August-September of every year. The maximum mixing depth occurred during March-April of every year and exceeded the deepest sampling point (450 m). Three layers characterizing the water column in the Gulf of Aqaba can be distinguished: (i) a deep and quasi- stagnant layer; (ii) an intermediate layer, and (iii) surface water. The deep layer is slightly colder than 21^0C and fills the Gulf below approximately 700 m (Section 6.2.7.1 of the ESIA study). ESIA field investigations of temperature and salinity at two monitoring locations and at 3 depths in the water column (i.e., surface, 25 m, and 50 m) showed that the highest salinity coincided with the highest temperature reflecting almost the same density of the upper 50 m of the water column, which is typical of the end of summer deepening of the upper mixed layer in the Gulf of Aqaba (Section 6.2.16 and Annex 12 of the ESIA study).

Nutrients and Chlorophyll a: Stratification of the water column during the summer months (April toNovember) causes recycled nutrients to accumulate in the deep reservoir (> 250 m) and prevents them from being transported into the photic zone, which is the upper layer of seawater to which enough sunlight can penetrate to permit photosynthesis. As a result, the surface layer concentrations of inorganic nutrients, particularly nitrogen and reactive phosphorus, in the Gulf of Aqaba, are especially low during summer (< 0.05 and < 0.01 $\mu mol.l^{-1}$, respectively). While during winter, deep convective mixing (> 250 m) results in nutrient enrichment (2 to3 orders of magnitude) of the open and coastal surface water. This enrichment supports phytoplankton and benthic macro algal blooms. In addition, from long term records of chlorophyll a concentrations, which is an indicator for the amount of photosynthetic plankton and which is used by marine flora to capture sunlight during the photosynthesis procedure, in the open water of the northern Gulf of Aqaba measured by the National Monitoring Programs in Aqaba and Eilat, it is evident that surface water concentrations vary between low levels of below 0.1µgl-1 during summer to about 1.0 μgl^{-1} during the spring end of mixed layer deepening at the end of March and beginning of April. During summer, stratification of a typical deep chlorophyll a maximum develops at 60 m –100 m depth near the limit of light penetration and across the nutricline, i.e., the seawater layer of high nutrient variability that begins at 100 m depth. Chlorophyll a concentration at this summer subsurface maximum is found to be relatively constant at about 0.50 μgl^{-1} and repeated annually. Nonetheless, the depth integrated concentration of chlorophyll a is greater by a factor of 2 during December to February than that of the summer months June to October. Conclusively, it can be derived that the seawater column biogeochemical characteristics follow the seawater thermohaline / density structure, where the nutrients and chlorophyll a concentrations as well as primary productivity are extremely low, almost depleted or at the detection limit of analytical techniques in the upper mixed layer down to about 30 m during the summer stratification period and almost homogeneous in the upper and intermediate waters down to 500 m during the winter mixing period (Section 6.2.7.2 of the ESIA study).

Plankton in the Gulf of Aqaba – Primary Productivity and Phytoplankton: Chlorophyll a concentration is a reliably measured indicator of the plankton community in the ecosystem. It has been established through monitoring that the photic zone in the Gulf of Aqaba extends to a great depth of 170 m during most of the year (April to November). The Gulf of Aqaba is oligotrophic (chlorophyll a 16 to 54 mg m^{-2}, primary production 200 to 900 mg Carbon m^{-2} day^{-1}), i.e., the nutrients required for phytoplankton growth (for instance, nitrate, phosphate, and silicic acid) are strongly depleted all year round, and surface chlorophyll a concentrations are low. Upper waters are much more productive during winter as compared to summer. The seasonal biological pattern of chlorophyll a concentrations, primary productivity, and microphytoplankton abundance was also expressed in the depth distribution of these indicators that follow the nutrients distribution in the water column, which in turn is determined by the circulation patterns in the Gulf. Productivity increased from the open waters towards the coral reef and from the northern to the southern basin next to the more productive Red Sea proper. Overall, the Gulf is moderately productive with an annual averaging of 160 grams of Carbon m^{-2} $year^{-1}$. In addition, it has been established by many studies that the primary productivity limiting nutrient in the Gulf of Aqaba is nitrogen (Section 6.2.7.3 of the ESIA study). ESIA field investigations of chlorophyll-a concentration varied within 0.17 µg/l to 0.22 µg/l with no major difference between the examined sites and water column depths and the reference site at the Gulf of Aqaba waters. Chlorophyll values were below 1 µg/l, which is commonly considered as the limiting concentration threshold for eutrophication in oiligotrophic waters (Section 6.2.16 and Annex 12 of the ESIA study).

Plankton in the Gulf of Aqaba – Zooplankton: The measurement of biomass zooplankton is important to evaluate the distribution of the zooplankton biomass abundance through the water column because it provides an indirect indication of the relative status of eutrophication at examined sites. A plankton survey was conducted in the summer months of June and July 2017 for the Red Sea Dead Sea (RSDS) Project. Samples were collected by vertical plankton net hauls from bottom depths of 25 m, 50 m, 75 m, 100 m, 130 m and 160 m. The survey indicated that there was no general trend in plankton biomass maximum or minimum values for the measured depth spans up to surface in the water column. However, the maximum plankton biomass of 0.064 $g.m^{-3}$ was found at the depth of 160 m in the haul 25 m above seabed to surface, i.e., from 135 m to surface. The survey concluded that the community structure of the different plankton taxa gained by the study represented the normal community taxa of the Gulf of Aqaba typical of summer months from May to August, in which gastropod and bivalves dominate the plankton community over the other taxa. However, while there was no significant difference between the plankton communities between the different sampling track locations, there were differences in established communities among the vertical water column depths. In particular, fish larvae and fish eggs showed a significant difference with water depth. The least abundance was observed between water depths of 10 m to 25 m (Section 6.2.7.3 of the ESIA study). ESIA field investigations of zooplankton biomass at two examined sites and at three depths in the water column (i.e., surface, 25 m, and 50 m) did not show any significant differences in the water column from surface down to 25 m depth (mean concentration 0.35 mg/l). Slightly lower biomass was found in the water column (50 m to 25 m) in one of the examined sites with mean concentration of 0.22 mg/l (Section 6.2.16 and Annex 12 of the ESIA study).

Seawater Characteristics at the AAWDC Coastal Site: The AAWDCP coastal site is just in front of the Jordan Phosphate Mines Company Industrial Complex, which has been subject of a regular long-term monitoring since 1996. Coastal water quality data at the Industrial Complex and Offshore (Cumulative Monthly Average 2014-2019) were analyzed in the ESIA report for different parameters including pH, salinity, Dissolved Oxygen, Ammonia:, Nitrate and Nitrite, Phosphate, Silicate, and Chlorophyll a. The comparative analysis of results indicated no discernible differences between sampled costal and offshore sites for pH, dissolved oxygen, and chorophyll a. Whereas seasonal variations were detected for nitrate and nitrite as well as increased concentrations at coastal sampling locations. For ammonia, higher concentrations were detected at the coastal sampling locations and no clear seasonal difference was observed. Further, phosphate and silicate concentrations did not present any clear seasonal pattern. For phosphate, there were no discernible differences between coastal and offshore sampled concentrations while for silicate offshore concentrations tended to be lower than coastal ones (Section 6.2.8 of the ESIA study).

Ecological Features of Gulf of Aqaba and AAWDCP Site: The Gulf of Aqaba hosts the northernmost latitude coral reefs in the world. Yet it enjoys high biodiversity. About 200 species of hard corals and 500 fish species have been recorded. Jordan's coral reefs have been generally maintained in good condition. However, localised impacts of human development can be observed. Flash floods and extreme low tides may also have considerable impacts. No major bleaching events have been recorded (Section 6.2.9 of the ESIA study).

The Jordan Phosphate Mines Company Industrial Complex environmental monitoring program (2019) found that most of the documented fish species (a total of 52) are of Least Concern. However, only one is considered Near Threatened and another has a Vulnerable status. The hawksbill turtle, currently classified as Critically Endangered, has also been sited in the area (Section 6.2.12 of the ESIA study).

Intake Area: According to the results of the monitoring program the shallow part (8 m and 15 m) hosts good live cover of healthy corals that collectively comprise 50%-60%. Towards the deep end (25 m), very limited numbers of live corals could be found, below 5%. Corals were also seen growing on the gas pipeline (Section 6.2.12 and Annex 9 of the ESIA study).

Outfall Area: The reef structure in the deep area (below 35 m) is mainly dead corals. Live coral cover is clearly very low, almost unnoticeable (Section 6.2.13 and Annex 9 of the ESIA study).

ESIA field investigations showed that Residual Chlorine and THMs are almost absent in the seawater at the site of AAWDC in spite of chlorine addition to the cooling water of all the facilities at the site, which include the Jordanian Fertilizers Complex, the Thermal Power Station and KEMAPCO. This calls for further analysis for verification as the result might be incidental or seasonal, especially that there are no regular records of these indicators at the site, based on available information (Section 6.2.15 and Annex 10 of the ESIA study).

Terrestrial Environment: Jordan is located within the eastern margins of the eastern Mediterranean area. Much of Jordan can be classified as semi-desert, with only the western highlands enjoying a Mediterranean climate. Despite the relatively small area, a number of diverse and distinct biotopes exist in Jordan, allowing diversity, heterogeneity and range expansion of the different faunal elements. Based on phytogeography, annual rainfall and soil types Jordan is divided into four main biogeographical regions/zones: the Mediterranean, Irano-Turanian, Saharo-Arabian and the Sudanian penetration. The research and field surveys found the following:

- The Project does not cross any established or proposed natural protected area. However, the conveyance line does pass through the buffer zone of the Wadi Rum Protected Area and World Heritage Site.
- ***Section from Intake/IPS to the RO Plant and to BPS4:*** Most of the vegetation is restricted to wadi beds that are mostly sandy and alluvial. Wadi Al Yutum area is situated along the western border of Wadi Rum protected area. The remoteness of this area makes it important as refuge for large mammals such as the hyena and the Nubian ibex, also the finding of the Aqaba Agama is important, this species has limited distribution along Aqaba Mountains in Jordan. The areas east of the RO site contains a small population of the Egyptian Spiny–tailed Lizard, internationally listed as near threatened. In addition to being a breeding site for some bird species, the area is also important for migratory raptors utilizing this mountain ridges as part of their migration flyway especially in Spring migration (Section 6.3.5.1 of the ESIA study).
- ***Section from BPS4 to RGT2:*** The vegetation cover along this section is limited and is estimated to be between 10% and 15%. Five of the recorded species of mammals have regional or national conservation status and 7 species are considered habitat-restricted. This zone is also significant for the presence of 8 species of bats that forage over the agricultural fields and artificial ponds within the villages. This section is home to restricted range breeding birds and experiences some winter visitors. (Section 6.3.5.1 of the ESIA study).
- ***Section from RGT2 to RGT3:*** The vegetation cover along this section is limited and is estimated to be around 5%. Three of the recorded mammal species in the area have regional and/or national conservation status and none are considered habitat-restricted. However, this zone is important for the presence of 8 species of insectivorous bats that forage over the agricultural fields and artificial ponds. At the eastern end of the section near Batn al Ghol area, remote rocky wadis represent good refuge habitat for the striped hyena, this species is heavily persecuted in Jordan. Avifaunal community of this section is similar to the previous one but due to less disturbance, habitats are more preserved hence support larger populations (Section 6.3.5.1 of the ESIA study).
- ***Section from RGT3 to the cross point of the alignment with the desert highway between Jurf Al-Drawish and Al Hasa:*** The vegetation cover along this section is limited and is estimated to be around 10%. In terms of mammalian species recorded in the area, one is globally threatened while 3 species are threatened at the local scale. The area is home to important breeding birds and attracts

small numbers of wintering waterfowls. It is also part of an important flyway for soaring birds in the world and two of the largest Palearctic–African flyways for waders and water birds and passerines (Section 6.3.5.1 of the ESIA study).

- ***Segments from the cross point of the alignment with the desert highway between Jurf Al-Drawish and Al Hasa to PS ADC and Abu A'landa Reservoir and to Al Muntazah reservoir:*** Due to the high disturbance from traffic and noise on the highway, the biodiversity is mostly low with has little records of high conservation value (Section 6.3.5.1 of the ESIA study).

Demographics and Population: Jordan's population is about 10.05 million people with 2.3% annual growth rate. Amman is the capital with about 1.81 million people and also acts as the city's cultural, economic, and political center. Around 62% of the population are in the 15 – 64-year age group and 3.7% are above 65. The number of households, total population and gender as well as the population density in each of the Governorates of Aqaba, Ma'an, Tafileh, Karak and Amman are presented in this ESIA. The highest number of refugees in Jordan is presented by the registered Refugees coming from Syrian with a total of 668,332 (88.3%). According to the UNHCR, there are 3,791 registered Syrian refugees in the Governorate of Aqaba, 8,332 in Ma'an governorate, 1,650 registered Syrian refugees in the governorate of Tafileh, 8,569 in Karak while Amman Governorate hosts 197,397 registered Syrian refugees (Section 6.4.1 of the ESIA study).

Economic Activities: Jordan's economy is among the smallest in the Middle East, with insufficient supplies of water, oil, and other natural resources. The pandemic has had particularly profound effects on the service sector, travel receipts, and tourism—all key sectors of growth for the Jordanian economy. Jordan's unemployment rate, which marginally increased from 18.3% to 19% between 2017 and 2019, rose sharply as a result of the economic shock from the pandemic, reaching 24.7% in Q4-2020. In addition, economic activities that characterize each of the Governorates where the project passes were identified in the ESIA. In summary, Aqaba and Ma'an govornorate are known for their administrative centers, industrial facilities, and free zones. As for Tafileh and Karak govornorates, these depend on the agriculture and industrial sectors as well as the mining sector. On the other hand, Amman is considered as the commercial, administrative, economic and educational hub of Jordan (Section 6.4.2 of the ESIA study).

Education: Arabic is the country's official language. English is taught in schools as a second language. In Jordan, 95% of the adult population (15 years old and above) are literate and can read and write (Figure 6 93). The rates of enrolment at all levels of education demonstrate that female participation in schools has increased significantly over the last 30 years with more women than men enrolled in tertiary education. The literacy rate for the adult male population is 97.4% and 92.6% for adult females. Jordan's literacy rate for women is among the highest in the Middle East. The total number of schools in governorates relevant to the project are as follows: 151 in Aqaba, 147 in Ma'an, 104 in Tafileh, 155 in Karak and 1,055 in Amman. Moreover, the Governorate of Amman, Ma'an and Tafileh hosts many universities (Section 6.4.3 of the ESIA study).

Health Services: The health care system in Jordan consists of 2 main sectors: the public/military sector and the private sector. Both sectors include hospitals, primary care clinics, pharmacies, and other ancillary services. There are a total of 117 private (58.1%) and public hospitals (41.9%) in Jordan, providing 15,003 beds. There are 72 hospitals and 179 healthcare centres within the project area (Section 6.4.4 of the ESIA study).

Land use: Actual land use of each component of the project varies from one to another, in line with the project size and its spread from the south of Jordan to the middle where it passes near various land types and uses. The actual land use of each component of the project is described in Section 6.4.5 of the ESIA report. The area from the IPS to the SWRO is occupied by major industrial complexes while some agricultural areas are existed between BPS4 to MUS2/BPS5.

Noise: The results of the noise survey show that noise levels exceeded the allowable daily maximum limit in some instances. This can be explained due to the surrounding facilities around the two sites, where site 1 was located near to the workshops of Rum Agriculture Company while site 2 was located near to King Abdullah II Ibn Al Hussein Industrial City in Sahab. However, on average, levels were in line with the national limits (Section 6.4.6 and Annex 8 of the ESIA study).

Water and Wastewater Infrastructure: Despite Jordan's severe water scarcity, over 94% of Jordanian population have access to safe drinking water and 93% have access to improved sanitation. These rates are considered some of the highest rates in the MENA region. However, water supply is intermittent, and the distribution system is still far from optimal and efficient. In 2014, the available renewable freshwater resources in Jordan were 533 MCM. This amount varies each year depending on annual rainfall. This amount was less than 60 m^3 per person. According to estimates generated in 2014, annually, the country requires about 1,400 MCM but has, on average, only 848 MCM of freshwater supply available for various uses. As for wastewater, it is estimated that the sanitation coverage for both the urban and rural population is 93%, out of which 63% are connected to the sewerage networks. The remaining of those having access to improved sanitation use on-site sanitation solutions such as septic tanks. Regarding wastewater treatment, the country has a fair operational capacity in wastewater treatment. Currently, 33 wastewater treatment plants treat 98% of collected wastewater. Wastewater collection and treatment produce about 137 MCM of treated wastewater annually of which 125 MCM is being reused primarily in agriculture. However, many of the existing treatment plants will need urgent rehabilitation and extension work. (Section 6.4.7 of the ESIA study).

Traffic and Transportation: The project involves several hotspot areas, highways, and roads that will be affected during construction by the excavation and construction works. There are three key traffic hotspot areas. The first is where the intake system of the project will be constructed. The system is located on undeveloped land within the Aqaba industrial zone by the Red Sea, and adjacent to the newly constructed industrial port. The second hotspot area is within the urban area of Amman, which includes heavily crowded areas, especially in Sahab and Abu Alanda, featuring mixed land use, including residential, commercial, and industrial uses. As for the conveyance pipeline that will connect the two hotspots, it will pass through several roads and key highways as such as the Desert Highway (R15), the “Ports Back Road” and several existing primary and secondary roads surrounded by localities, agricultural areas, and farms. In addition, Jordan has nine land-border points with neighbouring countries that are important for trade. Those borders were temporarily closed due to the wars in Iraq and Syria but have recently been reopened. As for airports, there are two airports within the project area, namely Queen Alia International Airport located at the northern part of the conveyance pipeline and King Hussein International Airport located in Aqaba. Moreover, Aqaba New Port and Industrial Port are located on the northern shore of the Gulf of Aqaba, on the Red Sea within the area of the desalination plant (Section 6.4.8 of the ESIA study).

Solid and Hazardous Waste Management: On average, 0.81 kg of municipal waste is generated per capita per day in Jordan. This rate is 26% higher than counterparts in other upper middle income countries, with city residents producing up to 50% more municipal solid waste compared to residents in rural areas. Moreover, the composition of municipal waste in Jordan is transitioning from mainly organic to a more complex mix with more plastics, paper, and cardboard, as well as e-waste. Most of the solid waste generated in the country is disposed of in one of its 21 landfills, seven of which are closed landfills, only one of which meets international best practice (Al Ghabawi landfill). In fact, Jordan annually disposes around 2.1 million tons of municipal solid waste in its landfills. A map showing the location of landfills in different governorates in relation to the project area is presented in this ESIA report. As for hazardous waste, Jordan’s Swaqa Hazardous Waste Landfill deals with 3,000 m^3 to 5,000 m^3 of hazardous waste per year (Section 6.4.9 of the ESIA study).

Cultural Resources: A total of 46 sites were identified within the project area during the field assessment. They covered approximately all periods and many types of sites, ranging from flint and shard scatters, stone circles and enclosures to towers and agricultural installations, as well as many cemeteries. Although none of the identified archaeological sites are located near areas where Project excavation or construction activities will occur, the conveyance pipeline will cross Al Hijaz Railway, which is considered as a cultural site, at six points and namely Aqaba/Wadi Rum-Near Marsad; Aqaba/ Wadi Yutum -Near Kithara & Qatra; Tafeileh/ Hasa–Near Hasa Railway Bridge; Tafeileh/Al Abyad; Madaba /Quneitra-Near the Railway Bridge; and Madaba/Lubban-Near Railway station (Section 6.4.9 of the ESIA study).

6. Stakeholder Engagement

The details related to the stakeholder engagement conducted during the preparation of the ESIA are provided in Chapter 7 and Annexes 12 and 13 of the ESIA study.

On March 1, 2021, the ESIA Team, in coordination with ASEZA and MWI, held a scoping session at the Hyatt Regency Aqaba Ayla Hotel and online (in hybrid format) to present the results of the scoping phase of the AAWDC project to stakeholders and obtain their feedback. Around 90 agencies and institutions were invited to this session such that 130 persons attended. During the session, the project was presented along with associated environmental and social issues and the methodology of the ESIA. The participants were invited to ask questions and voice concerns. In addition, meetings with local authorities and communities were conducted during the stakeholder engagement activities in the field, whereby 32 meetings were conducted during the months of June and July 2021.

Main issues raised during stakeholder engagement included:

- Consider the impact of brine discharge on marine life and potential to reuse the brine (or dry it) instead of discharging it;
- Provide details on energy consumption of the project;
- Study the impact on traffic;
- Need for an emergency plan for the project especially during spill incidents;
- Project should anticipate seismic events and earthquakes;
- Ensure consultation with the local community;
- Ensure recruitment of local community for jobs during construction and operation;
- Information about land acquisition was not presented;
- Consider the impact of withdrawing a large amount of water on the bay;
- Consider supplying all communities along the pipeline route with desalinated water.

All these voiced concerns have been taken into consideration in the assessment of impacts of the AAWDC Project so that effective mitigation is provided thereof. This is reflected in the Project's Environmental and Social Management Plan (ESMP) appended as Annex 15 to the ESIA study. More specifically:

- The impacts from the marine discharge of brine were assessed in detail in the Brine Risk Assessment Report and mitigation measures were based on near and far field modeling (Annex 1 of the ESIA study) and the precautionary approach so that any residual impacts were assessed as negligible (Chapter 8 of the ESIA study).
- Energy consumption related to the AAWDC Project components were provided in Chapter 2 of the ESIA study and further supplemented with GHG emissions calculations (Chapter 8 of the ESIA study).
- Traffic impacts were assessed in detail both during the construction and operation phases of the AAWDC Project (Chapter 8 of the ESIA study) and respective mitigation measures were included in the Project ESMP (Table 2-4 and Table 2-5 of the Project ESMP).
- The potential for seismic events was considered in the design mitigation measures for both the intake and the outfall works (Sections 2.8.1 to 2.8.3 of the Project ESMP).
- Initial consultations were conducted with the local communities and subsequent activities were put in place for efficient engagement (Annex 13 of the ESIA study).
- Recruitment and labor issues were assessed in the ESIA study and appropriate mitigation measures were provided in the Project ESMP (Table 2-4, Table 2-5 and Section 2.9.3.2 of the Project ESMP).

- Land acquisition activities were described in Section 8.1.3.2 and Annex 16 of the ESIA study provides the Land Acquisition and Resettlement Framework (LARF) for the AAWDC Project.
- The impacts from water abstraction relative to quantity and depth were assessed in detail in Section 8.2.2 of the ESIA study.
- The service coverage of communities along the route of the conveyance pipeline was considered by the MWI and the Project design team since the early stages of Project development (Chapter 2 of the ESIA study refers).

7. Impact Assessment and Mitigation

The tables below present the environmental and social impacts that may result from construction and operation of the AAWDC Project on the physical, biological and socioeconomic environment along with the required mitigation measures to be implemented by the BOT Contractor, all of which are described in detail in the Project's Environmental and Social Management Plan (ESMP).

During Construction

E&S Component / Project Component	Potential Impact	Significance	Proposed Mitigation	Residual Significance
Physical Environment				
Soil & Geology Water Desalination Component (Onshore Facilities) and Conveyance Pipeline	▪ Soil compaction and natural drainage blockage due to the movement of vehicles and workers on the site, and soil erosion as a result of topsoil layer removal, land preparation and vegetation stripping	Low	▪ Develop and implement Erosion and Sediment Management Procedures as per provisions in Section 2.10.1.3 of the ESMP.	Negligible
	▪ Disruption of soil quality and morphology from improper disposal of excess excavated material or unsuitable excavated material for fill	Low	▪ Develop and implement Waste Management Plan (WMP) as per provisions on Spoils and Excavation Material in Section 2.10.1.2.1 of the ESMP	Negligible
	▪ Soil pollution from accidental oil or chemical spills or from improper disposal of generated solid waste and wastewater	Low	▪ Develop and implement a Pollution Prevention Management Plan (PPMP) as per provisions in Section 2.10.1.1 of the ESMP and Emergency Preparedness and Response Plan (EPRP) in line with provisions of Section 2.10.3.1 of the ESMP ▪ Implement WMP as per provisions in Section 2.10.1.2 of the ESMP	Negligible
Soil & Geology Water Desalination Component (Onshore and Offshore Facilities)	▪ Disruption of sediment layering and structure ▪ Surface sealing (if structures placed on the seabed)	Low	▪ Optimise water abstraction depth considering suitable distances from seabed and sea surface and keeping the length of submerged intake pipelines as minimum as possible. ▪ Laying of outfall pipeline directly on the seabed as much as possible with minimum excavation and clearance of seabed floor and, if possible, just laying a gravel bed (conditioning).	Negligible

E&S Component / Project Component	Potential Impact	Significance	Proposed Mitigation	Residual Significance
			▪ Minimise footprint of excavation/dredging activities by considering placing intake and outfall pipelines into the same trench up to a certain depth. ▪ Appropriately plan and keep duration of construction activities according to schedule.	
Water Resources (Surface Water and Groundwater) Water Desalination Component (Onshore Facilities/SWRO) and Water Conveyance Component	▪ Contamination of seawater, surface and groundwater from seepage of domestic or construction wastewater, accidental oil and chemical spillages, and diversion of contaminated rainwater runoff from the construction site ▪ Sea water, surface and groundwater pollution with suspended particles, hydrocarbon or chemical substances and organic loads from improper management of the generated wastewater, improper handling and storage of chemicals along with improper management of the generated solid waste	Low	▪ Implement Effluent Management measures in Section 2.10.1.1.1 of the ESMP and Spill Prevention and Management in Section 2.10.1.1.2 of the of the ESMP ▪ Implement WMP	Negligible
Water Resources (Surface Water and Groundwater) Water Desalination Component (Onshore and Offshore Facilities)	▪ Resuspension of sediments that may increase turbidity, pollutant or nutrient levels or decrease oxygen levels from excavations/dredging, trenching, cut and fill, compaction and levelling activities, installation of the intake towers, laying of intake and outfall pipelines	Moderate	▪ Optimise water abstraction depth. ▪ Use turbidity screens (silt curtains) to enclose the perimeter of construction works. ▪ If marine works tunnelling of the outfalls (or intakes) is adopted, ensure drill cuttings, drilling muds and excavated materials generated by this operation are screened and contained in a barge for transportation and disposal on-shore in line with WMP provisions on Spoils and Excavation Material in Section 2.10.1.2.1 of the ESMP	Low
Water Resources Water Desalination Component (Onshore Facilities/SWRO) and	▪ Overconsumption and depletion of water resources due to overuse	Moderate	▪ All construction associated wells to have prior approval by the competent national regulatory authorities. ▪ Adopt water conservation measures for all activities.	Low

E&S Component / Project Component	Potential Impact	Significance	Proposed Mitigation	Residual Significance
Water Conveyance Component				
Energy Resources Water Desalination Component (Onshore Facilities/SWRO) and Water Conveyance Component	▪ Overconsumption and depletion of fuel due to generators and engines left running idle	Moderate	▪ Regularly maintain the generators, vehicles, and construction machinery ▪ Shut down lighting at site offices during the night ▪ Switch off machinery and equipment when not in use ▪ Raise awareness among site staff on energy conservation	Low
Air Quality Water Desalination Component (Onshore Facilities/SWRO) and Water Conveyance Component	▪ Exhaust gas emissions, including GHG emissions	Low	▪ Size equipment used for construction activities appropriately. ▪ Use of reusable concrete formwork. ▪ Implement Air Emission Control measures (Section 2.10.1.1.3 of the ESMP) in the PPMP	Negligible
	▪ Dust generation from construction machinery and construction activities	Low	▪ Implement by Air Emission Control measures (Section 2.10.1.1.3 of the ESMP) in the PPMP	Negligible
Biological Environment				
Biological Environment Water Desalination Component (Offshore Facilities)	▪ Habitat destruction by excavation works ▪ Disruption of haul-out sites of marine mammals or nesting sites of turtles in the landing area	Moderate	▪ Develop and implement Biodiversity Management Plan (BPM) in line with provisions in Section 2.10.1.4 of the ESMP ▪ Carefully collect and transplant any corals that might be encountered during the construction works before any construction works commence. ▪ Lay the outfall pipeline directly on the seabed as much as possible with minimum excavation and clearance of seabed floor and, if possible, just laying a gravel bed (conditioning). ▪ Minimise footprint of excavation/dredging activities by considering placing the intake and outfall pipelines into the same trench up to a certain depth.	Low
	▪ Damage to habitats from contamination by spills or leakages	Moderate	▪ Implement PPMP and WMP.	Low

E&S Component / Project Component	Potential Impact	Significance	Proposed Mitigation	Residual Significance
	▪ Exposure to residual chemicals that may be present in the discarded wastewater during commissioning			
	▪ Increased turbidity leading to reduced light penetration and increased sedimentation rates (blanketing) ▪ Remobilization of nutrients or pollutants from sediments ▪ Behavioural responses and temporary habitat loss due to sediment plumes, noise, and vibrations, etc.	Moderate	▪ Use turbidity screens (silt curtains) to enclose the perimeter of construction works ▪ If marine works tunnelling of the outfalls (or intakes) is adopted by the BOT Developer, then the drill cuttings, drilling muds and excavated materials generated by this operation should be screened and contained in a barge for transportation and disposal on-shore on dedicated sites in line with WMP provisions on Spoils and Excavation Material in Section 2.10.1.2.1 of the ESMP	Low
Biological Environment Water Desalination Component (Onshore Facilities)	▪ Habitat loss and clearance of vegetation cover ▪ Introduction of invasive alien species during revegetation ▪ Behavioural disturbance to avifauna during migratory and breeding seasons ▪ Constructed prominent features could preclude linkages and movement corridors	High	▪ Implement measures for Clearing of Vegetation and Revegetation set out in BMP (refer to Section 2.9.1.4.4 of the ESMP) ▪ Implement PPMP, NVMP and WMP	Low
	▪ Habitat loss within the routes for vehicles and machineries movement and parking	High	▪ Develop and implement Traffic and Transport Management Plan (TTMP) in line with Section 2.10.1.7 of the ESMP	Low
	▪ Generation of elevated noise disturbing nearby natural habitats	High	▪ Develop and implement Noise and Vibration Management Plan (NVMP) in line with Section 2.10.1.6 of the ESMP	Low
	▪ Emissions to air from the vehicles and machineries disturbing nearby species	High	▪ **(Section** 2.10.1.1.3 of the ESMP) set out in the PPMP	Low
	▪ Oil spills from machineries on, site lubrication and petrol supply, contamination due to leaks/spills of construction chemicals disturbing marine habitats	High	▪ Implement Spill Prevention and Management measures (Section 2.10.1.1.2 of the ESMP **Error! Reference source not found.**) set out in the PPMP	Low

E&S Component / Project Component	Potential Impact	Significance	Proposed Mitigation	Residual Significance
Biological Environment / Water Conveyance Components	▪ Habitat loss and fragmentation and impact to natural water flow in the intermittent wadis and streams	High	▪ Avoid the removal of the Acacia, Tamarix and other native tree community and translocation of those unavoidable ones (if applicable)	Low
Biological Environment / Water Conveyance Components	▪ Pollution impact on terrestrial biodiversity	Moderate	▪ Implement PPMP and WSP	Low
Biological Environment / Water Conveyance Components	▪ Disturbance of natural fauna from noise, vibration and lighting	Moderate	▪ Implement BMP and NVMP	Low
Biological Environment / Water Conveyance Components	▪ Hunting and active taking of wildlife	Moderate	Implement General Provisions (Section 2.10.1.4.1 of the ESMP) set out in the BMP including: ▪ Avoid and strictly prohibit wildlife persecution killing, hunting, and all forms of animal and plant collection and active taking. ▪ Strictly prohibit tree cutting by the project staff and workers, and apply fines and charges on none-compliance by the staff. ▪ Avoid introduction of pets	Low
Socioeconomic Environment				
Economic Activities / Water Desalination Component (Onshore Facilities/SWRO) and Water Conveyance Component	▪ Disruption of access to local businesses	Low	▪ Install temporary structures from excavation sites (mainly roads) to local businesses ▪ Inform the residents and shops' owners about construction activities and the planned schedule of works ▪ Proper communication and coordination with affected owners	Negligible
Land Use and Development Plans / Water Conveyance Component	▪ Land acquisition economically affecting landowners (no physical displacement is foreseen)	High	▪ The use of publicly owned land over privately owned land shall be encouraged ▪ Ensure fair compensation to affected persons (in case of private owned lands) in line with the LARPF.	Low

E&S Component / Project Component	Potential Impact	Significance	Proposed Mitigation	Residual Significance
			▪ Develop and Implement Land Acquisition and/or Resettlement Action Plan where needed in line with the LARPF ▪ Develop and implement community GRM (Section 2.10.3.3 of the ESMP)	
Noise / Water Conveyance Component	▪ Nuisance to local residents from sources of noise pollution such as excavators, generators, concrete mixers and other construction machinery and vehicles and from traffic related noise	Low	▪ Implement NVMP supplemented with a Noise/Vibration Monitoring Program. ▪ Inform occupiers of nearby properties prior to commencement of works where relevant, including the duration and likely noise and vibration impacts. ▪ Investigate and record noise complaints ▪ Implement TTMP.	Negligible
Infrastructure / Water Desalination Component (Offshore Facilities)	▪ Potential destruction of existing offshore utilities such as the gas pipeline and the gas storage ship and/or the phosphate export jetty facilities	Moderate	▪ Plan and coordinate with relevant authorities and abide by safety exclusion zone set in the detailed design for the protection of the submerged gas pipeline and the phosphate loading/unloading jetty	Negligible
Infrastructure / Water Desalination Component (Onshore Facilities) and Water Conveyance Component	▪ Generation of different types of solid waste and domestic wastewater ▪ Potential disruption and/or destruction in utilities (electricity network, water supply network and telecommunication services)	Low	▪ Repair any damage to people and property caused by the execution of the works or the procedures used for execution ▪ Develop and implement procedures to manage, rectify, and record any incidents related to utilities damages or community disturbances in line with Section 2.7.2 of the ESMP ▪ Plan and coordinate with other contractors and the municipality to avoid disruption to utilities and underground infrastructure. ▪ Integrate response to damage to infrastructure within the EPRP. ▪ Implement PPMP provisions on effluent management (Section 2.10.1.1.1 of the ESMP) and WSP	Negligible
Traffic and Transport / Water Desalination Component (Offshore Facilities)	▪ Potential alteration in ship mobility patterns due to construction activities	Low	▪ Coordinate with the relevant authorities in Aqaba especially for traffic movement in restricted cases. ▪ Set up flags and light signals as agreed with navigational authorities to alert maritime traffic. ▪ Limit construction activities and marine traffic restrictions.	Negligible

E&S Component / Project Component	Potential Impact	Significance	Proposed Mitigation	Residual Significance
			▪ Implement TTMP (integrating marine traffic management and restricted zones, if any) ▪ Strictly adhere to international standard best practice measures related to navigation and safety.	
Traffic and Transport / Water Desalination Component (Onshore Facilities) and Water Conveyance Component	▪ Traffic congestion due to construction activities ▪ Traffic delays due to the closure of certain streets	Moderate	▪ Implement TTMP	Low
Public Health and Safety / Water Desalination Component (Onshore Facilities/SWRO) and Water Conveyance Component	▪ Accident and injuries to public because of rehabilitation activities ▪ Health risks to the public from the generated dust and noise ▪ Traffic accidents and injuries	Low	▪ Develop and implement a Health and Safety Management Plan (HSMP) (Section 2.10.1.5 of the ESMP) ▪ Implement EPRP and TTMP ▪ Implement community GRM ▪ Ensure close coordination with relevant authorities in Aqaba and implement an exclusion zone in place surrounding the footprint of construction activities at sea. ▪ Mark routing of pipelines with buoys so that any obstruction to marine navigation and traffic is avoided. ▪ Strictly adhere to international standard best practice measures related to navigation and safety, including management of vessel movement via AIS	Negligible
Occupational Health and Safety Water Desalination Component (Onshore and Offshore Facilities/SWRO) and Water Conveyance Component	▪ Health risks from exposure to dust and noise and construction related accidents ▪ Injuries to workers working at confined spaces ▪ Health problems from natural environmental challenges such as extreme cold conditions, heat stroke or snake bites ▪ Traffic accidents and injuries ▪ Risk of spreading of communicable and infectious diseases (such as sexually	Moderate	▪ Implement a HSMP ▪ Keep record of health and safety incidents on site	Negligible

E&S Component / Project Component	Potential Impact	Significance	Proposed Mitigation	Residual Significance
	transmitted diseases (STDs), Influenza and Covid-19)			
Occupational Health and Safety Water Desalination Component (Offshore Facilities)	▪ Risk of drowning while working on construction of the offshore facilities.	Moderate	▪ Implement HSMP provisions on buoyancy equipment and PPEs (Section 2.10.1.5.13 of the ESMP)	Negligible
Labour Influx and General Labour Conditions Water Desalination Component (Onshore Facilities/SWRO) and Water Conveyance Component	▪ Social tension between local and foreign workers ▪ Culturally insensitive behaviour by workers	Low	▪ Implement and abide by Labour Conditions (Section 2.10.3.2 of the ESMP) ▪ Develop and train staff on Code of Conduct to be signed by all staff and enact a monitoring system to ensure compliance such that noncompliance leads to sanctions and possibly termination ▪ Implement community GRM and worker GRM (Section 2.10.3.2.7 of the ESMP) and respond to culturally insensitive behaviour and incidents as a matter of priority ▪ Coordinate and implement worker influx plan inclusive of community liaison to deal with the local population and minimize friction caused by contacts between the construction workforce and communities	Negligible
	▪ Gender discrimination and gender-based violence and harassment (GBVH)	Low	▪ Implement and abide by Labour Conditions ▪ Training of staff on Code of Conduct and raising awareness on GBVH ▪ Implement community and worker GRMs and respond to culturally insensitive behaviour and incidents as a matter of priority	Negligible
	▪ Recruitment of minors	Low	▪ Prohibit the recruitment of minors in any hazardous activity and abide by Labour Conditions on Child Work (Section 2.10.3.2.6 of the ESMP) ▪ Abide by national legislation and ILO convention on employment of minors	Negligible

E&S Component / Project Component	Potential Impact	Significance	Proposed Mitigation	Residual Significance
	▪ Increase demand/pressure on health services	Low	▪ Coordinate with local health facilities to ensure availability of health services within area of work	Negligible
Cultural Resources Water Conveyance Component	▪ Unknown artifacts may be uncovered during the excavation activities.	Low	▪ Develop and implement Chance Find Management Plan (Section 2.10.1.8 of the ESMP)	Negligible
	▪ Disruption of nearby sites from construction activities that are source of vibration and dust ▪ Effects of Al Hijaz Railway cultural site	Low	▪ Implement PPMP and NVMP. ▪ Leave a15-m buffer zone around each site	Negligible

During Operation

E&S Component / Project Component	Potential Impact	Significance	Proposed Mitigation	Residual Significance
Physical Environment				
Soil and Geology / Water Desalination Component (Onshore Facilities) and Water Conveyance Component	▪ Deterioration of soil quality from accidental spills from fuel, oil and other chemicals used for the maintenance and operation of the conveyance pipe or the PSs ▪ Soil pollution due to improper disposal of domestic and office waste as well as improper discharge of domestic wastewater at the various facilities	Low	▪ Develop and implement PPMP (Section 2.10.2.1 of the ESMP) including provisions for Effluent Management (Section 2.10.2.1.1 of the ESMP) and Spill Prevention and Management (Section 2.10.2.1.2 of the ESMP) ▪ Develop and implement by WSP (Section 2.10.2.2 of the ESMP)	Negligible
Coastal and Marine Environment / Water Desalination Component	▪ Brine plume may sink to the seafloor and may cause an increase in pore water salinity due to diffusion ▪ Increase in ambient seawater salinity at the mixing zone ▪ Large volumes may affect circulation and mixing processes in the discharge area ▪ Sinking of the brine plume and seafloor spreading ▪ Potential enrichment of nutrients, organic matter, pollutants, or trace metals ▪ Residual chemicals and heavy metals (if present in the concentrate due to corrosion) may accumulate in sediments at the discharge site ▪ Discharge of antiscalants may bind nutrients and ions dissolved in seawater ▪ Sedimentation and accumulation of coagulants in sediments ▪ Potential change in water circulation by open intakes when large volumes of water are extracted	Low	▪ Abide by design practices and criteria as presented in Section 2.9.2.2 of the ESMP for seawater abstraction and brine discharge	Negligible

E&S Component / Project Component	Potential Impact	Significance	Proposed Mitigation	Residual Significance
	▪ Direct discharge of acidic/alkaline solutions may affect ambient pH in the mixing zone ▪ Detergents or complexing agents if used and discharged with the brine may interfere with natural processes of dissolved constituents of seawater (e.g., metals			
Water Resources / Water Conveyance Component	▪ Wadis and groundwater pollution from accidental spills during maintenance activities or from the improper disposal of domestic wastewater and solid waste generated from the offices	Low	▪ Implement Spill Prevention and Management measures in the PPMP	Negligible
Energy Resources / Water Desalination Component and Water Conveyance Component	▪ Depletion of non-renewable energy resources such as fuels used for power generation ▪ Increase in the fiscal burden on the country as fuel is imported	High	▪ Regular maintenance of stand-by generators and pumps ▪ Ensure energy efficiency in all Project related operations	Moderate
Air Quality / Water Desalination Component and Water Conveyance Component	▪ GHG and other air emissions from transport methods related to Project operations	High	▪ Proper coordination of transportation of workers, materials, and waste. ▪ Considering options for construction crew transport to Project sites ▪ Maintain Project vehicles such that generated atmospheric emissions do not exceed threshold emission values set out in national regulations or international recognised standards including those of the EIB/USAID	Moderate
	▪ GHG emissions and other air emissions due to the significant power demand for the operation of the SWRO and PSs	High	▪ Regular maintenance of stand-by generators and pumps ▪ Ensure energy efficiency in all Project related operations and at all Project sites	Moderate
Biological Environment				
Marine Biodiversity / Water Desalination Component	▪ Entrainment of macro flora spores, invertebrate larvae, fish eggs and early stages through open intakes	Moderate	▪ Abide by Seawater Intake Recommendations in Section 2.9.2.2 of the ESMP	Low

E&S Component / Project Component	Potential Impact	Significance	Proposed Mitigation	Residual Significance
	▪ Impingement of nektonic species through seawater intake			
Marine Biodiversity / Water Desalination Component	▪ Potential change in moving fish species abundance and diversity in the discharge site ▪ Decline of algae stands and seagrass meadows due to increased salinity ▪ Potential toxicity to benthic species and change in abundance and diversity due to Increased salinity ▪ Loss of nutrients availability needed for plant growth due to binding with discharged antiscalants	Moderate	▪ Abide by the Brine Discharge Recommendations in Section 2.9.2.2 of the ESMP	Low
Terrestrial Biodiversity / Water Desalination Component and Water Conveyance Component	▪ Loss of habitat or loss of feeding and nesting grounds due to increased noise levels	High	▪ Design and implement NVMP (Section 2.10.2.5 of the ESMP) and BMP (Section 2.10.2.3 of the ESMP)	Low
Terrestrial Biodiversity / Water Desalination Component	▪ Wildlife killed or affected due to exposure to hazardous substances from accidental spillage or leakage	High	▪ Abide by provisions related to hazardous substances and waste in the PPMP, WMP and BMP. ▪ Upon occurrence of leaks/spillage, rehabilitate impacted site its original condition and monitor post leakage impacts on wildlife.	Low
Terrestrial Biodiversity / Water Conveyance Component	▪ Contamination of the biological habitat by spills or leaks of chemicals and lubricants causing deleterious impact on wildlife	High	▪ Abide by Spill Prevention and Management provisions in PPMP. ▪ Upon occurrence of leaks/spillage, rehabilitate impacted site to its original condition and monitor post leakage impacts on wildlife.	Low
Socioeconomic Environment				
General Labour Conditions / Water	▪ Social tension between local and foreign workers	Low	▪ Abide by national labour legislation and Labour Conditions specified in Section 2.10.3.2	Negligible

E&S Component / Project Component	Potential Impact	Significance	Proposed Mitigation	Residual Significance
Desalination Component and Water Conveyance Component	▪ Culturally insensitive behaviour by workers		▪ Implement Code of Conduct for workers and ensure that workers sign and understand the Code of Conduct ▪ Develop and implement a GRM and respond to culturally insensitive behaviour and incidents as a matter of priority ▪ Purchase materials and supplies required for O&M from local suppliers and businesses when possible	
	▪ Gender discrimination and GBVH	Low	▪ Implement and abide by Labour Conditions ▪ Training of staff on Code of Conduct and raising awareness on GBVH ▪ Implement community and worker GRMs and respond to culturally insensitive behaviour and incidents as a matter of priority	Negligible
	▪ Recruitment of minors	Low	▪ Prohibit the recruitment of minors in any hazardous activity and abide by Labour Conditions on Child Work (Section 2.10.3.2.6 of the ESMP) ▪ Abide by national legislation and ILO convention on employment of minors	Negligible
Noise / Water Desalination Component and Water Conveyance Component	▪ Disturbance to the local community from the noise generated from operation of PSs at the SWRO and along the conveyance pipeline	Moderate	▪ Implement NVMP ▪ Develop and implement TTMP (Section 2.10.2.6 of the ESMP) ▪ Use and maintain plant and equipment pursuant to the manufacturer's specifications ▪ Investigate and record noise complaints.	Low
Traffic and Transportation / Water Desalination Component and Water Conveyance Component	▪ Traffic congestion during maintenance activities	Low	▪ Implement TTMP	Negligible
Occupational Health and Safety / Water Desalination	▪ Worker exposure to risks of accidents, injuries and health impacts associated with working in	Moderate	▪ Develop and implement HSMP (Section 2.10.2.4 of the ESMP)	Negligible

E&S Component / Project Component	Potential Impact	Significance	Proposed Mitigation	Residual Significance
Component and Water Conveyance Component	confined spaces or exposure to chemicals and drowning (for the offshore facilities). ▪ Risk of spreading of communicable and infectious diseases (such as Influenza and Covid-19) between workers in offices.			

Overview of Marine Ecology Impacts of Seawater Abstraction

The optimisation of seawater abstraction conditions is fundamental for controlling the potential impacts on the coastal and marine biological environment and namely the entrainment of macro flora spores, invertebrate larvae, fish eggs and early stages and the imprisonnment of nektonic (i.e., swimming) species through the seawater intake system. To this end, recommending the optimum conditions related to the design and location for the seawater intake of the AAWDC Project constituted a serious challenge in the ESIA study (Section 4.4.1.1.1 and Section 8.2.2.1 of the ESIA study).

A previous intake optimization study for the Red Sea Dead Sea Project suggested an intake at a water depth of -144 m, which is technically infeasible in terms of operating a desalination plant with technology known to date. However, subsequent modelling and field studies proved that the -144m (and further the - 120 m) depth water intake is not the only solution to minimise entrainment of plankton and larvae (i.e., very early stages of marine life).

An in-depth analysis was undertaken in parallel with the ESIA to establish an optimum seawater intake depth in order to minimise entrainment of planktonic and small nektonic organisms and yet to provide practical operational conditions for desalination at the set capacity and availability with minimal environmental impact on the coastal and marine biological environment. Based on this analysis, locating the seawater abstraction at the seabed depth of -144 m was not considered pre-feasible for the AAWDC Project for the following reasons:

- The AAWDC Project differs considerably from that of the RSDS project concept. The intake for the RSDS project was from a gently sloping natural habitat at the northern tip of the Gulf of Aqaba, while the AAWDC Project concept intake is at a steeply sloping urban habitat at the Industrial Ports Area on the southern end of the Jordanian sector of the Gulf. Seawater abstraction for the AAWDC Project when operational at full capacity will be approx. 2.5 times less than that planned for the RSDS project.
- On the Gulf of Aqaba scale, seawater abstraction for the AAWDC Project is expected to have no significant impact, whether on larvae entrainment or on the heat flux. This is best understood by appreciating that flows in the Gulf from the Red Sea exchange a seawater volume several orders of magnitude larger than what would be induced by flows due to abstraction. In addition, expected larval mortality due to entrainment in the desalination intake is orders of magnitude smaller than any actual existing rates of natural mortality or growth resulting from the prevailing biological and ecological factors.
- The Gulf of Aqaba has very distinct characteristics of a deep light irradiance field, deep mixed water column during winter and spring and strong stratification during summer pushing most of the biological productivity of the water column to the bottom end of light field depth. It is difficult to prove that a deep-water intake (120–140 m), with established technical difficulties to construct and to operate, would result in significantly less plankton and larvae entrainment than a shallow intake (10 - 25 m).
- Coral larvae entrainment in a shallow intake of less than 20 m depth can be much more easily mitigated through design than a deeper one sited at more than 120 m depth.
- The final RSDS ESIA study indicated that the new modelling suggested alternative intakes at 50 m and 70 m, which were as suitable as the 120 m intake, concerning plankton entrainment. If an intake at 50 m or 70 m is as effective as the 120 m intake, any shallower intake should also be. This is because plankton concentration is almost homogeneous from the surface to at least below 200 m during the mixing period in the Gulf of Aqaba, as is well documented in the international literature and demonstrated in the ESIA baseline conditions. During the stratification period, plankton concentration decreases significantly in the upper mixed layer (above 20 m) and exhibits a peak deeper than 30 m, mainly between 50 m to 100 m depth.
- The intake tower screens must be cleaned of macrofouling regularly by plant operations to maintain the set operational capacity. This cannot not be achieved safely at depths of -144 m without the use of very specialized deep saturation divers equipped with support ships.
- The intake pipelines must be capable of being cleaned of macrofouling (barnacles/mollusks, etc.) to maintain the set operational capacity. The use of continuous chlorination to prevent macrofouling can fail due to underdosing chlorine and scaling of dosing lines. All intake pipelines shall have procedures for

manual cleaning by divers or mechanical cleaning through pig systems. This is not considered safe, even with use of saturation divers, because they would have to enter confined space pipes at extreme depths for potential manual cleaning or stuck pig retrieval.

- The location of the intake at -144 m would require 650 m of trench with 12-15 m bottom width to be excavated. Such a long deep trench will be more destructive to the seabed flora and fauna than a shorter intake solution in shallower water depths.
- Most large scale desalination plants have intakes with seabed depths of 10 to 20 m. The construction and operation of such long intake pipes and large scale intake towers at these extreme depths of -144 m have never been done before. Such extreme construction and operational risks without references would not be considered as technically credible, and would fail technical due diligence for project investment.

Subsequently, it was assessed that locating the seawater abstraction at a seabed depth of 12 – 20 m provides a pre-feasible solution for the AAWDCP seawater supply that respects the physical and environmental conditions at the Project location and provides the following environmental and technical/operational benefits:

- Due to natural marine stratification effects of nutrients in the area, the shallow depth location has relatively reduced algae productivity in the summer months compared to deeper water.
- The short distance intake location reduces the intake pipe trench requirements resulting in less disturbance of the benthic community.
- The intake towers and intake pipes are at depths that allow divers to have long dive durations for operational cleaning and maintenance without the need for decompression stops.
- Good seawater quality, which is necessary for the downstream proper operation of desalination processes, is available at a short distance from the shore.
- The short distance intake location avoids the path of docking phosphate ships and ensures operational safety.
- Relatively flat ground is available for construction of the large intake towers, reducing disturbance of the seabed.
- Large desalination plants with abstraction depths similar to suggested depth have many references.

Further to seawater abstraction depth, it was established that the entrainment and impingement impacts can be effectively minimised through mitigation in the design of the intake system as follows:

- A horizontal velocity cap design type of intake be selected if an intake tower is used.
- The through screen velocity shall not exceed 0.15 m/s with all intake towers in operation, the screens clean, and at the ultimate SWRO capacity of 300 MCM/y.
- The intake screens shall have an aperture hole size not exceeding 75 mm.
- The intake window lower sill shall be at least 3 m above the seabed to minimise sand, silt, and benthic organisms entrainment.
- The top of the intake tower window shall be at least 5 m below the seawater surface to minimise the potential of the entrainment of surface pollution, particularly oils.

Overview of Marine Ecology Impacts of Brine Discharge – Local, Regional and Cumulative

Marine Ecology Impact at the AAWDC Site

The ecological impact at the AAWDC site of brine discharge from the Project desalination plant is expected to be insignificant. Most significant impacts of development in coral reef areas are usually associated with construction, where corals could be physically destroyed. The site has already witnessed several construction activities that resulted in some impacts on the coral reef, clearly visible in the diving video survey conducted for the ESIA.

Near field modelling carried out for this project indicated that a brine discharge at a seabed depth of 25-30 m through 200 m long diffusers achieves the mixing zone requirement for brine salinity concentration of ≤2% at the end of the mixing zone, i.e., 100 m from the diffusers. The 2% above ambient salinity was shown to be achieved at a distance of 38 m from the diffusers (at 45% recovery) and the actual end of the near field region was assessed at 56 m from the diffusers where the brine plume salinity concentration was just 1.4% above the ambient seawater salinity. These results show that the project can be designed to ensure the protection of local the flora and fauna from elevated salinity.

Far field modelling carried out for this project predicted further brine salinity dispersion up to 3 km from the diffusers. More specifically, the model found that the brine plume started at ≤ 2% above ambient salinity and slowly became more diluted over several kilometres by underwater currents. The brine plume will travel as a density current following the bathymetry under gravity to deeper water. These results demonstrate that at distances of approx. 1.5 km from the diffusers, it would be difficult to detect the brine plume salinity concentration.

Marine Ecology Impact on Aqaba Marine Reserve

About 25% of the Jordanian coastline (7 km) has been under special management for coral reef conservation since the late 1970s. In 2020, this stretch was declared as the Aqaba Marine Reserve (AMR), whose southern boundary is about 3km north of the proposed AAWDC brine discharge location. According to design salinity of the AADWC, brine salinity concentration will drop to ≤ 2% above ambient seawater salinity at the boundaries of the mixing zone. This is 100 m from diffusers in all directions. The mixing zone will expand at a water depth between 25 m and 70 m. With brine being denser than the surrounding seawater it will have a significant tendency to sink down the steeply sloping bottom at the discharge location than to spread horizontally. Any horizontal dispersion will be more to the south in the opposite direction of AMR. Therefore, it is highly unlikely that any elevated salinity will be detected within the boundaries of the marine reserve.

Potential Wider Impacts (Gulf of Aqaba and Red Sea)

The near field dispersion modelling carried out for the AAWDC Project showed that the brine concentration that will be achieved at 100 m from the diffusers will be less than 1.5% to 2% above ambient. This is interpreted to mean that the set mixing zone rule for brine salinity concentration is met and in fact, even lower concentrations of brine salinity than 2% above ambient seawater salinity are achievable in less than 100 m from the diffusers. According to the far field modelling carried out for this Project, this salinity differential would continue to diminish as the brine flows as density current along the seabed to deeper waters. Whole Effluent Toxicity (WET) testing on local flora and fauna is proposed for this Project during plant construction and during operation to establish the no impact dilutions for the brine discharge.

Cumulative Effects

The brine from the AAWDC Project desalination plant once dispersed in the sea, is anticipated to behave in a similar manner to the brine formed by solar evaporation in the Gulf of Aqaba. The ultimate capacity of the desalination plant will remove approx. 740 MCM per year (or 2,017,471 m^3/d) of seawater to produce 300 MCM per year of treated water at 97% overall plant availability and 42% plant recovery, which is less than approx. 12% of the water volume naturally evaporated at 5mm per day. Given a surface area of the Gulf of about 3.2×10^9 m^2 this implies evaporation from the Gulf of about 16,000,000 m^3.day^{-1}. The brine produced by natural evaporation in the northern Gulf makes its way to the bottom of the Gulf of Aqaba where it discharges to the Red Sea at the Gulf of Aqaba. Lower salinity seawater enters the Gulf of Aqaba at the Straits of Tiran. The brine produced by solar evaporation in the Red Sea makes its way to the south of the Red Sea and discharges into the lower salinity Indian Ocean at the Strait of Bab el Mandeb, where lower salinity Indian Ocean seawater replenishes the Red Sea.

The existing Jordan power station at Aqaba Industrial port discharges 80,000 m^3/d of spent cooling seawater with a temperature of 3^0C above the ambient. The AAWDC Project desalination plant at ultimate capacity would discharge approx. 48,630 m^3/hr of brine (at 42% recovery) with a temperature ranging from 0.5^0C to 1^0C above the ambient. Because the Aqaba Gulf circulation and stratification are mainly affected by temperature changes, it is not anticipated that the AWDCC brine will significantly impact salinity levels, stratification, or the circulation currents of the Gulf. However, further confirmation canbenefit from longer term research.

It is possible that antiscalant will not be needed for the AAWDC Project SWRO desalination plant. However, if it is used, then it will need to be readily biodegradable to avoid persistence of the antiscalant and it needs to be free of nitrogen, considering that nitrogen is the limiting factor for primary productivity in the Gulf of Aqaba, to avoid its accumulation into the Gulf of Aqaba when degradation of the antiscalant occurs.

Small quantities of iron particulate and soluble iron used as coagulants in seawater pre-treatment will be discharged with the brine. This brine concentration will be diluted by at least a factor of 41 by the outfall diffuser design. It is not anticipated that this iron will settle quickly when leaving the near field mixing zone, because it has already passed through a solids process facility at the desalination plant using gravity thickening. The particulate iron (iron hydroxide) is anticipated to migrate to the deeper water (>700 m) in the centre of the Gulf of Aqaba as part of a density current. Iron is not toxic to marine life and accumulation of iron is not considered to raise concern because it is not the primary productivity limiting nutrient in the northern Gulf of Aqaba, which appears to be nitrogen.

8. Environmental and Social Management Plan

The Project ESMP was developed as a stand-alone document appended to the Project ESIA study with the purpose to set a framework ensuring that the social and environmental safeguards are effectively considered by the Project Promoter and the BOT Developer during the detailed design, construction, and operation of the AAWDC Project. The Project ESMP complements and forms an integral part of the ESIA and provides all appropriate mitigation/management measures to be implemented by the BOT Developer during the pre-construction, construction, and operation phases of the AAWDC Project, as well as overarching principles, guidelines, and procedures relative to the incorporation of said mitigation/management provisions into the BOT Developer's detailed design and required Construction and Operation ESMPs (Annex 15 of the ESIA study).