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Task 1.15: AAWDC Project – Final Environmental and Social Impact Assessment Report

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Table of Contents

List of Figures

List of Tables

Glossary of Terms and Abbreviations

AA	Abu Alanda
AAWDC	Aqaba-Amman Water Desalination and Conveyance
AAWDCP	Aqaba-Amman Water Desalination and Conveyance Project
ADC	Aqaba Development Corporation
ADC	Aqaba Development Corporation
AoI	Area of Influence
approx	Approximately
ASEZA	Aqaba Special Economic Zone Authority
AW	Aqaba Water Company
AWDR	Aqaba Water Distribution Reservoir
BOT	Build-Operate-Transfer
BPS	Booster Pump Station
BPT	Break Pressure Tank
Cabinet	Council of Ministers
CAPEX	Capital Expenditure
CIP	Cleaning-in-Place
CIP	clean-in-place
CO	Carbon Monoxide
DAF	Dissolved Air Flotation
DBPs	disinfection by-products
DI	Ductile iron
DMF	Dual Media Filtration
DOA	Department of Antiquities
DOLA	Department of Lands & Survey
DOS	Department of Statistics
E&S	Environmental and Social
EAs	Environmental Assessments
EBCT	empty bed contact time
EDCO	Electricity Distribution Company
EDTA	Ethylenediaminetetraacetic acid
EIB	European Investment Bank
EMARCU	Environment Monitoring and Research Central Unit
ERC	Environmental Research Centre

ERDs	Energy Recovery Devices
ERI	Economic Resilience Initiative
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESS	Environmental and Social Standard
EU	European Union
FRP	Fibre-reinforced plastic
GHG's	greenhouse gases
GMF	Glass MicroFiber
GPS	Global Positioning System
GRP	Glass Reinforced Plastic
GRP	Glass Reinforced Plastic
H&S	Health and Safety
HDPE	High Density Polyethylene
HPPs	High-Pressure Pumps
IBA	Important Birds Area
IEEs	Initial Environmental Examinations
ILO	International Labour Organization
INDC	Intended Nationally Determined Contribution
IPS	Intake Pumping Station
IUCN	International Union for Conservation of Nature
JD	Jordanian Dinar
JMA	Jordan Maritime Authority
JEPCO	Jordanian Electric Power Company
JPMC	Jordan Phosphate Mines Company
JVA	Jordan Valley Authority
KBA	Key Biodiversity Area
Km	Kilometre
LCA	Life Cycle Assessment
m3/h	Cubic meters per hour
MCM	Million Cubic Meters
MCM/y	million cubic meters per year
MF	Microfiltration
mg/L	milligrams per liter
mm	millimeter
MoA	Ministry of Agriculture

MoEnv	Ministry of Environment
MoLA	Ministry of Local Administration
MoM	Minutes of Meeting
MPWH	Ministry of Public Works and Housing
MSS	Marine Science Station
MWI	Ministry of Water and Irrigation
NO_2	Nitrogen Dioxide
O&M	Operation and Maintenance
O_3	Ozone
OD	Outside Diameter
OPEX	Operational Expenditure
PAI	Project Area of Influence
PAP	Project Affected Person
PM10	Particulate Matter (diameter < 10 microns)
PS	Pumping Station
PSs	Pumping Stations
PVC	polyvinyl chloride
PX	pressure exchange
QAIA	Queen Alia International Airport
Res.	Reservoir
RFP	Request for proposal
RGT	Regulating Tank
RO	Reverse Osmosis
ROW	Right of Way
LARPF	Land Acquisition and Resettlement Policy-Framework
RSCN	Royal Society for the Conservation of Nature
RSDS	Red Sea Dead Sea
RSS	Royal Scientific Society
RTMS	Real-Time Monitoring System
SBS	sodium bisulphite
SEP	Stakeholder Engagement Plan
SLS	surfactant
SLS	Sodium Lauryl Sulfate
SMBS	Sodium Meta Bisulphite
SO_2	Sulphur Dioxide
SSC	Social Security Corporation

SWRO	Sea Water Reverse Osmosis
TA	Technical Assistance (Referring to the team working on this project as part of a WYG-Led consortium under the ERI-ITA multi-facility contract)
TDS	Total Dissolved Solids
THMs	Trihalomethane
ToR	Terms of Reference
TTMP	Traffic and Transport Management Plan
UAE	United Arab Emirates
UF	Ultrafiltration
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WAJ	Water Authority of Jordan
WWTP	Wastewater Treatment Plant
µm	micrometers

1. Introduction

1.1. Project Background

Jordan has limited surface and groundwater resources, which are significantly less than the international threshold of 500 cm per capita, which is considered "absolute scarcity" [1]. 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.

The Ministry of Water and Irrigation (MWI), on 26th February 2020, announced the launch of the Aqaba-Amman Water Desalination and Conveyance National Project (AAWDC), describing it as “the largest water generation scheme to be implemented in the history of the Kingdom”. This came during a consultation workshop organised by the USAID to launch the Project’s first phase. In accordance with the relevant water strategy and projections, the Project will generate 300 MCM/year of drinking water after commissioning. The Project will be implemented through a build-operate-transfer (BOT) scheme.

The Aqaba-Amman Water Desalination and Conveyance (AAWDC) Project aims at reducing 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 by developing a water supply infrastructure entirely within Jordan’s boundaries and control starting from the Southern Red Sea coast in Aqaba at the industrial zone and ending in the capital city of Amman.

In outline, the AAWDC Project concept involves the development of desalination and water conveyance infrastructure comprising the following technical components:

- Offshore seawater intake system and on-shore Intake Pump Station (IPS);
- Seawater Pipeline from IPS to the SWRO Desalination Plant;
- SWRO Desalination Plant;
- Brine pipeline from the SWRO Desalination Plant to the IPS and offshore brine outfall system; and
- Pump Stations, Regulating Tanks and Conveyance Pipeline from the SWRO Desalination Plant to Amman.

1.2. Purpose and Need for the Project

Jordan is classified as being a semi-arid to arid region with annual rainfall of less than 200mm over 92% of the land. According to the “2016-2025 National Water Strategy of the Ministry of Water and Irrigation of Jordan”, Jordan has one of the lowest levels of water availability per capita in the world (about 123 m^3/capita/year) that is anticipated to decline even more during the next few years (projections for 90 m^3/capita/year by 2025).

Existing water resources in Jordan cannot sustain the increasing water demand. During the last few decades, the Jordanian Government has invested billions of dollars to utilise all available conventional and nonconventional water resources and technologies to bridge the gap between water supply and demand which is, evidently, widening with time.

The unfolding of the Syrian refugee crisis since 2011 has created real emergency conditions, especially in Northern Jordan. Water demand has jumped by additional 21% across Jordan and 40% in the Northern Governorates. Therefore, the provision of water and sanitation services has become lately a serious challenge and a significant axis of Jordan’s water and wastewater management planning.

Despite Jordan's severe water scarcity, more than 97% of Jordanians have access to improved water sources in urban areas and 91% in rural areas; whereas sewerage and wastewater treatment services cover 58% of the population.

In this context, the AAWDC Project as launched by the Ministry of Water and Irrigation (MWI) is aligned with the objectives and targets of the National Water Strategy 2016-2025 and will drastically contribute to the reduction of water scarcity facing the country through the provision of a reliable and sustainable non-conventional source of drinking water.

1.3. Purpose and Structure of the Report

This report, entitled "Environmental and Social Impact Assessment (ESIA) for the AAWDC Project" has the following objectives:

- Define the institutional and legal framework that governs the AAWDC Project;
- Present the project components, as well as all alternatives that have been considered;
- Describe baseline environmental conditions within the area of influence of the AAWDC Project;
- Identify and assess the significant impacts associated with construction and operation of the Project;
- Propose feasible mitigation / enhancement measures for the identified impacts and assess residual impacts;
- Develop a plan to monitor the identified impacts and their associated mitigation measures;
- Describe the institutional setup and capacity building measures needed to fulfil the requirements of the ESIA;
- Facilitate informed decision making, including setting the environmental terms and conditions for implementing the proposed scheme;
- Fulfil the requirements of the Jordanian environmental and social regulatory requirements and procedures, as well as the European Investment Bank (EIB) and United States Agency for International Development (USAID) environmental and social standards, and any other relevant environmental and social regulations and international best practices;
- Obtain the Environmental approval of the Jordanian Ministry of Environment (MoEnv) and Aqaba Special Economic Zone Authority (ASEZA).

Approval from the environmental authorities was obtained for this report as follows:

- MoEnv through their letter number 4/7/2387 dated 7 March 2022 for areas outside Aqaba Special Economic Zone, requesting an update of the study should any of the Project components change.
- ASEZA through their letter number MB/02/01/4542 dated 23 March 2022 for areas within Aqaba Special Economic Zone, with the following conditions
    - Upon completion of the detailed design, submission of the following detailed studies: Hazard Risk Assessment, Emergency Plan and Traffic Impact Study.
    - Commit to implementing mitigation measures in the ESIA study
    - Update of the study should any of the Project components with Aqaba Special Economic Zone change.

The approvals from MoEnv and ASEZA on the TOR and this ESIA study report can be found in **Annex 1** of this report.

This report was prepared in line with EIB, USAID, and national requirements for ESIA. The structure is presented in Table 1-1.

Table 1-1: ESIA Report Structure

Section	Contents
1. Introduction	Presents the Project's background, needs as well as ESIA objectives
2. Project Description	Provides a description of the Project and its components and their locations
3. Legal and Administrative Framework	Identifies the public entities that will be involved in the various aspects of Project construction and operation and the laws, regulations, and standards governing the environmental and social performance of the Project

Section	Contents
4. Project Alternatives	Presents the alternatives considered for the Project and the various advantages and disadvantages of each leading to selection of the preferred alternative
5. Methods	Defines the Project area of influence, presents the methods used to collect data on the physical, biological, and socioeconomic conditions within this area and describes the methodology used for impact assessment
6. Environmental and Social Baseline	Presents all relevant information collected on environmental and social conditions within the Project area of influence thus setting the current baseline conditions
7. Stakeholder Engagement	Describes all stakeholder engagement activities conducted to date regarding the Project and the main findings of these activities
8. Impact Assessment and Mitigation	Describes the anticipated positive and negative environmental and social impacts likely to result from the Project and the proposed mitigation measures
9. Environmental and Social Management Plan (ESMP)	Presents the Project ESMP that has been annexed as a stand-alone document to this report.
10. Annexes	All related annexes

2. Project Description

The AAWDC Project was developed to address the emerging challenges associated with the on-going water crisis in Jordan, with the primary objective to provide safe and reliable freshwater supply for Amman and other governorates in Jordan and areas along the Project conveyance pipeline route.

A summary of the Project scope of facilities was presented on 25/10/2020 by CDM Smith (Design Team assigned to the Project) for 250 MCM/year production capacity and subsequently updated on September 2021 to the set production capacity of 300 MCM/year is shown in Table 2-1 below.

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 BPS 1 to 4 Mudawarra PS 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

The AAWDC Project concept involves the development of infrastructure starting from the Southern Red Sea coast in Aqaba and ending in the capital city of Amman. The Project comprises several technical components as follows:

- Seawater Intake System off shore and Intake Pump Station (IPS) on shore;
- Seawater Pipeline from IPS to the Sea Water Reverse Osmosis (SWRO) Desalination Plant;
- SWRO Desalination Plant;
- Brine pipeline from the SWRO Desalination Plant to the IPS and brine outfall system off shore;
- Pump Stations along Conveyance Pipeline from SWRO Desalination Plant to Mudawwara;
- Regulating Tanks;
- Pump Station (PS) in Mudawarra;
- Conveyance Pipeline from Mudawarra to Amman terminating at a pump station next to Amman Development Corridor - PS ADC;
- PS ADC;
- Conveyance Pipeline to Abu Alanda Reservoir;
- Conveyance Pipeline to Al-Muntazah Reservoir;
- Aqaba Reservoir 1 at the BPS2 site; and

- Aqaba Reservoir 2 at the SWRO Desalination Plant site.

2.1. 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 Desalination Plant (SWRO), the Abu Alanda Reservoir and Al Muntazah Reservoir.

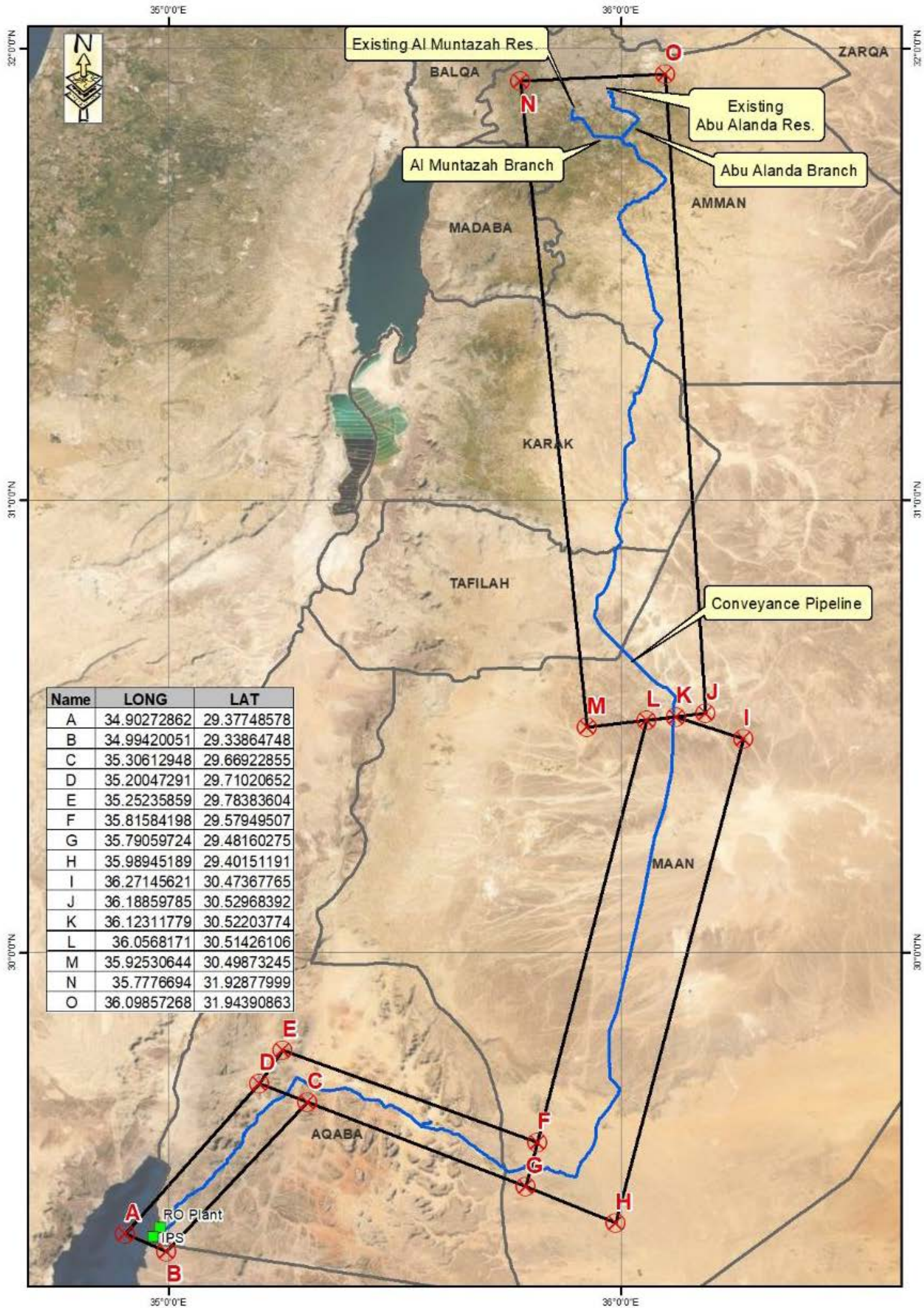

Figure 2-1: Overall Location of AAWDC Project

The following sections provide a more detailed description of the location of each technical component of the Project.

2.1.1. Intake System

The proposed intake system will include the intake towers, the submerged intake pipelines, the IPS and the seawater conveyance pipeline from the IPS to the SWRO Desalination Plant. The proposed location for the IPS is located approx. 18 km south of Aqaba City, within the Aqaba Industrial Zone by the Red Sea and adjacent to the recently constructed industrial port. The area on which the IPS will be constructed is approximately 2.77 hectares (ha) (Figure 2-2).

Figure 2-2: Location of Intake Pumping Station

The IPS will pump seawater to the SWRO desalination plant which is located at around 2 km northeast (Figure 2-3). The intake towers and submerged pipelines will be constructed at the marine side of the IPS.

Figure 2-3: Intake Pumping Station Location with respect to RO Plant

As part of and in parallel with the ESIA study, a pre-feasibility assessment was undertaken on the marine seawater intake and brine discharge components. This involved a technical, financial, and environmental pre-feasibility assessment of alternative options to identify relative advantages and disadvantages with the aim of recommending the least impact solutions for key technical aspects such as:

- Seawater intake inflow rate;
- Seawater intake structure;
- Brine discharge rate;
- Abstraction/discharge location into the Red Sea/Gulf of Aqaba;
- Abstraction/discharge depth;
- Necessary measures at the intake to protect it from contamination and ensure a continuous operational availability of 97%.

A feasible location for the intake tower and provisional routing for the submerged intake pipeline from the intake tower to the IPS resulted from the aforementioned pre-feasibility assessment, which took into account existing physical restrictions related to the marine area expanding opposite the IPS (e.g., ships anchoring, loading/unloading berths, submerged gas pipeline, etc., Figure 2-2 refers), technical and operability restrictions related to the construction of the marine works for the intake system, and environmental considerations related to entrainment effects by the proposed seawater abstraction.

A site visit was conducted on August 25, 2020, to the location of the IPS. During the site visit, the following existing facilities and infrastructure were observed in the surroundings of the IPS:

- Discharge pathway (cooling water outfall) of the thermal plant, 335 m northwest of the IPS location;
- “Permanent” gas storage ship, 400 m northwest of the IPS location (Figure 2-4);
- Water intake system of the Phosphate company, 180 m north of the IPS location;
- Gas line of the “Jordanian Egyptian Fajr Company” 170 m north of the IPS location;
- Phosphate (fertilizer cluster) discharge location/outfall (Figure 2-4);
- Phosphate berth southwest of the IPS location.

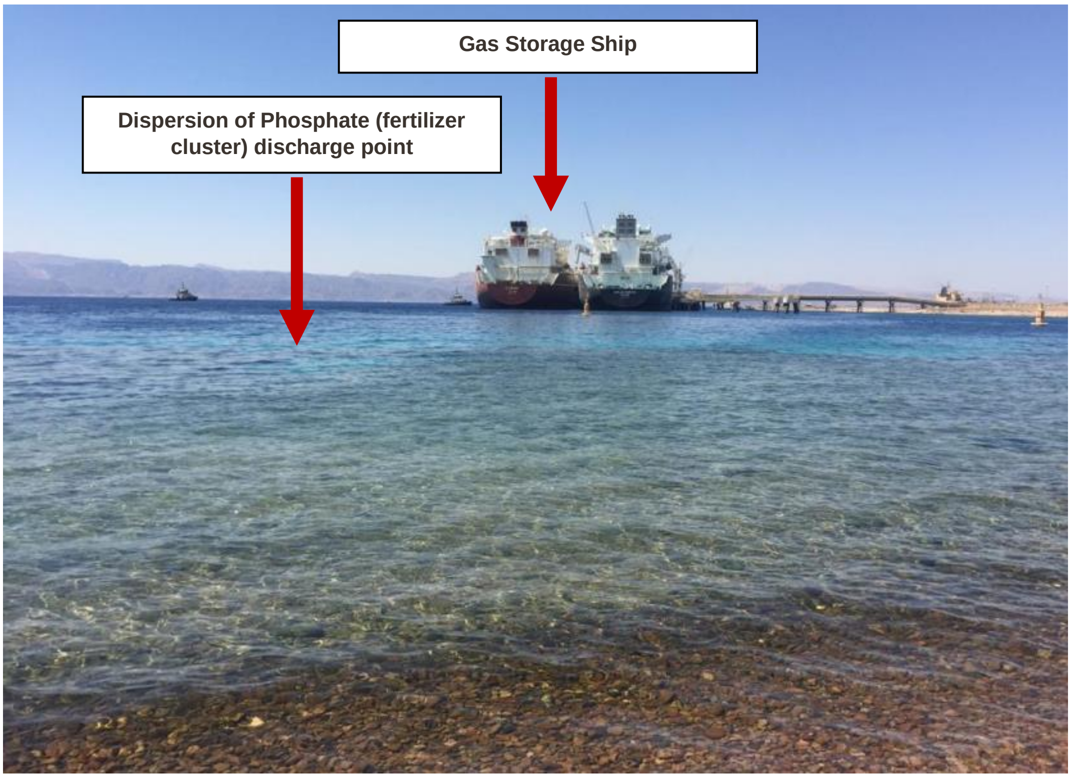

Figure 2-4: Location of the Gas Storage Ships Northwest of the IPS

Figure 2-5 illustrates all aforementioned existing facilities/infrastructure surrounding the IPS location.

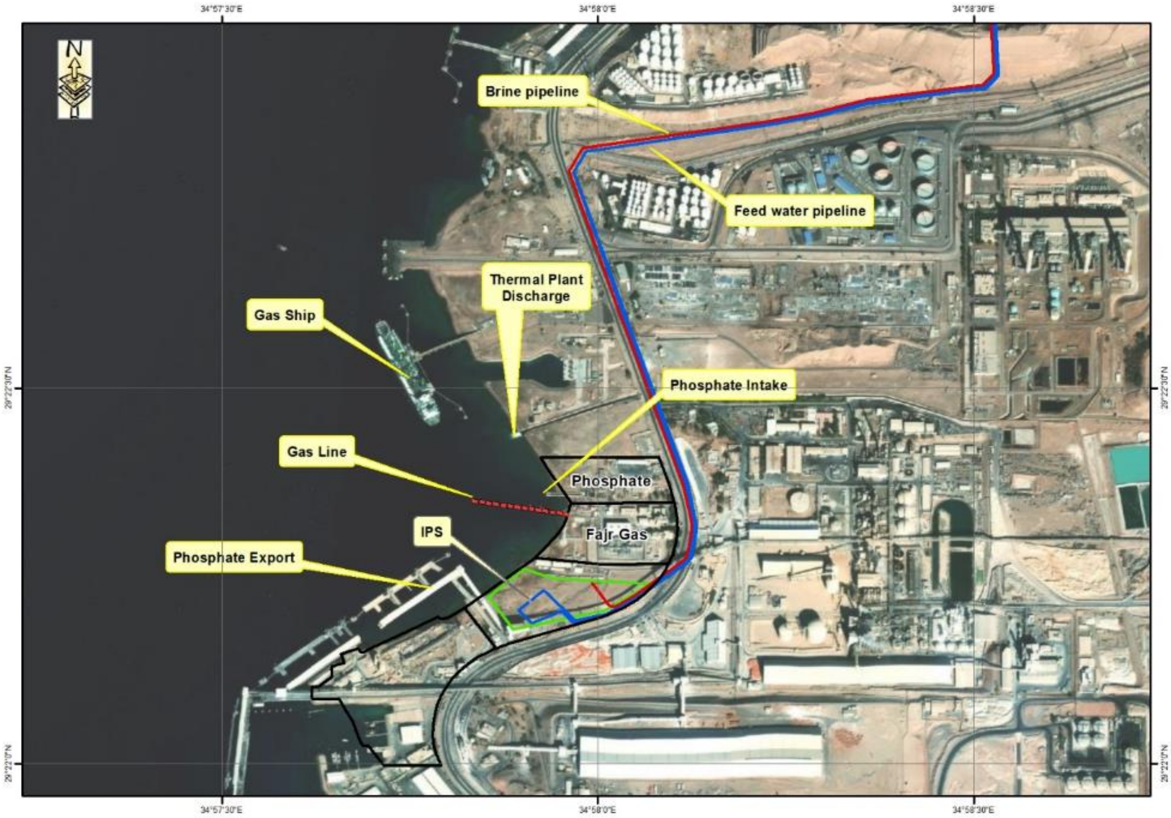

Figure 2-5 IPS Surrounding Facilities and Infrastructure

2.1.2. SWRO Desalination Plant

The available land for the SWRO desalination plant site is located approximately 16 km south of the City of Aqaba. The site will host the SWRO plant, and the treated water reservoir downstream. The site will also include the freshwater booster pump station 1 (BPS1).

The proposed 113.28 ha site (area bordered in green in Figure 2-6) on which the desalination plant will be constructed is located approximately 500 m from the coast of the Gulf of Aqaba. The proposed location is sited at an approximate elevation of +110 m. Following consultations of the Project Design Team, the MWI, and ASEZA, this location was found to be the most suitable site from a logistical and environmental point of view, as it is located within an established industrial zone south of Aqaba surrounded by several recently constructed highways. In fact, the site perimeter is itself surrounded by several highways. The area proposed for the SWRO desalination plant is 35 ha (area bordered in red) while the area provided by ASEZA covers approximately 100 ha, is shown in Figure 2-6, which also shows the IPS location with respect to the desalination plant location about 2km to the southwest. It is noted that the overall site (green border area) comprises the presence of two wadis in the east-west direction, Wadi 4 and Wadi 5, according to the Hydrologic Analysis Report prepared by CDM Smith in May 2009. These wadis divide the overall site into three subsites (north, central, south). The central site was eventually selected as it provides the necessary 50 ha of continuous land required for the construction of the RO Desalination Plant.

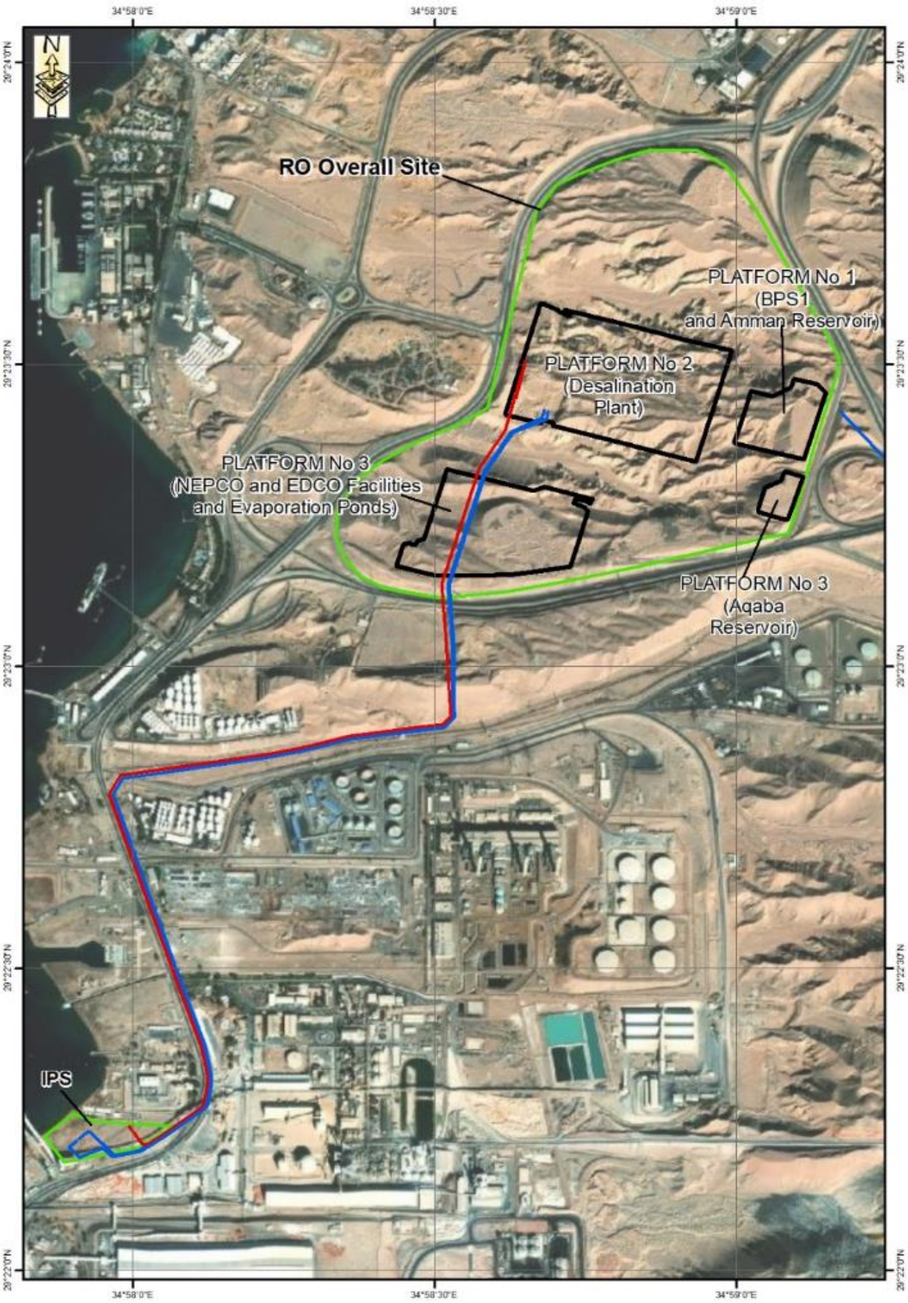

Figure 2-6: Desalination Plant Site Location

Figure 2-7, Figure 2-8 and Figure 2-9 provide photographic documentation of the proposed SWRO Desalination Plant location as taken during the site visit conducted on September 24, 2020.

Figure 2-7: Access Road within the Proposed RO Desalination Plant Site (West boundary of the Proposed SWRO Site)

Figure 2-8: High-power Transmission Lines within the SWRO Desalination Plant Site (Southwest boundary of the site)

Figure 2-9: Highway along the Western Boundary of the SWRO Desalination Plant Site

2.1.3. Brine Discharge System and Outfall

Brine generated by the SWRO desalination process will be conveyed from the brine reservoir at the SWRO Desalination Plant to the location of the IPS and is planned to pass through a hydropower generation system. From there, it will be discharged to the marine side of the IPS through a submerged pipeline ending at high velocity diffusers enhancing quick dilution of the brine into the marine environment.

Similar to the seawater intake system, the recommended key technical aspects (e.g., depth and outflow rate) of the marine brine discharge component resulted from the technical, financial, and environmental prefeasibility assessment that was conducted as part of and in parallel to the ESIA study. In addition, a brine discharge risk assessment was also conducted and is integrated into this ESIA study **(Annex 2).** A feasible location and provisional routing for the brine outfall system resulted from the aforementioned assessments, which took into account existing physical restrictions related to the marine area expanding opposite the IPS (e.g., ships anchoring, loading/unloading berths, etc., Figure 2-2 refers), technical and operability restrictions related to the construction of the marine works for the outfall system and its interaction with the intake system, and environmental considerations related to brine discharge effects and brine dispersion.

2.1.4. Conveyance Pipeline

The proposed pipeline will convey freshwater from the SWRO desalination plant to Abu Alanda Reservoir and Al Muntazah Reservoir located in Amman. Table 2-2 represents the coordinates of all technical components related to the water conveyance including regulating tanks and pump stations along the conveyance route. The table also presents the footprint of each facility and its elevation (obtained from the Technical

Memorandum-Technical Assessment of Pipe Materials report dated September 3, 2020 as submitted to MWI by the Project design team).

Table 2-2: Conveyance Pipeline Various Component Site Locations and Data

Facility	Coordinates	Area (ha)	Elevation (masl)
Booster Pump Station 1 - BPS1	29°23'26.97"N, 34°59'6.17"E	0.57	118
Booster Pump Station 2 - BPS2	29°26'26.00"N, 35°1'6.01"E	3.48	339
Booster Pump Station 3 - BPS3	29°28'26.82"N, 35°3'46.90"E	3.03	557
Regulating Tank 1 - RGT1	29°30'4.03"N, 35° 5'42.17"E	2.52	806
Booster Pump Station 4 - BPS4	29°42'9.65"N, 35°16'7.43"E	4.68	754
Regulating Tank 2 - RGT2	29°37'37.02"N, 35°34'38.20"E	2.22	921
Mudawwara Site 2/ Booster Pump Station 5 - MUS2/BPS5	29°33'24.51"N, 35°55'34.85"E	4.69	862
Regulating Tank 3 - RGT3	29°43'23.93"N, 35°58'30.14"E	2.4	1089
Break Pressure Tank - BPT	30°33'43.13"N, 36° 7'14.38"E	2.41	974
Pump Station Abu Alanda - PS ADC	31°48'6.29"N, 36° 0'4.85"E	6.42	762
Existing Abu Alanda Reservoir	31°54'13.59"N, 35°58'14.57"E	-	985
Existing Al Muntazah Reservoir	31°51'52.33"N, 35°53'40.35"E	-	860
Aqaba Reservoir 1 at the BPS2 site	29°26'25.37"N, 35° 1'0.74"E	0.12	336
Aqaba Reservoir 2 at the SWRO Desalination Plant site	29°23'19.97"N, 34°59'5.65"E	0.18	110

An overview of the location of all the BPSs and RGTs along the proposed conveyance pipeline is presented in Figure 2-10.

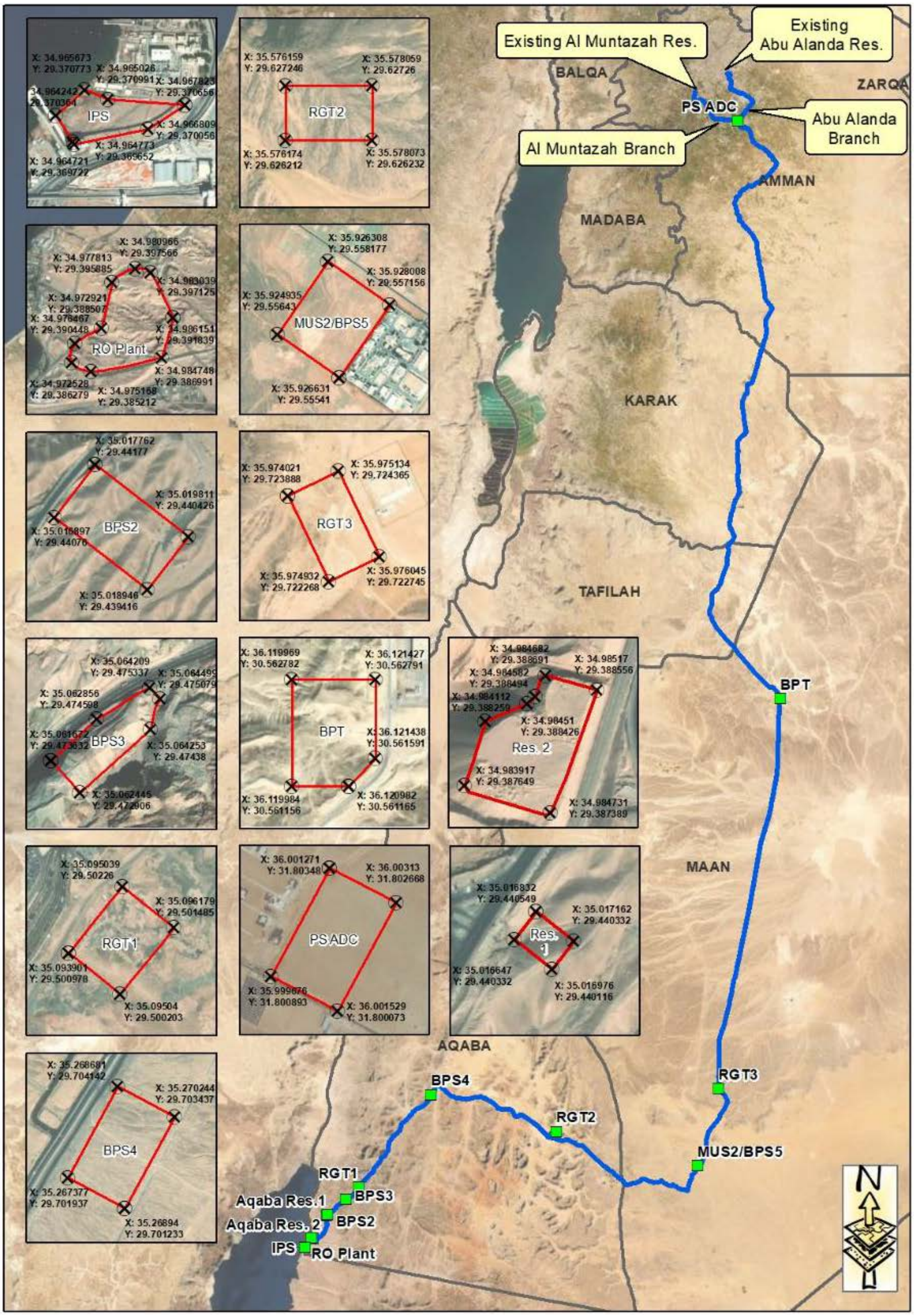

Figure 2-10: Location of different facilities along the Proposed AAWD Conveyance Pipeline

2.2. Description of Project Components

To deliver an extensive and clear description of the Project, the Project components have been divided into two major categories, mainly based on their locations (geographically) and common activities during both Project phases, i.e., construction, and operation.

The purpose of Table 2-3 below, is to summarize the two main Project component categories, which are the Water Desalination Component and the Water Conveyance Component. It also clarifies that the Water Desalination Component is further divided into offshore facilities (facilities related directly to the sea) and onshore facilities (desalination system facilities related to the coastal and inland sites).

Table 2-3: Summary of Project Components

Water Desalination Component		Water Conveyance Component
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

2.2.1. Water Desalination Component

The Water Desalination Component consists of several facilities to produce desalinated water (freshwater) through a Reverse Osmosis (RO) desalination process with an overall plant freshwater recovery efficiency ranging between 42% and 45%. The resulting brine from the RO process will be conveyed to the Gulf of Aqaba by a brine discharge pipeline (from the brine reservoir/tank at the RO Plant to the IPS) and discharged into the Gulf of Aqaba through an engineered sea outfall.

The following facilities comprise the water desalination component:

- Intake system (intake towers and submerged intake pipelines) and IPS;
- Seawater conveyance pipelines from the IPS to the SWRO desalination plant;
- SWRO desalination plant including:
  - Pre-treatment system
  - RO membranes in a building, including energy recovery system
  - Post-treatment system
  - Solids treatment system
  - Domestic Wastewater Treatment System
  - Bulk chemical storage area/systems
  - Instrumentation and control systems
  - Electrical facilities within the SWRO desalination plant site
  - Piping within the plant site
  - Civil works, including paving and grading within the SWRO desalination plant site
  - Administration and maintenance buildings
  - Seawater (optional), treated water, and brine reservoirs/tanks
  - High service pumps (freshwater booster pump station BPS1)

- Evaporation Ponds for RO membranes organic/detergent Cleaning-in-Place (CIP) waste
- BPS 1

- Brine conveyance pipelines from the SWRO plant to the IPS and brine discharge outfall system.
- Aqaba Res. 2 at the SWRO plant site

Figure 2-11 represents a simplified process flow diagram of the water desalination component starting from the intake system (at the Gulf of Aqaba), continuing to the SWRO desalination plant, reaching the freshwater booster pump station (BPS1), and ending at the brine discharge outfall.

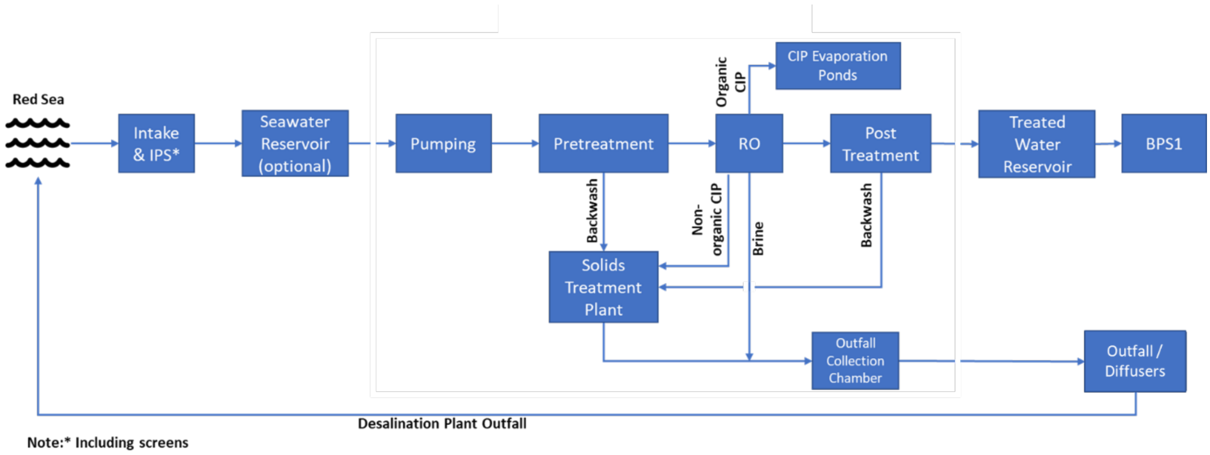

Figure 2-11: Process Flow of the Entire Desalination Plant. [2]

2.2.1.1. Offshore Facilities

The following descriptions were taken from the 'Aqaba-Amman Water Desalination and Conveyance (AAWDC) Project [300 MCM/yr Plant] Sewater Intake & Outfall Preliminary/Hydraulic Design' Report prepared by HR Wallingford for CDM Smith in September 2021. It is noted that this Report was meant to present a preliminary Project design and will be included in the RFP procurement documents for the BOT Developers for information only. It is noted that the BOT Developer's detailed design for the marine works will be allowed to select (a) specific locations for the intake and outfall pipes; (b) intake tower sizes, (c) pipe sizes, (d) diffuser number and sizes and respective works provided the Project constraints and design requirements set out in the ESMP, as appended to this ESIA study, are accounted for and achieved.

2.2.1.1.1. Intake towers and pipelines

According to the preliminary Project design, seawater will enter the intake system via submerged offshore intake towers that will be installed at the seabed (refer to **Annex 3** for the Marine works layout). 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 from reinforced concrete and will 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 the 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 divers' cleaning 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.

The intake towers will be designed and configured to allow for (a) an intake pipeline running through the intake tower to form a pig exit spur and (b) an arrangement of flanged inlet openings at the top of the intake pipeline inside the tower, which is required to avoid the pig exit inside the tower. Based on the preliminary design, this can be achieved by a more elongated/rectangular shaped intake tower structure. In dimensional terms, a rectangular structure of the order of typically 13 m long by 5.5 m wide is considered suitable to achieve the necessary inlet velocity limitations (nominally 0.15m/s where practicable). For a suitable 13m long by 5.5m wide intake tower structure, preliminary deign calculations showed that incorporating six (6) No. 4.5m wide by 2.8m high intake opening screens, can be appropriate in relation to achieving required "through bar" velocity limits by incorporating a screen arrangement with nominally 75mm openings. The bars/screen arrangements at the entrance openings for each of the intake towers can be fabricated using GRP bars arranged on frame arrangements that can be secured/bolted to the concrete tower structure. In this respect, the GRP screen frames can be considered removable/replaceable if/when maintenance or cleaning is required.

Based on the preliminary design, each intake pipeline will connect to the relevant intake tower below the sea bed level. In order to facilitate pigging of the intake lines (if/where this may be necessary), the intake pipeline will be required to continue running through the intake tower structure with an exit spur furnished with a blanked flange on the offshore side of the tower. At each intake tower, the inlet flow into the intake pipe connection is proposed to take the form of 3 No. Typ DN2300 openings (equipped with suitable flanges). During normal operation the 3 No. Type DN2300 inlet openings inside the intake tower will remain open whilst the blank flange at the end of the spur on the main intake pipe will remain closed/blanked. The requirement to access "inside" the intake tower to effect opening and closure of the flanges at the 3 No. Type DN2300 diameter inlet openings will necessitate a requirement to provide suitable diver access inside the tower. This may be provided in the form of a hatch/access cover in the roof slab of the tower or by temporarily removing one of the screen frames to allow diver access.

Based on relevant preliminary design calculations, the intake arrangement will comprise four (4) No. DN2300 intake pipelines, which are expected to be consistent with the desired maximum and minimum velocities, i.e., (a) in normal operation, with 4 No. pipes operating, velocities correspond to 0.9m/s and 1.7m/s for 50% and 100% flow capacities respectively, and (b) in maintenance case, with 3 No. pipes operating, velocities correspond to 1.1m/s and 2.3m/s for 50% and 100% flow capacities respectively.

2.2.1.1.2. Brine outfall pipeline and diffusers

Concept diffuser configurations were developed using near-field modelling methods. It is considered, however, that a "far-field" model study (considering the wider dispersion of the diluted plume by successive tides, drift currents and wind effects etc) will be needed and required by the regulatory authorities for final Project environmental permitting. As such, it is considered that a "far-field" modelling study will be required at the detailed design stage of the Project. The far field dispersion modelling may be enhanced at the detailed design/execution stage of the project by incorporating wider bathymetry survey data and currents data for use in model "calibration".

Based on the preliminary design, the outfall configuration will comprise (two) 2 No. DN2300 outfall pipelines, which is consistent with the maximum and minimum velocities required i.e.., velocities correspond to 1.0m/s and 2.1m/s for 50% and 100% flow capacities respectively, considering also maintaining a pipe size common with that of the intake and also to have a potentially wider selection of possible suppliers to this effect.

Based on the 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 pipelines in operation each terminating in a diffuser arrangement, around 86m 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 staggered – one further offshore than the other – such that the total combined diffuser length with both pipelines in operation will be just under 200 m. However, taking into account the outfall diffuser conceptual design and performance, it is considered preferential that, in the situation that the plant is in operation at a capacity up to and including 50% capacity, only one outfall pipeline will remain in operation. This can help ensure improved levels of dilution/near-field mixing when the plant is operating at a reduced capacity. 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. Moreover, the diffuser area can be determined to be a restricted area and marked with buoys to be an exclusion area.

2.2.1.2. Onshore Facilities

2.2.1.2.1. Intake Pumping Station

The intake pumping and screening systems will be designed to deliver sufficient raw seawater to the RO 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.

a. Screening System

Screens will be of a robust design and proven for use in seawater intakes. They will automatically remove debris to protect downstream equipment from damage and to prevent the entrainment of large solids. Screen mesh sizing will be selected to ensure sufficient removal of marine debris to protect the plant while preventing blinding of the screens.

b. Intake Pumping System (IPS)

Seawater pumps will be designed to deliver sufficient raw seawater to the RO 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/y to 300 MCM/y 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 be only provided unless manual cleaning by divers and/or mechanical cleaning through pigging are not technically feasible. The pig receiving station will be installed at the RO Desalination Plant for the pigging of the intake pipelines connecting the IPS to the Desalination Plant site.

Annex 3 shows the site layout configuration related to the IPS as provided by the Project design team.

2.2.1.2.2. Sea water and brine conveyance pipelines from the IPS to the SWRO desalination plant and from the SWRO desalination plant to the brine outfall system

According to the preliminary design, there will be two (2) seawater pipelines from the IPS to the RO Desalination Plant of 2,700 mm OD each, which will be placed on the same trench of an average depth of 5 m. A width of approx. 10 m will be required for the installation of said seawater pipelines. **Annex 4** illustrates the plan and profile of the seawater conveyance pipelines. In addition, there will be one (1) brine conveyance pipeline from the RO Desalination Plant to the IPS of 2,700 mm OD, which will be placed on the same trench as the seawater pipelines of an average depth of 5 m. A width of approx. 5 m is required for the brine pipeline. **Annex 5** illustrates the plan and profile of the brine conveyance 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.

2.2.1.2.3. SWRO Desalination Plant

The AAWDC Project will be implemented in one phase and will provide 300 MCM/year of potable water to Amman, Aqaba, and other cities along the pipeline route from a new reverse osmosis desalination plant located at the new industrial area of Aqaba to address the current water supply gap.

The selected treatment process will achieve the treated water quality goals for the Project while operating at the maximum production capacity. The design will ensure that the drinking water as well as brine discharge quality requirements set forth in the ESIA, ESMP and any other applicable permits, and the other performance guarantees for the AAWDC Project are maintained at all times.

Desalinated and remineralized finished water will be pumped to the delivery points and turn-outs via the conveyance system while the brine and certain liquid residuals from the Desalination Plant will be discharged into the Gulf of Aqaba to the Red Sea as dictated by the permits.

Design Flows

The SWRO 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%.

Treatment Process

The key water treatment process steps consist of seawater pre-treatment, single pass RO, water post-treatment stabilization, and finally product water disinfection to provide a disinfectant residual in the distribution system. The overall treatment plant recovery will achieve a minimum 42% recovery. The SWRO 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 (CIPs), 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. **Annex 6** shows a flow diagram of the entire treatment process.

Based on the preliminary design report for the desalination plant dated September 2021, the RO Desalination Plant is divided into two identical halves each with 150 MCM/y 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 Plant and the domestic Wastewater Treatment System are common for both plants.

Pre-treatment System

The Pre-treatment System will ensure that the raw water quality that is supplied to the SWRO will not result in damage or abnormally high fouling or scaling to the SWRO membranes and will allow sustained operation between clean-in-place (CIP) events of the RO membranes. The Pre-treatment System will include various necessary components, some of which are mandatory, as described below. A Raw Water quality monitoring system at IPS and upstream of the pre-treatment at the RO Desalination Plant will be also included in the system.

1. Coagulation and Flocculation

The treatment process will consider the addition of a coagulant, and coagulant aid, if deemed necessary, based on the selection of downstream processes. In the case where coagulant is used, the concentration of the metal coagulant in the discharge to the outfall shall comply with all pertinent regulations. If necessary to improve filter performance, acid addition to adjust the coagulation pH may be used. To guarantee the generation of appropriately sized floc, adding a coagulation, and/or flocculation chambers, upstream of the GMF or UF system may be considered.

2. Clarification System

Based on the expected raw water quality, the use of a clarification system based on either flotation or sedimentation principles may be included. It may be possible to bypass the clarification system during specific raw water quality periods.

3. Automatic Strainers

The feed water to the filtration system will pass through automatic strainers if the selected pre-treatment consists of a polymeric UF membrane filtration system. If the filtration consists of one or more stages of granular media filtration system or a ceramic UF membrane system, automatic strainers are not required.

The strainers will automatically backwash based upon a timer or differential pressure reading to remove accumulated solids from the screening element. To protect the UF membranes from debris and macroparticles in the feed water that could cause damage and/or excessive fouling of the UF membranes, strainers with a maximum screen size of 150 micrometers (µm) will be provided upstream of the membrane skids.

4. Filtration

The pre-treatment process will include a filtration system to provide high-quality feed water to the SWRO system. The Filtration System may consider either one-stage or two-stage GMF, a combination of media filtration and UF membrane filtration, or UF membrane filtration. Microfiltration (MF) may also be used in lieu of UF. The selected filtration system shall consistently meet the required total suspended solids (TSS) and SDI15 limits for filtered water to ensure stable performance of the RO System.

4.1 Granular Media Filtration System

If a GMF system is selected, either gravity or pressurized, the system will be designed to achieve the AAWDCP performance guarantees. GMF filters will be of the deep bed multimedia (anthracite over sand) type, with a graded gravel support layer.

Provisions for backwash by air scouring, followed by simultaneous application of air and low-rate water, and finally by a high-rate water rinse, will be considered. Also, provision for filter-to-waste will be provided.

The following design characteristics are provided for the granular media filters (GMFs) based on the preliminary design. It is noted that the BOT Developer will be free to select its filtration system meeting the set performance guarantees for the AAWDCP.

Multimedia filter: The AAWDCP GMF system included in the preliminary design is composed of 96 filter units divided into two identical plants each of three process lines (or trains) and three backwash systems (i.e., one dedicated backwash system per filter train). Each process line has been designed to achieve a surface loading rate of approximately 11 metres per hour (m/h) with one filter out of service for backwashing (n-1 configuration). A common feed water channel distributes water evenly across a train of individual filters. Once the water has passed through the filter media, it flows to a filtered water tank that provides flow equalization upstream of the RO process. The filter media is composed of a top layer of anthracite, a bottom layer of filter sand, and two supporting layers of garnet gravel. The actual number of filters and design criteria utilized should be expected to vary based on the detailed design of the BOT developers.

Filtered water equalization: Filtered water from the filters of each plant flows by gravity to the corresponding filtered water tank. This tank provides flow equalization upstream of the RO system and is designed to provide 13 minutes of retention time at design inlet flow of 37, 076 m^3/h. The net volume of the equalization tanks is 8,000 m^3.

GMF backwash system: The filters are assumed to be backwashed using RO brine sourced from the brine backwash tank and air from a low-pressure blower system of the corresponding plant. Each filter train contains dedicated backwash pumps while the duty and standby blowers are common for all three filter trains for each plant. The backwash procedure involves first draining down the filter until the water level is approximately 100–150 mm above the surface of the filter media. This will occur by closing the filter inlet and maintaining the filtered water outlet control valve at the final registered position prior to initiating the backwash. The estimated drain down duration is 30 minutes. Once the desired water level has been achieved, air scouring, combined air scouring and low rate backwashing (1,125 m^3/h) followed by high rate backwashing (5,250 m^3/h) will sequentially occur. One duty air scour blowers will be used along with a standby one. The design capacity for each blower is 4,125 Nm^3/h. The estimated total backwash duration is 54 minutes (including drain down, low-rate and high-rate backwash and refill). It is noted that backwashing with brine is used in several SWRO desalination plants, but it has the disadvantage of causing an osmotic shock to the biofiltration on Dual Media Filters (DMF). Instead, seawater filtrate can be used for this purpose. The BOT developers will be allowed to select brine or filtered seawater for filters' backwashing purposes in their detailed design.

GMF filter-to-waste: Once the high-rate water wash step of the backwash is complete, the filter is placed back into service. Initially, the filter inlet will open with the filter outlet control valve closed to allow the filter level to increase up to the desired operating water level. Once the desired operating level is reached, the filter outlet control valve will slowly open with the filter-to-waste isolation valve open and filtered water to filtered water tank isolation valve closed. While the filter is ripening, low-quality filtered water will be sent to the outfall via the brine reservoir rather than the RO system. The flow rate of the filter–to-waste is assumed to be 788 m^3/h. Initially, the filtered water will primarily be made up of RO brine remaining in the filter at the conclusion of the backwash. Once the desired filter-to-waste duration timer has expired (approx. 30 minutes), the filtered water will be redirected to the filtered water tank.

4.2 Ultrafiltration (UF) System

If a UF or MF system is selected, the system will be designed to achieve the AAWDCP performance guarantees. UF backwash water source can be either filtered water or RO brine. If brine backwash is selected, the process will also include the provision to perform backwashing using filtrate water during episodes where there is a significant increase in the organics content of the raw water.

Membrane modules will be assembled in racks of equal capacity. Each rack will be capable of independent operation throughout its process sequences upon initiation.

The effluents generated during the cleaning-in-place of the UF membranes will be first neutralised and then sent to the on-site solids treatment system for further processing before discharged to the brine chamber for outfall disposal.

5. Cartridge Filters

The feed water to the SWRO system will pass through cartridge filters unless a UF system pre-treatment is selected and directly coupled with the RO system, without an intermediate break tank.

Based on the preliminary design report for the desalination plant dated September 2021, the following design characteristics are provided for the cartridge filters.

RO Feed Water Cartridge Filtration: Five-micron cartridge filters are located upstream of the RO system of each plant to remove particulates that may have been introduced into the water after GMF or by biological activity in the filtered water tank. The cartridge filters of each plant are divided into two process lines: one dedicated to the HPP feed water pumps and one dedicated to the ERD feed water pumps. Each set of cartridge filters is designed to maintain the desired loading rate with one unit out of service (total of 36 cartridge filters, 18 per plant, 9 per process line). For both lines, the number of filter elements per vessel is 433 each having a length of 178 cm. The design capacity of the HPP and ERD process lines are 17,288 m^3/h and 19,788 m^3/h respectively with one unit offline.

6. Periodic Pre-treatment System Disinfection

6.1 Periodic Disinfection

The Pre-treatment System will include processes to prevent the build-up of biological organisms and biofilms in the raw water pipeline(s) and pre-treatment system. Periodic disinfection will be provided at the intake tower, screening, and IPS, as well as at the pre-treatment processes located downstream of the IPS. Based on the preliminary design report for the desalination plant dated September 2021, intermittent chlorination will be used upstream of the RO system which is anticipated to result in lower biofouling rates and less chlorine consumption than continuous chlorination.

In the preliminary design, intermittent shock chlorination in the RO feed water pipelines at the RO Plant for 7 hours every 15 days is sought for fouling control. Whereas for the protection of the RO membranes, de-chlorination with sodium bisulphite is also sought. A dedicated gas chlorinator is included in the design for this dosing point along with the sodium bisulphite dosing for de-chlorination. Two chlorine gas carrier water pumps will be used along with one standby pump at two dosing points of the plant feed.

If chlorine gas is selected, all chlorine buildings will have chlorine gas detectors, automatic shutdown system to isolate storage drums, and chlorine gas scrubber(s).

Considering the length of the intake pipelines from the IPS to the SWRO plant (of approx. 3 km) and the fact that that shock chlorination only slows down and does not eliminate the growth of macrofouling, the cleaning of the intake pipelines will require mechanical means (pigging and/or manual cleaning) to ensure operation at the set plant availability. Continuous chlorination may also be employed to reduce the required frequency of mechanical cleaning.

6.2 Intake System Macrofouling Strategy

The intake pipelines from the sea to the onshore (IPS) will have a macrofouling strategy to ensure sufficient seawater supply that subsequently ensures the RO Desalination Plant availability. The intake pipelines from the intake towers to the IPS are anticipated to be relative short at less than 200 m and it should be possible to maintain hydraulic intake capacity in these short length pipelines by the use of diver cleaning or by the use of mechanical pigging without the use of chlorine.

Further, there will be two large diameter (2.7 m) pipelines from the IPS to the RO Desalination Plant, at a distance of approx. 3km. If these pipes can be mechanically pigged, then chlorine dosing should not be needed for intake fouling control. However, if mechanical pigging is not technically feasible, the pipe fouling control strategy will require the intake pipes to be manually cleaned, and the use of shock or continuous chlorination will likely be essential to reduce the frequency of manual pipe cleaning requirements, with the note that shock chlorination only slows down and does not eliminate the growth of macrofouling.

6.3 Residual Chlorine Neutralization

The treatment process will include the addition of sodium bisulphite (SBS) injection point(s) to neutralize any residual chlorine in the pipeline upstream of the SWRO system. At no time should there be any free chlorine in:

- the feed to the SWRO membranes to avoid any irreparable oxidation damage of the membranes; or
- the RO brine stream at the outfall monitoring point.

Ultimately, the macrofouling strategy and the need for feed water chlorination at pre-treatment will be left free to the BOT Developer's detailed design.

However, considering that:

- Residual chlorine itself can be eliminated from the brine at the RO Desalination Plant using de-chlorination chemicals such as Sodium Bisulphite (SBS);
- The use of chlorine generates carcinogenic by-products THMs, which cannot be eliminated from the brine through neutralisation and would end up discharged into the marine environment with the RO brine; and
- The special and very sensitive nature of the marine environment of the AAWDC Project

the use of chlorine for macrofouling control and RO pre-treatment shall be avoided unless there is not other technical alternative.

7. Antiscalant and Acid/Base Chemical Injection

The process may include antiscalant addition upstream of the SWRO system to provide optimum operating conditions and avoid scale deposition on the SWRO membranes. If an antiscalant is required to be used, nitrogen - free antiscalants must be selected for the RO process. The nitrogen-free antiscalants must also be biodegradable for more rapid decomposition in the sea.

If required, sulfuric acid or caustic soda may be used for pH adjustment.

<u>Seawater Reverse Osmosis System</u>

The SWRO system will be designed with a maximum recovery of 47% to produce the required total permeate production while meeting the contractual Desalinated Water quality goals over the specified range of feedwater TDS and temperature.

Based on the preliminary design report for the desalination plant dated September 2021, the following design characteristics are provided for the SWRO system.

RO and ERD Feed Water Transfer Pumps: The RO feed water pumping system of each plant is divided into two pump groups: one dedicated to supplying the High-Pressure Pumps (HPPs) and one for the Energy Recovery Devices (ERDs). This arrangement allows for improved control flexibility and reduced energy consumption overall, as the ERD system requires less suction pressure than the HPP. Both pumping systems are divided into 9 pumps and one standby pump (total of 40 pumps, 20 pumps per plant, 10 pumps per HPP/ERD system). Under normal operation the design capacity is 1,921 m^3/h and 2,199 m^3/h for the HPP and ERD feed pump respectively. Both pump groups are connected to the filtered water tank through a dedicated suction header for each plant.

RO Membrane Skids: The purpose of the RO system is to remove dissolved constituents of concern for potable water consumption, including sodium, chloride, sulphate, bromide, boron, and other constituents with elevated levels in seawater. The AAWDCP RO system is composed of 18 RO skids per plant (total of 36 RO skids), each plant is divided into three trains of six skids. Each individual RO skid has a dedicated HPP and is designed to operate with a maximum recovery rate of 47%. The overall RO system is designed to maintain nominal permeate production with one skid offline for clean-in-place (CIP) or maintenance.

Energy Recovery Devices: Energy recovery using ERDs has become a critical component of modern desalination plant design as RO brine can contain more than half of the energy imparted to the RO feed. ERDs allow for a significant reduction in the size of the HPPs. For the AAWDCP, pressure exchange (PX) type isobaric ERDs have been considered because of their low maintenance requirements and high energy recovery potential (approximately 97%). Because a small amount of energy is lost during the pressure exchange process (RO brine to ERD feed water) and across the RO membranes, a booster pump downstream of the ERD discharge is required. Each RO skid contains a dedicated ERD system consisting of 19 PX units and one booster pump. It is designed to maintain the desired level of performance with one unit offline for maintenance.

RO CIP System: The RO system is maintained periodically by performing chemical cleaning of the RO membranes in-situ. During these CIP events, a tailored chemical solution is prepared depending on the type of fouling observed on the membranes. The primary RO cleaning chemicals anticipated for use in the facility are citric acid for low pH cleaning and sodium hydroxide for high pH cleaning. Other acids or bases may be required for less common cleaning applications. The CIP system of each plant consists of pumps, tanks (with heaters), cartridge filters (to protect RO membranes from material removed from the membrane surface during the cleaning process), and associated instrumentation. Based on the preliminary design report for the desalination plant dated September 2021, the AAWDCP CIP system of each plant is composed of two CIP tanks (one dedicated to low pH cleaning and one to high pH cleaning), one set of common CIP/ Flushing pumps, and two duty cartridge filters. All CIP wastes will be neutralized. Non-organic neutralized CIP waste will be sent to the solids treatment system prior outfall disposal. Should proprietary chemicals, organic chemical, chelating agents be used for CIP, the effluents of the cleaning process will be sent to the on-site evaporation ponds.

RO Permeate Flush System: Permeate flushing is performed every time an RO skid is taken offline or following CIP. Flushing consists of pumping RO permeate through the RO system (RO skids and membranes, HPPs, ERDs) to displace seawater and brine from the equipment to prevent membrane scaling and organic fouling. The AAWDCP flushing system of each plant consists of a dedicated flushing tank and pump set shared with the CIP resources.

CIP Waste Neutralization: Spent CIP cleaning solution contains chemicals that must be neutralized prior to this waste stream being sent to the on-site solids treatment system or to the on-site evaporation ponds. The CIP neutralization system of each plant will consist of a neutralization tank, neutralization pumps, associated instrumentation, and chemical dosing system. Details of the chemical dosing system are presented below in **Chemical Storage and Feed Systems** section and are based on typical CIP chemical make-up solutions as described in RO CIP System.

Post-treatment System

RO permeate has low concentrations of hardness and alkalinity and must be remineralized (i.e., stabilized) to prevent corrosion within the potable water distribution network.

The post treatment system will be designed to comply with the project Desalinated Water quality requirements, including the latest version of the Jordan Drinking Water Quality Standards and specific treated water quality requirements set by MWI. In addition, post treatment will be designed to protect the downstream conveyance system components from corrosion.

To meet the Desalinated Water Quality Requirements, the dosing of the following chemicals will be included in the design:

- Carbon dioxide;
- Calcite or calcium hydroxide;
- Sodium hydroxide (optional); and
- Chlorine gas or sodium hypochlorite.

1. Carbon Dioxide

The treatment process will use carbon dioxide to increase the carbonate species in the treated water, allowing for a more stable alkalinity in the desalinated water.

Based on the preliminary design report for the desalination plant dated September 2021, one carbon dioxide dosing system was provided per RO process line.

2. Calcite Filters

If calcite filters are selected as part of its remineralization process for RO permeate, the filters will be constructed in concrete, coated steel, or FRP. Provision for the periodic removal of insoluble materials contained in the commercial calcite will be considered. Backwash operations, including air and water, will be done automatically by actuated valves, pumps, and blowers. For the backwash of the contactors, desalinated water will be used.

Based on the preliminary design report for the desalination plant dated September 2021, the following design characteristics are provided for the Calcite Filters.

Calcite Contactors and Remineralized Water Tank: Calcite contactors are filled with calcite in the form of granules. RO permeate flows through these contactors, which will be designed to provide sufficient detention time for dissolution of calcium carbonate yielding the desired end products of hardness and alkalinity that determine the stability of the water. Over time, calcite is consumed in this treatment process and the granules must be replenished.

For the AAWDC Project, one calcite contactors system will be provided for each plant. Each system will be divided into three separated process lines – one associated with each RO process line. Each process line will containsnine (9) individual contactors which were designed to maintain the desired maximum surface loading rate and minimum empty bed contact time (EBCT) with one contactor offline for backwashing or maintenance.

Backwashing will be done every six (6) months to flush impurities present with the dry calcite from the contactors after loading in order to prevent them from passing into the treated water and affecting the aesthetic quality of the finished product but it may be done more often depending on calcite quality. For this reason, a dedicated backwash system including both pumps and low-pressure blowers was included in the design for each plant. Backwash waste may be directed to the solids treatment system or be sent to a separate buffering tank for solids settlement. The high solids content stream from the bottom of the buffering tank will be sent to the solids treatment system and not to the brine chamber for direct outfall disposal.

Remineralized water flows under gravity to the corresponding remineralized water tank of each plant having a net volume of 2,400 m^3. This provides flow equalization to the permeate booster pumps used to convey water up to the treated water reservoir.

Details on chemical storage and feed systems are described below in **Chemical Storage and Feed Systems** section.

3. Calcium Hydroxide System

If a calcium hydroxide (lime) system is selected for the remineralization of permeate water, the system will include silos, lime dilution tanks, and lime saturators. Saturators will be fed with milk of lime produced in tanks with vertical agitators. Saturators will produce a stable concentration of low turbidity lime solution for injection into the main process stream. Lime sludge from the saturators will ultimately be removed and transported for offsite disposal. It is noted that lime saturator waste will be first neutralised for pH before being discharged to the on-site solids treatment system.

- **Caustic Soda (Sodium Hydroxide)**

The treatment process may include in its design provisions for final pH trim adjustment using sodium hydroxide.

- **Disinfection**

The disinfection system is intended to meet potable water quality standards, as set out in the Jordanian Drinking Water standards, and to safeguard the transmission pipe against biological growth. Disinfection of the desalinated water can be achieved using liquid sodium hypochlorite or gaseous chlorine. Chlorination will take place upstream of the desalinated water reservoir. A secondary chlorination point will be provided downstream of the desalinated water reservoir, to adjust the chlorine residual prior to leaving the Desalination Plant site.

Based on the preliminary design report for the desalination plant dated September 2021, the following design characteristics are provided for the Disinfection and Pumping system.

Permeate Disinfection and Pumping

Permeate Booster Pumps to Treated Water Reservoir: The treated water reservoir is located approximately 35 m above the remineralized water tank; therefore, a permeate booster pump system has been designed to convey the water up to this location.

The permeate booster water pumping system of each plant is divided into 9 pumps and one standby pump (total of 20 pumps, 10 pumps per plant). Under normal operation the design capacity is 1,903 m^3/h. Both pump groups are connected to the corresponding remineralized water tank through a dedicated suction header.

Disinfection: Chlorine will be dosed in the treated water for initial disinfection and to maintain a minimum of 1 to 1.5 mg/L of chlorine residual in the distribution system. Chlorine will be added downstream of the permeate transfer pumps of each plant and upstream of the treated water reservoirs. A dedicated gas chlorinator will be included in the design for these dosing points. A common chlorine storage building and chlorinator room for both plants will contain the chlorine dosing equipment for post-treatment and shock chlorination applications. It is divided into two areas:

- One-ton chlorine cylinder storage room with monorail system to allow for lifting and transportation of the chlorine cylinders.
- Chlorine feed room for the chlorinators (this feed room will share a wall with the storage building but remain separated for health and safety purposes).

A one-ton chlorine air scrubber will be provided outside the chemical building in case of an emergency cylinder leakage.

Details on chlorine storage and feed systems are presented below in **Chemical Storage and Feed Systems** section.

Brine Disposal to Brine Reservoir

Based on the preliminary design report for the desalination plant dated September 2021, the following design characteristics are provided for the brine disposal system.

Brine from the RO system from each plant flows to the brine backwash tank. The brine backwash tank overflows to the outfall collection chamber. All the other process waste discharges after the solids treatment system will be directed to the outfall collection chamber for disposal via the marine outfall. The GMF backwash pumps draw water directly from the brine backwash tank.

The outfall collection chamber receives the following plant streams:

- RO brine overflow from the brine backwash tank
- Solids Treatment Plant effluent
- GMF filter-to-waste
- Equipment drain downs
- Instrument sample wastes
- Tanks overflows

Solids Treatment System

Thickened solids from the clarification process (if used), pre-treatment backwash wastewater (generated either from GMF or from UF), waste streams produced by the selected post-treatment technology (e.g., calcite contactor backwash wastewater or neutralized lime saturator waste) and neutralized non-organic CIP wastes will be sent to an on-site solids treatment system. It is noted that post-treatment backwash effluents could be sent to a separate buffering tank for solids settlement instead of being sent to the solids treatment system provided that the high solids content stream from the bottom of the buffering tank will be sent to the solids treatment system and not directly to the brine chamber for outfall disposal.

The solids treatment system will include, at a minimum, the following treatment components: flow balancing and storage, solids thickening, and mechanical dewatering.

Supernatant from the thickening process, as well as liquid waste (centrate, pressate, etc.) from the mechanical dewatering process, will be sent to a mixing chamber to be blended with other discharge effluents prior being discharged to the brine outfall.

Thickened sludge will be stored and conveyed at a controlled and constant rate to the sludge dewatering system. Polymer may be dosed to aid the thickening and dewatering processes.

Dewatered solids will be disposed to an authorized landfill or other location permitted by the regulators (MoEnv, ASEZA).

Domestic Wastewater Treatment System

Raw Wastewater Characteristics

The wastewater plant will be sized to treat the expected wastewater flows 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 flowrate to be treated.

The expected incoming domestic wastewater quality characteristics are provided in Table 2-4.

Table 2-4: Wastewater quality characteristics

Parameters	Unit	Value
BOD5	mg/L	130-400
Total Suspended Solids	mg/L	130-400
Total Phosphorus	mg/L P	4-11
Total Kjeldahl Nitrogen	mg/L N-TKN	20-70

Note: Metcalf&Eddy 2014

Treated Wastewater Characteristics

The BOT Developers will be left free to select using the treated wastewater for irrigation within the Desalination Plant site if all Jordanian regulations for irrigation water quality are fully complied. Under this alternative, the treated wastewater shall comply with the limit values established in the Standard JS893/2021 - Water – Reclaimed domestic wastewater for Class A (for cooked vegetables, parks, playgrounds, and roadsides within city limits). The main requirement in terms of treated wastewater (reclaimed) characteristics are summarized in the following table.

Table 2-5: Treated wastewater quality characteristics

Parameters	Unit	Value JS893/2006	Value JS893/2021
BOD5	mg/L	30	30
Total Suspended Solids	mg/L	50	50
Total Nitrogen - TN	mg/L N	45	70
Total Phosphate	mg/L P-PO4	30	10

The BOT Developers will be also free to select a submerged disposal system as long as it meets the requirements set out by ASEZA. In such a case, treated wastewater quality, before mixing with any other waste streams for outfall disposal, shall comply with the following limits:

- Ammonia: 95 percentile value ≤ 2 mg/L
- BOD: 95 percentile value ≤ 25 mg/L
- COD: 95 percentile value ≤ 125 mg/L
- Total P: Average value ≤ 2 mg/L
- Total Nitrogen: Average value ≤ 15 mg/L as N
- Turbidity: Maximum value ≤ 30 NTU

Wastewater Treatment Plant Description

Based on the preliminary design, aconventional packaged activated sludge WWTP will be provided including the following process treatment steps:

- Pretreatment;
- Aeration;
- Sedimentation;
- Disinfection.

The description of the different process treatment steps is presented below.

Pretreatment

The pretreatment step involves the settlement of a portion of the suspended solids and the reduction of the suspended organic matter load.

Aeration

The aeration step allows for the degradation of organic matter and nutrients present in the wastewater using biomass. Excess biomass (sludge) will be digested aerobically in the aeration reactor itself obtaining stabilized sludge.

The aeration treatment step will include the following equipment:

- Aeration system, which supplies air through fine bubble diffusers from air blowers, oxygenating the biomass for oxidation of the organic matter;
- Recirculation system, which allows the recirculation of the secondary settled sludge from the secondary clarifier to the aeration reactor.
- Sludge wasting system, which allows to extract the excess biomass from the aeration reactor or from the secondary clarifier.

Nutrient Removal

If the BOT Developers select to treat the wastewater and send the treated wastewater effluent to the RO Plant brine outfall for final disposal, a nutrient removal process shall be designed and installed in order to meet the ESIA nitrogen and phosphorus limits.

Secondary clarifier

The clarification step consists of the flocculation and sedimentation of the biomass from the aeration reactor. The clarified supernatant from the secondary clarifier will be gravitationally conveyed to the disinfection basin.

Disinfection

The disinfection step consists of a process of chlorination of the effluent in a chlorine contactor tank in order to inhibit the growth of microbial activity.

Ancillary Facilities

The WWTP treated effluent will be stored in a treated wastewater tank with sufficient capacity to contain the water for approximately 2 days of treatment.

In addition, the treatment plant will operate in fully automatic mode. The BOT Developer will provide and operate a SCADA monitoring system developed by an experienced operator for controlling each treatment process step status and treated effluent quality.

Sludge Storage

Excess biomass (sludge) will be thickened and stored in a separate tank for final disposal.

The maximum stabilized thickened sludge production will be around 2 - 3 m^3/month, which will be stored in a separate tank for final disposal. The sludge quality shall comply with JS1145:2016.

Sludge Disposal

The final thickened stabilized sludge will be disposed in an authorized disposal site approved by the competent national authority (ASEZA). However, the specific disposal site has not been defined, it should be a wastewater treatment plant for the final dewatering and conditioning and final disposition in a landfill or authorized site.

Plant Effluent Management

The mixture of the brine, solids treatment system effluent, and other waste streams to the Aqaba Gulf shall comply with all regulatory requirements, including the requirements listed in this ESIA study and its associated ESMP. The discharge water streams will include the following:

- SWRO concentrate and permeate used for flushing the SWRO;
- Liquid effluents recovered from the on-site solids treatment process;
- Equalized post-treatment backwash provided that the high solids content from the bottom of the buffering tank is sent to the on-site solids treatment system;
- Lime saturator waste shall be first neutralised and then sent to the on-site solids treatment system; and
- Neutralized cleaning solutions for UF (if used) and SWRO as follows:
  - Effluents from non-organic chemical cleaning (CEB or CIP) of SWRO and MF/UF membranes shall be neutralized before being sent to the on-site solids treatment system, and
  - Any waste from organic, surfactant (SLS), chelating agents, EDTA, biocides or proprietary chemicals shall be disposed of via onsite evaporation ponds.

Chemical Storage and Feed Systems

A detailed description of all chemicals to be used during the treatment process is summarized in Table 2-6 below including chemical function and storage specifications for 30 days storage capacity based on the preliminary design report for the desalination plant dated September 2021.

According to the preliminary design, a common Chemical Storage facility will be provided for both process lines. Chlorine gas and CO_2 will be delivered and stored on-site as compressed gases or in a liquid state. Each of these will be diluted with a dedicated carrier water stream prior to dosing. Sodium metabisulfite and citric acid will be delivered and stored on-site as dry chemicals. They will be batched on demand with water to create dilute chemical dosing solutions in make-up tanks and dosed using chemical dosing pumps. All other chemicals will be delivered as liquid solutions and dosed with chemical dosing pumps. Dosing locations are mainly at GMF feed, RO feed, RO CIP, CIP's effluent neutralization and post treatment.

Table 2-6: Function and Storage of Used Chemicals

Chemical	Form	Function	Storage tank specifications
Sulfuric Acid	Liquid	Dosed upstream of the GMF to adjust pH to enhance coagulant performance if needed. Neutralize CIP waste solutions. May be used periodically for RO and UF CIP solution preparation.	N:2 Volume/tank: 37 m^3 Material: carbon steel
Antiscalant	Liquid	Dosed upstream of the RO HPPs and ERD systems to prevent sparingly soluble salts from precipitating out in the brine and prevent mineral scaling	N:2 Volume/tank: 30 m^3 Material: FRP
Sodium Hydroxide	Liquid	Dosed downstream of the calcite contactors for final pH adjustment of remineralized water Used periodically for the RO and UF CIP solution preparation and neutralization of spent CIP solutions	N:4 Volume/tank: 81 m^3 Material: FRP
Carbon Dioxide	Compressed gas	Post-treatment stabilization	N:8 Capacity/tank: 106,000 kg
Citric Acid	Solid	Prepare the RO and UF CIP acid-cleaning solution	N (batch tank): 1 Batch tank volume: 12 m^3

Chemical	Form	Function	Storage tank specifications
Sodium Bisulfite	Solid	Neutralize free chlorine present in the RO feed water whenever shock chlorination of the feed water is performed	N (batch tank): 2 Batch tank volume: 5 m^3
Ferric Chloride	Liquid	Used as a coagulant for the feed water ahead of the GMF	N:6 Volume/tank: 96 m^3 Material: FRP
Chlorine gas	Compressed gas	Used at the desalination plant upstream of the RO unit to control biofouling Post-treatment dosing. May be used periodically for UF CIP solution preparation or for chemically enhanced backwashing.	N (cylinder): 62 Cylinder capacity: 1,000kg
Polymer	Liquid	Use to improve solids settleability for the sludge treatment plant process	N (IBC): 15 IBC Capacity: 1,000 m^3

Facility Safety Measures

The SWRO desalination plant will be designed to comply with the Occupational Safety and Health Administration (OSHA) standards and requirements. In outline, the following safety measures will be considered for the different RO process elements:

- Chemical Dosing Lines: Above grade access at regular intervals; double contained piping
- Chemical Dosing Points: Adjacent safety showers located near all chemical dosing points
- Major Valves: Major valves to be generally less than 1,200 mm above finished floor to limit the use of ladders to maintain equipment
- RO Building: Pipe installation to consider access around medium voltage motors and HPP equipment
- RO racks: The racks will include on their front and rear, protection barriers for any pressure vessels below a height of 2.5 m to reduce the risk to plant operators in the event of an end cap failure.
- Chemical storage area: Secondary containment provided for all chemical storage tanks, incompatible chemicals to be properly segregated, and safety showers/eyewash stations located at required intervals throughout the area
- Electrical room: Appropriate separation of all medium voltage equipment to be provided

In addition, ladders will be discouraged where stairs can be provided. Underground pits and vaults for water metering will be discouraged because of safety concerns relative to confined spaces.

2.2.1.2.4. BPS 1 and Aqaba Reservoir 2

At the SWRO Desalination plant site will be Aqaba Reservoir 2 (as shown in Figure 2-12), designed for 9,000 m^3 and planned within the site boundaries of the plant to supply Aqaba Governorate.

Figure 2-12: Aqaba reservoir 2 at SWRO plant site

2.2.1.2.5. General Layout of SWRO Desalination Plant

Based on the preliminary design, the RO desalination plant and its complementary infrastructure will be constructed on multiple graded areas (i.e., platforms). This platform configuration has been defined to optimize the available space for the desalination plant and its complementary infrastructure, due to the topographic complexity, existing wadis, and existing infrastructure of the available site.

More specifically, based on the preliminary design report for the desalination plant dated September 2021, the desalination plant will be constructed on Platform 2, which is the largest of three platforms and is bounded by a highway on its western boundary. The treated water reservoir and the treated water pump station (BPS1) will be constructed on Platform 1, which is the smallest of the three platforms and is bounded by a highway on its eastern boundary. The evaporation ponds and electrical substation will be constructed on Platform 3, which is on the south side of Platform 1 on the other side of Wadi 4 and is bounded by a highway on its south boundary There is a 38 m elevation difference between Platforms 1 and 2: Platform 2 is located at an elevation of +75 - +80 m.a.s.l. , Platform 1 is located at an elevation of +115 m.a.s.l. and Platform 3 is located at an elevation of +70 m.a.s.l. **Annex 7** presents the general layout of the RO desalination plant and its related facilities, based on the preliminary design report.

The BOT Developer will be free to optimise the arrangement of the RO Desalination Plant process facilities within the available land plot by considering the associated physical and geotechnical constraints.

2.2.2. Water Conveyance Component

The alignment of the conveyance pipeline was selected based on the alignment provided by MWI, minimizing the total length of the pipeline, resulting in minimal disruption to agricultural areas and providing accessibility for construction and maintenance. The water conveyance comprises the following technical components:

- Conveyance pipeline form SWRO plant/BPS1/ to Wadi Al Yutum Customs Department conveyance system including regulating tank RGT1 and intermediate pump stations BPS2/Aqaba Reservoir 1, BPS3 and BPS4;
- Regulating tank RGT2 located in the Mudawwara west well field;
- RGT2 to Mudawwara conveyance system including pump station at Mudawwara BPS5;
- Mudawwara to Hasa - Giza – airport road conveyance system including associated regulating tank RGT3 and break pressure tank (BPT);
- Airport road to Amman - Abu Alanda (AA) conveyance system including pump station PS ADC and delivery to existing Abu Alanda reservoir and existing Al Muntazah Reservoir.

Based on the Concept Design and Technical Feasibility Report dated October 2018, and several discussions on the conveyance system in addition to the latest correspondence with MWI and CDM smith dated January 04, 2021, each of the above-mentioned technical components is detailed below.

2.2.2.1. BPS2/Aqaba Res 1 and BPS3 and RGT1

Freshwater will be pumped from the RO Plant Site/BPS1 to the first regulating tank RGT1. Two intermediate pumping stations are required between the RO plant/BPS1 and the first regulating tank (RGT1). The total static head between these two locations is around 700m. The locations of BPS2 and BPS3 were selected based on available sites close to the road and to allow pumping at equivalent head at the three pumping stations (BPS2 and BPS3) (Figure 2-13 and Figure 2-14 refer). Within the site of BPS2, Aqaba Reservoir 1 will be constructed (Figure 2-13). With a capacity of 6,000 m^3 storage, the reservoir will supply fresh water to Aqaba Governorate.

Figure 2-13: Booster Pump Station 2

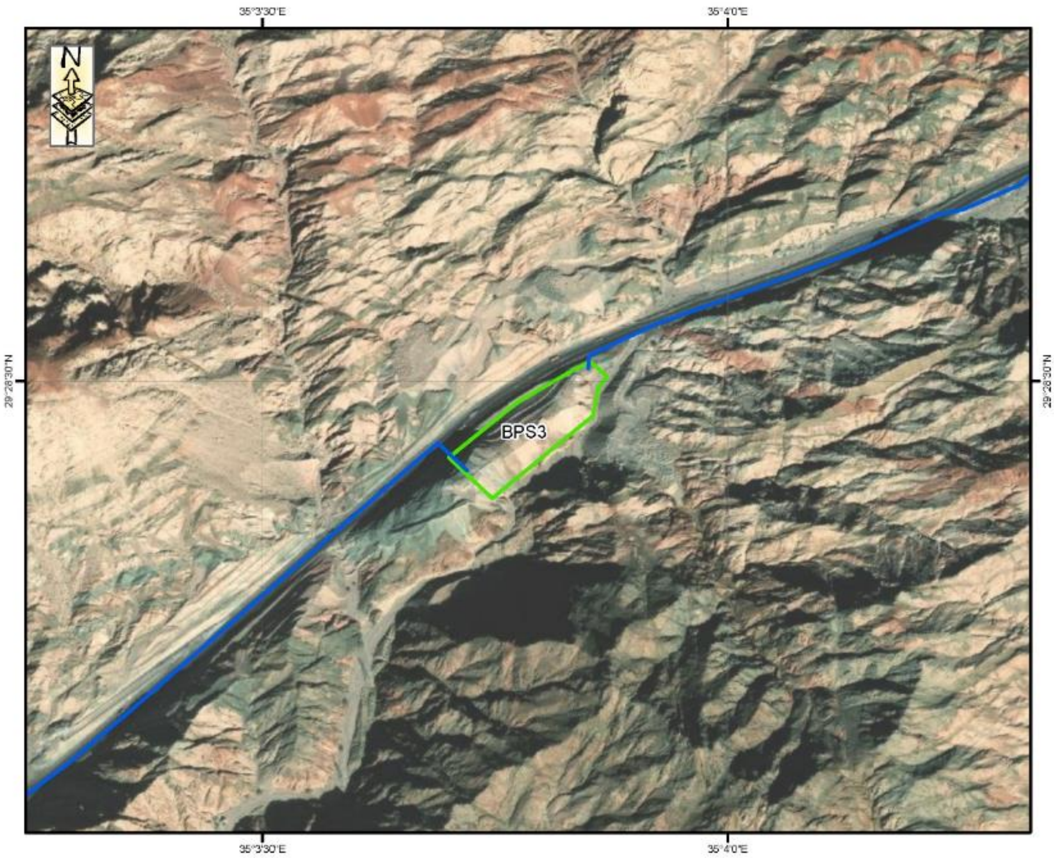

Figure 2-14: Booster Pump Station 3

The location of RGT1 was selected at the highest elevation between the RO and Wadi Al Yutum Customs Department where the pipeline will pass to allow flow under gravity head downstream (Figure 2-15). The location was confirmed by topographic surveys. The elevation of RGT1 is at +800 m, which allows a flow under gravity head over a distance of around 30km where an additional booster pump station (BPS4) is proposed to convey the water to the RGT2 (72 km from RGT1). BPS4 will be located at an approximate elevation of +750 m (Figure 2-16).

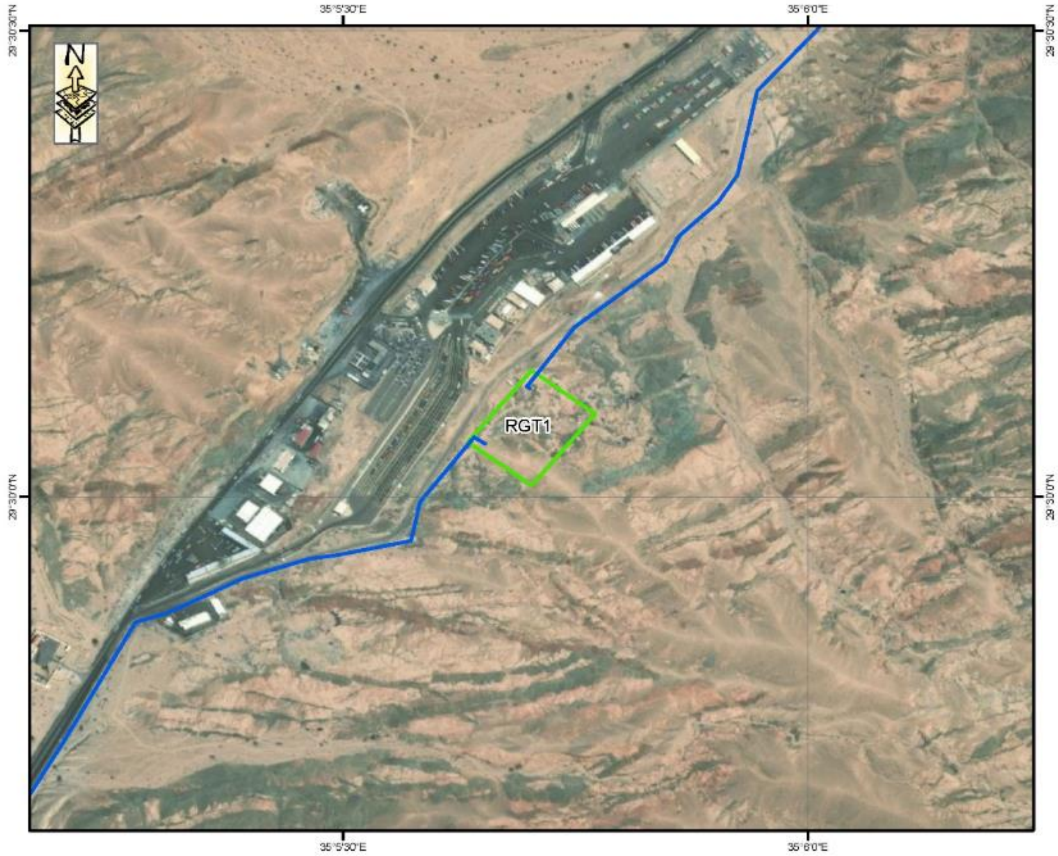

Figure 2-15: Regulating Tank 1

The conveyor will follow the alignment of Aqaba backroad from BPS1 to BPS4 (Figure 2-16) before branching to the East towards RGT2. Coordination with Ministry of Public Works and Housing (MPWH) regarding this alignment is necessary to accommodate any of their requirements regarding road widening and pipeline construction adjacent to the road.

Figure 2-16: Booster Pump Station 4

2.2.2.2. RGT2

Freshwater from the RO plant will be pumped from BPS4 location to the Mudawwara wellfield area where a collection/regulating tank is proposed for the complete transmission system from the SWRO desalination plant. RGT2 will be located at the west well field area (Figure 2-17). The required elevation is around +920 m. The proposed location was found to be hydraulically suitable; however, the topography of the plot is extremely difficult and was inaccessible for soil investigation purposes. This location will require coordination with the concerned authorities.

Figure 2-17: Regulating Tank 2

The use of the existing Aqaba collection tank as a replacement of RGT2 was studied but reportedly found not suitable for the AAWDC configuration due to the following:

- The existing tank and collection piping were operated for more than 20 years and may not be in good condition to serve AAWDC.
- Existing tank elevation does not allow flow by gravity head to Mudawwara and hence additional pumping will be required.
- The tank capacity (5,000 m^3) is not sufficient for the proper operation of the system, as it is not sized to receive inflows from the RO. As an example, the required size of similar regulating tanks in Disi conveying only 100 MCM/year is above 15,000 m^3.

2.2.2.3. MUS2 & BPS5

The elevation of RGT2 allows the flow under gravity head to reach Mudawwara area. This site will include the booster pump station BPS5 as well (Figure 2-18). The conveyor between RGT2 and MUS2/BSP5 will follow the alignment of existing roads and partially in the last stretch follow the Disi alignment.

Figure 2-18: Mudawwara Site 2 and Booster Pump Station 5

2.2.2.4. RGT3 and BPT

This part of the system follows the same alignment and concept as the existing Disi - Amman conveyance system. The length of this section is around 268 km; 140 km off-road till Hasa and 128 km along the Aqaba-Amman highway until the junction of the Airport Road with Amman Ring Road. Available corridors along the highway will need to be coordinated with the MPWH.

Similar to the Disi system, water will be pumped from BPS5 to the RGT3 located at the highest elevation between the Mudawwara site and Amman at elevation +1,085 m (Figure 2-19).

Figure 2-19: Regulating Tank 3

Water will flow under gravity head over around 245 km with an intermediate BPT 95 km downstream of RGT3. The BPT for AAWDC will be adjacent to the tank provided for the Disi system at elevation +970 m. This tank will allow reducing the pressure rating of the piping to Amman (Figure 2-20).

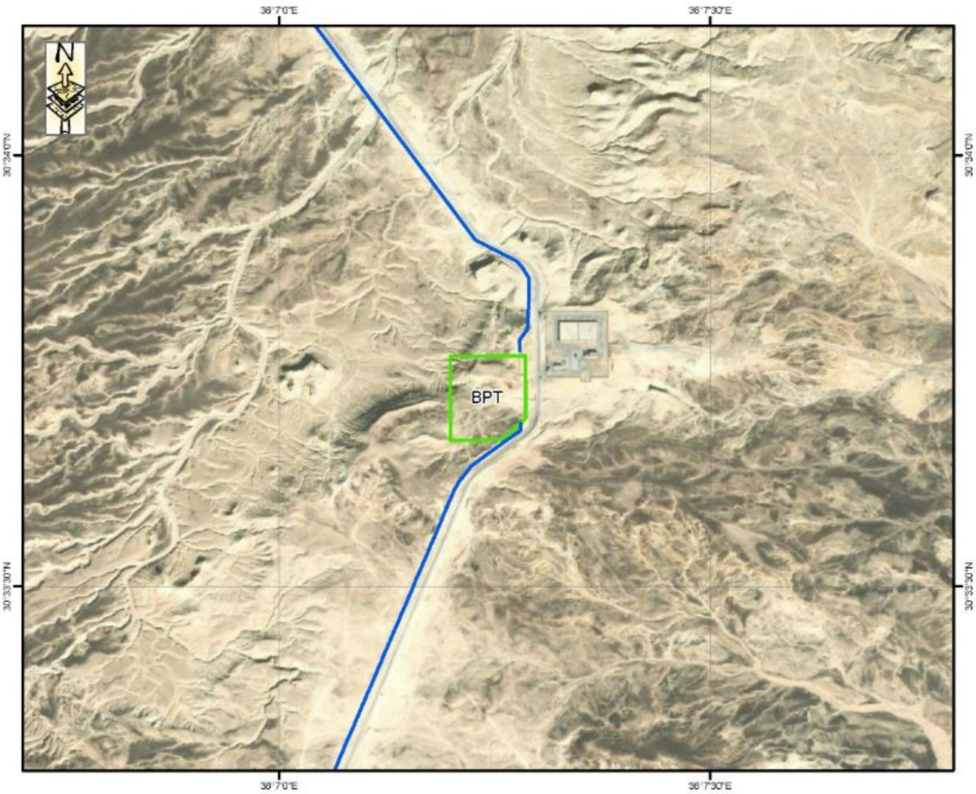

Figure 2-20: Break Pressure Tank

2.2.2.5. PS ADC, Existing Abu Alanda Reservoir (AA RES) and Al Muntazah Existing Reservoir

The elevation of RGT3 will allow flow under gravity head to the connection to Abu Alanda - at the junction of the airport road with Amman Ring Road. The elevation in the area is around +770 m. A pump station PS ADC will lift water from this location to Abu Alanda Reservoir 2. The site will house pump station PS ADC and associated upstream tank (Figure 2-21).

Figure 2-21: Pumping station - ADC

AAWDC project will deliver water to Amman - Abu Alanda area. An existing reservoir 100,000 m^3 capacity was built under the Disi conveyance project and is currently operated by Miyahuna. This reservoir receives inflows from several sources and distributes water to Amman (Figure 2-22).

The conveyance system between PS ADC and Abu Alanda follows the alignment of existing roads, avoids some highly congested areas and some major interchanges.

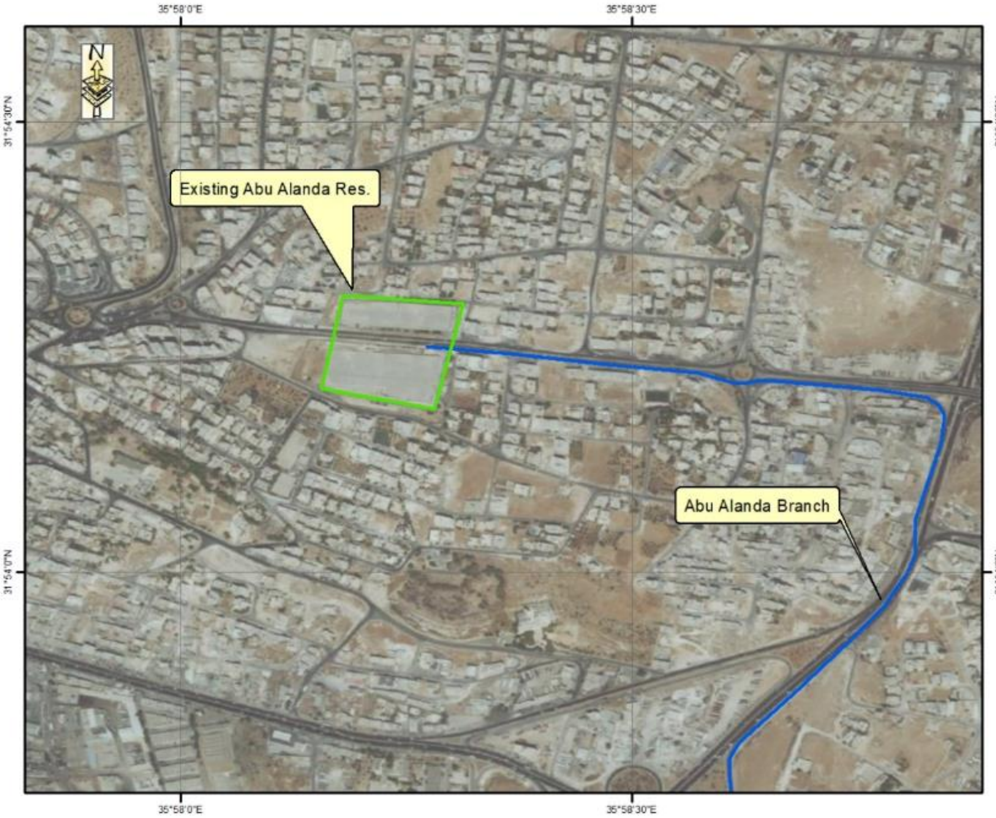

Figure 2-22: Existing Abu Alanda Reservoir

In addition to lifting the water supply to Abu Alanda Reservoir, the PS ADC will also feed Al-Muntazah preliminary pipeline, which conveys the flow to Al-Muntazah Reservoir (Figure 2-23).

Figure 2-23: PS ADC to existing Al Muntazah Reservoir

2.2.2.6. Schematic Profile of the AAWDC Project components

Figure 2-24 represents the schematic profile of the conveyance including all Project technical components.

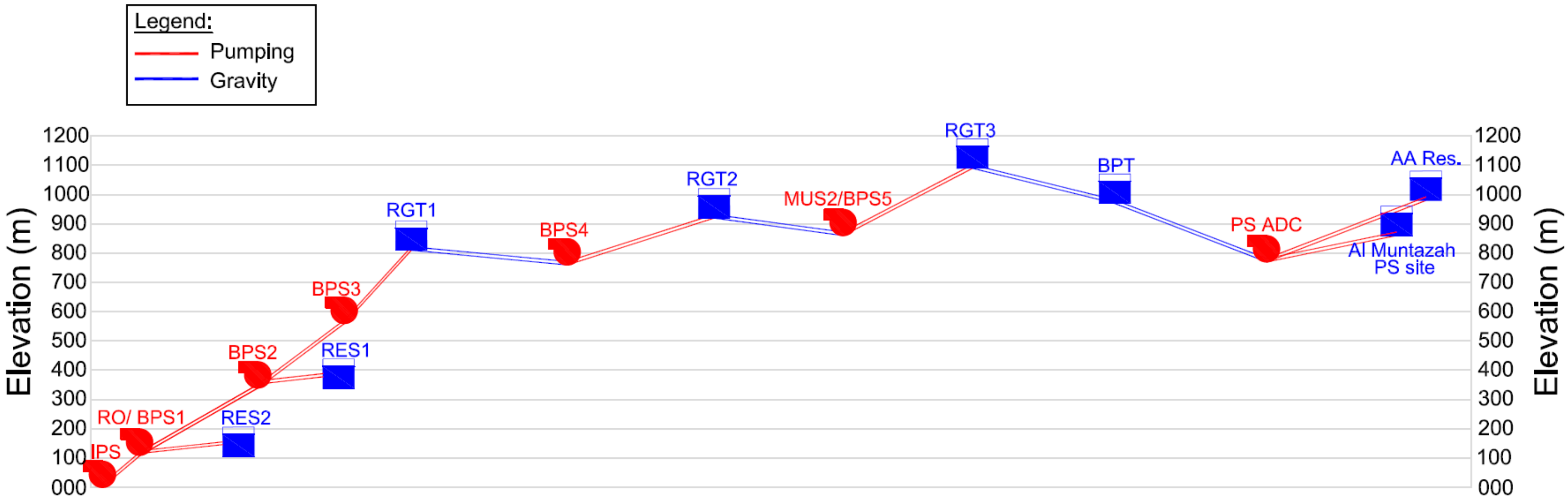

Figure 2-24: Schematic Profile of the AAWDC Project components

2.2.2.7. Capacity and Flow

In order to meet MWI target and provide the required flexibility in the system, the conveyance system from the SWRO desalination plant to Abu Alanda is designed for a capacity at the ultimate development capacity of 300 MCM/year for 97% of availabitliy.

It is important to note that during a stakeholders' coordination meeting held on 25th October 2020, the ESIA Team were informed of an agreement between MWI and Aqaba Water Company (AW) to provide Aqaba (South Coast) with 7.7 MCM per year (21,096 m^3/d) of the desalinated water being produced by the SWRO Plant.

The ESIA Team understand that 250MCM of fresh water per year will be conveyed from the SWRO plant through the conveyance pipeline to Amman and other governorates. On the other hand, the destination of the remaining 50 MCM of fresh water per year is still to be decided and 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. 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, 500 mm diameter, pipeline (Line B) will be constructed to serve "Zone-2" of the Aqaba distribution zone.

The ESIA Team also understood during the meeting that diversion of flows to Ma'an, Tafileh, Karak and Madaba Governorates were being considered. However, since these concepts have not yet been sufficiently developed to enable incorporating them in the analysis, and given the relative small impact on the overall project, the ESIA team is not looking at the impacts of these changes to the project and quantities to governorates along the conveyor which will be determined by operators on demand basis.

2.2.2.8. Conveyance Piping Description

2.2.2.8.1. Material

Based on the Project design team's (CDM Smith) Technical Memorandum-Technical Assessment of Pipe Materials report dated September 3, 2020, several pipe material options were presented for the conveyance pipelines including steel pipes, ductile iron (DI) pipes, glass fibre reinforced plastic (GRP) pipes, prestressed concrete cylinder pipes and high density polyethylene pipes. The pipe material has not been selected at this stage as the final selection will be left to the BOT Developers and is covered in the analysis of alternatives as mentioned in Section 4.4.2.

Nevertheless, for the purpose of progressing with the Concept Design, the Project design team have selected certain materials in their Technical Memorandum. In this report, both GRP pipes and steel pipes were selected for the primary freshwater conveyance system and DI and steel pipes were selected for the secondary conveyance system from PS ADC to Abu Alanda and Al Muntazah. The Project design team therefore developed the Concept Design for the freshwater conveyance system using both a full steel option and a hybrid steel/GRP option. For either the full steel or the hybrid systems, the pipeline material to be used for the marine intake pipeline will be HDPE whereas the marine brine pipeline may be HDPE or GRP. However, the final selection of the pipe material will be left to the BOT Developers.

2.2.2.8.2. Pipe Sizing

The conveyance system from the RO to Abu Alanda was designed for a capacity at ultimate development of 250 MCM/year. The system design flow accounts for an additional 5% capacity.

Based on the Technical Memorandum-Technical Assessment of Pipe Materials report dated September 3, 2020, Table 2-7 represents the conveyance pipe sizes and intermediate lengths for different reaches of the Project.

Table 2-7: Pipe Sizing

Reach	Diameter (mm)	Length (km)
Submarine intake pipes	3 No 2400-2600	2.4
IPS – RO	2 No 2200-2500	6

Reach	Diameter (mm)	Length (km)
RO – IPS	1 No 2200-2500	3.8 (includes sea outfall)
RO - BPS1 - RGT1	1 No 2000-2200	14.5
RGT1 - BPS 4	1 No 2000-2200	29.5
BPS 4 - RGT 2 - BPS 5	1 No 2000-2200	85
BPS 5 - RGT 3	1 No 2000-2200	21
RGT 4- BPT – PSADC	1 No 2000-2200	256
PSADC - Abu Alanda Reservoir	1 No 1800-2000	16
PSADC – Muntazah Reservoir	1 No 1200-1400	16
BPS 2 - Aqaba Reservoir 1	1 No 500	6
RO – Aqaba Reservoir 2	1 No 500	2

2.2.3. Power Demand

The estimate of power demand of the AAWDC Project facilities is summarized in the Table 2-8 and Table 2-9 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 2-8: Power Demand Estimates at AAWDC Facilities (Except for SWRO Plant)

AAWDC Facilities	Assumed Provider	Total Connected Load		Total Demand Load		Estimated Energy Consumption
		MW	MVA[1]	MW	MVA[1]	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 2-9: 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.**				

2.2.4. Schedule of Works

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

Milestone	Tagreted 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

3.1. Authorities and Institutions

3.1.1. Water Sector Management and Planning

The main institution that takes responsibility for water administration in Jordan is the Ministry of Water and Irrigation (MWI) and it is the AAWDC Project Promoter.

The **Ministry of Water and Irrigation (MWI)** is responsible for the overall national leadership on policy, strategic direction and planning. Under Bylaw No. 14 of 2014, MWI assumes full responsibility for water and public sewage and all related projects in the Kingdom. MWI aims to upgrade, develop and regulate the water sector and enhance the quality of water services. MWI's mandate is mainly to: develop sectorial policies and strategies; endorse plans and programs related to water resources protection; implement international agreements; develop laws, bylaws, regulations and normative and technical standards; develop private sector partnerships; supervise the implementation of strategic plans and programs; and follow up on the performance of the water companies and utilities.

Under the umbrella of MWI, the **Water Authority of Jordan (WAJ)** is responsible for the operational management of the water sector, which includes bulk water supply and retail distribution where commercialization of distribution services has not occurred. WAJ is mandated for all operational functions of the water sector including management of water and wastewater services; regulation of construction and quality of service provision projects, operations and maintenance; monitoring of all levels of sector services; and supervision of the water utilities and water companies. WAJ recommends water service cost changes and capital projects, but the Government of Jordan through the Council of Ministers (Cabinet) has the ultimate regulatory authority, especially for setting tariffs.

Miyahuna is a government-owned (WAJ) utility company that operates through commercial entities to provide retail distribution and other functions such as water and wastewater treatment in Greater Amman as well as Balqa, Zarqa and Madaba with several hundred thousand of customers. Miyahuna ensures that operations follow Jordanian regulatory requirements.

3.1.2. Government Departments and Institutions

The **Ministry of Environment (MoEnv)** has a mission to maintain and improve the quality of Jordan's environment, conserve natural resources and contribute to sustainable development through effective policies, legislations strategies, monitoring and by mainstreaming environmental concepts into all national development plans. The MoEnv includes many technical divisions among which are the land use, environmental impact assessment, water quality and air quality monitoring divisions. The environmental monitoring department of the MoEnv is responsible for water resources quality monitoring. Water quality analysis is subcontracted to the Environment Monitoring and Research Central Unit (EMARCU) of the Royal Scientific Society (RSS). The responsibility of EMARCU is to collect and make available water quality data from a Real-Time Monitoring System (RTMS) and from national water testing Laboratories located at WAJ, JVA, and the Environmental Research Centre (ERC). The MoEnv has implemented a monitoring program to monitor and assess the quality of water in different water resources in the Kingdom and in cooperation with the RSS through "The National Project for Monitoring Water Quality in Jordan". The project monitors the quality of water at different locations across the Kingdom.

The **Ministry of Local Administration (MoLA)** contributes to the achievement of local governance that enhances the independence of municipalities and enables them to carry out their duties within the concepts of integrity and good governance. MoLA supports, guides, and assists the municipalities and other local governance institutions through providing technical support, programs and projects that enhance local governance.

The **Aqaba Special Economic Zone Authority (ASEZA)** is a separate governance entity, sitting within the Aqaba Governorate. It was established in 2001 over a 375 km^2 (37,500 hectares) area around the port city of

Aqaba. The zone includes Jordan's entire marine coastline of 27km. Its purpose is to attract and facilitate investment in Aqaba in the areas of industry, port development, tourism, infrastructure, utilities and services.

ASEZA has the authority of a municipality, as well as being the regulator for permitting investments including environmental permitting. Economic entities wishing to operate in the Zone register with ASEZA. The Zone offers a low tax environment to stimulate economic activity, attract investments, promote exports and deliver social, economic and environmental benefits to the people of the region and the country. ASEZA has sole jurisdiction over environmental regulation within Aqaba Special Economic Zone including the entire coastline.

Aqaba Development Corporation (ADC): In 2004, ASEZA and the Jordanian Government launched the Aqaba Development Corporation (ADC) as the development agency for the Aqaba Special Economic Zone. ADC is a Government and ASEZA owned company which was given ownership of all Government held assets in the Zone (including the ports and the airport), and mandated to develop the Zone, through infrastructure development, and business enablers, and through managing the key assets. One of ADC's main roles is the attraction of private sector developers and operators in the Zone. ADC also has the responsibility of implementing the ASEZA Master Plan.

Jordan Maritime Authority (JMA) regulates, controls and develops the maritime sector in Jordan including all maritime transportation modes and the related labor force. The Authority is responsible for the inspection and regulation of shipping, ship movements, ship safety, and records. While the Authority has a role in the regulation of on-board equipment, the role of the environmental regulator with regard to pollution in marine environment and coastline lies with ASEZA.

The Royal Jordanian Navy conducts daily patrols of port areas and keeps a patrol boat on 24-hour watch in the ship anchorage area next to the Main Port. The Navy, in collaboration with the Ports Corporation, assists in preventing polluting discharges from ships and helps bring the polluters before the courts. The Naval Base is located between the Marine Park and the Southern Port area.

Municipalities. Jordan has close to 100 local municipalities providing local government services such as waste collection, street cleaning, street and road maintenance, public lighting, culture and sports. Municipalities are run by a mayor who answers to a locally elected municipal council. Municipalities in Jordan vary greatly in size from populations of less than 5,000 people to greater than 100,000 people. They also vary in capacity. Municipalities relate to the central Ministry of Local Administration.

Other entities include:

- Ministry of Interior
- Ministry of Public Works and Housing
- Ministry of Planning and International Cooperation
- Ministry of Transport
- Ministry of Labour
- Ministry of Health
- Ministry of Agriculture
- Department of Lands and Survey (DLS)
- Public Security Directorate / Traffic Department
- Ministry of Social Development
- Ministry of Energy and Mineral Resources
- Ministry of Tourism and Antiquities
- Public Security Department
- Civil Defence Directorate
- Royal Society for the Conservation of Nature

- The Royal Department for Environmental Protection
- Miyahuna
- Aqaba Water Company
- Jordan Institution for Standards and Metrology
- Energy & Minerals Regulatory Commission
- Central Electricity Generating Company - Aqaba Thermal Power Station
- National Electric Power Company
- Jordan Hejaz Railway
- Land Transport Regulatory Commission
- Aqaba Company for Ports Operation and Management
- Aqaba Port Marine Service Company
- Aqaba Container Terminal

3.1.3. Donors and Financing Institutions

The European Investment Bank (EIB) is the long-term financing body of the European Union (EU). It promotes EU policies through financial and other forms of support to sustainable investment projects. The increasing prominence given to environmental and social considerations within the EU and throughout the other regions of operation of the Bank is reflected in its priority lending objectives. The Bank regularly reviews its environmental and social requirements and operational practices.

The European Investment Bank has worked over the past years to provide facilitated financing through loans and technical and investment grants to Jordan to finance projects in key sectors, including water and sanitation, and to strengthen the efficiency and sustainability of water resources management in the Kingdom. EIB is the Contracting Authority for the study of the Preliminary Risks Assessment and ESIA for the Aqaba-Amman Water Desalination and Conveyance Project.

The environmental and social policies, principles and standards as well as the operational practices of the EIB derive from and reflect the evolving EU approach and that of other international institutions towards the promotion of environmental sustainability and social well-being to achieve the goals of sustainable development.

All projects financed by EIB must comply with the environmental and social requirements of the Bank. The EIB seeks to enhance the environmental and social sustainability of all the projects that it is financing, in particular, climate change, biodiversity and ecosystems considerations. These are integrated into the lending policies and practices of the Bank.

Projects that receive financing priority by the Bank are those that make a significant contribution to the Priority Areas and Thematic Strategies of the EU Sixth Environment Action Program (EAP), and/or fulfil the objectives of EU Urban and Public Health strategies, including the Leipzig Charter.

EIB continuously reviews and upgrades its approach to climate change to guide its lending and operational practices related to climate change mitigation and adaptation in support of the European Climate Change Program and the EU Action Plan on Climate Change and Development.

The Statement applies to all forms of EIB financing, in all regions of Bank operations in both the public and private sector. EU principles and standards are the guide for all projects financed by the EIB. In the case of co-financing, the Bank can accept a common approach based on the relevant requirements of one of its financial partners, for reasons of consistency and harmonization, and to avoid duplication.

The United States Agency for International Cooperation (USAID) leads international development and humanitarian efforts to save lives, reduce poverty, strengthen democratic governance and help people progress beyond assistance. USAID works to strengthen the water and wastewater infrastructure in Jordan, improve water sector management, protect natural resources, increase water supply, and conserve water use.

USAID has provided substantial assistance to the water sector in Jordan through construction of wastewater and water treatment plants, community-based water projects in all governorates, major improvements to Amman's water network, the establishment of the Aqaba Water Company, and the rehabilitation of Jordan's water infrastructure.

USAID uses the Environmental Impact Assessment process to evaluate the potential impact of USAID's activities on the environment prior to implementation. USAID's environmental procedures assure that the potential adverse impacts of development activities on ecosystems, environmental resources, and human health and welfare are identified prior to implementation; that this information fully informs the decision of whether or not to proceed to implementation; and that activities are designed and implemented to minimize these impacts.

22 CFR 216 (Reg. 216) is the US federal regulation defining USAID's pre-implementation environmental impact assessment process. The output of this process is Reg. 216 documentation – Requests for Categorical Exclusion (RCEs), Initial Environmental Examinations (IEEs), and Environmental Assessments (EAs). All EAs and most IEEs establish mandatory environmental "conditions" (or mitigation measures) that must be fulfilled during the implementation of the project or activity to protect the environment and human health and welfare.

Based on USAID's environmental safeguards and procedures, the EIA process consists of two main phases; Screening or Preliminary Assessment and Detailed EIA Study. Most USAID-funded projects involve low or moderate risks which require preliminary environmental assessments. Only activities with significant potential adverse impacts require a detailed EIA study.

USAID's factsheet on stakeholder engagement in the environmental and social impact assessment process provides background information on stakeholder engagement as well as clear guidance and best practices to assist USAID staff and partners in incorporating stakeholder engagement into USAID's environmental procedures.

3.2. National Policies and Legislation

3.2.1. Policies and Strategies

The National Water Strategy (2016-2025). The Strategy, developed by MWI, focuses on building a resilient water sector based on a unified approach for a comprehensive social, economic and environmentally viable water sector development. It recognizes the main sector stakeholders and proposes a policy-driven implementation plan that ensures coordination and integration of efforts based on individual and collective accountability and efficiency. The Strategy links water scarcity with water security and builds on recent successes in achieving the Millennium Development Goals. It takes into account the challenges of meeting the growing national water demand, the impact of continued water scarcity, the changing geo-political scenarios, emerging needs, and Jordan's commitment to the global sustainable development goals for 2016-2025. The Strategy contains provisions for climate change and water-energy nexus. It calls for increased private sector participation and new water source options including harvesting water, brackish and seawater desalination, increased storage of water runoff, and artificial recharge.

Jordan's Climate Change Policy. Jordan submitted its commitment to the United Nations Framework Convention on Climate Change (UNFCCC) in September 2015 in the form of Intended Nationally Determined Contribution (INDC). The Kingdom put forward a dual target: an "unconditional" target of 1.5% reduction of greenhouse gases (GHG's) by 2030 compared to business-as-usual scenario, and a "conditional" target of 12.5% reduction by 2030 if financial assistance by the international community is made available. The INDC refers to 70 projects that have been identified to reach the 14% target and indicates that the energy sector (inclusive of generation and transport) represent 73% of total GHG emissions.

The Sector Strategic Guidance Framework of the National Climate Change Policy of the Hashemite Kingdom of Jordan (2013-2020) calls for building the adaptive capacity of communities and institutions in Jordan in order to increase the resilience of natural ecosystems and water resources, as well as agricultural resources, to climate change.

3.2.2. Laws, Regulations and Standards

3.2.2.1. Laws

Environmental Protection Law 6 of 2017

This law is the cornerstone for environmental protection in Jordan and although it repeals its predecessor, Environmental Protection Law 52 of 2006, all regulations and standards issued pursuant to Law No. 52 of 2006 remain valid under Law No. 6 of 2017. This Law consists of 33 articles that aim at protecting the environment and provides that the Ministry of Environment is the authority responsible for environmental protection. It also provides that the Ministry together with the related parties shall develop the policies and prepare the plans and programs, work on forecasting climate change, follow the implementation of international environmental agreements, protect the biodiversity, and identify areas that need special attention, MoEnv's responsibilities according to the Law include, but are not limited to, the following: Setting necessary policies and plans for environmental protection; and issuing specifications to fulfil environmental quality objectives. This is applied in the process of licensing and license renewal of facilities.

The regulations issued by MoEnv include handling of hazardous substances and their final disposal. The entry of hazardous substances and waste into the Kingdom is prohibited through the provisions of the Law. The Law introduces the need to carry out Environmental Impact Assessments (EIAs) for certain projects prior to their commencement. MoEnv grants approval for environmental studies and projects submitted on behalf of any official entity to a donor agency. Penalties and consequences associated with environmental violations are further described in the Law.

The Law stipulates that MoEnv is responsible for ensuring ambient quality, environmental protection, and water resources protection against pollution and for securing the quality of irrigation water supplies.

Aqaba Special Economic Zone Law No. 32 of 2000

Article 52 states that the Commissioner of Environmental Affairs of ASEZA shall assume the powers of Ministry of Environment for the purpose of protecting and maintaining the environment in Aqaba region and for ensuring sustainable development. In particular, Article 6 stipulates that all legislation in force in the Kingdom shall apply to the Zone unless superseded by contradiction by the provisions of ASEZA legislation. This means, that more stringent legislation in the ASEZA area will supersede (weaker) national legislation.

Water Authority of Jordan (WAJ) Law No. 18 of 1988

Article 24 stipulates that the Water Authority has the right to install private or public pipelines, or maintain them, through public roads. In case this is not possible for technical reasons, according to its sole evaluations, the Authority has (as added by Law No. 62 of 2001) the right to install these pipes within private lands and real estates. The Water Authority or its agents shall restore in all cases the conditions as they were before implementing the installations. The Water Authority shall assess the amounts of compensation to be paid to the owner if he suffered any loss. The Water Authority has the right to enter private lands and real estates to carry out its above-mentioned works stated in this Article.

Public Health Law No. 47 of 2008

Public Health Law No. 47 of 2008 is a framework law that establishes the responsibilities of the Ministry of Health over public health issues, including monitoring and surveillance for diseases. Protecting the Environment in Emergency Situations (Regulation No. 26 of 2005 governs government planning in case of emergencies).

Agriculture Law No. 13 of 2015

Developed by the Ministry of Agriculture (MoA), this law prohibits the disposal of any type of solid or liquid waste or other harmful substances in the environment. Owners of any project or establishment must ensure that no borders of forests or agricultural areas are to be violated. There are several legislations that relate to the protection of ecosystems and biodiversity in Jordan, including the legal mandates of the Royal Society for the Conservation of Nature (RSCN), the Environmental Protection Law No. 6 of 2017, and Regulation No. 43 of 2008 for the Classification of Birds and Wild Animals Species Forbidden from Hunting.

Antiquities Law No. 20 of 2004

This law, developed by Ministry of Tourism and Department of Antiquities, outlines the responsibilities and necessary actions to ensure the protection and conservation of the country's cultural heritage including archaeology. The Law outlines the required actions to be undertaken for the appraisal of archaeological objects and sites and their importance. In addition to penalties associated to the violation of any provisions of this law.

Labour Laws and Regulations

- Labour Law No. 8 of 1996 and its amendments: This applies to private sector labour and includes occupational health and safety requirements.
- Labour Law Amendment No. 26 of 2010: Related to rights and protection of non-Jordanian workers.
- The Social Security Law No. 1 of 2014.
- Social Security Corporation (SSC) Law – Work Injuries Instructions.
- Regulation on Preventive Medical Care and Treatment for Institutional Workers (No. 42, 1998).
- Regulation on Protection and Safety from Industrial Machinery and Equipment on Worksites (No. 43, 1998).
- Instructions - Initial Medical Examination of Workers in Institutions of 1999 which requires periodic medical examination of workers in certain risky environments, including working in waste management.
- Instructions for the Protection of Workers against the Risks of the Work Environment No. 8 of 1996. These instructions include the requirements to reduce the risk to health and safety of workers in certain environments and protective measures (such as PPE), welfare facilities (e.g. changing rooms), noise and lighting levels.
- Jordanian Standard JS 525:1987 - Heat Levels in the Work Environment.
- Jordanian Standard JS 524:1987 - Lighting Levels in the Work Environment.
- Jordan is a member of the International Labour Organization (ILO) and has ratified seven of the core conventions in addition to 13 other conventions.

Real Estate Ownership Law No. 13 of 2019

This law is the legal instrument in Jordan for land acquisition and applies to all cases of land acquisition in the country through its Chapter 9 (Articles 178-213). No land can be acquired away unless it is for a public benefit project and there is fair and just compensation. The law requires direct negotiation between the purchasers for public benefit project and landowners until an agreement is reached. If an agreement cannot be reached between the two parties, cases can be referred to the courts. Any land acquisition must be approved by the Council of Ministers. Additional information about this law and the land acquisition process can be found in the Land Acquisition and Resettlement Policy Framework (**Annex 8**).

Law on Guarantee of Access to Information No. 47 of 2007

Article 7 of the Law states that, "Every Jordanian has to right to obtain the information he/she requires in accordance with the provisions of this Law, if he/she has a lawful interest or a legitimate reason therefore". Article 8 obligates officials "to facilitate access to information and guarantee the disclosure thereof without delay and in the manner stipulated in the present Law".

Other Laws

Additional laws that are relevant to the project include:

- Social Security Law No. 1 of 2014
- Prevention of Human Trafficking Law No.9 of 2009
- Traffic Law No. 49 of 2008
- Protection of Cultural Heritage and Sites Law No. 5 of 2005
- Solid Waste Management Framework Law No. 16 of 2020

3.2.2.2. Regulations

Environmental Classification and Licensing Regulation No. 69 for 2020 and amendment No. 97 for 2020

This regulation sets out the EIA process in Jordan and is developed by virtue of Clause A of Article 5 of the Environment Protection Law No. 6 of 2017. Its annexes provide screening criteria, listing the types of projects which require a comprehensive EIA or a preliminary EIA study, and those for which neither is needed. For Category 1 projects, a public scoping hearing is required to prepare the EIA Terms of Reference (ToR). The Regulation requires that the EIA describe the project and environmental baseline conditions, and cover impacts to be assessed, and mitigation measures to be developed.

Based on this regulation, the AAWDC Project is classified as Category 1 (High Risk) Project thus requiring a comprehensive environmental impact assessment.

Regulation No 21 for 2001 for the Protection of the Environment in the Aqaba Special Economic Zone

Defines the environmental impact assessment process applicable in ASEZA in its Articles 8 to 24. According to Annex 2 of the regulation, Industrial estate development projects are subject to a comprehensive EIA.

Regulation for the Protection of Air No. 28 of 2005

This regulation describes the requirements of several entities including the Ministry of Environment in relation to protecting the environment against air pollution. This regulation is supported by Jordanian Standard – Ambient Air Quality (JS1140/2006). This standard outlines the technical requirements and allowable limits for air pollutants in regards to ambient air quality. Several pollutants are considered including CO, SO_2, NO_2, and TSP. The presence of stationary air emission sources at the RO Plant, pumping stations and other major stationary emission sources may trigger Jordanian Standard 1189 of 2006 - Maximum Allowable Limits of Air Pollutants Emitted from Stationary (JS 1189/2006).

Regulation for the Prevention of Health Nuisances within Municipal Areas, Regulation No. 1 of 1978 and its amendments

This Regulation operates under the Law of Municipalities and requires preventing health nuisances and avoiding adverse impacts on the environment and public health. This is applicable to the proposed sites of some project components.

Other Regulations

Additional relevant regulations include the following:

- Regulation on Protecting the Environment from Pollution in Emergency Situations No. 26 of 2005
- Soil Protection Regulation No. 25 of 2005
- Management, Transportation and Handling of Harmful and Hazardous Substances Regulation No. 24 of 2005
- Regulation for Obligatory Employment of Jordanian Workforce from Surrounding Communities in Development Projects No. 131 of 2016
- Regulation No. 43 of 2008 for the Classification of Birds and Wild Animals Species Forbidden from Hunting
- Regulation No. 43 of 1998 on Protection and Safety from Industrial Machinery and Equipment on Worksites
- Regulation No. 26 of 2005 governs government planning in case of emergencies
- Regulation on Preventive Medical Care and Treatment for Institutional Workers No. 42 for 1998

3.2.2.3. Instructions and Standards

Noise Prevention - Instruction for Reduction and Prevention of Noise for 2003

This instruction describes the requirements of several entities including the Ministry of Environment for protecting the environment against noise pollution, in relation to the noise levels outside the work environment (i.e., the fence of the facility). Noise levels within the work environment are listed under the Ministry of Labour's (MoL) "Instruction for the Protection of Employees and institutions against risk of work Environment". This instruction outlines the noise limits within the workplace and the number of acceptable exposure hours.

Drinking Water Standards (JS 286/2015)

This standard specifies the microbiological, chemical, physical and radiological requirements and procedures for monitoring and evaluating the quality of drinking water, whether from public or private sources. The standard provides the minimum required quality of water for drinking purposes. Exceedance of the maximum limit allowed for any parameter is considered as a violation to the standards. The Ministry of Health is the responsible agency to ensure compliance of drinking water with the standards.

The desalination plant will be designed to comply with the Jordan Drinking Water Standards No. 286/2015 (JS/286/2015) provided in Table 3-1.

Table 3-1: Treated Water Quality Limits and Proposed Monitoring Frequency

Parameters	Maximum Concentration (Based on JS/286/2015)
Turbidity	< 5 NTU
Color	< 15 TCU
pH	6.5-8.5
Total Dissolved Solids	< 1,000 mg/L
Total Hardness	< 500 mg/L
Sodium	< 200 mg/L
Chloride	< 500 mg/L
Sulfates	< 500 mg/L
Boron	< 2.40 mg/L
Residual Chlorine Level at the Delivery Point	0.2-1.5 mg/L
Bromide	-
Temperature	-
Conductivity	-
Calcium	-
Total Alkalinity	-
LSI	-
Other Parameters	Refer to JS/286/2015 Regulatory Limits (Appendix B)

Water – Reclaimed Domestic Wastewater (JS893/2021)

This standard details the characteristics of the treated wastewater resulting from domestic uses. It contains the reuse standards for irrigation, ground water recharge as well as discharge to water bodies and wadies. However, the standard does not allow any discharge of treated domestic wastewater into any wadi leading to the Gulf of Aqaba.

For the part of using treated wastewater for irrigation, the standard differentiate between four classes:

- Class A: for parks, playgrounds and roadsides within city limits
- Class B: for fruit trees, roadsides outside city limits and land-scape
- Class C: for field crops, industrial crops and forest trees.
- Class D: for flowers customized for uses

Table 3-2: JS893/2021 Characteristics and standards for reclaimed water reused for irrigation purposes

Parameter	Limits according to the uses mg/l (unless indicated otherwise)			
	Parks, playgrounds and roadsides within cities	Fruit trees, side roads and green areas	Agricultural crops, field crops and forest trees	Flowers customized for uses
BOD5	30	100	200	15
COD	100	200	300	50
Dissolved oxygen	2<	--	--	2<
Total suspended solid	50	100	100	15
pH	6-9 [a]	6-9 [a]	6-9 [a]	6-9 [a]
Turbidity	10 [b]	--	--	5 [b]
NO3 - N	16	16	16	16
TN	70	70	70	70
E-coli	100 [c]	1000 [c]	--	1.1 [c]
Intestinal Hemlines Eggs	2 $\geq$[d]	1 $\geq$[d]	1 $\geq$[d]	1 $\geq$[d]
FOG	8	8	8	8
MBAS	100	100	100	15
Total dissolved solid	1500	1500	1500	1500
Phenol	0.02	0.02	0.02	0.02
PO4 - P	10	10	10	10
Cl	500	500	500	500
SO4	500	500	500	500
HCO3	400	400	400	400
SAR	9.0 [e]	9.0 [e]	9.0 [e]	9.0 [e]
Al	5.0	5.0	5.0	5.0
As	0.1	0.1	0.1	0.1
Be	0.1	0.1	0.1	0.1
Cu	2.0	2.0	2.0	2.0
F	2.0	2.0	2.0	2.0
Fe	2.0	2.0	2.0	2.0
Li	2.5	2.5 (0.075 citrus)	2.5	0.075
Mn	0.4	0.4	0.4	0.4
Mo	0.27	0.27	0.27	0.27
Ni	0.2	0.2	0.2	0.2
Pb	0.2	0.2	0.2	0.2
Se	0.05	0.05	0.05	0.05
Cd	0.01	0.01	0.01	0.01

Parameter	Limits according to the uses mg/l (unless indicated otherwise)			
	Parks, playgrounds and roadsides within cities	Fruit trees, side roads and green areas	Agricultural crops, field crops and forest trees	Flowers customized for uses
Zn	5.0	5.0	5.0	5.0
Cr	0.1	0.1	0.1	0.1
Hg	0.006	0.006	0.006	0.006
V	0.1	0.1	0.1	0.1
Co	0.05	0.05	0.05	0.05
B	2.4	2.4	2.4	
CN	0.1	0.1	0.1	0.1

[a] **Unit**
[b] **nivilometer**
[c] **Bacillus - most likely number or CFU/100ml.**
[d] **Egg per liter.**
[e] **Sodium absorption rate%.**

Others

Additional instructions that are relevant to the Project implementation include:

- Instructions on Safety Measures to Prevent the Spread of Coronavirus at construction sites (07/04/2020)
- Instructions for Management of Solid Waste of 2006
- Instructions for the protection of workers and institutions from occupational hazards/risks issued by virtue of Article (79) of Labour Law No.8 of 1996
- Instructions for the Protection of Workers against the Risks of the Work Environment No. 8 of 1996
- Instruction for Reduction and Prevention of Noise of 2003
- Initial Medical Examination of Workers in Institutions of 1999
- Work Injuries Instructions.

3.3. International Standards and Commitments

3.3.1. EIB Standards

The EIB requires that project promoters apply good international practices. Relevant standards are identified in discussions between the Bank and the project promoter during project preparation, appraisal and negotiation and are applied by the project promoter during project implementation and operation. The standards, though derived from EU environmental law, are supplemented where necessary by other good international practices, and the Bank reserves the right to require standards that are more stringent than EU legal requirements. Where justified within the framework of the Statement, the Bank also reserves the right to apply a phased approach to the implementation of its standards.

The EIB requires that all projects that it finances comply at least with:

- Applicable national environmental laws and regulations;

- Applicable EU environmental law, notably the EU EIA Directive and the nature conservation Directives, as well as sector-specific Directives and "cross-cutting" Directives; and
- The principles and standards of relevant international environmental conventions incorporated into EU law.

With reference to the EIA Directive, the EIB requires that its provisions are respected in particular related to the following:

- An EIA should be carried out if a project is likely to have a significant impact on the environment; for an Annex II project according to the EIA Directive, the decision not to carry out an EIA should be justified.
- The public concerned should be given early and effective opportunities to participate, to express comments on the project and to receive a response to those comments.
- Any residual impacts should be suitably mitigated, compensated and/or offset.

In projects for which the EIB requires a formal EIA, the EIA process and content must be consistent with the requirements of the EU Directive.

The EIB restricts its financing to projects that respect human rights and comply with EIB social standards, based on the principles of the Charter of the Fundamental Rights of the European Union and international good practices. EIB expects that all policies, practices, programs and activities developed and implemented by the project promoter should pay special attention to the rights of vulnerable groups.

3.3.1.1. EIB Criteria for Project Classification

The objective of Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (the Environmental Impact Assessment, or EIA, Directive) is to ensure that projects that are likely to have a significant effect on the environment are adequately assessed before they are approved. The EIA Directive of “1985” has been amended three times, in 1997, in 2003 and in 2009.

Before any decision is taken to allow a project to proceed, the possible impacts it may have on the environment (either from its construction or operation) are to be identified and assessed. The Directive also ensures the participation of environmental authorities and the public in environmental decision-making procedures. In particular, members of the public concerned must be given the opportunity to comment on any proposal while all options are still open, i.e., before a final decision is taken by the competent authority on a request for development consent. When approving a project, the competent authority is required to take into consideration the results of consultations and to inform the public, notably on the measures envisaged to avoid, reduce or compensate for environmental impacts.

Subject to EU's Directive on EIA, Article 2(4), all projects listed in Annex I are considered as having significant effects on the environment and require an in accordance with Articles 5 to 10, while for projects listed in Annex II, Member States shall determine whether the project shall be made subject to an assessment in accordance with Articles 5 to 10. For projects listed in Annex II, the national authorities have to decide whether an EIA is needed. This is done through a "screening procedure" which determines the effects of projects on the basis of thresholds/criteria or a case-by-case examination. However, the national authorities must take into account the criteria laid down in Annex III. The projects listed in Annex II are in general those not included in Annex I (railways, roads, waste disposal installations, wastewater treatment plants), but also other types such as urban development projects.

Although Annex I of the Directive stipulates that "*Works for the transfer of water resources between river basins where that transfer aims at preventing possible shortages of water and where the amount of water transferred exceeds 100 million cubic meters/year*", it does, however, exclude projects from the Annex if the transfer involves piped drinking water. Annex II includes "*Installations of long-distance aqueducts*" as one of its projects thus leaving the decision up to the national authorities to determine the need for an EIA based on screening its environmental impacts.

3.3.1.2. EIB Environmental and Social Standards

EIB Environmental and Social Principals and Standards are presented in the EIB Statement of Environmental and Social Principals and Standards (ESS) for the year 2009, and are elaborated and explained in the European Investment Bank Environmental and Social Handbook (2013). EIB's environmental and social standards are:

- ESS 1: Assessment and Management of Environmental and Social Impacts and Risks

- ESS 1: Pollution Prevention and Abatement
- ESS 1: Biodiversity and Ecosystems
- ESS 4: Climate-related Standards
- ESS 5: Cultural heritage
- ESS 6: Involuntary Resettlement
- ESS 7: Rights and Interests of Vulnerable Groups
- ESS 8: Labour Standards
- ESS 9: Occupational and Public Health, Safety and Security
- ESS 10: Stakeholder Engagement

EIB social standards aim to "*protect the rights and enhance the livelihoods of people directly and indirectly affected by projects financed by the EIB*" (EIB, 2009). Outcomes expected and targeted from the enforcement and implementation of these standards are oriented toward the benefit of individual well-being, social inclusion and sustainable communities.

EIB social standards pay particular attention to the rights and interests of vulnerable groups. They provide clear basis for assessment of vulnerability and the main vulnerable groups (e.g., women, people with disabilities, indigenous communities, ethnic groups, etc.)

Practices and procedures related to the implementation of the EIB Standards are based on the second volume of the EIB Environmental and Social Handbook (2013). These procedures provide detailed elaboration on the objectives to achieve, means (framework and tools) of achieving the objectives, and procedures to fully comply with the set-forth standards.

The EIB Standards are based on the principles of the Charter of the Fundamental Rights of the European Union and international good practices and address all obligations and requirements related to the international conventions and agreements on social and human rights.

3.3.2. USAID Requirements

USAID uses the Environmental Assessment process to evaluate the potential impact of USAID's activities on the environment prior to implementation. USAID's environmental procedure ensure that the potential adverse impacts of development activities on ecosystems, environmental resources, and human health and welfare are identified prior to implementation; that this information fully informs the decision of whether or not to proceed to implementation; and that activities are designed and implemented to minimize these impacts. The procedures are a life-of-project process for achieving sustainable actions that promote community self-reliance.

22 CFR 216 ("Reg. 216") is the US federal regulation defining USAID's pre-implementation environmental impact assessment process. The output of this process is Reg. 216 documentation – Requests for Categorical Exclusion (RCEs), Initial Environmental Examinations (IEEs), and Environmental Assessments (EAs). All EAs and most IEEs establish mandatory environmental "conditions" (or mitigation measures) that must be fulfilled during the implementation of the project or activity to protect the environment and human health and welfare.

Based on USAID's environmental safeguards and procedures, the EIA process consists of two main phases: Screening or Preliminary Assessment and Detailed EIA Study. Most USAID-funded projects involve low or moderate risks which require preliminary environmental assessments. Only activities with significant potential adverse impacts require a detailed EIA study.

3.3.3. EU Directives

This section provides a brief description of the relevant EU Directives that are considered as most applicable to the AAWDC Project.

Directive 85/337/EEC - Directive on EIA

This directive was in force since 1985 and has been amended recently in 2014. It is applied to various public and private projects. The amended EIA Directive 2014 came into force on May 15th 2015, amending 2011/92/EU, stating that it will "simplify the rules for assessing the potential effects of projects on the environment." Member States must implement it by May 16th 2017. The EIA Directive 2014 makes a number of changes, including a new definition of EIA and standardization of the EIA screening process across Member

States with information that developers must provide for the screening process to be prescribed. There is also clarification that the cumulative impact of a project and other existing or approved projects should be considered as part of the screening process; and a requirement for the main reasons behind the screening decision or screening opinion to be published at the same time, as well as a new time frame for the screening process (to be carried out within 90 days).

It should be noted that the Jordanian EIA legislation (No. 37 of 2005) is broadly in line with the process required by the EU Directives, although it is somehow limiting on matters of social assessment, consultation, information disclosure, and implementation and follow up especially in relation on the ESMP.

Directive 98/83/EC - The Drinking Water Directive

This directive regulates the quality of water intended for human consumption. Its objective is to protect human health from adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean. The latest amendments include Commission Directive (EU) 2015/1787 of 6 October 2015. The Drinking Water Directive applies to all distribution systems serving more than 50 people or supplying more than 10 cubic meter per day, but also distribution systems serving less than 50 people / supplying less than 10 cubic meter per day if the water is supplied as part of an economic activity.

The Directive provides the essential quality standards at EU level. It requires the regular monitoring and testing of a total of 48 microbiological, chemical and indicator parameters. In general, World Health Organization's guidelines for drinking water and the opinion of the Commission's Scientific Advisory Committee are used as the scientific basis for the quality standards in the drinking water.

Directive 91/271/EEC on Urban Wastewater Treatment

Council Directive 91/271/EEC concerning urban wastewater treatment was adopted on the 21st of May 1991 to protect the water environment from the adverse effects of discharges of urban wastewater and from certain industrial discharges. For this purpose, it sets out provisions relative to the collection, treatment and discharge of urban wastewater and the treatment and discharge of wastewater from certain industrial sectors. The areas into which urban wastewater entering collecting systems shall be discharged are divided into: (a) sensitive areas; and (b) less sensitive areas for which specific discharge limit values apply (Annex I and Annex II of the Directive refer). On the 27th of February 1998 the Commission issued Directive 98/15/EC, which amended Directive 91/271/EEC, with regards to clarifying the requirements of the Directive 91/271/EEC in relation to discharges from urban wastewater treatment plants to sensitive areas, which are subject to eutrophication. As a result, Table 2 of Annex I of the Directive 91/271/EEC was subsequently amended.

Directives related to Labour and Working Conditions

- Directive 2006/54/EC – Equal opportunities
- Directive 2002/14/EC – Informing and consulting employees
- Directive 2000/78/EC – Equal treatment
- Directive 89/391/EEC – OHS- Framework & Directive
- Directive 2009/104/EC – Use of work equipment
- Directive 92/58/EEC – Safety and/or health signs
- Directive 89/656/EEC – Use of personal protective equipment
- Directive 89/654/EEC – Workplace requirements
- Directive 2009/161/EU – Occupational exposure limit values
- Directive2012/18/EU – Major-accident hazards
- Directive 90/269/EC – Manual handling of loads

Directive 96/62/EC - Air Quality Framework Directive

This directive describes the basic principles for assessing and managing air quality in Member States. The directive lists the pollutants for which air quality standards and objectives will be developed and specified in legislation

Directive 2002/49/EC - Assessment and Management of Environmental Noise

This Directive relates to the assessment and management of environmental noise. It is the main EU instrument to identify noise pollution levels and to identify the necessary action both at Member States and at EU level. Since this EU Directive does not specify noise limits, the IFC "**Environmental, Health, and Safety (EHS) Guidelines: Environmental – 1.7 Noise Management**" are referred to for noise limits specifications.

Directive 2008/98/EC - Waste Framework

This directive sets the general framework of waste management requirements and the basic waste management definitions for the EU. It determines the basic concepts and definitions related to waste management and lays down waste management principles such as the "polluter pays principle" or the "waste hierarchy".

Directives relating to Public Participation

- Directive 2003/04/EC – Access to Environmental Information
- Directive 2003/35/EC – Providing for Public Participation

Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the Conservation of Wild Birds

This directive provides a legal framework for the protection of all wild birds in the EU, including their eggs, nests and habitats. It also prohibits the sale, transport for sale, keeping for sale and the offering for sale of live or dead birds and of any readily recognisable parts or derivatives of such birds.

Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora

This directive addresses the conservation of natural habitats and of wild fauna and flora and aims to promote the maintenance of biodiversity, taking account of economic, social, cultural and regional requirements.

3.4. Gaps in Relevant Environmental and Social Regulations

The following table presents the gaps that exist between the national environmental and social requirements in Jordan and those of EIB particularly as they relate to the following key aspects: Environmental Permitting, Environmental Management, Land Acquisition, and Public Consultations and Disclosure.

Table 3-3– Gaps in Regulations and Measures to Bridge them

Requirement	Gaps	Measures to Bridge Gaps
Environmental Permitting	▪ The EIA is regarded as a permitting requirement to fulfil Jordanian legal requirements and is often commissioned after the project proponent has made key project decisions especially those related to project alternatives, site selection, project size, etc. According to the EIA regulation (Environmental Classification & Licensing Regulation No. 69 of 2020), the Ministry of the Environment is the sole authority responsible for requesting, screening, reviewing, and approving environmental impact assessment studies in areas outside the boundaries of Aqaba region. ▪ ASEZA has sole jurisdiction over environmental regulation within Aqaba region including the entire coastline and thus ASEZA's Environmental Clearance Procedures apply to all economic activities and projects located there. ▪ Larger projects in Jordan are often donor-	▪ The more stringent of the two requirements has been applied for the project. ▪ EIB requirements were used for aspects not covered by local Jordanian legislation especially related to public consultations and land acquisition.

Requirement	Gaps	Measures to Bridge Gaps
	financed (including by EIB) and so are appraised to donor requirements which are usually more stringent than national Jordanian requirements especially in areas related to social impacts, land acquisition, public consultation and gender integration.	
Environmental Management	▪ Jordanian legislation does not allocate sufficient resources to conduct post-permitting follow up regarding the implementation of the provisions of Environmental Management Plans especially during the construction phase (as the operation phase is mostly covered through the auditing process). ▪ There are inadequate provisions for institutionalizing controls and performance requirements and applying them on contractors and project operators. ▪ Projects that have obligations to monitor and report on environmental performance (e.g. air emissions, discharges, etc.) often do so under different legislation.	MWI, in cooperation with the environmental authorities, to allocate sufficient resources to ensure the full and timely implementation by the BOT Developer of the requirements of the Environmental and Social Management Plan (which is part of the ESIA) including the monitoring and reporting requirements.
Resettlement and Land Acquisition	▪ The Jordanian Real Estate Ownership Law No. 13 of 2019 does not recognize displaced people (physically or economically) without formal legal rights. Furthermore, it does not recognize the term 'involuntary resettlement'. ▪ The focus in Jordanian legislation is confined to land and assets such as buildings, trees and other fixed objects which may be expropriated or damaged by the project. ▪ Resettlement assistance is not covered except for the provision of cash compensation for the loss of land or assets for persons with formal legal rights. ▪ Loss of value and economic resettlement are not covered by the local legislation. ▪ The Jordanian legislation does not require the preparation of Resettlement Action Plans or Livelihood Restoration Plans, nor to undertake a socio-economic survey prior to commencing project activities. Furthermore, it does not require performing consultation with project affected people or conducting monitoring or reporting. ▪ The Jordanian legislation offers the owner the right to negotiate to reach agreement over the compensation and to refer the case to the courts but only as it relates to the amount of the compensation. ▪ Project affected persons and host communities have very limited opportunity under the law to participate in defining or agreeing eligibility criteria.	Under the terms of the contract, MWI will: ▪ Develop a Resettlement Action Plan or a Livelihood Restoration Plan. ▪ Undertake a full socio-economic survey prior to commencing project activities. ▪ Maintain open communication channels and on-going consultations with project affected people throughout the project lifecycle. ▪ Establish a grievance mechanism accessible to all project affected persons ▪ Conduct regular monitoring and reporting. Disputed tribal lands in some parts of Jordan including the project area can sometimes be problematic. MWI (through the Resttlement Action Plan/Livelihood Restoration Plan) will pay special attention to this issue.

Requirement	Gaps	Measures to Bridge Gaps
Public Consultations and Disclosure	▪ Jordan's local legislation require one or two consultation sessions during ESIA preparation that are open to the public and for which feedback can be obtained to feed into the study while EIB requires stakeholder engagement throughout the duration of the project including during construction and operation. ▪ The EIB also requires full dislosure of all ESIA documents while this is not necessarily required by local legislation.	▪ Stakeholder engagement, including disclosure and dissemination of information, should be planned for and carried out in line with the principles of prior, informed and free engagement and informed participation, in order to lead to broad community support by the affected communities and longer-term sustainability of the project's activities. ▪ MWI must adopt, update and implement the Project's Stakeholder Engagement Plan (**Annex 9**) and provide stakeholders with access to timely, relevant and understandable information, and to engage relevant internal and external stakeholders throughout the project life to ensure effective communication. ▪ MWI and the BOT Contractor must ensure that the level of engagement corresponds to the type and scale of the potential impacts and will take the concerns of stakeholders into consideration in decision-making.
Grievance Mechanism	▪ While some form of grievance mechanism exists at the various relevant agencies (MoEnv, ASEZA and MWI), a formal project-related Grievance Mechansim is not required by the legislation. This mechanism is required according to EIB standards.	▪ Applying EIB standards will ensure that a grievance mechanism is established and grievances from affected communities and other stakeholders are recorded, addressed and managed appropriately.

3.5. Multilateral Environmental Agreements

Jordan is a signatory to a number of international environmental conventions and multi-lateral environmental agreements, treaties, and protocols aiming at protecting the environment. The most relevant to the AAWDC Project are the following:

- Kyoto Protocol on Climate Change, 2003
- Ramsar Convention of Wetlands of International Importance, 1971
- Vienna Convention and the Montreal Protocol for the Protection of the Ozone Layer, 1988
- Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal, 1992
- UN Convention to Combat Desertification (UNCCD), 1996

- Cartagena Protocol on Bio-safety, 2003
- Convention on the Protection of African-Eurasian Migratory Waterfowls, 1996
- Convention on the Conservation of Migratory Species of Wild Animals, 1979
- Stockholm Protocol on Persistent Organic Pollutants (POPs), 2004
- Convention on Biological Diversity (CBD), 1994
- Jordan is a member of the International Labour Organization (ILO) and has ratified seven of the core conventions in addition to 13 other conventions.
  - Right to Organise and Collective Bargaining Convention, 1949 (No. 98)
  - Forced Labor Convention, 1930 (No. 29)
  - Abolition of Forced Labor Convention, 1957 (No. 105)
  - Minimum Age Convention, 1973 (No. 138)
  - Worst Forms of Child Labor Convention, 1999 (No. 182)
  - Equal Remuneration Convention, 1951 (No. 100)
  - Discrimination (Employment and Occupation) Convention, 1958 (No. 111)

3.6. Project Ownership

The **Ministry of Water and Irrigation** is the main public water institution in Jordan. The Water Authority of Jordan (WAJ) operates under the umbrella of MWI and is responsible for the operational management of water facilities including water supply and wastewater treatment in Jordan. 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, mostly 25 - 35 years, after which it is transferred to the Jordanian government.

3.7. Project Categorization and Permitting

3.7.1. National Environmental Requirements

According to the Environmental Classification and Licensing Regulations No. 69 for 2020 and its amended regulation No. 97 for 2020, desalination projects and projects supplying water to a population of over 100,000 are required to undergo a comprehensive environmental impact assessment (EIA) to be approved by the MoEnv. Consequently, the Project Promoter (MWI) has addressed MoEnv as per the formal letter No. 1/5/39/1259 dated September 28, 2020 in order to classify the AAWDC Project. In line with the regulations, MoEnv has concluded that the AAWDC Project requires conducting a comprehensive EIA as per its letter No. 4/7/6983 dated October 01, 2020 included **in Annex 1**. On the other hand, on July 01, 2021, MoEnv. has approved the submitted TOR as per their formal letter No. 4/7/5141 included in **Annex 1.**

ASEZA has sole jurisdiction over environmental regulation within Aqaba Special Economic Zone including the entire coastline and thus ASEZA's Environmental Clearance Procedures apply to all economic activities and projects located there. Screening is conducted by ASEZA's environmental department to decide the nature and extent of the environmental analysis to be carried out for a proposed project/activity. The classification of each proposed project depends on the type, location, sensitivity, and the scale of the proposed project, as well as the nature and magnitude of its potential impacts. As per Regulation No 21 for 2001 for the Protection of the Environment in the Aqaba Special Economic Zone, Category I projects require a comprehensive EIA due to the expected significant environmental impacts of its activities. Category II projects require a preliminary environmental evaluation. Similarly, MWI has addressed ASEZA as per letter No. 1/5/26/1258 dated September 28, 2020 for the same purpose of screening the AAWDC Project. ASEZA had also concluded that the AAWDC Project requires conducting a comprehensive EIA as per its letter No. 2/1/13778 dated October 21, 2020 included in **Annex 1** along with ASEZA’s approval on the submitted TOR, as per formal letter No. 02/01/6241 dated May 10, 2021.

3.7.2. EIB Criteria for Project Classification

EIB Environmental and Social Standard # 1 - Assessment and Management of Environmental and Social Impacts and Risks - outlines the project promoter’s responsibilities in the process of assessing, managing and monitoring environmental and social impacts and risks associated with a project. This Standard applies to all operations likely to have significant and material environmental and social impacts and requires that risks be taken into account at the earliest possible stage of the decision-making process. According to this standard, projects which are likely to have significant effects on the environment, human health and well-being must be subject to an assessment according to the EU EIA Directive 2011/92/EU.

The objective of Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (the EIA Directive) is to ensure that projects that are likely to have a significant effect on the environment are adequately assessed before they are approved. The EIA Directive of 1985 and its 3 amendments have been codified by Directive 2011/92/EU, which has been further amended in 2014 by Directive 2014/52/EU.

Before any decision is taken to allow a project to proceed, the possible impacts it may have on the environment (either from its construction or operation) are to be identified and assessed. The Directive also ensures the participation of environmental authorities and the public in environmental decision-making procedures. In particular, members of the public concerned must be given the opportunity to comment on any proposal while all options are still open, i.e., before a final decision is taken by the competent authority on a request for development consent. When approving a project, the competent authority is required to take into consideration the results of consultations and to inform the public, notably on the measures envisaged to avoid, reduce or compensate for environmental impacts.

According to Article 4 of the EIA Directive, projects listed in Annex I are considered as having significant effects on the environment and require an EIA in accordance with Articles 5 to 10, while for projects listed in Annex II, Member States shall determine whether the project shall be made subject to an EIA. For projects listed in Annex II, the national authorities have to decide whether an EIA is needed. This is done through a "screening procedure" which determines the effects of projects on the basis of thresholds/criteria or a case-by-case examination. However, the national authorities must take into account the criteria laid down in Annex III. The projects listed in Annex II are in general those not included in Annex I (railways, roads waste disposal installations, wastewater treatment plants), but also other types such as urban development projects.

Although Annex I of the Directive stipulates that "Works for the transfer of water resources between river basins where that transfer aims at preventing possible shortages of water and where the amount of water transferred exceeds 100 million cubic meters/year", it does, however, exclude projects from the Annex if the transfer involves piped drinking water. Annex II includes "Installations of long-distance aqueducts" as one of its projects thus leaving the decision up to the national authorities to determine the need for an EIA based on screening its environmental impacts. Desalination plants are not listed in any of the annexes.

Based on the types of projects listed in Annex II of the EU EIA Directive 2011/92/EU and the above discussion, the proposed AAWDC Project would require an EIA study.

4. Project Alternatives

4.1. Purpose

The purpose of this section is to present feasible alternatives, from a technical, financial, and environmental perspective, that have been examined during the development of the AAWDC Project, inclusive of the No-Project alternative and the preferred Project alternative(s).

Further to the description of the No-Project alternative, the examined alternatives for the AAWDC Project components, as described below, are grouped into three (3) broader categories involving site (location) alternatives, technology / process alternatives, and construction materials alternatives, for which design,environmental and social and economic considerations (pros & cons) are presented vis-à-vis the key Project objectives and the minimum environmental and social standards and legal requirements. The selected Project alternative(s) for Project preliminary design was subject to a detailed assessment of potential impacts pursuant to the methodology presented in Section 5.3 of this Report, are also described in similar context, taking into account that the AAWDC Project will be procured as a BOT scheme and therefore a certain level of flexibility, related mostly to the desalination component, will be provided to the BOT Developer regarding technology options achieving the same level of legal compliance and environmental protection. However, any material deviation / major change in Project design by the BOT Developer would need the approval of ASEZA and MoEnv and an update of the ESIA study may be required.

In light of the above, the following sub-sections provide a concise presentation of the examined alternative options for the Project.

4.2. No Project Alternative

It is understood that the AAWCC Project sits under and complements the National Water Strategy of the Ministry of Water and Irrigation (MWI) in Jordan. The Project will substantially contribute to reducing 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 by developing a water supply infrastructure entirely within Jordan's boundaries and control and thus providing substantial socioeconomic benefits for the served population.

The No-Project alternative suggests remaining with the current water supply conditions without proceeding with the implementation of the AAWDC Project. The No-Project alternative is used to compare the current situation in terms of environmental and social settings with environmental and social impacts resulting during the implementation related construction and operation phases of the Project.

In the absence of the Project, the pressures related to the severe water scarcity facing the country will continue to exist and negatively impact the served population's livelihood and health conditions and the existing water supply infrastructure will continue not sustaining the increasing water demand. Whereas investment to drive operational efficiencies and establish long term, secure and sustainable recovery routes and outlets will not occur, which in turn will lead to further deterioration of existing environmental and material assets (Table 4-1 refers).

Table 4-1: Likely Evolution of the Baseline Without Implementation of the Proposed Water and Wastewater Infrastructure Investments

Environmental/Social Theme	Likely Evolution Without the AAWDC Project
Soil and Geology	In the absence of the Project, the soils and geology in the target areas would continue to exist in much the same pattern and/or degraded as a result of climate change extremes (i.e., increased temperatures and

Environmental/Social Theme	Likely Evolution Without the AAWDC Project
	floods). Considering that under the water scarcity facing the country, water is treated as a precious resource rather than a disposable commodity, the cultivation of agricultural fields is unlikely to be expanded because water supply to this effect is either expensive or insufficient.
Air, and Climatic Factors	Rural air quality in Jordan is mainly affected by the uncontrolled burning of household and agricultural waste, the operation of medium to large size industrial activities with, not always, appropriate air pollutants emissions abatement measures, and transportation means. The absence of the Project is not expected to affect the global rural air quality trends. However, the operation of existing water supply infrastructure that does not meet increasing demand and in several cases lucks energy efficiency measures would continue to result in unnecessary impacts on localized air quality from indirect GHG emissions as result of energy consumption by outdated and to some extent inefficient water supply facilities (i.e., WTPs, PSs) related equipment such as pumps, aerators, etc. With regards to climate change vulnerability, Jordan has experienced high rates of population growth in recent decades which was further exacerbated by the unfolding of the Syrian refugee crisis since 2011 that created real emergency conditions, especially in Northern Jordan. It is understood that water demand has jumped by additional 21% across Jordan and 40% in the Northern Governorates. Water scarcity and management remains the most pressing issue in terms of climate vulnerability, as temperatures are forecast to increase every year [3] and groundwater levels are declining by as much as 12 meters per year [4]. While more than 98% of the population has access to an improved water source, only 93% access a safely- managed source and 86% to a piped network. In urban areas, water is usually available once a week, but less than once every two weeks in rural areas, with reduced frequency during the summer [5]. The occurrence of frequent droughts and adverse climate change effects will drive climate displacement towards the capital city of Amman as more secured water sources are existing. As such, migration from rural to urban areas was expected to increase with an approximate 15% of the country's farmers in 2018, who would leave their lands or shift their use from agriculture to other uses [6] Given these remarks, in the absence of the Project, the pressures stemming from climate change are likely to increase over time and multidimensional vulnerabilities such as water scarcity, constrained agricultural and economic growth, and increased food insecurity and desertification will continue to prevail despite the efforts of GoJ to adapt to climate change. Further, in the absence of the Project, the vulnerability of the existing water supply infrastructure to the inevitable climate change and associated risks would continue to be high, whereas their resilience would continue to be diminishing as a result of restricted financial resources.
Surface Water and Groundwater	Jordan relies to aquifers, located in twelve main groundwater basins, to provide the country's needed water supply. Most of Jordan's water supply (around 59%) is extracted from 10 renewable and two non-renewable groundwater basins. Over-extraction of these basins is currently 160% and 123% of safe yield, respectively [4]. It is understood that of Jordan's 12 groundwater basins, 10 are being pumped at a deficit and groundwater is

Environmental/Social Theme	Likely Evolution Without the AAWDC Project
	being extracted almost at twice the replenishment rate. In the absence of the Project, the existing groundwater resources will continue to be dramatically overexploited which ultimately would lead to their depletion.
Biodiversity, Flora, and Fauna	Without the implementation of the Project, the biodiversity, flora, and fauna of the target regions, including protected sites, habitats, and species, would continue to exist in much the same pattern, abundance, and density as today.
Population and Human Health	Without the Project, it could reasonably be argued based on historical trends to date that the existing water supply infrastructure would not cope with increasing water demand, which was further exacerbated by the COVID-19 outbreak, resulting in lack of water and/or inefficient treatment and subsequent significant health risks to the population as a result of exposure to waterborne diseases. In addition, while agriculture is considered as a key sector for economic growth in the country, irrigated lands account for only 33% of total cultivated area but still consume around 65% of total available water and provide only around 19% of Jordan's food requirements [7]. The projected water deficit would, therefore, put this value chain at stake and result in economic impacts on agriculture due to the continuing soil degradation, the inability to expand the cultivation of crops, including export crops, and the subsequent reliance to food imports. By ensuring drinking water supply through a non-conventional water source as seawater, the existing conventional water resources could be more effectively managed in support of irrigation and subsequent enhancement agricultural practices.
Cultural Heritage	Without the implementation of the Project, the existing cultural heritage resources would continue to exist in much the same pattern as today. However, tourism is a significant source of income in some of the target regions, and tourism is attracted by the country's cultural heritage. Hence, it could be reasonably argued that the lack of sufficient and high-quality water supply in these areas would have an impact on local economy due to the likely change in tourism trends.
Landscape and Land Uses	Without the implementation of the Project the land uses in the target areas would continue to exist in much the same pattern as today. However, in the absence of the Project, water scarcity would continue to exacerbate the quality of lands and possibly put in in risk the safety of food production and increase the reliance of the country in food exports.

The preceding analysis suggests that if the AAWDC Project is not implemented:

1. Drinking water quality standards will not be met with significant health risks for the population of the target regions.
2. Existing groundwater resources will continue to be overexploited and most likely be depleted.
3. The existing water supply infrastructure will continue not being able to meet water demand and legally required drinking water quality.
4. The existing water supply infrastructure will continue to be highly vulnerable, with diminishing resilience to climate change risks.
5. Livelihood conditions and public health will continue to be adversely affected due to continuing water deficit.

Assuming that the impacts relating to the construction and operation activities of the AAWDC Project will be either prevented at source or managed to levels where the environmental effect will be either insignificant or manageable, the No-Project alternative is not favored from an environmental and social perspective.

4.3. Siting Alternatives

4.3.1. Water Desalination Component

4.3.1.1. Intake and Brine Disposal Systems

Intake Pumping Station (onshore)

An intake pump station location was initially proposed in the MWI Concept Design and Technical Feasibility Report for the AAWDC Project dated October 2018 as shown in Figure 4-1.

Figure 4-1: Initial Location of the IPS

This location situated a few kms south of Aqaba, within the Aqaba Marine Park. This location was also close to the 'Japanese Garden' and the 'Cedar Pride Wreck' both of which are popular snorkelling and diving sites (Figure 4-2 refers).

Figure 4-2: Initial Location of the IPS and Intake Pipe

Following consultations with various stakeholders, this location was dropped and, in coordination with ASEZA, a new site location was proposed and agreed on for the construction of the IPS (Figure 4-3 refers). The proposed location, which will be further assessed in the comprehensive ESIA study, is situated within the Aqaba Industrial Zone and adjacent to the recently constructed industrial port. It will pump seawater to the SWRO desalination plant which is located at around 2 km northeast.

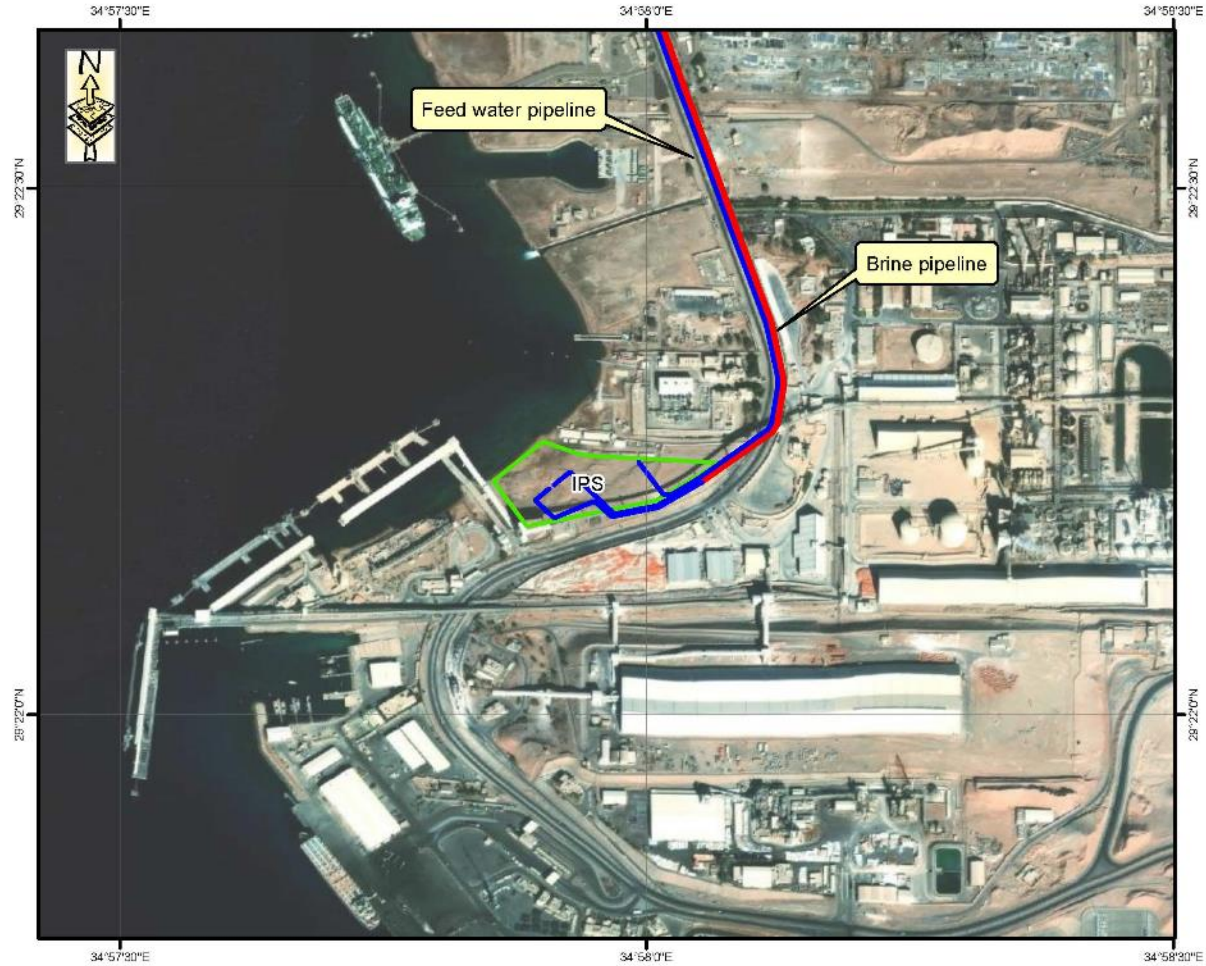

Figure 4-3: New Proposed Location of the Intake IPS

Marine Works (water intake and brine outfall systems)

A potential location for the intake pipe and brine outfall systems was initially proposed in the CDM Smith Concept Design and Technical Feasibility Report for the AAWDC Project dated October 2018. As with the IPS, this location lies a few kilometres south of Aqaba, within the Aqaba Marine Park and is close to the 'Japanese Garden' and the 'Cedar Pride Wreck', both of which are popular snorkelling and diving sites. Two intake depth options were considered in this study; at -50 m and -140 m. In depths down to -50 m, an intake structure was reportedly required to be designed with a low water entrance velocity to reduce entrainment of fish. Large diameter intake tower/s would be necessary. For large depths, classical intake structures were not to be used, as it was considered impossible to assemble such structures at -140 m depths and to connect pipes to them. In this case, the intakes would simply be open mouth pipes with an end device raising them above seabed.

It should be noted that experience from major SWRO desalination plants operating in the Red Sea and elsewhere in the world suggests that these plants abstract seawater from depths of less than 25 m (typically 10-20 m) because this allows the intake tower to be manually cleaned by divers from macrofouling by barnacles, seaweeds, etc. The intake pipes themselves have the potential to heavily foul with barnacles and will require to be cleaned by divers, despite the use of chlorination for fouling control and/or pig cleaning systems. Divers have limited allowed dive time at depths below 30m, which makes maintenance of the intake tower and intake pipes potentially hazardous. Given these remarks, the ESIA TA team considers that depths beyond -50 m as well as -140 m might not be suitable for the operational supply of the Project SWRO plant. This was further assessed and justified under the relevant task involving the prefeasibility assessment of seawater intake and brine discharge components, where it was recommended, based on the physical constraints of the examined marine site, and constructability, operability, environmental, and economic considerations, that a feasible water depth for the intake towers should be equal to or exceed 12 m.

Regarding the brine discharge location, two options were considered in the CDM Smith Concept & Technical Feasibility Study dated October 2018 relative to the intake system location at -50 m and at -140 m depth. In the case of a 300 m long intake (to -50 m depth), the brine outlet pipe was to end at about -100 m depth. In the case of the 600 m long intake, the brine outfall pipe will be 650 m to 700 m. A simple diffuser was to be placed at the pipe mouth to dilute brine. Similar to the intake system, the location of the brine outfall was further assessed and justified under the relevant tasks involving the brine discharge risk assessment and the prefeasibility assessment of seawater intake and brine discharge components, where it was recommended, based on the physical constraints of the examined marine site, constructability, operability, environmental, and economic considerations, that a feasible water depth for the outfall diffusers, for a diffusers manifold configuration parallel to the shore, should exceed 35 m and recommended to be 50 m due to the phosphate jetty and associated ship loading/unloading operations. Whereas for a diffusers manifold configuration perpendicular to the shore, the first pair of diffusers should be located at a water depth exceeding 25 m.

4.3.1.2. SWRO Desalination Plant

The following factors were taken into account in the examination of suitable locations for the SWRO desalination plant:

- Permitting constraints;
- Environmental concerns;
- Public acceptance;
- Land availability;
- Order of magnitude costs for land purchase; and
- Co-location potential with other industrial operations.

Along the course of the AAWDC Project development, several locations for the siting of the desalination plant were investigated by a Committee formed by His Excellency the Minister of Water and Irrigation. The original location of the AAWDC SWRO desalination plant (Figure 4-4 refers) was ultimately disregarded due to environmental concerns as the wider area is classified as an ecological reserve for diving and ecotourism.

Figure 4-4: Initial Location of SWRO Desalination Plant

Consequently, two other site locations for the desalination plant siting were investigated as follows:

- The second proposed location is shown in Figure 4-5 below. This site was found to be the most suitable site from an organizational and environmental point of view as it is situated within the industrial zone.
- A third location was also investigated, requiring leasing a site on the property on which the power station owned by Aqaba Development Company, the National Electricity Company (NEPCO) and the Central Electricity Generating Company (CEGCO) is located. The major advantage of this site was the ability to use the existing cooling water intake of the Aqaba Thermal Power Plant as the intake system for the desalination plant. Another potential advantage would be combining the cooling water discharge from the power station with the concentrate from the desalination plant to dilute the total dissolved solids (TDS) of the combined discharge. These options were disregarded after further discussions with the Central Electricity Generating Company.

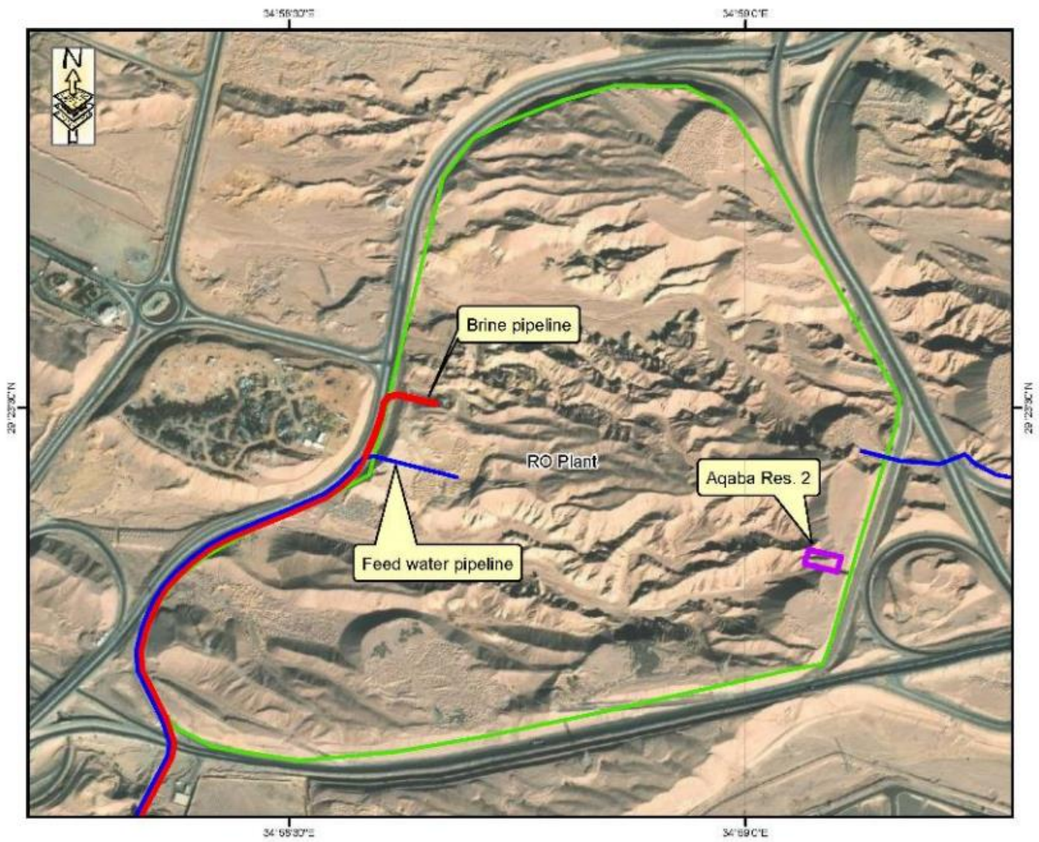

Figure 4-5: 2nd Proposed Location of SWRO Desalination Plant

The preferred and finally selected site (Figure 4-5 refers) is in the industrial area constructed in 2010 south of Aqaba city (at approx. 16 km distance), and is surrounded by several highways. The site occupies a surface area of 100 ha.

4.3.2. Water Conveyance Component

The studies of the conveyance components have mainly focused on laying the conveyance parallel to the existing Disi pipeline, to avoid changes in existing land use and land acquisition as much as practically possible. Even though a large part of the pipeline will run parallel to the Disi pipeline, other parts will be laid within public roads ROW. On the other hand, a small part of the alignment will be laid on private lands.

The Project design team has studied alternative alignments in the South Amman area adjacent to Queen Alia International Airport (QAIA) and Al Jeza municipality to ensure that the selected pipeline alignment is optimized in terms of costs, ease of construction, reduced interference with other existing services and reduced impact on the commercial activities in the area during construction. To achieve these objectives, four alternative alignments were considered. These are shown below in Figure 4-6. A description of each alternative is presented below.

Alternative 1:

This alignment runs to the east of QAIA away from main roads and urban areas. It crosses the Hijaz Railroad at 1 location. The pipe will run mainly along water courses and planned or existing tertiary roads and /or along boundaries between private plots. The rationale for this alternative is to expropriate for a service road along the alignment. Once the service road land is acquired, the pipeline can run adjacent to the road within the expropriated ROW. The length of this alternative is about 25 km.

Alternative 2:

In this alternative, the pipeline will run in as much as possible along existing roads to the east of QAIA; however, few stretches may need expropriation for a service road. It crosses the Hijaz Railroad at 1 location. The length of the pipe in this alternative is about 30 km.

Alternative 3:

This alternative will run about 7.2 km along the existing Amman Aqaba Highway and about 1.3 km along a service road to the east of the highway before it joins the alignment of Hijaz RR for about 14 km until it intersects with Sahab Road. To reach the pump station site, the pipeline needs to run along Sahab Road for about 4 km. The total pipe length along this alternative is about 26.5km. The main advantage of this alternative is the relatively short length (26.5 km) as compared with Alternative 2; however, the main disadvantage is that a service road will still be needed with the pipeline running along Hijaz Railroad incurring an annual fee of JD 70/m for using the ROW of Hijaz Railroad.

Alternative 4:

In this alternative, the pipe will run along Amman Aqaba Highway and has to cross along Al Jeza city commercial area, heavily congested with services particularly the Disi pipeline of diameter 1,600 mm and Hasa pipeline of diameter of 800 mm. It must also run along the airport highway eastern service road. There are several construction issues along this alignment and it is doubtful that a 2.2 m diameter pipe can be laid without encroaching the highway, adjacent buildings and shops or both. To avoid and stay away from these services and pipelines, the pipe alignment may have to be shifted either into the highway or into the road or adjacent private property. This alignment is about 30 km long.

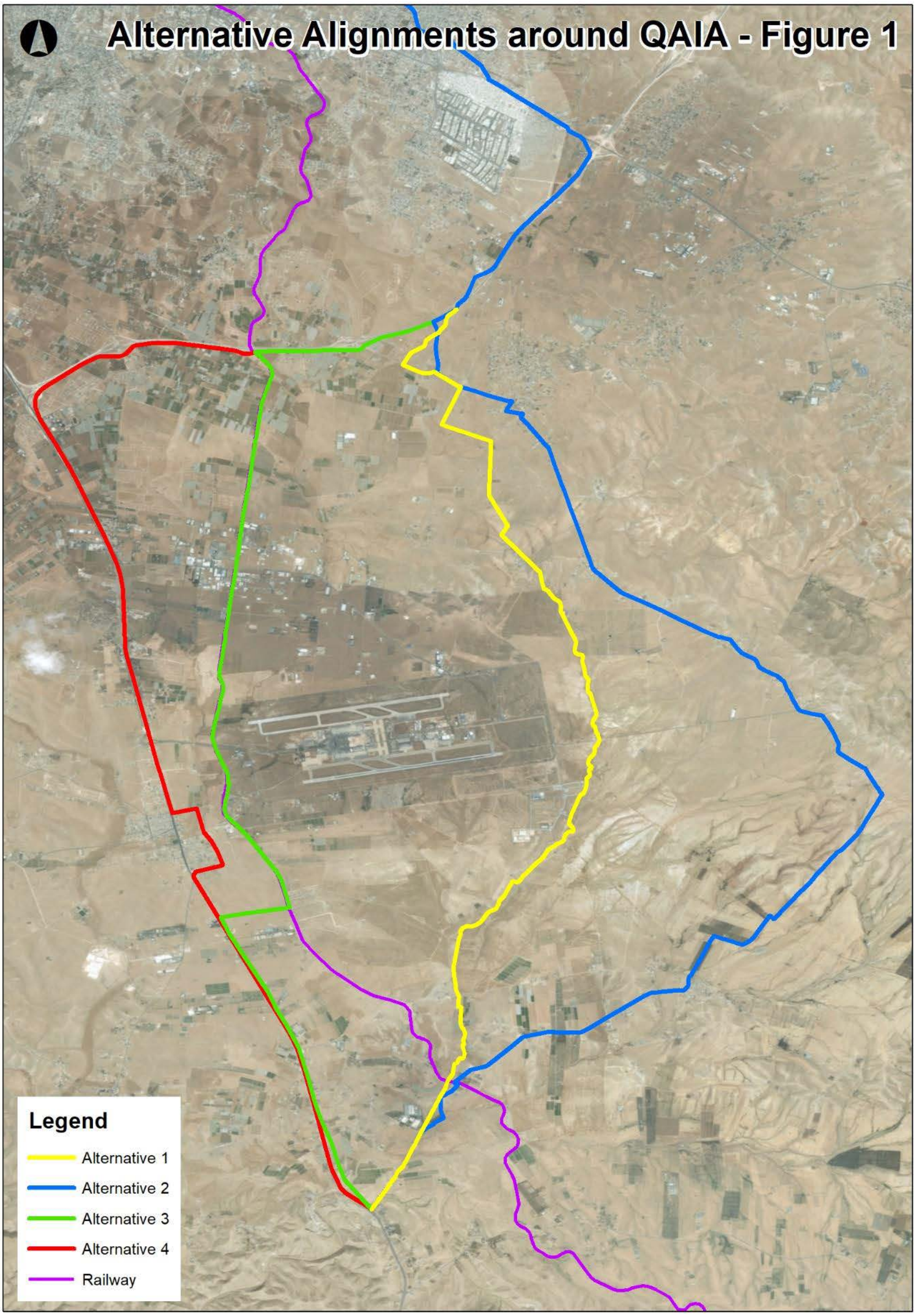

Figure 4-6: Alternative Alignments around QAIA (Source: CDM Smith)

Conclusion

A summary of the alternative analysis undertaken for these four routes by the design consultant is presented below:

- Alternative 1 is the least expensive but requires expropriation probably through MPWH.
- Alternative 2 is about 17% more expensive than Alternative 1 and will require expropriation through MPWH.
- Alternative 3 is the most expensive and this is mainly due to the Hijaz Railroad fees. If these fees can be waived, this alternative would become attractive.
- Alternative 4: This alternative will have impacts on traffic, adjacent utilities and commercial activities and was not recommended to adopt.

As a result, Alternative 2 was selected as it had a relatively low cost and did not require significant land expropriation.

4.4. Technology / Process Alternatives

4.4.1. Water Desalination Component

4.4.1.1. Intake and Outfall Systems

In parallel with the development of this Project ESIA study, the ESIA team worked on the pre-feasibility assessment of alternative options related to the marine works for the intake system and the brine marine disposal with the aim of recommending a solution that combines the best possible performance from an environmental, technical, and financial/economic perspective. It is noted that the Preliminary Design for the Intake and Outfall Systems dated September 2021, which will be included in the BOT Tender Documentation (RFP) as information only, has already taken into consideration the vast majority of ESIA recommendations emanated from the above-mentioned pre-feasibility assessment.

4.4.1.1.1. Intake System

More specifically, for the intake system, the following alternative options were examined:

1. Seawater Abstraction Type
2. Intake Fouling Control
3. Intake and Outfall Material
4. Intake Abstraction Depth

These alternatives were assessed on the basis of identified constraints for the AAWDC Project and recommendations were drawn in terms of technical and environmental advantages and disadvantages as well as capital and operational economic considerations.

Further, for both intake and outfall systems, an assessment was undertaken relative to construction materials and in particular (a) High Density Polyethylene (HDPE) with concrete ballast collars, (b), Glass Reinforced Plastic (GRP) pipes, and (c) Concrete Tunnels.

Similarly, these alternatives were assessed on the basis of identified constraints for the AAWDC Project and recommendations were drawn in terms of technical and environmental advantages and disadvantages as well as capital and operational economic considerations.

The following tables provide a concise overview of the key advantages and disadvantages and resulted recommendations thereof vis-à-vis the identified AAWDCP constraints for each of the above mentioned examined alternatives.

Table 4-2: Key Advantages and Disadvantages and Recommendations Relative to Seawater Abstraction Type Options

Intake Towers	Passive Screens	Shore Intake Channel
Key Advantages: The key advantage of intake towers is that they have so many references for SWRO projects. With only a few exceptions, the vast majority of large SWRO projects use velocity cap towers for seawater extraction. Typical examples of such SWROs which are sized over 100,000 m^3/d are: • All the Australian SWRO projects: Brisbane, Perth 1 & 2, Sydney, Melbourne, Adelaide. • All the Algerian SWRO projects: Hamma, Magtaa, Mostaganem, Beni Saf, Skidda, Hounaine, • All the Israeli SWRO projects: Ashkelon, Hadera, Sorek, Ashdod, Palmachim. **Key Disadvantages:** The key disadvantages of intake towers with regard to the identified AAWDCP constraints are: • Operational: The screens need to be cleaned by divers on a regular basis to remove seaweeds, barnacles and mollusks. This requires the intake tower to be located in water with depth of preferably less than 20 m to allow enough dive time for the divers to clean the towers. • Operational: The towers need to be adapted for the pigging system of the intake pipes. Pigging systems used must not discharge the removed shell debris from the intake pipes into the tower. • Construction: Intake tower structures become very large for mega sized SWRO desalination	**Key Advantages:** The key advantages of using passive screens are: • Environmental: The screens because of their smaller aperture (5mm) will exclude more marine fauna from entrainment compared to 75-100mm aperture screens of an intake tower solution. • Environmental: No requirement for land disposal of screenings. • Construction: The screens can eliminate the need for fine screening on the shore which are normally used to protect the intake pumps and the SWRO pretreatment. This provides some room for additional equipment, although air blast compressors and receivers will need to be provided. There is potential to direct couple the intake pumps to the intake pipes, and eliminating the wet well of an intake pump station entirely. • Construction: No need for very large and heavy concrete intake towers and their extremely heavy lift capacity requirements, the passive screens can be attached to the top of the intake pipes. • Operational: Less vulnerable to jellyfish swarms blocking screens because it can use air burst facility to remove jelly fish. **Key Disadvantages:** • Environmental: The copper is toxic to the marine life hence, this is why it is effective for inhibiting marine fouling, but it also gradually	**Key Advantages:** • Construction: No intake pipes or intake towers are needed; this is a major consideration in e.g., the UAE where it can require distances from the shore of greater than 6 km to achieve seabed depths of equal or greater than 10 m which are typically used for seawater intake towers. This is not an advantage for the AAWDC project where seawater depths of equal or greater than 12 m can be achieved at distances of approx. 140 m from shore. • Operational: Cleaning of intake screens and intake pipes is not required, however accumulated sand/ silt still will need to be removed from an intake channel by periodic dredging. • Environmental: Less excavation is required than that of an intake tower solution. The excavation for the intake channel will be similar to that required just for the surf zone of an intake pipe solution. **Key Disadvantages:** • Operational: Very serious risk of hydrocarbon oil pollution at this location due to the phosphate loading ships and from other shipping traffic passing along the part of the gulf of Aqaba. This is a critical issue for a shore intake. • The SWRO plant could incorporate Dissolved Air Floatation (DAF) in the pre-treatment step for some oil removal; however DAF technology

<table>
<tr><th>Intake Towers</th><th>Passive Screens</th><th>Shore Intake Channel</th></tr>
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<td>plants. These need special heavy lifting barges and multiple towers are needed to reduce individual tower size for the largest SWRO plants.
• Operational: The large apertures of tower face screens can allow jelly fish to enter, if there are jelly fish swarms then these can block the fine screens on shore. Mitigation for jelly fish can be achieved by using temporary nets or air bubble curtains around the intake towers.
Recommendations:
A velocity cap tower intake solution is the most widely adopted and proven solution for SWRO seawater abstraction. The operation of such a tower is considered to be pre-feasible provided the following conditions are achieved:
• The intake tower shall be located at a seawater depth of equal to or greater than 12 m.
• The intake window lower sill shall be at least 3 m above the seabed to minimize sand and silt entrainment.
• The top of the intake tower window shall be at least 5 m below the seawater surface (MSWL) to minimize the potential of the entrainment of surface pollution, particularly oils.
• In addition, for environmental protection, the following shall be achieved:
- A horizontal velocity cap design type of intake shall be selected (if intake tower is used).
- The through screen velocity shall be less or equal than 0.15 m/s with all intake towers in</td>
<td>corrodes and enters the marine environment in small quantities, which is not desirable.
• Operational: Because of the gradual corroding screens mesh material of the passive screens, it should be anticipated that the passive screens may need replacement during a BOT scheme SWRO concession life.
• Operational: Additional diver cleaning of screens would be anticipated for these screens, more than would be anticipated for velocity cap screen designs.
• Operational: The pigging arrangements are more complicated and time consuming, as it more difficult to isolate each passive screen from the intake manifold pipe.
• Operational: A 200 mm, HDPE Air blast pipework needs to be provided and maintained externally of the intake pipe for each of 9 to 14 or more screens or alternatively an underwater electrically actuated valve is provided for each screen from a common air blast cleaning pipe system
• Operational: An exclusion zone must be provided above passive screens because the air blast system when active would remove the buoyancy of any boat.
• Construction: Residual air entrainment from the air blast cleaning into the intake pipe needs to be designed to be avoided or released to prevent reduction in hydraulic capacity of the intake pipe. Air entrainment would be particularly important if the intake pumps are directly coupled to the intake pipes.</td>
<td>suppliers do not guarantee performance for the removal of oils.
• Operational: Shallow intake channels abstracting water at the shore will be likely to have higher suspended solids from seabed fine sand and silt.
• Operational: If there are jelly fish swarms then these can block the fine screens on shore. Mitigation for jelly fish can be by using temporary nets or air bubble curtains around entrance of the intake channel.
• Due Diligence: Lack of reference of SWRO with shore intake channels with no DAF. This is a critical issue for a shore intake solution selection.
Recommendations:
A shore intake channel is not recommended for the AWDDC project for the following reasons:
• There is high a risk of oil surface contamination of the seawater from the top surface layer of seawater. This could cause large loss of availability. This is of particular risk at this location due to the proximity of the phosphate loading ships and power plant oil transfer jetty.
• There is, at this time, a lack of operation references of large SWRO plants with shore channel intakes. There are only two major plants, both in the UAE, that are constructing shore intake channels. However, these plants also use Dissolved Air Floatation before dual media filtration (DMF). Most of the large BOT SWRO projects in the Red Sea are using only single stage DMF with no DAF.</td>
</tr>
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<table>
<tr><th>Intake Towers</th><th>Passive Screens</th><th>Shore Intake Channel</th></tr>
<tr><td>service, the screens clean, and at the ultimate SWRO capacity of 300 MCM/y.
- The intake screens shall have an aperture hole size of less than or equal to 75mm.
- For protection against hydrocarbons spill events, an oil detection system and an alarm system should be installed at the IPS or intake towers seawater quality monitoring buoy. The plant should subsequently shut-down when the set alarm level is reached. In addition, a floating barrier should be installed around the intake towers.</td><td>• Operational: Passive screens normally require currents of 0.30 cm/s to effectively carry away the screenings debris; such currents may not be reliably and constantly available at the AAWDC marine location. However, the screens could potentially be located where the seabed bathymetry starts to become steep, this should allow the screens to disperse by gravity downslope. From the bathymetry, a suitable location is where the seabed is 15 m water depth or deeper.
Recommendations:
The use of passive screens is considered to be also pre-feasible and shall be allowed to be offered by BOT Developers because it offers the potential to eliminate shore screening and also possibly direct intake pump coupling to the intake pipes, which could give a developer flexibility of footprint within the intake pump station. However, the sea current velocities in the area are low and the BOT Developers shall satisfy themselves with the passive screen suppliers that the currents are sufficient with the steep bathymetry of the intake location selected by the Developer to remove the screenings released by air blast cleaning systems.
If passive screens are to be provided, then they shall have the following features:
• Aperture size shall be less than or equal to 5 mm.
• Through screen velocity shall be less than or equal to 0.15 m/s with all screens in service and at the ultimate SWRO production capacity of 300 MCM/y.</td><td></td></tr>
</table>

Intake Towers	Passive Screens	Shore Intake Channel
	• Copper nickel alloys shall be used for mesh material, which inhibits marine biofouling. • Ability to air blast each passive screen automatically and individually shall be provided. • Means to isolate passive screens from intake pipes when an intake pipe is being pigged shall be provided if pigging is selected for intake pipes macrofouling control. • Passive screens shall be located where the seabed depth is at least 15 m so that the screenings can disperse away downslope. • The bottom of the screen must be at least 3 m above the seabed to minimise sand and silt entrainment. • The top of the intake screen should be at least 5 m below the seawater surface (MSWL) to minimise the potential for entrainment of surface pollution particularly hydrocarbons.	

Table 4-3: Key Advantages and Disadvantages and Recommendations Relative to Intake Fouling Control Options

Continuous Chlorination	Shock Chlorination	Pigging Systems
Key Advantages Continuous chlorination is a very effective method to maintain the hydraulic capacity of an intake pipe system. **Key Disadvantages** • Operational: Continuous chlorination results in the generation of readily biodegradable substrate from organic material in the sea. This results in very fast biomass growth on RO membranes referred to as RO biofouling and this requires very frequent RO CIPs and faster replacement of the RO membranes. • Operational: Intake pipes shall be designed with a means of pipe cleaning in the case that inadequate chlorine dose has been used. Higher continuous dosing of chlorine dosing will kill but will not remove barnacles that have already been developed. • Environmental: Chlorination results in the generation of mutagenic disinfection by-products (THMs), which end up being discharged to the sea. Chlorination should be avoided if this is technically possible. • Operational: Salt would be needed for the electrolysis and not seawater, to prevent scaling of the dosing line to the intake towers. • Economic: Power plant continuous chlorination facilities typically use seawater electro-chlorination. These facilities have significant capital cost of magnitude of 3-5 million USD at	**Key Advantages** • Operational: Less formation of readily biodegradable organics over continuous chlorination therefore lower biofouling of the RO membranes. • Operational: Lower consumption and storage of chlorine. • Environmental: Less generation of unwanted THMs. **Key Disadvantages** • Operational: The process does not stop the development of barnacles and other foulants, it only slows down their growth. The intake pipes will need eventually to be cleaned by divers or by pigging. • Environmental: THM formation and their discharge with the brine is still present albeit in lower quantities than continuous chlorination. This a very considerable environmental negative impact of chlorination irrespective of its type (continuous or shock). • Construction Footprint: Large quantities of sodium hypochlorite or chlorine gas have to be stored on site at the intake pump station area. This is difficult to accommodate with the limited footprint available, and chlorine gas has safety/security concerns considering that the intake pump station is located remotely from the main SWRO facility. • Operational and Environmental: Liquid hypochlorite dosing generally uses carrier	**Key Advantages** • Operational Availability: Mandrel pigs have proven to be very effective at restoring lost intake hydraulic capacity due to barnacle fouling for SWRO intakes (Ashkelon, Hadera, and Ghana). • Environmental: Can avoid the use of chlorine entirely for the intake pipe fouling control. Can avoid the generation of chlorine generated THMs. • Operational and Environmental: Can avoid large high purity hypochlorite storage. **Key Disadvantages** • Construction: Shore facilities to launch the pig are needed such as 5-10 ton crane for pig and launcher and motive pipe work from the intake pumps. Such cranes are, however, commonly provided for intake pump stations anyway. • Operation: Potential loss of availability if no source of motive seawater provided in design to push the pig. However, two intake pipes could be allowed to operate with high velocity (and associated higher head loss) to provide full production capacity and motive supply for pigging. • Operation: Divers are needed on shore and in the sea during pigging operations for the following activities: i) attach pig launcher to intake pipe; ii) connect motive pipework to the pig; iii) open pig outlet in the sea; iv) close

Continuous Chlorination	Shock Chlorination	Pigging Systems
this scale, and consume power, salt, and permeate.	water. However, when seawater carrier water is used, the high pH of the hypochlorite causes scaling of the dosing pipe. RO permeate is usually needed as carrier water; this will not be available because the SWRO plant is 3 km from the intake pump station. High purity hypochlorite would need to be dosed. • Environmental: The small dosing pipelines of neat hypochlorite can be vulnerable to damage and leak to the marine environment. This should be mitigated with double containment of the dosing lines. • A shock chlorination regime would slow the rate of macrofouling of the intake pipes but it should be anticipated that pig/manual diver cleaning of the intake pipes would still be required every 1 to 3 years or more frequently.	intake tower sea inlet pipe; v) retrieve pig from the sea; and vi) remove pig launcher. • Environmental: When a pig exits the intake pipe it pushes out into the sea the marine barnacles/ mollusks wall slime, etc. that have been scraped off the inside pipe wall; this causes a spike of silt/shell debris turbidity in a small region of the exit area of the pig. This material settles very quickly (in 15-30 mins) and water clarity is restored. Because of the short duration, this not considered as a significant environmental concern.
Recommendations for Intake Fouling Control		
• Chlorine used for pre-treatment and the intake pipelines barnacle fouling protection shall be avoided by the Project if it is technically and long term operationally possible to maintain the intake pipeline hydraulic capacity by other methods such as diver's manual cleaning and/or mechanical pigging. This is to prevent chlorinated disinfection by products such as Trihalomethanes (THMs) entering the marine receptor with the brine. It shall be noted that although residual chlorine itself can be eliminated from the brine at the SWRO plant by using de-chlorination chemicals such as Sodium Bisulphite (SBS), the use of chlorine generates carcinogenic by-products THMs which cannot be eliminated from the brine with dechlorination through SBS and would end up discharged into the marine environment with the RO brine. • If chlorination is technically deemed essential for intake pipeline macrofouling control, full de-chlorination of any shock chlorinated, or continuous chlorinated, or pulse chlorinated seawater shall be carried out before it is allowed to discharge to the bulk brine flow for outfall disposal. A zero-chlorine residual shall be achieved before discharge to the outfall. • **THMs should be monitored daily if chlorine is used for intake fouling control.** A**n end-of-pipe standard** for THMs shall apply to read 'Zero increase above limit concentration'. Where **the limit concentration for THMs** will **be** the **ambient measured THMs** concentration **multiplied by the plant concentration factor (at overall recovery).**		

Table 4-4: Key Advantages and Disadvantages and Recommendation Relative to Water Abstraction Depth Options

Seabed depth: - 144m	Seabed depth: at -12m to -20m
Locating the seawater abstraction at the seabed depth of -144 m was considered for the RSDS project to reduce plankton entrainment. This depth is not considered pre-feasible for the AAWDC Project due to the following considerations: • The intake tower screens must be cleaned of macrofouling regularly by plant operations. This cannot not be achieved safely at depths of -144 m without the use of very specialized deep saturation divers equipped with support ships. This is a critical feasibility issue. • The intake pipelines must be capable of being cleaned of macrofouling (barnacles/mollusks, etc.). The use of continuous chlorination to prevent macrofouling can fail due to underdosing chlorine and scaling of dosing lines. All intake pipe lines must have procedures to manually or pig clean intake pipes of macrofouling. It is considered that it is not safe to do so 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. This is a critical prefeasibility issue. • Most desalination plants have intakes with seabed depths of 10-20 m, there are no SWRO plants with intake depths > 30 m. The construction and operation of such large intake pipe pipes and 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 by lenders technical advisors, and would fail technical due diligence for project investment. This is critical prefeasibility issue. • The location of the intake at -144 m will require 650 m of trench with 12-15 m bottom width 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. • Building a tower at the 120-140 m option is not considered possible, which may allow large organisms to enter the intake pipelines resulting in both environmental loss and operational problems.	Locating the seawater abstraction at a seabed depth of at least -12 m provides a pre-feasible solution for the seawater supply of the AAWDCP SWRO plant that respects the physical and environmental constraints of the project location. The key benefits of depth at ≥ -12m seabed location are: • Good seawater quality is available at a short distance of 140 m from the shore where the seabed depth is at least -12 m. • The short intake location reduces the intake pipe trench requirements for the intake and thus resulting in less disturbance of the benthic community. • 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 intake towers and intake pipes are at depths that can allow divers to have long dive durations for operational cleaning and maintenance without the need for decompression stops. • The short intake location avoids the path of docking phosphate ships, this facilitates construction and ensures operational safety. • Relatively flat ground is available for construction of the large intake towers, thus reducing disturbance of the seabed. • Large desalination plants with abstraction depths of ≥ -12 m have many references.

Seabed depth: - 144m	Seabed depth: at -12m to -20m
Environmental Considerations: • **Plankton entrainment including Coral Larvae: Both options will have negligible impact on a Gulf scale. Locally, both options will result in minimal plankton entrainment as compared to any depth in the range 30-100 m. Mitigation of Coral Larvae entrainment at Depth 10-20 m is simpler and more practical than at 120-140 m depth.** • **Dredging through reef structure and bottom habitat disturbance: Evidently, the deeper seabed depth option will result in increased dredging through reef structure and subsequently increased bottom habitat disturbance.** • **Primary Productivity: Both options will have negligible impact on a Gulf scale. Locally, the 120-140 m depth option will result in higher loss of nutrients from the relatively nutrient rich layer just below the euphotic zone, which feeds nutrients to the bottom of the euphotic zone during the summer stratification conditions. The upper 20 m of the water column is almost depleted of nutrients during the summer stratification period. During winter mixing the two options have similar impact.** • **Larger species entrainment: The 10-20 m option will allow building an intake tower which will be designed to deter and repel fish from entering the intake pipeline. Building a tower at the 120-140 m option is not considered possible, which may allow large organisms to enter the intake pipelines resulting in both environmental loss and operational problems.**	
Environmental Remarks: • The AAWDC Project differs considerably from that of the RSDS concept. The intake for the RSDS was from a gently sloping natural habitat at the northern tip of the Gulf of Aqaba while the AAWDC concept intake is at 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. • On the Gulf of Aqaba scale seawater abstraction for the AAWDCP is expected to have no significant impact 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. Also 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, presenting a 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 all its deterring cost and difficulties in operation and with all its technical difficulties to construct and to operate, would result in significantly less larvae entrainment than a shallow intake (10-25 m). Coral larvae entrainment in a shallow intake of less than 20m depth can be much more easily mitigated for than a deeper one sited at more than 120 m depth. • Modelling involved in suggesting a deep-water intake due to time pressure was not completed nor well calibrated and needed to be revised. Alternative modelling was conducted in 2017, but not included in the final RSDS ESIA study produced in June 2018. 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 120m intake, concerning plankton entrainment. The study also stated that it needed to be updated after the alternative modelling results are reviewed and cleared. 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	

Seabed depth: - 144m	Seabed depth: at -12m to -20m
200 m during the mixing period of the Gulf of Aqaba, as well documented in the international literature and demonstrated in this Report. During the stratification period, plankton concentration decreases significantly in the upper mixed layer (above 20 m) and exhibits a peak deeper than 30m, mainly between 50 m to 100 m depth.	

Table 4-5: Key Advantages and Disadvantages ;and Recommendation Relative to Intake and Outfall Materials

HDPE Pipes	GRP Pipes	Concrete Tunnels
Key Advantages: • Economic construction: The pipes have a high degree of flexibility allowing the pipes to be sunk into a prepared trench in steep seabed gradients. HDPE intake and outfall pipes can sometimes be laid directly onto the seabed or in shallow trench with correct ballast supports; it is often not essential to fully bury them except in the surf zone near the shore. The outfall pipe will need to traverse ground of very extreme slopes of up to 1:1, this outfall HDPE pipe work may need to be fully buried, and other ground anchoring methods may be needed. • Operation availability: Very good resilience to earthquakes. • Operation availability: Long strings of 300 m can be produced in factory with no mechanical connections. These will have lower risk of breakage during plant operation under seismic events and during pigging. Notably, in September 2020, 12 number 2.3 m OD pipes with lengths of 500 m-620 m passed through the Suez Canal on route to Bangladesh. • Environmental: Could be laid in deep water with a shallow trench with reduced excavation compared to full depth buried GRP pipe. • Operation availability: Solid wall type HDPE have a proven record for pigging cleaning with mandrel type pigs. **Key Disadvantages:**	**Key Advantages:** • Construction: Very large diameters can be made available locally from Saudi Arabia (up to 4m ID). • Construction: No concrete collars are required to sink the pipe. **Key Disadvantages:** • Construction: Pipes must be fully buried and the backfilling compacted properly to prevent any movement of the pipe. • Operational: GRP pipes do not have a history of marine pigging on SWRO desalination plants with large mandrel type pigs. ESIA team considers GRP flexible joints to be at risk of separation during a pigging event. Soft foam pigs may have been used on some power plant GRP intake pipes but these are not very effective for barnacle removal. • Operational: Joints that are made in the sea cannot be tested on land. Failure in service during a pigging event by operations is increased. • Operational: It is considered that there is significant risk of pipe separation at joints during earthquake. This is of particular concern given the very steep seabed required to be traversed for the outfall. • Construction: More demanding trench bedding and backfilling quality control requirements needed compared to HDPE. • Operational: Pipes are brittle and more subject to impact damage than HDPE and reverse impact cracking leading to softening of the fibres and pipe failure.	**Key Advantages:** • Construction: Marine sea and weather conditions do not impact the schedule installation of intake and outfall pipes. This is not a factor for consideration given the calm low current waters of AAWDC. • Environmental: Shoreline flora not disturbed, there would be considerable disturbance for the excavation needed to remove the tunnel bore machines from far below the seabed. **Key Disadvantages:** • Operational: It is considered that shallow marine concrete tunnels are vulnerable to damage from a major seismic earthquake. Repair of such marine tunnels after an earthquake may not be possible with potential for complete loss of plant availability. • Construction: There is not sufficient shore footprint available for the launch shaft, and tunneling facilities needed such as excavations separation and pipe storage. • Construction: Tunneling solutions have potential ground risk issues that the developers cannot mitigate without extensive time-consuming marine ground investigations. • Economic: Tunnel intake solutions are normally the most capital-intensive intake solution with costs circa 2-3 times that of

HDPE Pipes	GRP Pipes	Concrete Tunnels
• Construction Quality: Welding of pipe sections onsite requires skilled operation and quality control. The use of long strings that are factory welded and towed to site should be preferred. This is particularly important where pigging operations are intended where joints are potential points of weakness and should be minimized if possible. • Construction footprint: Welding strings of HDPE pipe on site requires large footprint availability for construction. This footprint is not available at the IPS site. The HDPE can however be supplied from the factory HDPE pipe string towed to site which would eliminate any need to construct long HDPE strings on shore		HDPE/GRP pipe in trench solutions for large capacity SWRO plants. • Environmental: The excavated material separation plant from the drilling slurry fluid requires a large footprint, which in addition to footprint of tunneling excavation shaft and operations would be difficult to accommodate on the allocated pump station location while pump station construction was also occurring.

Recommendations:

Intake pipeline material

The pipe material that is considered pre-feasible is HDPE. The core reasons are:

- The intake pipe must be designed to be suitable for pigging. Solid wall HDPE pipes have been proven to be suitable for pigging.
- HDPE pipe have proven to be very resilient to earthquakes.
- The pipes do not need to be fully buried; this reduces the environmental impact of excavation.

GRP pipes are not considered suitable for this intake application for the following reasons:

- There are major concerns that the GRP pipes could separate at the joints during an earthquake and would be difficult to repair because they will be fully buried. This would cause a major and long duration loss of product water availability.
- GRP intakes are considered high risk for intake pigging with mandrel pigs. Manual cleaning of the pipes will result in excessive loss of availability, soft foam pigs were not shown to be as effective as mandrel pigs.

Outfall pipeline material

The use of the HDPE pipes is considered preferable for the outfall pipes and is likely to be more favorable than a GRP solution because the seabed slope is very steep and the HDPE pipe is more flexible than GRP. However, GRP pipe solutions for the outfall shall be allowed to be offered by BOT Developer.

HDPE Pipes	GRP Pipes	Concrete Tunnels
Concrete marine tunnels are not considered feasible for the intake or outfall pipelines due to: • Suspected vulnerability to earthquakes, and inability to repair damaged marine tunnel. • Lack of the shore footprint to allow the tunnel launch shaft /facilities and pipe storage.		

4.4.1.1.2. Outfall System

In parallel with the development of this Project ESIA study, the ESIA team undertook a specific brine discharge risk assessment, which involved a detailed critical review of the key adverse impacts relative to brine disposal into the marine environment, proceeded in dispersion modelling of the brine discharge relative to the AAWDC Project and concluded in key recommendations relative to best practicable brine discharge standards relative to mixing zone rule and end-of-pipe standards as well as design features of the outfall system and the SWRO Desalination Plant for the AAWDC Project that ensure marine environmental protection. It is noted that the Preliminary Design for the Intake and Outfall Systems and the Preliminary Design for the Desalination Plant both dated September 2021, which will be included in the BOT Tender Documentation (RFP) as information only, have taken into consideration the vast majority of ESIA recommendations relative to brine discharge risk assessment.

Considering that the flora and fauna of the Gulf of Aqaba require the highest protection, it is essential that the outfall system to comprise high velocity diffusers that will be designed to enable very high dilutions in the near field mixing zone region. It has been assessed that this could be achieved through different configurations of the diffusers' section of the outfall system but due consideration of the following design principles:

- The diffusers design must achieve dispersion of the brine salinity to less than or equal to 2% above the ambient seawater salinity concentration at 100 m from the diffusers, in stagnant seawater conditions.
- Multiport diffusers shall be used.
- The diffusers design shall have a Froude number, F, equal to or more than 20, where F

  - F = Uo / (g1 - do)^0.5
  - Uo = Velocity of brine at the diffuser port
  - g1 = g*(ρo-ρa)/ρa
  - g = acceleration due to gravity
  - ρo = density of brine leaving the diffuser
  - ρa = density of the ambient seawater
  - do = diffuser port diameter

- The discharge angle of the diffuser port to the horizontal shall be 60 degrees.
- The diffusers' direction shall be orientated so that the brine plumes do not return to the diffusers. The diffusers can be back-to-back provided this is restriction is respected.
- The design of the diffusers shall ensure that the variation in flowrate due to diffusers laid at different depths shall not exceed 10% between the diffusers at the design flow to maximise brine dispersion.
- To prevent interference between the brine plumes of each diffuser, the minimum separation distance between the diffusers or (back-to-back diffusers pair) centrelines shall be in minimum 2 x do x F, where do is the diffuser port diameter (m), F is the Froude Number.
- The diffusers shall be located at a seawater depth that ensures a gap of equal to or more than 5m between the maximum height of brine plume rise above the diffusers and the seawater surface is achieved. The maximum brine plume height above the diffusers being calculated as 2.25 x F x do, where do is the diffuser port diameter (m), F is the Froude Number.
- The diffusers must be located in seawater depth that is at least 5m deeper than that at the closest intake tower location.

More specifically, a configuration for the diffusers manifold parallel to the shore and located at the same isobath where the seabed depth is -50 m, opposite to the phosphate jetty, with the diffusers discharging towards the deeper bathymetry was assessed by the ESIA team for a former Project capacity of 250 MCM/year (Figure 4-7). Near field and far field dispersion modelling confirmed that the mixing zone rule requirements were achieved, further dilution of brine plume occurred in the far field zone, and no recirculation occurred to the intake system. The same assessments were undertaken for the target Project capacity of 300 MCM/year and the outfall configuration comprised in the Preliminary Design For the Intake and Outfall Systems dated September 2021 (Figure 4-8), which resulted in alike results of the near field and far field modelling undertaken by the ESIA team.

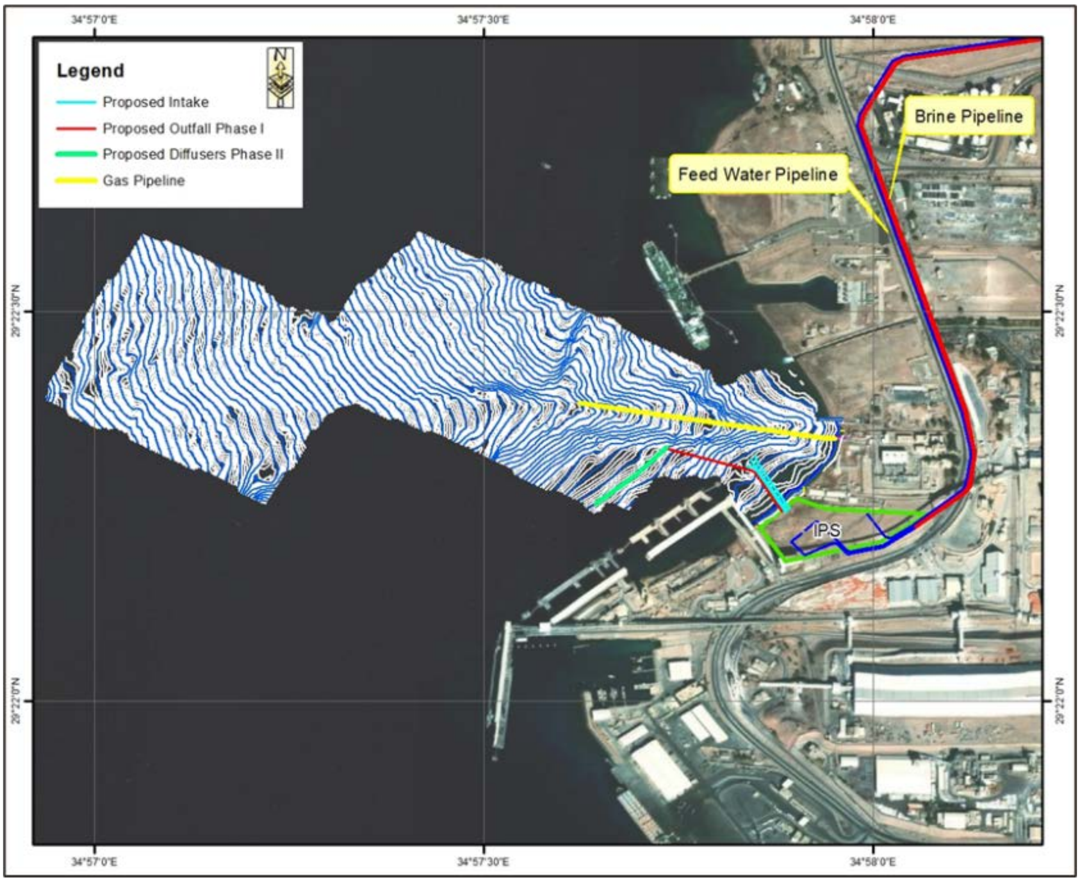


Figure 4-7: ESIA Pre-feasible Intake and Outfall Locations – Diffusers Manifold Parallel to the Shore

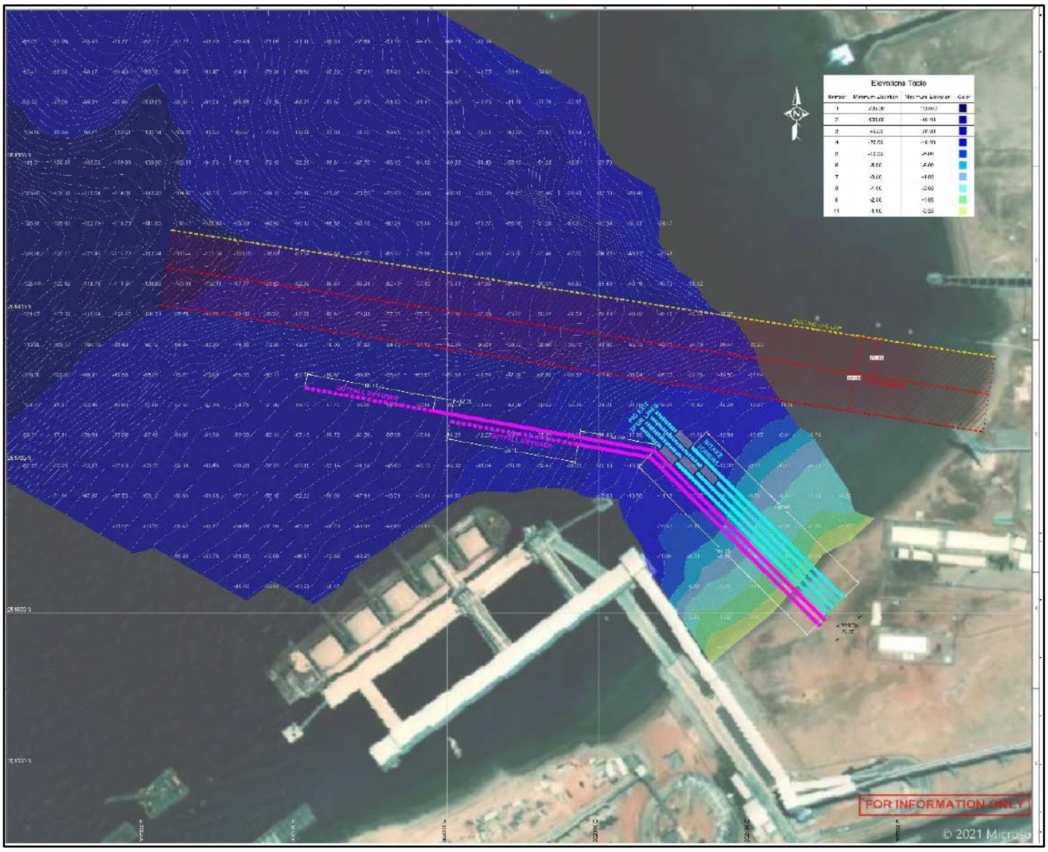


Figure 4-8: Layout of Marine Works as per the Preliminary Design Dated August 2021 – Diffusers Manifold Perpendicular to the Shore [8]

Conclusively, it is noted that the BOT Developer's detailed design shall be allowed to select (a) specific locations for the intake and outfall pipes; (b) intake tower sizes, (c) pipe sizes, (d) diffuser number and sizes and respective works provided that the Project constraints in Section 2.9.2.1 of the Project ESMP appended as a standalone document to this ESIA study are accounted for and all requirements in Section 2.9 of the Project ESMP are achieved.

4.4.1.2. SWRO Desalination Plant

Seawater desalination is a worldwide acknowledged means of dealing with natural water resource scarcity and satisfying increased water demand, with a long history in Middle East and Mediterranean countries, and continuously expanding capacities in the coastal areas of the Middle East Northern Africa (MENA) region, United States, Australia, and European countries.

The desalination technology to be used for potable water production under the AAWDC Project has been agreed and fixed among the key Project stakeholders. Seawater Reverse Osmosis (SWRO) was preferred over thermal desalination, given (a) the gradual preference of the SWRO over the thermal desalination processes in recent years due to its lower capital and operating cost and improved environmental footprint, and (b) the importance and high ecological value of the ultimate receptor, i.e., the Red Sea.

It is noted that for the purposes of conducting the conceptual / preliminary design for the AAWDC Project, which will be procured under a BOT scheme, the assigned Project design team (CDM Smith) studied different process alternatives for the target SWRO desalination plant in order to select preferred treatment option(s).

The SWRO treatment involves three (3) key process areas, namely pre-treatment systems, RO systems, and post-treatment systems with the following operational characteristics:

- **Pretreatment:** The pretreatment system aiming at ensuring that high quality water is fed to the RO system, in order to protect the RO membranes from accelerated fouling, breakage or obstructions, allowing for optimized performance of the membranes. Hence, pretreatment focuses on the removal of particulate, colloidal, organic and microbial foulants existing in the feed water.
- **RO System:** The main target of the RO system is to reduce the concentration of dissolved solids from the seawater, including TDS, sodium, chloride, and boron, among other constituents. To achieve this separation, water is pumped at high pressure through semipermeable membranes in the RO system, producing a high purity permeate for use, and a concentrated brine stream for disposal.
- **Post-treatment:** This system serves to provide disinfection and stabilisation of the RO permeate, increasing the pH, hardness, and alkalinity and producing a finished water that continues to meet drinking water standards throughout the transmission and distribution systems.

In outline, the examined process alternatives per key process area involved the following:

1. **Pre-treatment**

The following technologies were examined for the clarification process step that might be needed prior to filtration:

- Sedimentation; and
- Dissolved Air Flotation (DAF)

The assessment concluded that in locations where there is a low probability of red tide occurrence (i.e., harmful algal blooms), such as the Gulf of Aqaba, and relatively low concentrations of suspended solids and silts, the pretreatment can be designed with no clarification process step and rely solely on a direct filtration step upstream of the RO system.

Further, the following technologies were examined relative to the filtration process step which is needed prior to the RO system to remove particulate, colloidal and some of natural organic matter present in seawater and protect the RO membranes from fouling.

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

The assessment concluded that the gravity filtration and membrane filtration are both acceptable pretreatment options for the AAWDC Project.

The BOT developers will be allowed to include either of these options (gravity filtration, membrane filtration, and dissolved air flotation) as pre-treatment process step in their detailed design.

2. RO system

A typical RO system comprises a high-pressure pump (HPP), RO skids, and energy recovery system. The following options were examined for the RO units:

- Single pass RO
- Two pass RO

The assessment concluded that based on preliminary projections of boron removal and current Jordanian Drinking Water Standards, a single pass RO configuration can achieve the set drinking water standards, is easier to operate, and is much lower in CAPEX and OPEX than a two pass RO system.

Regarding the energy recovery system, two technology types were assessed:

- Isobaric ERD Systems, and
- Centrifugal ERD Systems (Turbocharger)

The assessment of advantages and disadvantages suggested that the isobaric PX system is preferable to be used as the energy recovery system for the purposes of the Project due to its higher efficiency compared to the turbocharger, which will result in significant OPEX savings for the target capacity SWRO desalination plant.

3. Post-treatment

The post-treatment process step comprises remineralization, pH adjustment, and disinfection of desalinated water to achieve the legally required treated water quality standards and to protect the integrity of the water conveyance system.

The following remineralization and pH adjustment alternatives, which are typically used to the majority of SWRO desalination plants worldwide, were assessed:

- CO2 + Lime slurry dosing; and
- CO2 + Calcite contactors.

The assessment of advantages and disadvantages suggested that calcite contactors are preferred as a conservative planning solution over the lime saturators despite their higher CAPEX and larger footprint. This is because they are a proven technology, with lower O&M costs and easier operation, that produces more stable finished water quality with lower turbidity levels.

Regarding disinfection, the following technology options were assessed:

- Use of chlorine gas
- Use of sodium hypochlorite

The assessment concluded that the use of chlorine gas, complemented with pollution prevention equipment and emergency response procedures and equipment, is preferred to the use of bulk sodium hypochlorite solution at commercial concentrations, due to the availability and lower price of chlorine gas in Jordan, and inherent risk of sodium hypochlorite to decompose when exposed to elevated temperatures and sunlight. However, both options are technically acceptable and the BOT developers will be allowed to include either option in their detailed design.

Conclusively, it is noted that the BOT Developer's detailed design shall be allowed to select between various process configurations provided that the requirements set out in this ESIA study and its associated Project

ESMP that is appended as a standalone document are achieved and so be the other Project performance provisions as set out in the BOT Tender Documents (RFP).

4.4.2. Conveyance Components

The construction materials for both civil works construction and pipelines comprising the AAWDC Project are based on the results of preliminary geotechnical investigations and other duty factors that will be confirmed by the BOT Developer during their detailed design.

Although the ultimate selection of construction and piping materials lies with the BOT Developer, materials will conform to the technical specifications that will form part of the tender dossiers / Request for Proposal (RFP). It is noted that equipment, materials, components, and functions will be designed, built, rated, and tested per the latest edition, applicable, international codes and standards, as well as any local requirements and codes.

The governing codes for the Project will be as follows, and in no case will the strength, serviceability, or quality standards for materials and procedures be less than that required by the following institutions and codes in their most recent editions:

- Jordanian Building Codes – Ministry of Public Works
- Loads and Forces Code
- Site Investigation Code
- Foundations and Retaining Walls Code
- Building resistance due to earthquakes loads, 2005
- British Standard Codes of Practice – British Standard Institute – UK
- AASHTO Standard Specification for Highway Bridges Codes and Standards

Where the provisions contained or referenced in the technical specifications differ from those in the governing code[s], the design will be performed per the most stringent requirements.

The complete list of standards to which the Project design and construction should conform will be part of the tender dossiers to the BOT developers.

Pipe Material

For the AAWDC project, several pipe materials were considered by the Design Consultant, CDM Smiths. These are Steel, Ductile Iron (DI), Glass Reinforced Plastic (GRP) and Pre-stressed Concrete Cylinder (PCCP). The materials were analyzed based on several considerations including cost, market availability, strength, durability, ease of repair and possibility of partly manufacturing in Jordan. Although High Density Polyethylene (HDPE) pipelines need to be towed by sea from North Europe as they are not available in Jordan and there is no manufacturing facility in the Middle East, the CDM Smiths report proposed to use HDPE or GRP pipes for the sea water intake pipes and the marine outfall.

The abovementioned five (5) pipeline materials were assessed for various environmental categories to the extent possible, such as Global Warming Potential (GWP), ozone layer depletion, ecotoxicity, and energy consumption during production, transportation, and installation phases for each pipe material. The assessment was mainly based on a review of the scientific literature and its findings are presented in this section.

The following activities are usually considered in each phase:

- Production: raw materials such as steel, polyethylene, iron, limestone, cement, synthetic fibers, etc), pipe manufacturing equipment (extruder for plastic pipes, castings, etc.), protective coatings for pipes (bitumen glue, cement mortar, zinc)
- Transportation: Transportation distance, type of vehicle used, amount of fuel consumed
- Installation: Use of excavator for trench excavation, roller for compaction, materials required in trenches (sand, gravel, concrete)
- Use: Friction losses during transmission, maintenance and repair

The following flowchart illustrates the system boundary of the abovementioned phases including a series of activities carried out in each phase (Figure 4-9).

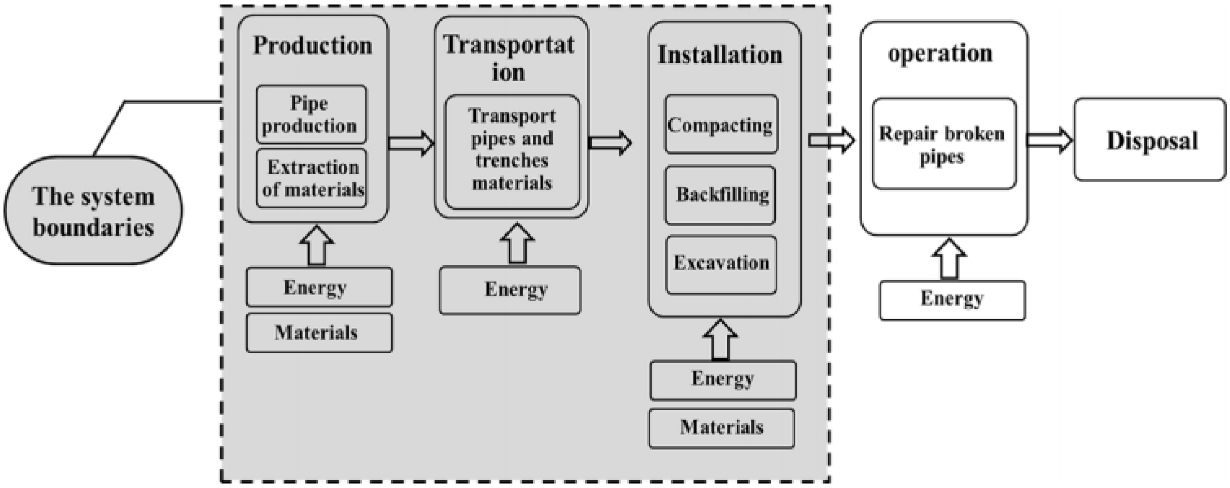


Figure 4-9: System Boundary for Environmental Consideration [9]

In an effort to assess the environmental impacts of various pipe materials, several studies used the Life Cycle Assessment (LCA) method. The LCA is a compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14044:2006). For example, [10] performed a comparative LCA for four different types of pipe materials namely composite fiber reinforced polymer (FRP) also known as GRP, polyvinyl chloride (PVC), DI, and concrete. The studied environmental impacts were quantified for all pipe materials in terms of "ozone layer depletion", eco-toxicity", and "energy consumption" at different life cycle stages. When comparing all stages in terms of environmental impacts, the results showed that the production stage has the maximum impact on different environmental categories for all four studied materials. Moreover, the results presented in Figure 4-10 (a) demonstrate that the most harmful material to produce pipes is DI. In fact, the production of DI pipes has an impact on almost all categories except for ecotoxicity whereby the production stage of concrete has the highest impact on this category.

Even though the production of DI pipes has a significant negative impact on ozone layer depletion, FRP or GRP production stage is considered as the most impactful stage on ozone layer depletion due to the use of polystyrene and generation of hydrochlorofluorocarbons (HCFCs). As an overall conclusion, the production of FRP (or GRP) pipes also has a significant environmental impact but is much lower than that for DI. In addition, the impact of ecotoxicity was found the highest for the production of concrete pipelines [10]. In order to assess the effect of the production process of each pipe material in the various environmental categories, the single scores of the production phase of different pipe materials was calculated. This score is calculated as the weighted average of each environmental category over all other categories. The obtained single scores are presented in Figure 4-10 (b).

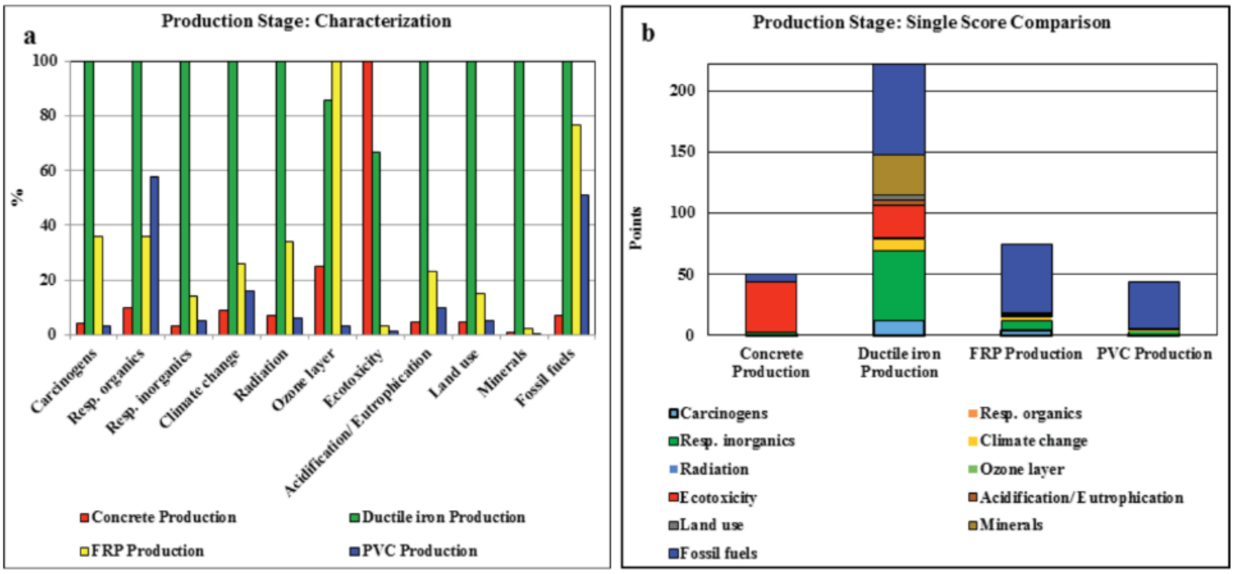


Figure 4-10: (a) Characterization Graph for Production Stage Comparison for all Piping Materials, (b) Single Score Graph for Production Stage Comparison for all Piping Materials. [10]

From the obtained single score results on concrete pipes production stage (Figure 4-10 (b)), it can be noted that the main environmental impact categories are ecotoxicity and use of fossil fuels with a higher score of ecotoxicity (90%) compared to that of fossil (around 10%) [10]. Ecotoxicity was further confirmed by other studies assessing the potential release of heavy metals and other toxic inorganic compounds found in cement, a primary raw material used for the production of concrete pipes, into the environment [11]. As for DI pipe production, the distribution was as follows: 35% impact on fossil fuels, 28% impact on ozone layer and around 13% impact on eco-toxicity. On the other hand, the production of FRP (or GRP) pipes has the single largest impact in terms of use of fossil fuels with a significant percentage of around 75% [10].

In the same study a comprehensive comparison of the life cycle stages for the four different pipe materials was conducted and the obtained results indicate that the life cycle of the DI has the highest impact within the various environmental categories. The scores of the life cycle of different pipe materials were also calculated and are presented in Figure 4-11. The study concluded that DI life cycle primarily has around 35% impact on fossil fuel consumption. As for the life cycle of FRP (or GRP) pipes, the results presented in the figure indicates that the single largest impact was on fossil fuels with a considerable percentage of around 75%. In general, it can be noted that the impact on fossil fuel consumption from the life cycle of DI, PVC, and FRP pipes is dominant and that eco-toxicity is the most impactful category in the life cycle of concrete piping materials [10].

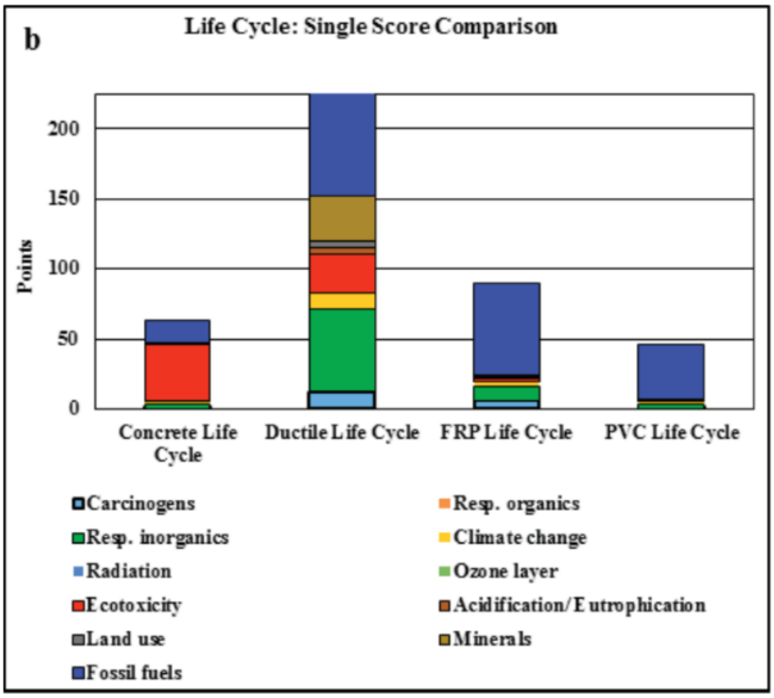


Figure 4-11: Characterization Graph for Life Cycle Comparison for all Piping Materials, b) Single Score Graph for Life Cycle Comparison for all Piping Materials. [10]

Another study conducted a LCA on six commonly used types of water and wastewater pipe materials namely PVC, DI, cast iron, HDPE, concrete, and reinforced concrete or PPCP to assess their impacts in terms of GWP during the different phases including pipeline production, transportation, installation, and use. The GWP values in units of equivalent CO_2 emissions per km of pipeline were compared for the six pipeline types. The results indicated that DI pipes contributed the greatest addition to GWP among the six kinds of pipe materials. Concrete pipes had the lowest GWP, despite the energy demand associated with cement production. The results also indicated that HDPE contribute to GWP more than reinforced concrete [12].

Table 4-6: Summary of Phase-Dependent and Total GWP per km of Different Pipeline Materials. [12]

Pipe Materials (12-in pipe)	Total GWP (10^3 kg CO_2/km)	Production Phase (10^3 kg CO_2/km)	Installation Phase (10^3 kg CO_2/km)	Transportation Phase (10^3 kg CO_2/km)
PVC	318	215	2.81	0.26
Dutile Iron	472	468	3.28	0.88
Concrete	68.3	63.1	2.91	0.26
HDPE	218	215	2.81	0.17
Reinforced Concrete	152	146	2.91	2.47
Cast Iron	353	349	3.28	0.84

The LCA methodology was also used in a study conducted on five types of pipe materials used in drinking water distribution networks. The materials included are PVC, HDPE, DI, fibrocement, and steel and were evaluated in the following environmental categories: GWP, Ozone Layer Depletion (OLD), photochemical Oxidation (PO), Acidification Potential (AP), Eutrophication (EU) and the Cumulative Energy Demand (CED) [9]. The results of this study indicate that during the production phase, PVC pipes produce the least impact in almost all environmental categories. In general, HDPE generates similar impacts to PVC and is therefore comparable but has slightly higher impacts. Moreover, the results show that DI produce more environmental impact in all assessed impact categories except for CED. This is mainly because DI requires more materials for pipe manufacturing. As for steel pipes, the same order of magnitude was observed in the GWP category as DI pipe material. This was also the case with the CED category whereby the energy demand of DI and steel pipe materials are 1,680 MJ and 1,400 MJ, respectively. In addition, the result of the CED shows that the energy demand for DI pipes is approximately 2 to 3 times greater than for HDPE and PVC pipes (Table 4-6) [9].

Table 4-7: Environmental Impact of Each Material in the Production Phase. [9]

Impact Category	Unit	Steel	HDPE	Fibrocement	DI	PVC
GWP	Kg CO2 eq	1/05E+02	2/55E+01	2/84E+01	1/28E+02	2/11E+01
OLD	Kg CFC-11 eq	6/25E-06	4/36E-07	2/41E-06	1/20E-05	4/69E-07
PO	Kg C2H4 eq	4/22E-02	7/82E-03	1/60E-02	6/50E-02	3/77E-03
AP	Kg SO2 eq	5/29E-01	9/78E-02	3/79E-01	9/05E-01	7/07E-02
EU	Kg PO4 – eq	2/73E-01	1/59E-02	1/40E-01	4/18E-01	1/62E-02
CED	MJ	1/40E+03	9/98E+02	7/15E+03	1/68E-03	5/77E+02

The study also assessed the environmental impacts during the transportation phase. Table 4-8 shows that steel and DI pipe materials represent the least environmental impact during the transportation phase. This is due to the fact that the materials used in DI and steel trenches have the least weight compared to those used in the other trenches. It is worth mentioning that although PVC and HDPE pipes require less materials compared to DI and steel pipes in the production phase, PVC and HDPE have more environmental impact in the transportation phase due to the required use of materials such as crushed gravel and sand for the trench construction [9]

Table 4-8: Environmental Impact in the Transportation Phase. [9]

Impact Category	Unit	Steel	PVC	DI	HDPE	Fibrocement II	Fibrocement I
GWP	Kg CO2 eq	3/23E+00	3/76E+00	3/25E+00	3/76E+00	4/39E+00	4/34E+00
OLD	Kg CFC-11 eq	5/99E-07	6/96E-07	6/03E-07	6/96E-07	8/14E-07	8/04E-07
PO	Kg C2H4 eq	5/44E-04	6/33E-04	5/48E-04	6/33E-04	7/40E+04	7/31E-04
AP	Kg SO2 eq	1/29E-02	1/50E-02	1/30E-02	1/50E-02	1/76E-02	1/73E-02
EU	Kg PO4 – eq	2/92E-03	3/39E-03	2/94E-03	3/39E-03	3/79E-03	3/92E-03
CED	MJ	5/32E-01	6/18E-01	5/35E+01	6/18E+01	7/23E+01	7/15E+01

The observed results during the installation phase presented in Table 4-9 shows that fibrocement has the highest impact across all environmental categories while PVC and HDPE have similar results as DI and steel pipes [9]

Table 4-9: Environmental Impacts in the Installation phase. [9]

Impact Category	Unit	PVC & HDPE	Fibrocement II	Fibrocement I	DI & Steel
GWP	Kg CO2 eq	8/83E+00	1/07E+01	2/80E+01	8/73E+00
OLD	Kg CFC-11 eq	1/34E-06	1/56E-06	2/46E-06	1/27E-06
PO	Kg C2H4 eq	2/75E-03	3/35E-03	4/93E-03	2/73E-03
AP	Kg SO2 eq	5/28E-02	6/41E-02	1/02E-01	5/17E-02
EU	Kg PO4 – eq	1/29E-02	1/60E-02	2/74E-02	1/30E-02
CED	MJ	1/37E+02	1/65E+02	2/76E+02	1/35E+02

Another aspect that should be taken into consideration when assessing the environmental impacts of the pipeline materials is the availability of such material in the country where the water supply system will be installed. This is an important aspect since importing material will contribute to GHG emissions from different means transportation. According to CDM Smith's Technical Memorandum-Technical Assessment of Pipe Materials report dated September 3, 2020, all proposed pipeline materials for the AAWDC project are available in the Middle East except for HDPE pipes. These pipes need to be towed by sea from North Europe, thus shipping of this pipe material will contribute significantly to GHG emission in comparison to other materials. In addition, the report found that unlike GRP pipe material, steel pipelines have the ability to withstand high operating pressure thus reducing the required number of booster pumping stations. This increases the GWP of GRP during operation compared to steel.

The studies show that DI pipes has the highest environmental impact compared to other pipeline materials and that the production of concrete has a significant impact on eco-toxicity. Table 4-10 presents a summary of environmental performance of the different pipe materials proposed for the AAWDC project.

Table 4-10: Summary of Environmental Performance of the Different Pipe Materials Considered

Pipe material	Summary of Environmental Performance
Steel	• High impact on ecosystem quality and resources during different life cycle phases • Low energy consumption during operation
Ductile Iron	• High environmental impact in terms of ozone layer depletion, ecotoxicity, energy consumption, global warming potential, photochemical oxidation, acidification potential, and eutrophication during different stages of its life cycle
GRP	• Life cycle of GRP has a significant impact on fossil fuel consumption, eco-toxicity and ozone layer depletion • Low energy consumption during operation
PCCP	• Extremely heavy thus transporting this material has a high impact on global warming potential • Relatively medium to low contribution to global warming potential during different life cycle phases
HDPE	• Relatively medium to low environmental impact in terms of ecosystem quality and resources during different life cycle phases • Not available in the Middle East thus significant GHG emissions during transportation

5. Methods

5.1. Defining the Project Area of Influence

5.1.1. General Considerations

Reference is made to the definition of the Project Area of Influence (PAI) as provided in the EIB Environmental and Social Standards, Version 10.0 dated October 2018:

'Areas, individuals and communities impacted beyond the footprint of the project or activity by cumulative impacts from further planned development of the project or other sources of similar impacts in the geographical area, any existing project or condition, and other project-related developments that can realistically be expected at the time due diligence is undertaken. In addition to the area of geographical or spatial influence, temporal influence should also be determined.'

Reference is also made to the definition of the 'Study Areas' as provided in the Guidance for Preparing Environmental Impact Assessments issued by the Jordanian Ministry of Environment in October 2014:

'Study areas should encompass the area in which impacts may occur for each technical parameter. The size of the study area may vary depending on the resource area and type of impact (direct, indirect, induced or cumulative), and should include both primary (direct impacts) and secondary (indirect or secondary impacts) study areas when appropriate.'

5.1.2. Area of Influence for the AAWDC Project

The AAWDC Project is expected to have a physical impact directly on those areas that will be used for constructing the various Project technical components, as described in Chapter 1 of this Report, including the social related impacts. In addition, the Project will have a direct influence on a wider area around these locations as described in the sections below.

More specifically, the Project will influence directly a strip of land adjacent to the pipeline route and associated Project facilities, as well as the Gulf of Aqaba in terms of seawater abstraction and discharge of brine. For certain aspects, e.g., salinity, the impacts might go beyond this immediate PAI (i.e., project-specific), and expand to a wider area (i.e., regional PAI). The socio-economic impacts, both positive and negative, are expected to also reach a wider area beyond the project-specific one.

Physical Environment

The project will influence the physical environment including air, water and soil quality at different areas. As such, the PAI for the physical environment is defined in the following paragraphs.

Regarding air quality and noise, the construction of the conveyance pipe will directly influence adjacent residential areas and sensitive receptors as well as the ambient air quality along the conveyance route where construction activities including excavation and movement of heavy machinery will occur. In addition, impacts on air quality during construction will directly influence areas adjacent to the proposed SWRO site. During operation, sensitive receptors in close proximity to the pumping stations and the SWRO plant including residential area will be considered as PAI with respect to the assessment of noise impact during operation.

The area boundaries that are considered as the PAI relative to soil quality are the strip of lands adjacent to the pipeline route and project facilities, which will be directly affected by construction activities. The area of the SWRO plant is also identified as a PAI for the assessment of impacts on soil quality during both construction and operation.

During construction, water resources in wadis within the area of the SWRO plant may be affected along with the groundwater quality of existing wells adjacent to the entire route of the conveyance pipeline. As such the site of the SWRO plant along with areas including groundwater resources are considered as the PAI.

Marine Ecology

Through the Brine Discharge Risk Assessment and the dispersion modelling undertaken for the 250 MCM/y Project capacity scheme, a feasible depth location (i.e., depth exceeding 35 m) was proposed for the setting of the brine outfall system coupled with provisional routing for the submerged outfall pipelines extending to a depth of 50 m based on the physical constraints of the examined area, which will have to be defined by the BOT developers in their detailed design. Brine dispersion modelling involved two areas; the near field region which expanded at a distance of 100 meters from the outfall diffusers and the far field region which expanded at a distance of 3 km from the boundary of the near field mixing zone (i.e., 3 km beyond the 100 m). These areas comprise the boundaries of the project-specific PAI and regional PAI, respectively, relative to brine salinity assessment.

Moreover, through the pre-feasibility analysis of intake and outfall options, a feasible depth location (i.e., depth equal to or exceeding 12 m) was proposed for the installation of the intake towers coupled with provisional routing for the submerged intake pipelines based on the physical constraints of the examined area, which will have to be defined by the BOT developers in their detailed design. Therefore, seawater intake assessment (project-specific PAI) focuses on the water circulation surrounding the intake towers proposed location to predict changes in the present currents scheme from the shoreline to around 150 m offshore.

The project-specific PAI in relation to marine video recording involved an area expanding from the coastline opposite the IPS location down to the 35m depth contour (from the shoreline to about 100 m offshore, covering an approximate area of 39,000 m^2) following U shape transects interspaced 5 m from each other starting and ending at the shoreline. It also involved a 10m width corridor following the provisional routing of the overall length of the brine outfall (outfall pipeline from shore and diffusers manifold) expanding at about 300 m beyond the 35 m depth contour.

The same area boundaries are considered as the project-specific PAI relative to (a) seawater quality (transparency/turbidity, temperature, salinity, pH, dissolved oxygen, nutrients, chlorophyll a, total hydrocarbons oil and grease, plankton biomass and total suspended matter), (b) benthic habitats with associated nekton and sessile organisms following standard reef check methodology, and (c) interstitial habitats.

Regarding the regional PAI related to marine habitats and ecosystems targeted for literature review, this will involve the entire Gulf of Aqaba from the proposed feasible locations for the intake tower and the brine outfall.

Terrestrial Ecology

The regional PAI for the terrestrial ecology assessment is defined as all bio-geographic regions and vegetation types and habitat crossed by the project at width of 2 km from each side of the alignment for the review of literature, and 100 m for the field activity at the project-specific PAI.

This study assumes the construction corridor to be 50m in total width which include the trenching and heavy machinery movement/operation. Accordingly, the PAI for the assessment of project impacts and which shall be subject to additional field surveys is identified as a corridor of 100 m for the pipeline (i.e., 50 m from each side of the centreline of the route), in addition to the footprint of the planned/designed above ground installations (AGIs) which can be defined as the total area of the land plot where each AGI will be installed. This 100 m PAI will also cover the campsites, storage sites and machineries parking.

Socioeconomic

Table 5-1 shows the PAI in terms of communities that may be affected by the Project. The areas affected are detailed down to the level of municipalities, towns, and villages.

Table 5-1: Communities within the Project's Area of Influence

No.	Governorate	District	Municipality	Locality	Project Component
1	Aqaba	Qasabat Aqaba	Aqaba City, Houd Al Disi, Rum	Aqaba, Dieseh, Rum, Salhiyeh, Twaiseh, and Al-Shakryeh	Water Desalination / Water Conveyance / Pumping Stations / Tanks
2	Maan	Qasabat Maan	Jafr	Jafr, Mudawara	Water Conveyance / Pumping Stations / Tanks
3	Tafileh	Hasa	Hasa	Hasa	Water Conveyance / Pumping Stations

No.	Governorate	District	Municipality	Locality	Project Component
4	Karak	Qatrana	Qatrana, Sultani	Qatrana, Sad Sultani, Wadi Abyad	Water Conveyance / Pumping Stations
5	Amman	Jeza	Jeza Al Jadida	Jeza, Qastal, Dabaa, Dobiaa, Saifieh, Qunaitera, Kteifeh, Lusane, Dheibeh Al Sharqiyyeh, Al Rjeib	Water Conveyance / Pumping Stations / Tanks
		Mouwaqer	Mouwaqer	Sewaqa, Damikhy, Rojem Al-Shami Al-Gharbi, Al-Dhaihybeh Al-Gharbieh, Al Kteifeh	
		Quwaismeh	Quwaismeh	Quwaismeh, Abu Alanda	
		Sahab	Sahab	Sahab	

Cultural Heritage

The construction works including excavation and movement of machinery might influence cultural heritage and archaeological sites along the route of the conveyance pipeline. As such, the PAI is defined as area where excavation works will take place.

5.2. Establishing Baseline Conditions

This section describes the process followed to establish the Environmental and Social baseline conditions. The description has considered a variety of data and information collected and gathered from various sources, including literature review undertaken to date, information gaps identified, and site visits and investigation.

5.2.1. Physical Environment

Establishing the physical environmental baseline for the Project study area has been conducted through a combination of literature review, field investigations, site visits and interviews with relevant stakeholders. The physical baseline conditions cover the following topics:

- Topography
- Geology and Soil
- Water Resources
- Weather Parameters
- Air quality
- Noise

5.2.1.1. Review of Literature and Desktop Research

The ESIA team has established the meteorological data using “meteoblue climate diagrams” which is based on 30 years of hourly weather model simulations and complimented by “climate-data organization”.

As for the project topographical baseline conditions, it has been established based on available secondary data and the project technical description gathered from the project design team.

Baseline conditions in relation to water resources (surface and groundwater) quality and quantity along the route are based on secondary available data and MWI annual reports. Water uses along the routing have also been reviewed.

The ESIA team referred to various geological reports and maps concerning the Project Area [3] to extract information and data for establishing the soil and geology baseline conditions for the water conveyance components.

Information about socioeconomic conditions such as demographics, economic activities, employment and poverty rates and education, health and infrastructure services in the project area were obtained from statistics published by the Department of Statistics as well relevant reports prepared by international organizations.

5.2.1.2. Data Obtained from Stakeholders

Air and sea water quality data for the last two years have been collected from ASEZA's New Port Air Quality Station to establish baseline conditions for the desalination component. As for the conveyance component, the ESIA team has gathered MoEnv available air quality monitoring data from Ma'an Governorate Building and King Abdullah II Ibn Al Hussein Industrial City in Sahab. Monitoring data includes SO_2, CO, NO_2, NO, NOx and PM2.5 for the years 2018 and 2019.

5.2.1.3. Site Visits

The ESIA team has conducted several visits to the sites of the water desalination component and IPS to observe the surrounding environment and identify any additional nearby environmentally sensitive receptors or significant environmental issues. The ESIA team has conducted additional site visits to all Project technical components and documented their observations.

5.2.2. Marine Environment

5.2.2.1. Review of Literature

In order to establish the marine environment baseline, a literature review related to the coastal and marine environment of the Project was conducted. This included documentation provided by the MWI and EIB and additional studies and documentation considered important and relevant to be reviewed by the ESIA team.

The following existing studies and documentation were provided by the MWI/EIB:

- Project preparatory studies undertaken by the Promoter (MWI).
- Red Sea Dead Sea Water Conveyance Study Environmental and Social Assessment; Final Environmental and Social Assessment [13].
- Red Sea Dead Sea Water Conveyance Study Program Feasibility Study [14]
- Red Sea Study – Final Report [14]
- Preliminary Environmental Impact Assessment Study for Arab Fertilizers and Chemicals Industries (KEMAPCO) Desalination Project.

Additional documents and information that the ESIA team considered important for the establishment of the coastal and marine environment baseline conditions included the following:

- Aqaba Industrial Ports Feasibility and Environmental Studies.
- National Monitoring Program of the Coastal Environment: Data and Reports of the last 10 years.
- Data and Reports of ongoing Monitoring Programs of Coastal Enterprises around the proposed location of the IPS and the RO Plant.
- State of Aqaba Marine Environment Report (2015).
- Draft Aqaba Marine Spatial Plan (2015).
- Jordan's Integrated Coastal Zone Management Country Report 2014.
- Published scientific work on impacts of coagulants, antiscalants and increased salinity on coastal habitats and seawater properties.

5.2.2.2. Deatiled Field Investigation

5.2.2.2.1. Revised Bathymetry Survey

A bathymetry survey was conducted to confirm seabed morphology at the marine side of the proposed IPS (Figure 5-1).

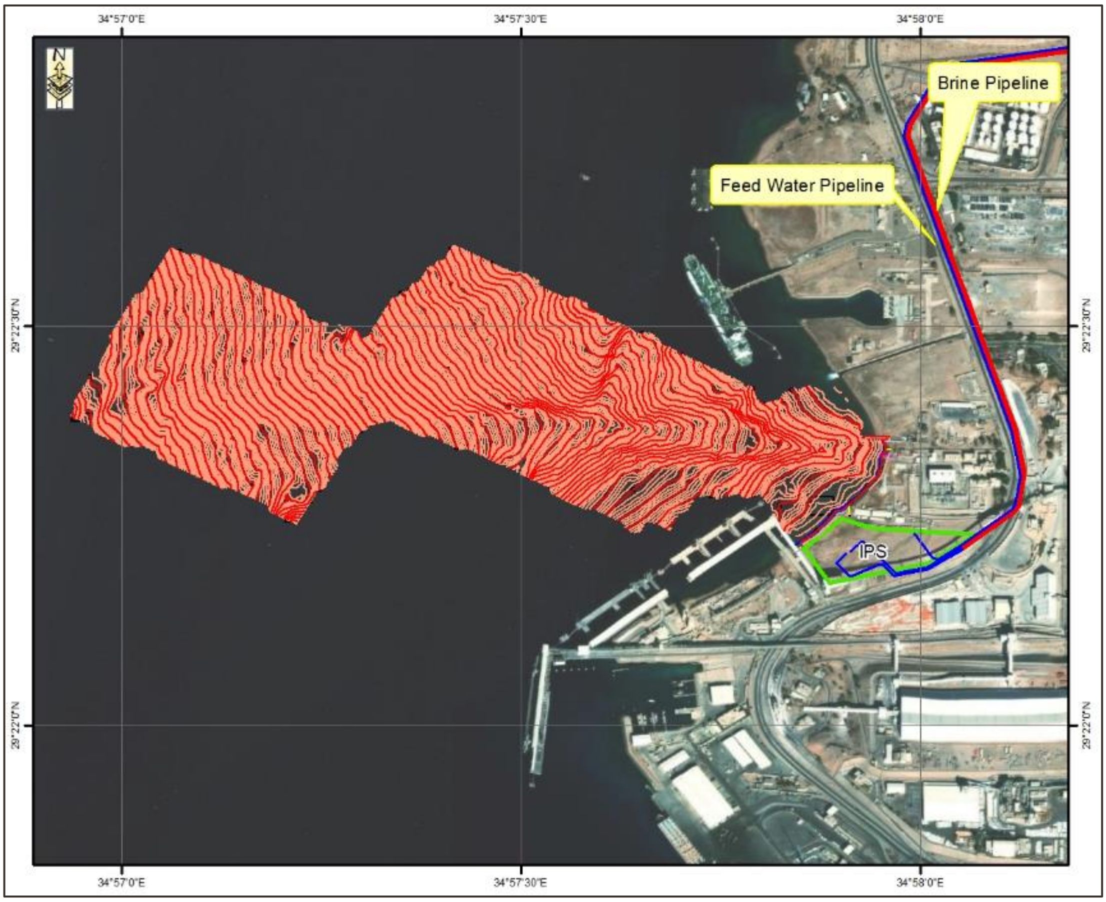


Figure 5-1: AAWDC Coastal Site Bathymetry

5.2.2.2.2. Video Recording Survey of the Intake System Area

In addition to the desktop literature review, the ESIA team conducted a sea bottom video survey at the suggested intake area. This provided the advantage of giving an actual visual appreciation of the sea ground at that area.

The diving video survey had the following objectives:

- Verification of the suggested site bottom topography / bathymetry.
- Verification of presence / absence of any obstacles from previous constructions and running activities.
- Verification of presence / absence of coral reefs and providing a general view of the bottom habitat.
- Providing a general appreciation of dominant sessile and nekton organisms.
- Providing a general visual record of the seabed before initiating activities of the desalination project.

The survey was conducted by divers using high-definition wide angle still and video cameras with red light filters in suitable underwater housing. GPS coordinates of the survey area were taken from the surface above the divers by a swimmer. The survey was conducted from the coastline to a water depth of 35m (Figure 5-2). The eastern side of the survey area was the coastline, the western side was the 35m contour, the northern side was the Gas Pipeline and the southern side was the Phosphate Loading Jetty. The survey was completed and site observation sheets of Standard Reef Check Methodology were filled for everyday diving belt. The survey site was covered in 36 belts about 5 m wide each bound either North to South or South to North following as far as possible the same depth contour. This could not be perfectly realized because the northern end was deeper than the southern end in most belts. Two additional belts were surveyed from east to west and west to east at the northern side and the southern side respectively. The east to west belt started at the shoreline next to the Gas Pipeline and ended at 35 m depth. The west to east belt started at 35 m contour next to the Phosphate Loading Jetty and ended at the shoreline.

Figure 5-2: Diving Photographic and Video Survey at the Seawater Intake Site

5.2.2.2.3. Video Recording Survey of the Outfall System Area

Similar to the intake area, a bottom video survey was conducted by the ESIA team for the proposed outfall pipeline and diffusers area. While the shallow video survey covered the entire area the deeper one was planned to cover 10m wide belts on the target parts of the outfall. The survey was conducted in January 2021. It had the following objectives:

- Verification of the suggested site bottom topography / bathymetry.
- Verification of presence/absence of obstacles from previous constructions and running activities.
- Verification of presence / absence of coral reefs and providing a general view of the bottom habitat.
- Providing a general appreciation of dominant sessile and nekton organisms.

Providing a general visual record of the seabed at the suggested brine discharge route and diffusers before initiating activities of the desalination project, the photographic and video survey was conducted by divers using high-definition wide angle still and video cameras with red light filters in suitable underwater housing. Two divers moved slowly and gently above the seabed handling the video recording, while a third person swam at the surface to keep track of the GPS coordinates of the survey area and watch for safety of the divers at the bottom. A boat was used to take the team to and from the survey site and remained there for safety for the entire length of the dives. All divers were professional and highly qualified. Divers at the bottom in particular were master divers with long experience in deep diving. Trimix breathing gas (oxygen, helium, nitrogen) was used.

The original plan was to conduct the survey for 10 m width on the suggested route of the brine discharge pipeline from 35 m to 50 m depth, then to cover a 200 m long 10 m wide belt at 50 m depth where the diffusers are suggested to be installed (Blue belt in Figure 5-3). In reality and after completing the 35 m to 50 m depth belt it was found that (i) the 50 m depth contour was closer to the shoreline than indicated in the plan (29°22'18.88"N, 34°57'46.13"E) instead of (29°22'19.62"N, 34°57'44.20"E) and (ii) the end of the 35 m to 50 m depth belt was mainly consolidated sand and closer to the phosphate loading jetty than in the plan. Therefore, the 50 m depth contour belt video survey conducted was much longer than planned and extended about 150 m extra to the north. Also because of the bottom nature at the end of the 35 m to 50 m depth belt two belts, about 6m interspaced at the 50m depth contour were video surveyed instead of one. This had the advantage of emphasizing the bottom features shallower than 50 m grasped by the eastern belt video and the bottom features deeper than 50 m grasped by the western belt video. To address the identified offset between planned and actual 50 m depth survey belt, a repeated survey was organised and undertaken during which coordinates and depths of the two previously 50 m depth surveyed belts were rechecked from the boat by dropping two depth gauges attached to a line with weight to insure vertical dropping. In addition, divers went down to a slightly deeper point at the southern end of the belt and verified a depth of 52 m. This verification revealed an error of about 6m drift to the east of the previous coordinates which was amended in the survey findings. Moreover, given the perfect sea conditions and good visibility at the day of the repeated survey, the team surveyed a third belt at the 50-52 m depth. After verifying the 52 m depth the divers ascended to 46 m and made an additional video from the south to north. Figure 5-3 illustrates the surveyed area.

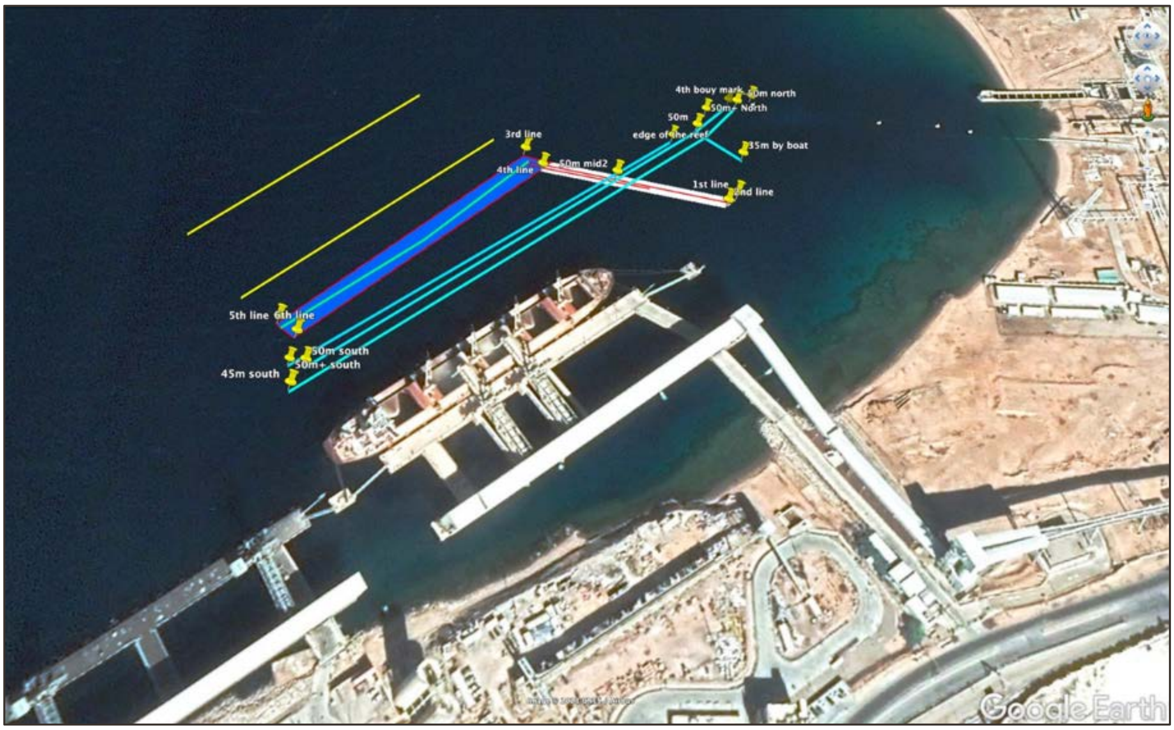


Figure 5-3: Diving Photographic and Video Survey at proposed Brine Discharge Pipeline Path and Diffusers Location

5.2.2.2.4. ROV Survey

Between October 10, 2021 and October 19, 2021, a deep video survey was conducted using a remotely operated vehicle (ROV), equipped with digital video and still camera. The ROV machine (type Video Ray, USA) was operated from a control station at the surface water (using relatively large boats). Figure 5-4 and was used to record videos as well as taking digital photos from the bottom habitat. Prior to deployment, the equipment was loaded on a suitable boat equipped with power supply, working space and ropes to maintain position. The boats used were stable in water, but to ensure full stability, the boat was tied to the industrial jetty and the captain kept maneuvering the boat to keep its direction and position. Stability of the boat was very critical for the work with the ROV, because unstable constantly moving boat will lead to misdirection and possible damage to the ROV tether and the ROV machine itself.

Figure 5-4: The ROV and Boat that Were used to Carry Out the Deep Video Survey

The syrvey has been conducted in front of the new Phosphate Jetty within the industrial area. The coordinates of the study site are (29 22.9032N and 34 53.4452E). The two transects with the GPS readings are shown in an aerial photo (Figure 5-5). The depth is shown next to it. There were two depth contours, i.e. the 60 m and 70 m that where included in the survey. At each depth, a transect of about 350 m extending from north to south and starting from the gas pipe was surveyed. The study location had the coordinates (29ᵒ 22'.335 N, 34ᵒ57'.663 E and 29ᵒ22'.9032 N 34ᵒ53'.4452 E; 29ᵒ22'.9032N and 34ᵒ53'.4452E).

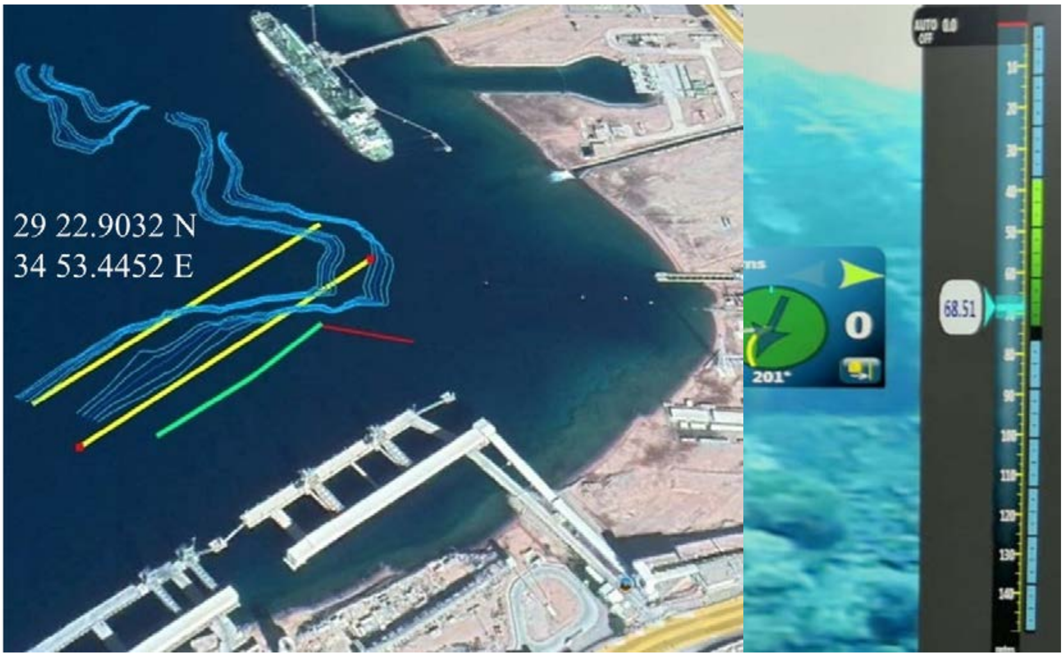


Figure 5-5:Study Site Showing the Two Belts (Yellow) and the Coordinates in the Site (Left). Screen Shot Showing the Depth (68.51 M) at this Moment of the Survey (Right)

5.2.2.2.5. Trihalomethanes and Residual Chlorine Analysis

Samples for analysis of Trihalomethans and free Chlorine were taken from 16 sites on the southern part of the Jordanian coast of the Gulf of Aqaba starting from the Marine Science Station, which represents the beginning of the Aqaba Marine Reserve. Samples were taken in duplicates, resulting in 32 samples collected from the 16 sites as shown in Figure 5-6 and Table 5-2. The reason for this selection of sites and number of samples was that no historical records of Trihalomethans and free Chlorine in the Jordanian waters of the Gulf of Aqaba exist. Therefore, the survey design took in consideration covering this relatively long stretch with respect to the Jordanian coast to provide baseline information on these indicators at different sites occupied with different human activities. The samples were taken from sites in the Marine Reserve relatively far from human activities and from sites that have industrial cooling water with chlorine added as an antifouling agent.

The samples were taken from the surface and various depths (15, 20 and 25 m) using Kemmerer Water Sampler Vertical Acrylic TT PU Type in 250 ml plastic bottles for free chlorine test and 50ml amber glass vial with 1:1 Acetic acid and distilled water preservative for THM`s test. Collected samples were immediately transported to the laboratory in ice boxes.

Figure 5-6: THM and Residual Chlorine Testing Sites

Table 5-2: THM and Residual Chlorine Testing Sites and Depths

Location	Depth (m)
KEMAPCO Cooling Water	Outlet at source, Surface
KEMAPCO Cooling Water	Marina open Sea Interface, Surface
KEMAPCO Cooling Water	Marina Open Sea Interface, 20 m
JPMC IC Cooling Water Outlet	Surface
JPMC IC Cooling Water Outlet	at Source, 25 m
AAWDC Proposed Intake	Surface
AAWDC Proposed Intake	Near Bottom, 15 m depth
Thermal Power Station Cooling Water Outfall	Surface
Thermal Power Station Cooling Water Outfall	at Source 20 m
Tala Bay	Marina Inside Central, Surface
Tala Bay	Marina Open Sea Interface, Surface
Tala Bay	Marina Open Sea Interface, Bottom 20 m depth
Aqaba Marine Reserve Visitors Centre	Surface
Aqaba Marine Reserve Visitors Centre	20 m depth
Aqaba Marine Reserve – Marine Science Station	Surface
Aqaba Marine Reserve – Marine Science Station	20 m

The method for the analysis of THMs was the agilent technologies application No 5990-3285EN "Analysis of Volatile Organic Compounds in Water Using Static Headspace-GC/MS" while for the Cl_2, the standard methods for the examination of Water and Wastewater, 23rd Edition 4500- Cl G. DPD Colorimetric method using Portable data logging colorimeter DR/900, HACH was followed.

5.2.2.2.6. Marine Characteristics and Analysis

Seawater Currents

Water currents were measured using an Acoustic Doppler Current Profiler (ADCP 1200 kHz or 600 kHz).

Seawater Measurements

Inorganic nutrients ammonium, nitrate, nitrite, phosphate and silicate were analyzed spectrophotometrically according to Grasshoff (1999). Chlorophyll-a in water samples was measured fluorometrically using the method of Elizabith and Gary (1992) by using acetone (95%) as the extraction agent. White-Secchi disk was used to measure transparency of the water. pH was measured in-situ using portable pH meter. Temperature, salinity, oxygen was recorded using a self-recording Conductivity, Temperature and Pressure Recorder (SBE 19pluseV2 SEACAT PROFILER).

Zooplankton biomass

A simple plankton net (200 µm mesh; ARI, USA) was towed vertically from a boat at a speed of 1-2 sec/meter along the water column in each selected site. Zooplankton samples were kept on ice for about 2 hours until delivered to the Marine Science Station laboratories. Samples were filtered on pre-dried and pre-weight GF/C filters for 24-48 hrs at 60 °C, and re-weighed. Biomass (mg. dry wt. m^{-3}) was calculated as follows:

Biomass (mg.l-1) = [zooplankton dry weight (gm) /volume of water filtrate (m3)] × 1000, Where the volume of water filtrate = velocity (m. sec-1) × area of net (m2) × time of collection (sec).

Siltation and Bio-fouling Potential

Siltation and Bio-fouling Potential was measured according to Abushaban et al, 2020, and Abushaban et al, 2021.

Bottom Habitat Survey

The Standard Reef Check Methodology; Tropical Program, Red Sea was followed.
https://www.reefcheck.org/tropical-program/tropical-monitoring-instruction/

Interstitial Living Assemblage

Bottom sediments were collected from seabed at the different selected locations. In laboratory, the weight of sediment was measured to nearest gram and was preserved in 80% alcohol and Rose Bengal for further study and identification. Encountered taxons were identified to lowest possible taxon level. Counts of major categories were made using binocular Olympus microscope and hand counter in a sample of 100 g dry weight of sediment.

Sediment physio-chemical properties

The following parameters were analyzed in these samples and included particle size analysis (PSA) analyses using a set of calibrated analytical sieves (US standard sieves), total organic matter (TOM) was measured by determining the ignition loss (IL) value for sediment (combustion at 500°C). The total organic carbon (TOC) was measured by titration with ferrous ammonium sulphate solution (Gaudette et al., 1974).

Study site and sampling

Sampling sites for physio-chemical properties of seawater and bottom sediment and biological quality are provided in table Table 5-3 Table 5-4 and Figure 5-7 below :

Table 5-3: Summary of Sampling Locations and Description

Item General	No.	Location	Indicative Coordinates (Degrees, Minutes, Seconds)	Item Specific / Quantity
Currents by ADCP	SWC1	At 25 m depth	29°22'19.09"N, 34°57'48.05"E	Two 24 hour deployment
	SWC2	At 50 m depth	29°22'19.38"N, 34°57'43.88"E	
In situ seawater measurements	ISM	At 50 m depth	29°22'19.38"N, 34°57'43.88"E	CTD down to 50m, Transparency, Dissolved Oxygen and pH just below surface at a water depth of 50m
Seawater sampling and analysis	SSA1	Surface at 5 m	29°22'16.80"N, 34°57'51.55"E	Ammonia, Nitrate, Nitrite, Phosphate, Particulate Matter, Chlorophyll *a*, Plankton Biomass, Siltation Potential, Biofouling Potential, Total Hydrocarbons,
	SSA2	Surface and bottom at 25 m depth	29°22'19.09"N, 34°57'48.05"E	
	SSA3	Surface at 50 m depth	29°22'19.38"N, 34°57'43.88"E	
Bottom Habitat Survey	BHS1	At 10 m bottom	29°22'17.46"N, 34°57'50.94"E	Visual census: Standard Reef Check at two sites
	BHS2	At 20m bottom	29°22'18.97"N, 34°57'48.62"E	
Interstitial Habitat	ISH1	At 10m bottom	29°22'17.46"N, 34°57'50.94"E	Color, Odor, Interstitial Living Assemblages, Grain Size, Calcium carbonate and Organic carbon Concentrations
	ISH2	At 20 m bottom	29°22'18.97"N, 34°57'48.62"E	

Figure 5-7: Sampling Sites

5.2.3. Biological Environment

The approach for establishing the terrestrial ecological baseline conditions was designed to comply with best international practices and is described below.

5.2.3.1. Review of Literature

The review of literature comprises (a) the review of Project-related documents and maps thus to familiarize the team with the Project components, and (b) multi-database search and review of secondary data about biodiversity and ecology within the PAI. This literature review addressed biogeographic zones, ecosystems, faunal migration routes, key biological habitat, sensitive and important habitat, species diversity with concentration on red list, indicator and flagship species, inhibited areas, and finally natural and cultural heritage sites.

The desktop review covered past project reports, published scientific papers, reference books, national and global environmental databases and databanks, available satellite images from published sources (e.g. Google Earth) and satellite or aerial images available from the client, statistical data available from official national sources, United Nations and the World Bank data sources, and technical ecological and biodiversity reports available to the study team, in addition to any other scientific sources.

5.2.3.2. Field Surveys

5.2.3.2.1. Rapid Diagnosis

The field study was based on site rapid diagnosis (reconnaissance) of pre-identified valued environmental components (VECs) within the PAI. It used the information available from secondary sources to provide the reference point for diagnosis and validation of changes to the ecological character of the study area against the baseline data available from secondary sources. It also further investigated biodiversity in localities that are lacking sufficient details about its ecological character, habitat conditions and species diversity. The specific objectives of the rapid evaluation were to:

- Broadly describe the bio-physical character of the study area;
- Document environmental characteristics of the area including land uses and bio-physical resources that are directly linked to the presence of terrestrial biodiversity;
- Broadly classify the habitat types along the alignment and identify areas of special ecological interest;
- Rapidly identify/verify the Project-anticipated ecological footprint zones.

The diagnosis has been carried out by driving/walking the identified geo-referenced study area using either Arch-GPS or Garmin handheld GPS-navigation. The rapid survey in each consists of reconnaissance by car (slow-speed) and site walkovers in selected location(s) by specialists to record:

- Typical vegetation type;
- Notable vegetation stands;
- Evidence of protected, rare/threatened flora/fauna (terrestrial and marine);
- Resource use and level of previous disturbance (including pollution and waste disposal);
- Hydrological features and water resources of value for biodiversity;
- Landscape features / habitat features (rocky mountains, plateaus, wadis etc.);
- Dominant land cover features and main uses (i.e. urban versus rural versus wilderness).

The walkover for the selected locations has concentrated wherever applicable on the geo-referenced PAI, in addition to a buffer zone which identified based on the topography and general characteristics of the site. Broader areas described as part of the diagnosis at different locations of the study area due to ecosystem integrity and habitat fragmentation considerations.

For each section, a photographic record was made noting the:

- Broad character of the area;
- Any specific items of interest (vegetation stands[1], notable species, vegetated wadis, livestock enterprises and practices, etc.) will be marked with GPS whenever possible.

5.2.3.2.2. Field Survey at Sampling Locations

Field surveys were undertaken for plants, reptiles, birds, and mammals at the locations of the desalination plant in Aqaba, intake pump station in Aqaba, and the conveyance line (Table 5-4).

Table 5-4: Locations for sampling survey and for stop-over diagnosis

Sampling Sites for trapping and transects	Primary Stop-over locations for rapid investigation and verification of habitat condition	Other stop-over locations for rapid diagnosis
• Pipeline alignment crossing Disi area • SWRO Plant location • Intake	• BPS2 • BPS3 • RGT1 • BPS4 • MUS2/BPS5 • RGT3 • BPT • PS ADC	To be determined during the field activity based on apparent ecological features (Consultant judgement for verification)

At terrestrial survey locations, the following surveys were conducted utilizing standard items such as GPS, identification guides, binoculars and telescopes, and camera traps as follows:

- Flora survey

Flora transects were conducted at the selected sampling sites to identify existing plant species.

[1] A stand is the basic physical unit of vegetation in a landscape. It has no set size. Some vegetation stands are very small, and some may be several square kilometers in size, such as desert or forest types.

- Bird survey

Transects were conducted at the selected sampling sites. Birds' observation points were implemented at areas of importance, whereby the Bird Specialist spent 1 hour at each point to record all observed bird species in all directions.

- Mammal Survey

Mammal transects were implemented at the selected sampling sites.

- Reptile Survey

Reptile transects were implemented at the selected sampling sites.

5.2.3.3. Segmentation of the Study Area

The study area was divided into three segments and nine sections based on bio-geographic zones, vegetation types and habitat types, whereby mono-typic habitat has been considered as one section regardless of its length, as follows:

- **Segment A (Southern Part)** which extends from the Wellfield at Disi to Jurf Al Drawish - Qatraneh Junction (Desert Highway)
    - Section A-1: from the Intak and RO Plant to BPS4
    - Section A-2: from BPS2 to RGT2
    - Section A-3: from RGT2 to RGT4
    - Section A-4: from RGT4 to the cross point of the alignment with the desert highway between Jurf Al-Drawish and Al Hasa
- **Segment B (Middle Segment)** which extends from the cross point of the alignment with the desert highway between Jurf Al-Drawish and Al Hasa to the beginning of Al Jiza Area (South of Amman)
    - Section B-1: from the cross point of the alignment with the desert highway between Jurf Al-Drawish and Al Hasa to Al Qatraneh
    - Section B-2: from Al Qatraneh to Al Jizah area
- **Segment C (Northern Segment)** which extends from Al Jiza to PS ADC and Abu A'landa Resrvoir and to Al Muntazah reservoir
    - Section C-1: from Al Jiza to PS ADC
    - Section C-2: from PS ADC to Abu Alanda Reservoir
    - Section C-3: from PS ADC to Al Muntazah reservoir

5.2.4. Socioeconomic Environment

The following methodology was used to establish the socio-economic conditions of the Project area:

- Review of available literature / studies / surveys that provide information and data on the baseline conditions of the Project's influence area.
- Conduct of meetings / interviews/ focus groups with a selected number of stakeholders including governmental and public institutions; project-affected persons (PAPs); representatives from industries, NGOs, vulnerable groups, adjacent facilities and investors; local authorities; and local communities. A total of 32 meetings were held during several field visits (refer to Section 7.2 for a full list).

As for the noise level monitoring, noise level measurements were conducted on September 19, 2021, at two locations along the conveyance pipeline route (Figure 5-8), based on 72 hours logging with 1-hour interval. The testing period took place from September 19, 2021, to September 29, 2021, using the monitoring devices provided in **Annex 10**.

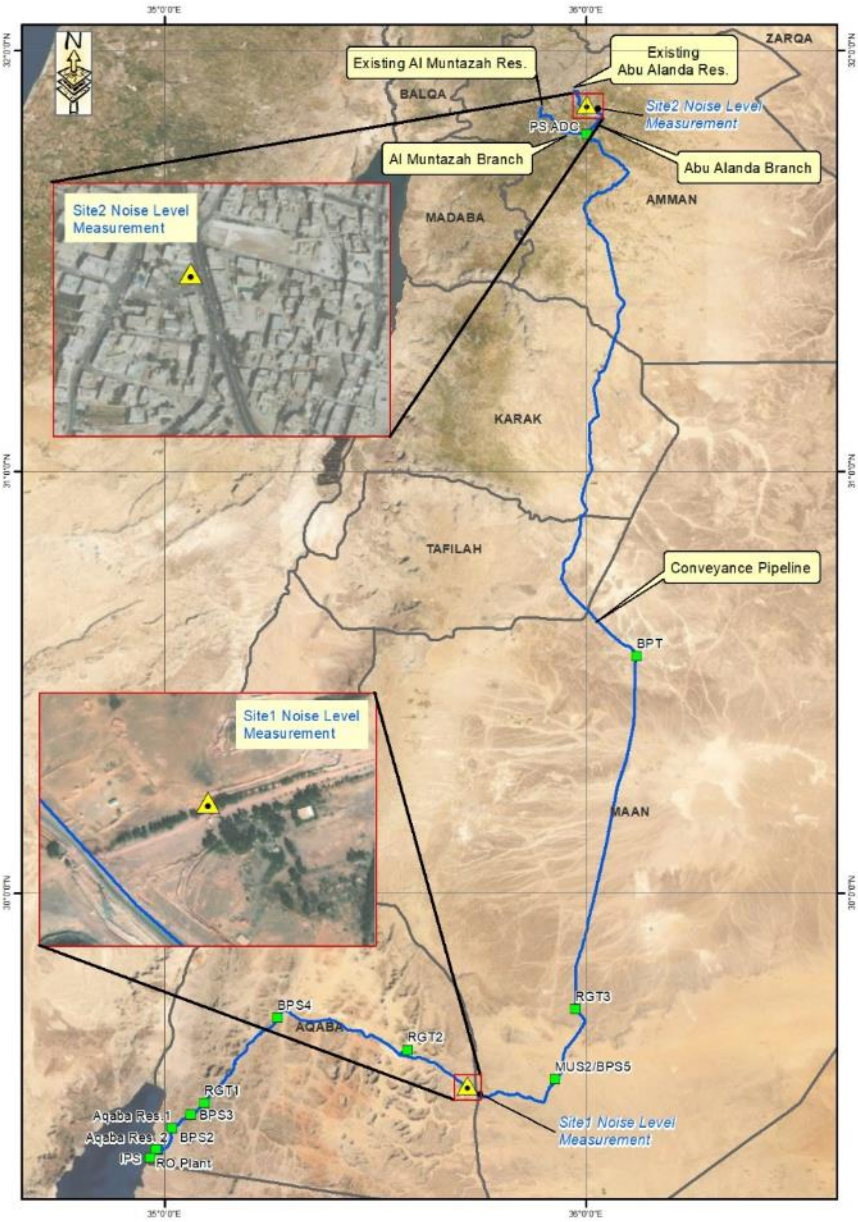


Figure 5-8: Noise Level Monitoring Locations

5.2.4.1. Cultural Resources Baseline Conditions

The methodology used for the establishment of baseline conditions relative to cultural heritage complies with internationally accepted charters and guidelines such as those adopted by ICCROM (International Centre for the Study of Preservation and Restoration of Cultural Property), ICOMOS (International Council of Monuments and Sites) and UNESCO and was undertaken through the following activities:

- Review of existing ESIA reports for previous projects in consultation with the MoEnv, Ministry of Tourism & Antiquities and the MWI;
- Consulting the database of the Department of Antiquities;
- Library research
- Determining actual and potential locations of relevant cultural heritage sites and determine those that require field verification;
- Field investigations to all relevant sites at the intake point and desalination plant and along the proposed conveyance route up to the reservoirs in Amman;

- Documentation and report writing.

5.2.4.1.1. Literature Review

This includes previously conducted surveys, excavation, limited studies, preliminary reports, old maps or any written document about the PAI subjected to intensive assessment and evaluation. A preliminary desk-based assessment revealed the following readily available information:

- The archaeological and cultural heritage sites identified close to the project route in Aqaba, Wadi Rum to northern area toward Amman-Abu Alanda Reservoir;
- The current condition/state of these sites;
- Legislative frameworks governing studies, field investigation, excavation, conservation and use of archaeological and cultural heritage resources.

The Archaeology and Cultural Heritage Team completed the research in national and international libraries such as the Department of Antiquities of Jordan's previous JADIS program (Jordan Antiquates Database and Information system) and the current Mega (Middle Eastern Geodatabase for Antiquities-Jordan), the Library of American School of Oriental Research (ACOR) and Library of British Council for Research in Levant (BCRL), German Institute of the Holy Land, and libraries at Jordanian universities.

5.2.4.1.2. Field Investigations

Based on the inventory of actual and potential sites, for the sites known and/or sufficiently described more assessment for the current situation has been undertaken. For other / new sites, diagnostic cultural remains were investigated, such as archaeological remains pottery shreds and lithic tools scattered over the surface. The archaeological remains have been properly evaluated, and few samples have been checked in field to get more accurate dating in coordination with Department of Antiquities. Table 5-5 presents the areas investigated in detail during the field activities.

Table 5-5: Areas to be Investigated during Field Activities Relative to Cultural Resources

No	Areas
1	Abu –Alanda –Sahab- Abu-Alanda Pump Staion
2	Dhuheybah – Alsyn-Al-Kuteifeh
3	Al-Quneitrah – Areinbah Al-Sharkyh – Al-Amriyeh-Dabbaa
4	Qatraneh – Hasa
5	Hasa- Jafer
6	Wadi Rum
7	Aqaba- Aqaba Back Road–Intake Area

5.3. Evaluation of Impact Significance

This section describes the methodology that was uniformly applied in the final ESIA study for the AADWC Project for the identification and assessment of impacts resulting from implementation of the Project throughout its life cycle. It is noted that some of these impacts can be avoided during the early stages of the Project through appropriate design and construction management procedures guided through the precautionary principle.

The key stages of the applied approach involve:

1. Identification of Project related activities (during both construction/commissioning and operation phases) that are likely to result in environmental and social impacts (environmental stressors);
2. Identification of the environmental and social features at the PAI that could be affected by Project activities (environmental receptors);
3. Identification of potential impacts on the physical, biological, and socioeconomic environment (environmental receptors) that may arise from the Project activities during its life cycle; and
4. Assessment and evaluation of potential impacts to determine their significance and subsequently their priority ranking in terms of mitigation based on pre-set criteria.

Stages 1 to 3 above relate to the process of identifying potential environmental and social impacts of the AADWC Project implementation during its life cycle. The following documentation served as basis to this effect:

- Concept design data related to Project components (desalination; water conveyance) as being available at the stage of the assessment;
- Collected baseline information relative to environmental and social settings in target areas where the Project unfolds (secondary sources data complemented with field surveys as applicable); and
- Literature review of projects similar in nature and size.

The following tables present the criteria used for the assessment and evaluation of impacts in Stage 4 as listed above.

First, the potential impacts resulting from the Project activities to the physical, biological, and socioeconomic environment are assessed and characterised as per (a) their nature, i.e., beneficial or adverse, and (b) type of induced interaction between the stressors and the receptors (Table 5-6 refers).

Table 5-6: Characterisation of Nature and Type of Impacts

Term	Descriptor	Impact Evaluation Definition
Nature	Beneficial	Impacts are considered to improve the baseline condition or introduces a new desirable factor.
	Adverse	Impacts result in an adverse change of the baseline condition or lead to a new undesirable factor.
Type	Direct	Impacts resulting from a direct interaction between a project activity and the surrounding environment.
	Indirect	Impacts generated from subsequent interactions within the environment.
	Cumulative	Combined impacts that act together with other impacts arising from other projects including future developments, to disturb the same environmental receptor or resource.

Once the nature of the impact has been defined, the adverse impacts, irrespective of their type, are further **evaluated per their significance** based on the criteria provided in below. More specifically, for each predicted adverse impact, the magnitude (at the indicated spatial scale), the probability of occurrence, the duration (time scale) and the extent (spatial scale) are assessed based on the respective rating definition per criterion. These criteria are used to determine the significance of each identified impact through following Steps 1 to 5 below. As for Beneficial impacts, no further analysis is undertaken, and they are described qualitatively and with measures proposed to enhance them.

Step 1

Step 1 assesses the **magnitude** and **probability** of each impact in line with the rating definitions in Table 5-7.

Table 5-7: Step 1 - Assessing Magnitude and Likelihood

Term	Descriptor	Rating Definition
Magnitude	High	Major alteration of natural properties, functions, processes.
	Medium	Notable alteration of natural properties, functions, processes.
	Low	Negligible alteration of natural properties, functions, processes.
Likelihood	High	Definite or highly probable (estimated greater than 90% chance of the impact occurring).
	Medium	Fair chance of occurring (estimated 10% to 90% chance of the impact occurring).

Term	Descriptor	Rating Definition
	Low	No chance or unlikely to occur (estimated less than 10% chance of the impact occurring.)

Step 2

Once the impact is rated for **magnitude** and **probability**, Step 2 uses the matrix in Table 5-8 to determine the impact **intensity**.

Table 5-8: Step 2 – Assessing Intensity

Intensity Rating				
Magnitude		High	Medium	Low
Likelihood	High	High	High	Medium
	Medium	High	Medium	Low
	Low	Medium	Low	Low

Step 3

Step 3 assesses the **duration (temporal scale)** and **extent (geographic scale)** of each impact in line with the rating definitions in Table 5-9.

Table 5-9: Step 3 - Assessing Duration and Extent

Criterion	Descriptor	Rating Definition
Duration	Long-term	Continuous or regular (once per day) over Project life, with effects of long duration (> 10 years after construction).
	Medium-term	Effect of medium duration (2 to 10 years after construction).
	Short-term	Effect restricted to construction and/or up to 2 years after construction.
Extent	Regional	Far-range impact; beyond a 5 km radius of Project site(s)
	Local	Medium-range impact within a 5 km radius of Project site(s)
	Site	Onsite specific impact within 100m radius from Project site(s)

Step 4

Once the impact has been rated for **duration** and **extent**, Step 4 uses of the matrix in Table 5-10 to determine the impact **scale** (temporal and geographic).

Table 5-10: Step 4 – Assessing Scale

Scale Level				
Duration		**Long-term**	**Medium-term**	**Short-term**
Extent	**Regional**	High	High	Medium
	Local	High	Medium	Low
	Site	Medium	Low	Low

Step 5

After determining the impact's intensity and temporal and geographic, the fifth and final step is to determine its **significance** based on the matrix in Table 5-11.

Table 5-11: Step 5 – Impact Significance Assessment

Scale Level				
Intensity		**High**	**Moderate**	**Low**
Scale	**High**	Critical	High	Medium
	Medium	High	Medium	Low
	Low	Medium	Low	Negligible

Impact Significance

Impacts are rated as either Critical, High, Moderate, Low or Critical. Table 5-12 describes the implications of each significance rating as adopted for this Project.

Table 5-12: Description of Impact Significance Results

Significance	N	**Negligible:** • No measurable impact. Issues identified as negligible can be scoped out.
	L	**Low:** • No considerable adverse alteration of the existing environment • Low priority mitigation or mitigated through best practices
	M	**Moderate:** • Results in considerable adverse alteration of the existing environment • Impact is a priority for mitigation to minimize or prevent the significance of the impact
	H	**High:** • Results in considerable adverse alteration of the existing environment • Project cannot be safely implemented without mitigation measures; compensation or offsetting may be necessary
	C	**Critical:** • Results in critically adverse alteration of the existing environment • Project cannot be safely implemented. Alternatives including the no project alternative need to be investigated in depth for reducing the level of impact significance

It should be noted that there is no universally applied definition of significance whereas whether an impact is assessed to be significant or not depends also on factors such as the project size and design, and the sensitivity of the environment (receptors) at the selected project site(s).

As a result, a narrative description of each assessed impact is followed by the table below summarizing the impacts and evaluating their significance in line with the methodology described above.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature		
Type		

Parameter	Assessed Impact	Residual Impact
Magnitude		
Likelihood		
Intensity		
Duration		
Extent		
Scale		
Significance		

6. Environmental and Social Baseline

6.1. Physical Environment

This section presents the physical baseline conditions in the Project area in relation to the following attributes: topography, geology and soils, water resources, weather parameters, and air quality.

6.1.1. Topography

Figure 6-1 shows the topographic map of Jordan, which varies between -431 to 1842 m above sea level.

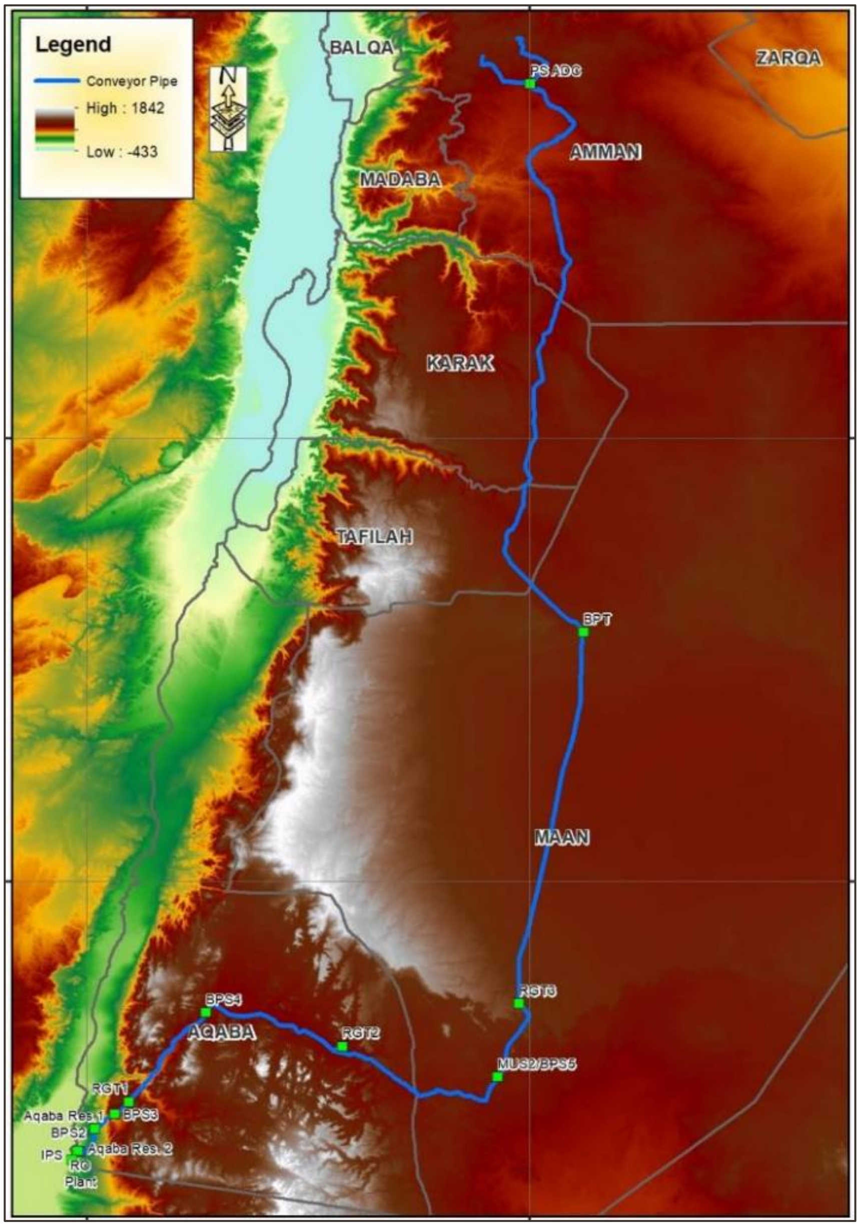


Figure 6-1: Topographic Map of Jordan

The Project topography varies between the different components; from the sea level where the IPS is located along to reach Amman, where the existing Abu Alanda reservoir and the existing Al Muntazah Reservoir. The topographic survey concluded to the below Figure 6-2 which illustrates the project profile.

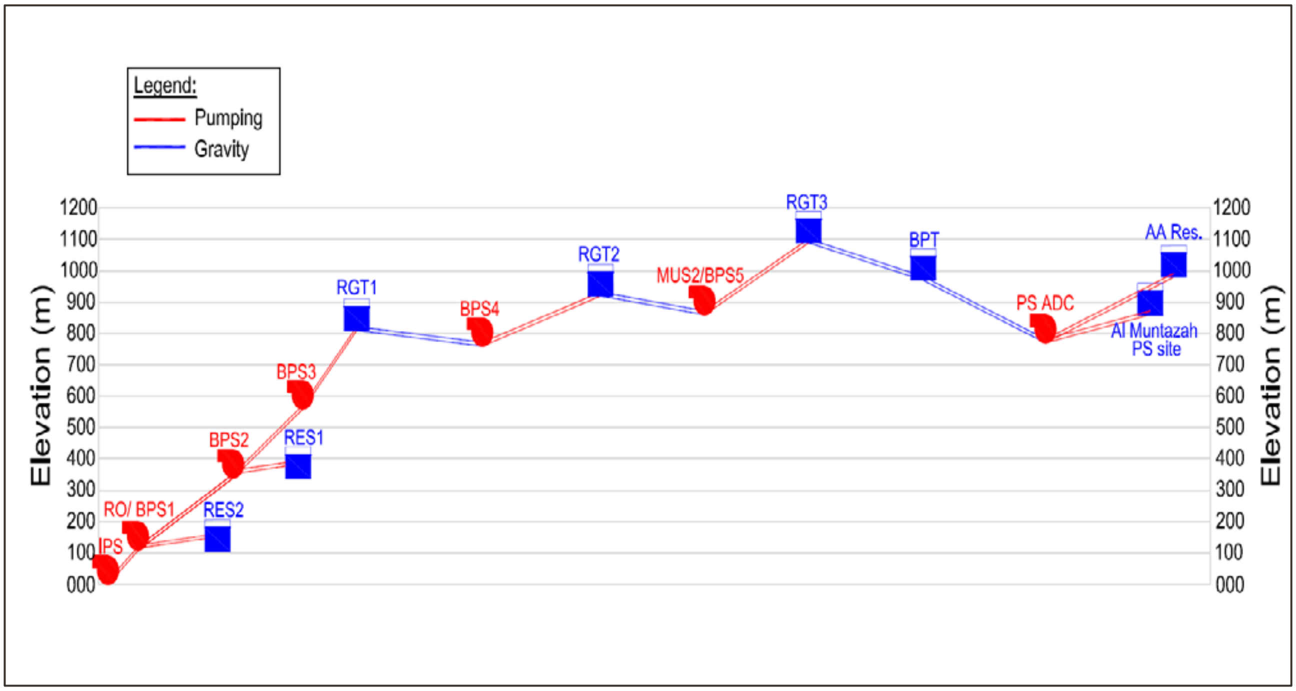


Figure 6-2: AAWDC Project profile

6.1.2. Geology and Soils

The Project area is situated to the east of the Dead Sea rift. It is dominated mostly by sedimentary rocks, Igneous rocks exposed at limited areas, Quaternary and Recent deposits are also present covering the older geologic formations.

6.1.2.1. Stratigraphy

The rocks outcropping along the pipeline route range in age from Ordovician to Eocene Age. Quaternary and recent deposits are present at several locations covering the bedrock.

The rock sequence is presented in the following paragraphs. Geologic formations described in this text follows the nomenclatures used in the 1:50 000 National Geologic Mapping Project for Jordan directed by the Natural Resources Authority.

6.1.2.1.1. Upper Proterozoic (Aqaba Complex)

Yutum Granitic Suite of the Aqaba Complex exposed along the route, it was subdivided into four main units based on lithological and structural grounds, as follows: the, Mubarak and Humrat granites. However, only two units exposed along the route (Imran Monzogranite and the Abu Jadda Granite)

Imran Monzogranite Unit is a medium-to coarse-grained phanerocrystalline monzogranite which is pinkish to whitish grey in colour. It is characterized by the presence of hornblende occurring in small clots or aggregates, and distinctive coarse pink K-feldspars (subporphyritic).

Abu Jadda Granite is medium-to coarse-grained, pinkish white, leucocratic granite with clusters, of subhedral, smoky to milky quarts and perthitic feldspar. Essential minerals include perthitic alkali feldspar, orthoclase and microcline, quartz, oligoclase and biotite.

6.1.2.1.2. Lower Paleozoic

Ram Sandstone Group presents along the route, it comprises in upward sequence: the Salib Arkosic Sandstone, Umm Ishrin Sandstone, Disi Sandstone and Umm Sahm Sandstone formations. Only Umm Sahm Sandstone Formation exposed along the route.

The Umm Sahm Sandstone Formation consists of cross-bedded, medium-to coarse- grained sandstone, characterized by its dark brown weathering patina, regular tabular bedded morphology, closely spaced joint pattern, steep cliffs and table or pyramidal mountain tops. The Umm Sahm Sandstone is early Ordovician in age.

6.1.2.1.3. Paleozoic

Mudawwara Sandstone Formation of Khreim Group is the only formation exposed along the route, this formation is exposed and or covered by Pleistocene sediments at some locations and consists of pale green to beige, finely laminated, wavy and hummocky cross-bedded, ripple-marked, micaceous, fine-grained sandstone alternating with green micaceous siltstone to silty mudstone. A thick bed of grey-white mudstone is present near the base. Age of this formation is Silurian – Ordovician.

Mudawwara Sandstone Formation has been sub- divided into three members ; in ascending order Tubayliyat Sandstone, Batra Mud- stone and Ratiya Sandstone. Only Tubayliyat Sandstone exposed along the route, it consists of beds of fine-grained micaceous sandstone, and green silty shale and pale brown, micaceous sandy siltstone.

6.1.2.1.4. Mezozoic

Cretaceous age rocks of Mezozoic present along the route, these contains three groups, Kurnub Batn El Ghul (undifferntiated), Ajlun and Balqa.

Kurnub Batn El Ghul Group (Undifferntiated)

The Kurnub Sandstone Group consists of white to varicoloured, fine-medium and coarse-grained sand- stone, well-sorted sand interbedded with silty clay, mottled clayey silt and clayey silty sand.

Batn Al Ghul Group consists mainly of varicoloured cross-bedded sandstone interbedded with silty clay, clayey glauconitic sandstone. The age of Kurnub/Batn Al Ghul group is Neocomian to Santonian.

Ajlun Group

This Group consists of a thick sequence of carbonate rocks of Cenomanian to Turonian age.

The Ajlun Group is subdivided into the five formations from bottom to top: Nau'r Limestone, Fuhays, Hummar, Shuyb and Wadi Es Sir Limestone which is the only formation exposed at the end of the route.

The Wadi As Sir Limestone Formation formation, consists of dolomite dolomitic limestone recrystallised limestone, marly limestone and thick-bedded to massive limestones. The age of this formation is Turonian.

Balqa Group

Balqa Group comprises chalk, marl, chert and phosphate. This group comprises five formations: Wadi Umm Ghudran (not exposed), Amman Silicified Limestone, Al Hisa Phosphorite, Muwwaqar Chalk Marl and Umm Rijam Chert Limestone.

Amman silicifed limestone Formation overlays the Wadi Umm Ghudran formation and consists chert, brecciated chert and phosphatic chert, interbedded with microcrystalline limestone, bituminous chalk, and marl. The age of this formation is Campanian - Santonian

Al Hisa Phspshorite Formation overlays the Amman silicifed limestone Formation consisting of thin bedded chert, marl, chalky marl, phosphate, phosphatic chert, microcystalline limestone and oyster-coquinal grainstone. Age of this formation is Campanian Maastrichtian.

Muwaqqar Chalk Marl Formation overlays the Al Hisa Phspshorite Formation, it consists of yellow-pink and pale grey to white chalk marl, soft marly limestone, phosphatic marl and bituminous marl. Age of this formation is Maastrichtian – Paleocene.

Umm Rijam Chert Limestone Formation overlays the Muwaqqar Chalk Marl and consists of and consists of white, grey-white chalky limestone, chalk and grey bedded micro crystalline limestone intercalated with brown and black bedded chert. The age of this formation is early Paleocene to Eocene.

6.1.2.1.5. Quaternary And Recent Sediments

Pleistocene Gravel

Pleistocene gravel, consisting of an uncemented, poorly-sorted deposits of chert and limestone clasts, these sediments include coarse-grained sands with pebbles, cobbles and boulders of the regional bedrock, such as chert, phosphatic chert and limestone.

Alluvium and Wadi Sediments

These sediments comprise Recent alluvial deposits in the channels and on associated flood plains of ephemeral streams. They consist of sub-rounded, matrix and clast-supported gravels ranging in size from pebbles to cobbles; the clasts, derived from the local bedrock, are mostly of chert and limestone.

Alluvial fans are widely developed within the granite mountains of (at the southern sections of the route) They consist typically of poorly sorted gravels and sands with clasts of boulder to granule size set in a coarse-grained sand matrix.

Shallow alluvial mudflat depressions present at limited areas. Fine-grained silt and clay were deposited and accumulated in low topographic areas during flooding to form mudflats.

Soil

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 unconformably overlying any of the above-described formations. They range in thickness from few centimeters when the bedrock is exposed to several meters

6.1.2.2. Geology Along the Pipeline Route

The pipeline route is about 435 km long.,The following description along the route divided it into sections, each section having its own geological characteristics. Figure 6-3 below shows the general layout of these sections.

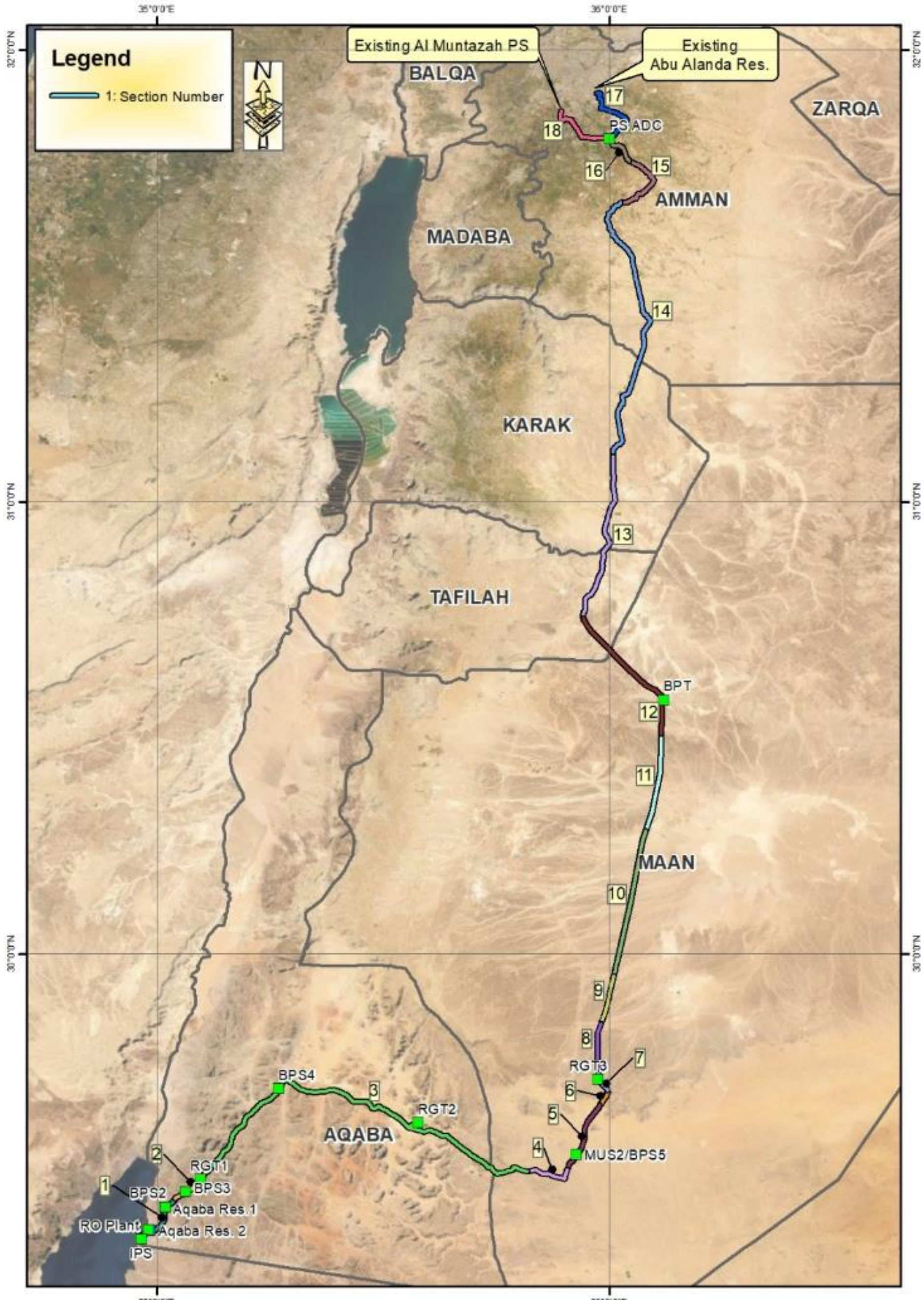


Figure 6-3: Geology Sections along the Project Components

Section 1

This section is about 15 km starting from the IPS location. Pleistocene gravel and alluvial deposits present within this zone consist of sand with gravels and boulders. The **IPS**, **RO** and **BPS 2** are located within this section, the material at the location of IPS is alluvium whereas at the sites of RO and BPS2, it consists of Pleistocene gravels.

Section 2

This section extends about 12 km, passing through granitic rock of Yutum Granitic Suite, alluvium and alluvial fans cover the granitic rock at the wadis.

At this section **BPS 3** is located, granitic rock exposed at this site.

Section 3

This section extends to about 95 km. The prominent material within this section which extend to about 96Km is alluvial deposits consists of unsorted to poorly sorted gravels and sands with clasts of boulder to granule size set in a coarse-grained sand matrix. This section is characterized also by the presence of alluvial sand and alluvial fans. **BPS 4** is located within this zone on alluvial deposits.

Sandstone outcrops at limited locations, this bedrock belongs to Umm Sahm Sandstone and Hiswa sandstone formations. Basalt present at a limited location closed to the end of this section.

The site of **RG 2** is located within the sandstone.

Section 4

This section is about 11 km. The prominent material within this section is fine-grained micaceous sandstone and alternating thin to very thin beds of green silty shale and pale brown, micaceous sandy siltstone. This material belongs to Mudawwara Sandstone formation of Khrayim Group.

Section 5

This section (approximately 18 km) consists mostly of sand with gravels and boulders belongs to Pleistocene and Recent age. Sandstone rocks outcrops at limited locations.

The site of **MUS2/BPS 5** is located within this section, the material at the site is Pleistocene gravels.

Section 6

Sandstone rock outcrops at this section (approximately 5 km), it consists of white to varicoloured, fine-medium and coarse-grained sandstone, well-sorted sand interbedded with silty clay. This bedrock belongs to Kurnub and Batn Al Ghul Group.

Section 7

The rock exposed at this section (approximately 6 km) consists of chert, and silicified limestone which belongs to Amman Silicified Limestone Formation. Alluvium covered the bedrock at wadis.

RGT 3 site is located within this section, the existing material is bedrock.

Section 8

This section is about 11 km, such that Alluvial deposits and Pleistocene gravel present within this zone consist of sand with gravels and boulders.

Section 9

Bedrock exposed at this section (approximately 13 km) consist of chert, marl, chalky marl, phosphate, phosphatic chert, and oyster-coquinal grainstone. This bedrock belongs to Al Hisa Phosphorite Formation, alluvium cover the bed rock at the wadis.

Section 10

This section is about 35 km, such that Pleistocene gravel present within this section consist of silty sand with gravels and boulders. Alluvial deposits present at wadi bed.

Section 11

This section is about 24 km. The prominent material at the first 4.5Km of this section consists of yellow-pink and pale grey to white chalk marl, soft marly limestone, phosphatic marl and bituminous marl, this rock material belongs to Muwwaqar Chalk Marl Formation. Then bedrock becomes mostly chert with minor chalky limestone which belongs to URC, Pleistocene gravel and wadi sediments covering the bedrock 6 km after start extend for 14 km.

Section 12

This exposed rock within this section (approximately 35 km) consists of yellow-pink and pale grey to white chalk marl, soft marly limestone, phosphatic marl and bituminous marl, this rock material belongs to Muwwaqar Chalk Marl Formation. Pleistocene gravel covers the bedrock at several places.

Section 13

This section is about 43 km, bedrock exposed at this section consisting of chert, marl, chalky marl, phosphate, phosphatic chert, and oyster-coquinal grainstone. This bedrock belongs to Al Hisa Phosphorite Formation, alluvial fan deposits and Pleistocene gravel present at this section (5 km from the beginning of the section extending for 8 km) covering the bedrock.

Section 14

This section (approximately 70 km) passes through two geologic formations The Muwwaqar Chalk marl and Al Hisa Phosphorite, the exposed rock consists of chalk marl, soft marly limestone, chert, marl, chalky marl, phosphatic marl, phosphatic chert, and oyster-coquinal grainstone. alluvium cover the bed rock at the wadis. yellow-pink and pale grey to white, phosphatic marl and bituminous marl. This rock material belongs to Muwwaqar Chalk Marl Formation. Pleistocene gravel covers the bedrock at several places.

This section passes/crosses a major geologic structure, which is the Zarqa Ma’in Fault zone (closed to the end of this section).

Section 15

This section (approximately 16 km) passes through Pleistocene gravel on consisting of silty sand with gravels and boulders. Alluvial deposits present at wadi bed.

Section 16

The rock outcrops at this section (approximately 10 km) consisting of chert and chalky limestone. This bedrock belongs to Umm Rijam Chert Limestone Formation. The rock is covered at several locations by Pleistocene gravels. **PSADC** is located within this section. The material at the site is Pleistocene gravels.

Section 17

This section (approximately 16 km) is mostly covered by soil, Silicified limestone and chert exposed at limited locations. At the last 1.8 km (end of the route) of the route, Limestone of Wadi As Sir Limestone Formation out crops.

Section 18

This section is mostly covered by soil, Silicified limestone and chert of Amman Silicified Limestone Formation and Marly Limestone of Wadi As Sir Limestone Formation exposed at several locations of the route.

6.1.3. Water Resources

Several groundwater basins are included within the Project area (Figure 6-4). Agriculture and potable water are mostly taken from groundwater resources through wells that exist all over the study area. Yet, over pumping at rates exceeding their sustainable yield (over 60% of the wells are over pumped) results in lowering the water table throughout the Project area thus increasing salinity levels of some aquifers and degrading their quality. Based on the 2011 ESA of the Red Sea Dead Sea Project [15], the Dead Sea, North Wadi Araba and South

Wadi Araba basins have 426, 31 and 54 operating wells, and are over pumped at rates of 148%, 138%, and 151% of the safe yield respectively. It is worth mentioning that the southern Wadi Araba catchments include some major wadis that occasionally collect significant amounts of rainwater, leading to floods in the direction of Aqaba such as the flood event that occurred in February 2006 whereby, Wadi Yutum, northeast of Aqaba, gave rise to a significant flood event that inundated large parts of the city. It has been estimated that the flood peak was about 550 m^3/s [13].

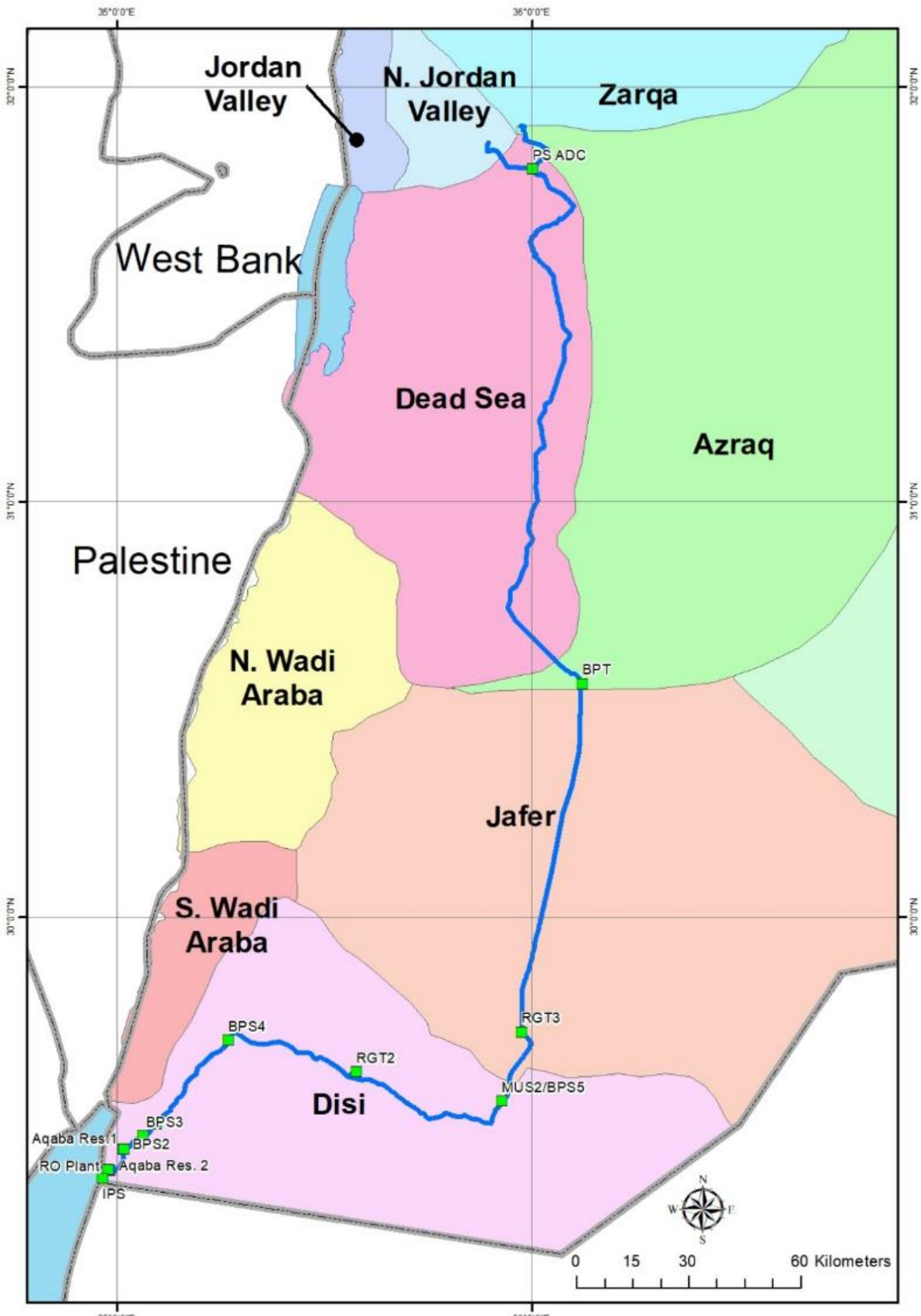


Figure 6-4: Groundwater Aquifer Systems in the Region

One of the groundwater basins is Wadi Araba. Rainwater recharges to the south of this watershed and drain from east and west directly into the Gulf of Aqaba. As for the rainwater that recharge to the north of this watershed, this drains towards the Dead Sea. At certain points in the central and southern Araba groundwater occasionally rises to the surface, where it is collected in basins. The groundwater aquifers in Wadi Araba mainly consist of limestone, which are recharged by the winter rainfall [16]. The boundaries of the common groundwater basins including the southern and northern Wadi Araba catchments are presented in Figure 6-5.

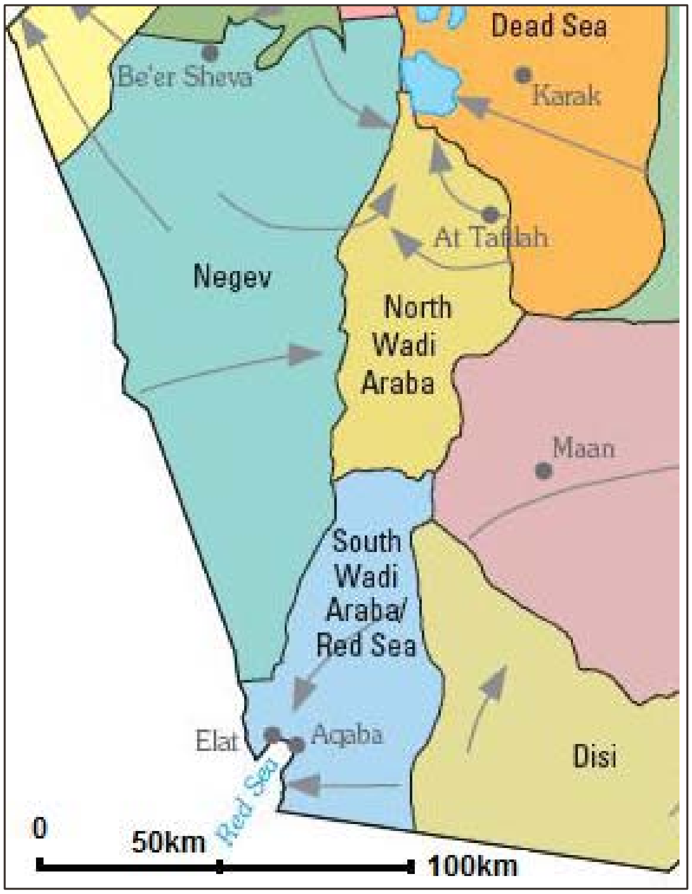


Figure 6-5: Common Groundwater Catchment Basins within the Project Area [16]

In terms of water quality, sampling, and water quality analysis for different wells in Wadi Rum area was conducted by the laboratory team of the MWI as part of the Energy Efficiency in the Jordanian Water Sector (Phase 2) project on December 18 and 19, 2017. Several water quality parameters were analysed including Electrical Conductivity, pH, Hardness as $CaCO_3$, Magnesium, Nitrate, Potasium, Sodium, Sulfate, Bicarbonate, Carbonate, Hydroxide, Ammonium, Iron Manganese, Calcium, Chloride, Gross Alpha, Gross Beta, Carbon13, Deuterium, Oxygen18, Rn222, Thorium 232, Uranium 238, Radium 226, and Radium 228. Based on the water quality analysis of these parameters, significant deviations were observed with regard to the Alpha and Beta Radionuclides that exceed the limit values for drinking water by 0.5 Bq/l and 1.0 Bq/l, respectively. The results also showed that there is higher level of nitrite (< 50 mg/l), sodium (< 200 mg/l), sulphate (<200 mg/l) and chloride (<200 mg/l) in one of the wells. This is most probably due to agricultural activities and the use of fertilizers [17].

Another main aquifer within the project area is the Disi aquifer in southern Jordan. This aquifer is considered the main source of water for Mudawara Region and one of the most permeable and productive Sandstone aquifers in the Jordan. This aquifer was assessed for its water quality within the framework of a study conducted by Mehasneh (2017) [18]. The results showed that the water is of good quality and acceptable for drinking purposes according to national and EU standards.

As for the surface water, about 37% of the total water supply from 16 basins [19] (Figure 6-6) and the Yarmouk River is the main tributary of the Jordan River, with a historic flow of 450 MCM/yr [20]. While the Zarqa River is the only major river completely within Jordan's jurisdiction, about 50% of the river's flow originates from the Al-Samra wastewater treatment plant.

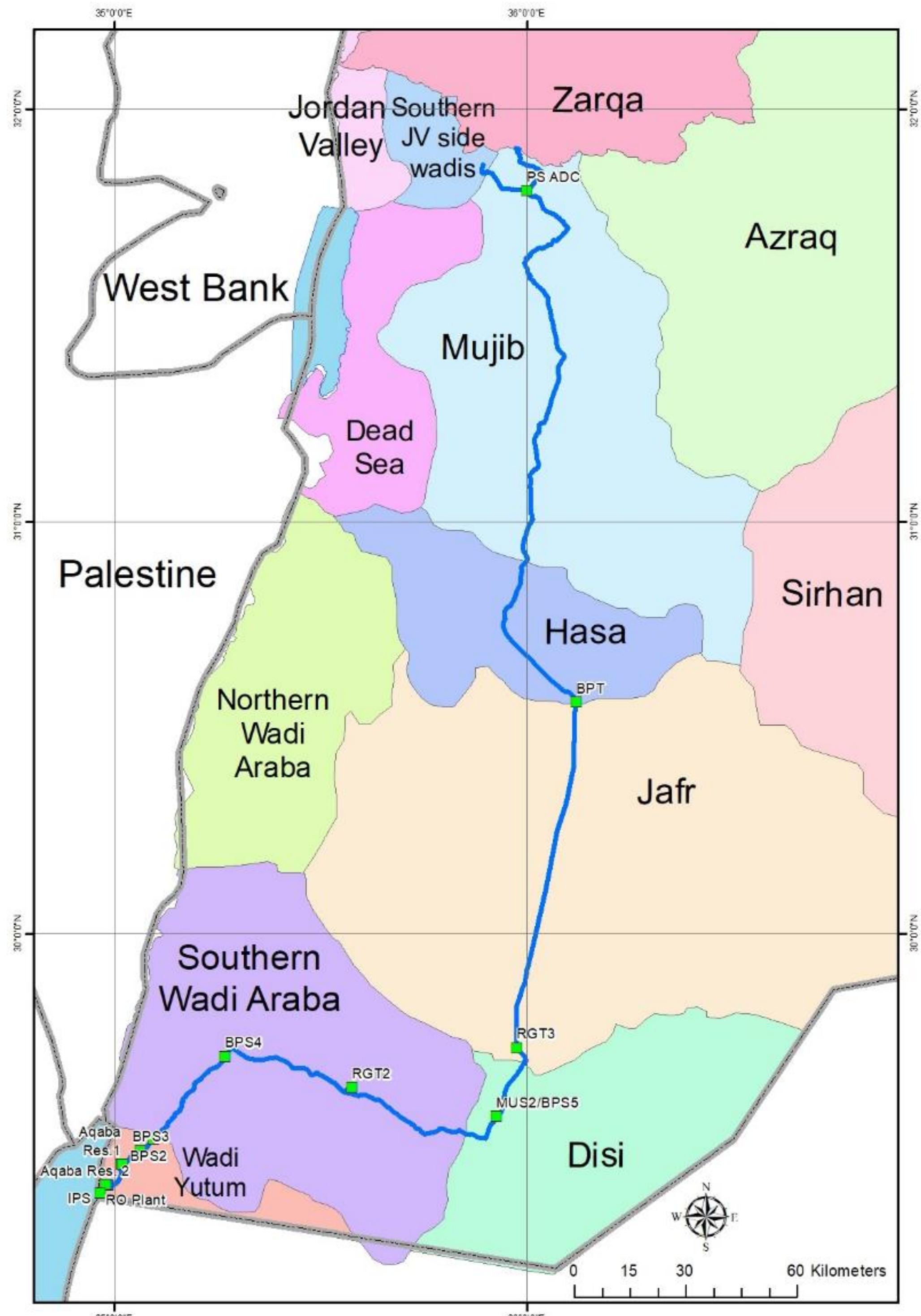


Figure 6-6: Surface Water Basins in Jordan

Along the Project sites, seasonal streams usually arise (Figure 6-7). During the site visits, no major streams were observed. However, the SWRO plant includes two wadis in the east-west direction, Wadi 4 and Wadi 5, according to the Hydrologic Analysis Report prepared by CDM Smith in May 2009. These wadis divide the overall site into three subsites (north, central, south).

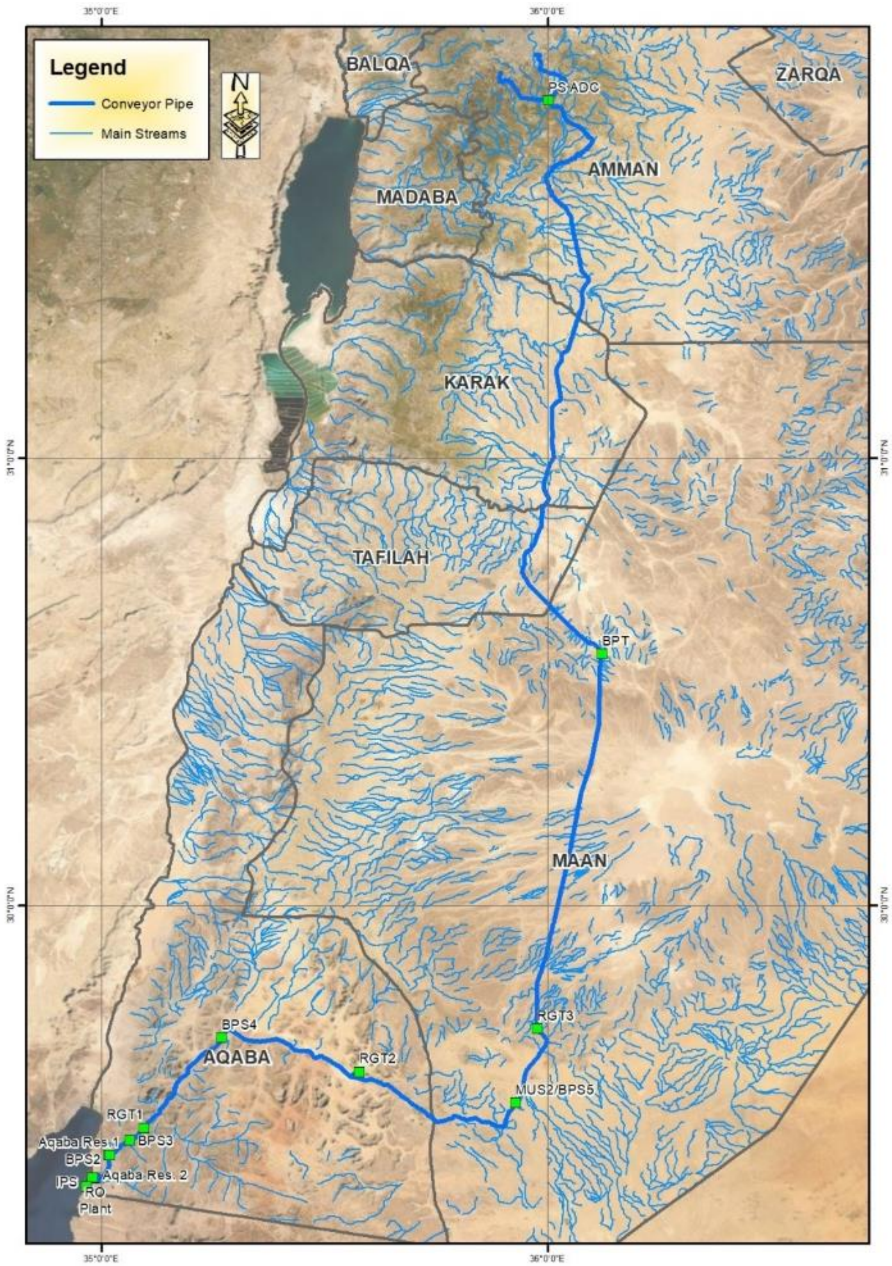


Figure 6-7: Main Streams in Jordan

6.1.4. Weather Parameters (Climate)

Jordan is considered as having a hot, dry climate characterized by long, hot, dry summers and short, cold winters. The climate in Jordan is influenced by its location between the subtropical aridity of the Arabian desert areas and the subtropical humidity of the eastern Mediterranean area. 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. Daily temperatures can be very hot, especially in the summer; on some days reaching 40°C or more [21].

About 70% of the average rainfall in the country falls between November and March; June through August are often dry. Rainfall varies from season to season and from year to year such that precipitation is often concentrated in violent storms, causing erosion and local flooding, especially in the winter months. 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 within the project area varies by location. For Aqaba, Figure 6-8 below shows average monthly temperatures (mean daily minimum and maximum) and precipitation for the last 30 years. The average annual temperature in Aqaba according to Aqaba station is 22.1°C. August is the warmest month of the year with an average temperature of 30.1°C while January, the coldest month, has an average temperature of 13.2°C. The average annual rainfall in the town is 30 mm [22].

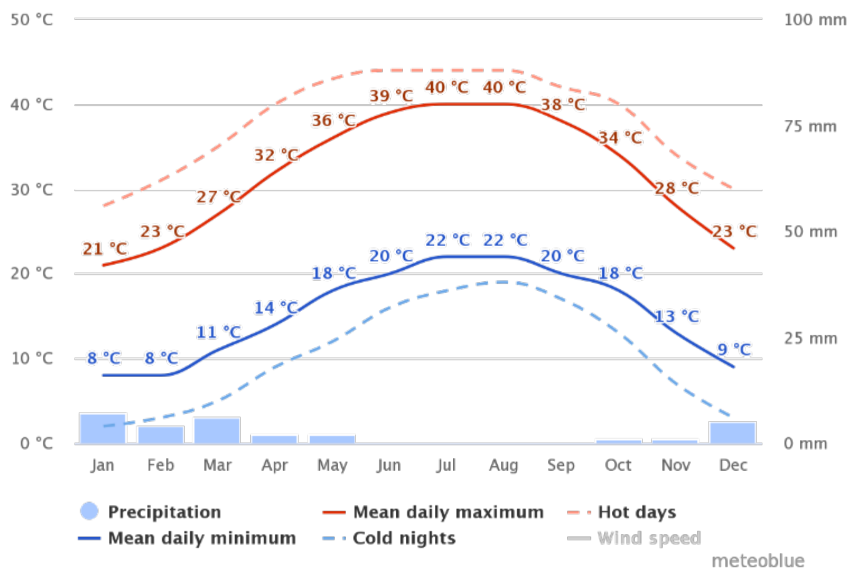


Figure 6-8: Aqaba Average Temperatures and Precipitation [23]

Figure 6-9 presents a modelled wind rose for Aqaba, showing how many hours per year the wind blows from the indicated direction. According to the figure, wind in the area mostly blows from the northwest.

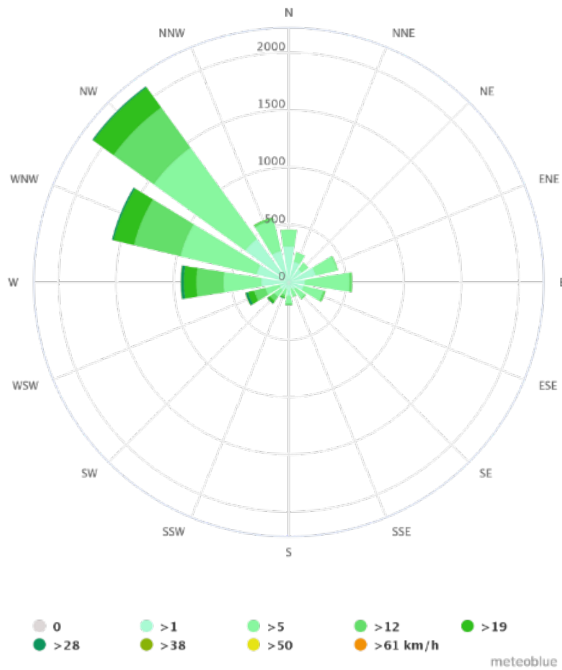


Figure 6-9: Aqaba Wind Rose [23]

Ma'an's climate is a desert one with average temperature of 18.9°C and rainfall of around 40 mm per year, according to Rum station [22]. Average monthly temperatures and precipitation for the last 30 years are shown in Figure 6-10. The wind in Ma'an mostly blows from west-northwest (Figure 6-11).

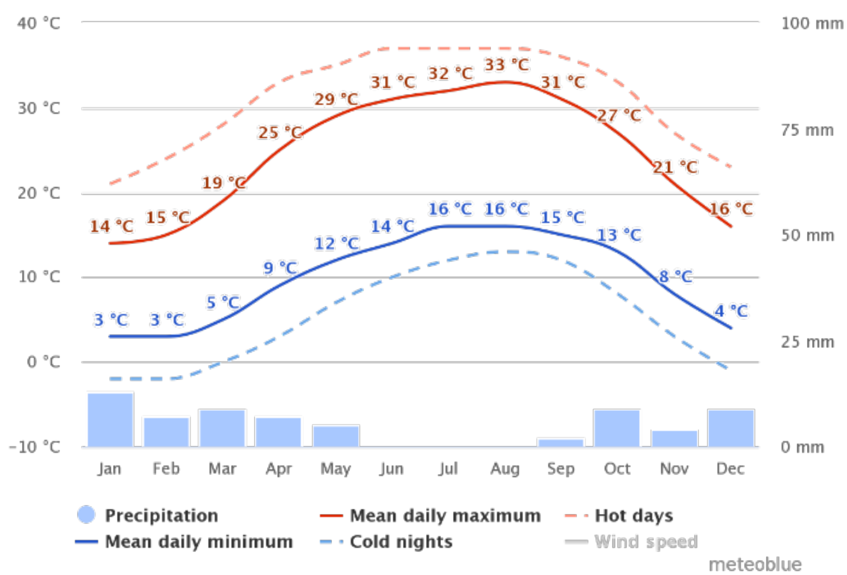


Figure 6-10: Ma'an Average Temperatures and Precipitation [23]

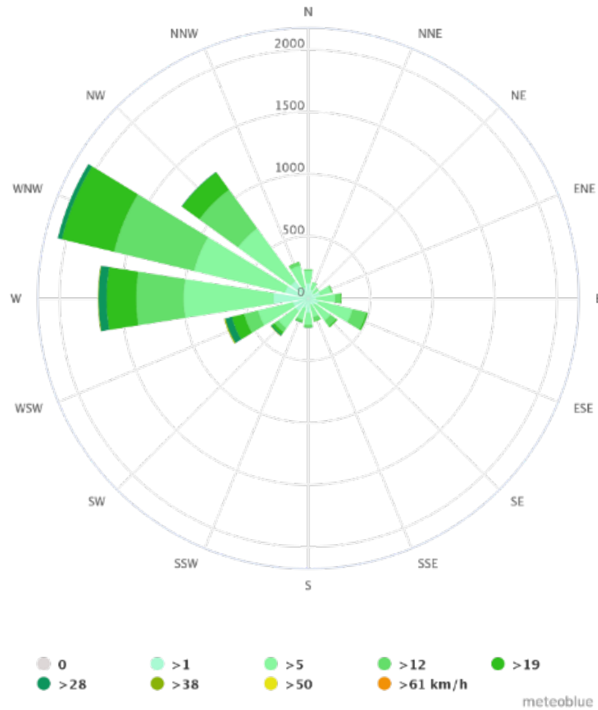


Figure 6-11: Ma'an Wind Rose [23]

According to Dana's station in Tafila, the average annual temperature is 17.7°C and the annual rainfall is 74 mm [22]. With regard to the average temperatures and precipitation in Tafila for the last 30 years, it is presented in Figure 6-12 while Tafila's wind rose is presented in Figure 6-13 showing that wind mostly blows from the west in Tafila.

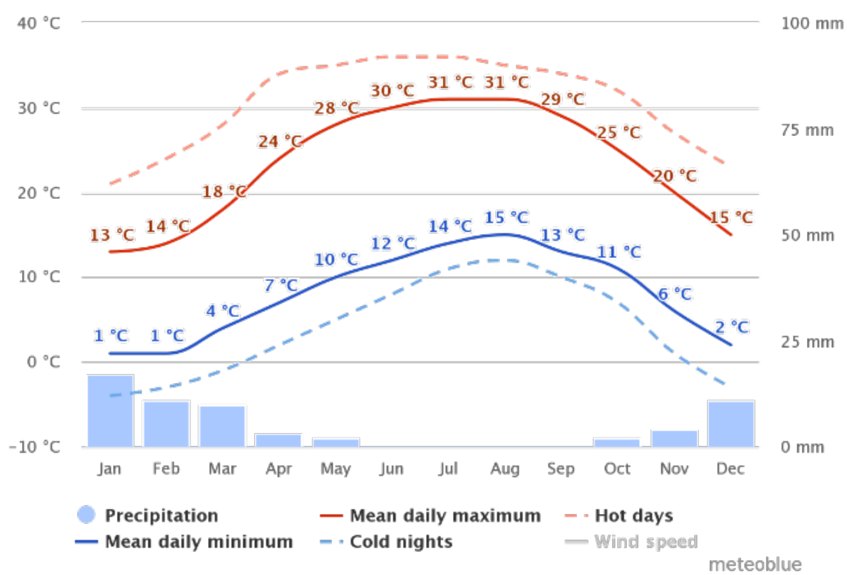


Figure 6-12: Tafila Average Temperatures and Precipitation [23]

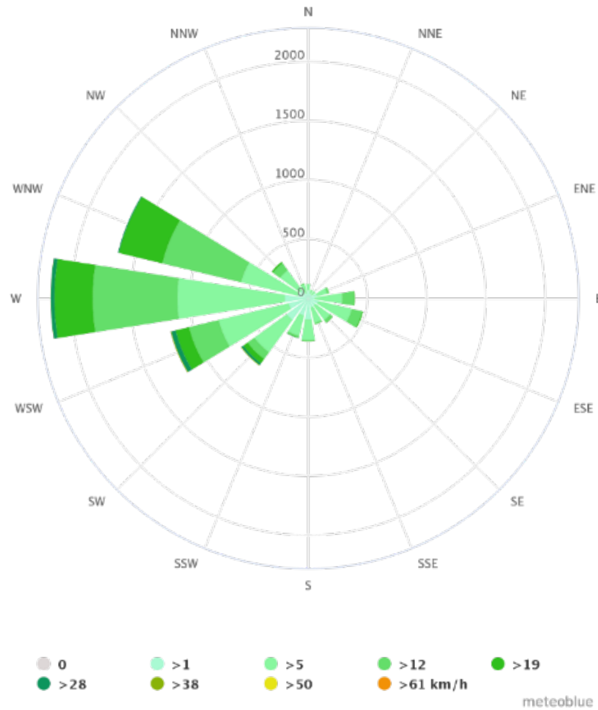


Figure 6-13: Tafila Wind Rose [23]

Climate in Karak is similar to Tafila and Ma'an, which is also a desert climate whereby the average annual temperature is 17.8°C and precipitation is about 113 mm per year [22]. Figure 6-14 below shows average temperatures and precipitation in Karak for the last 30 years while the wind rose of Karak is similar to that of Tafila dominated by westerly winds.

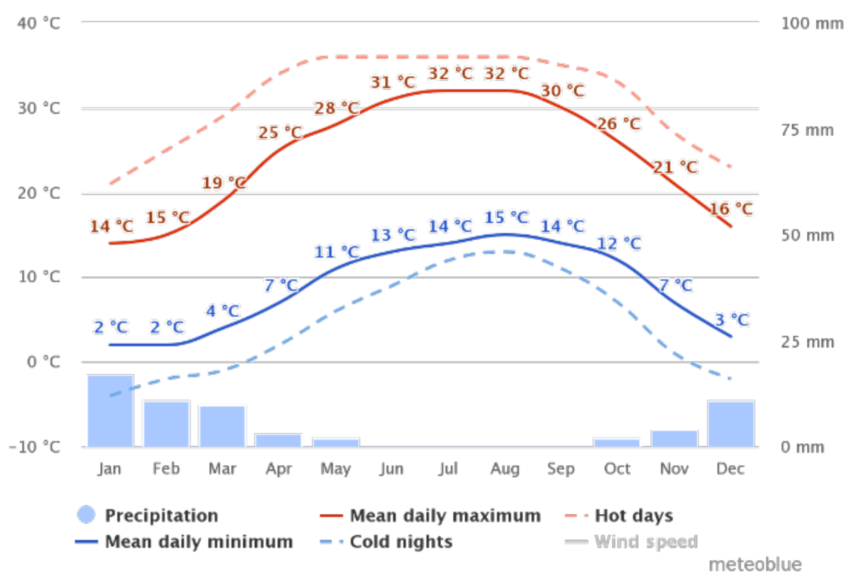


Figure 6-14: Karak Average Temperatures and Precipitation [23]

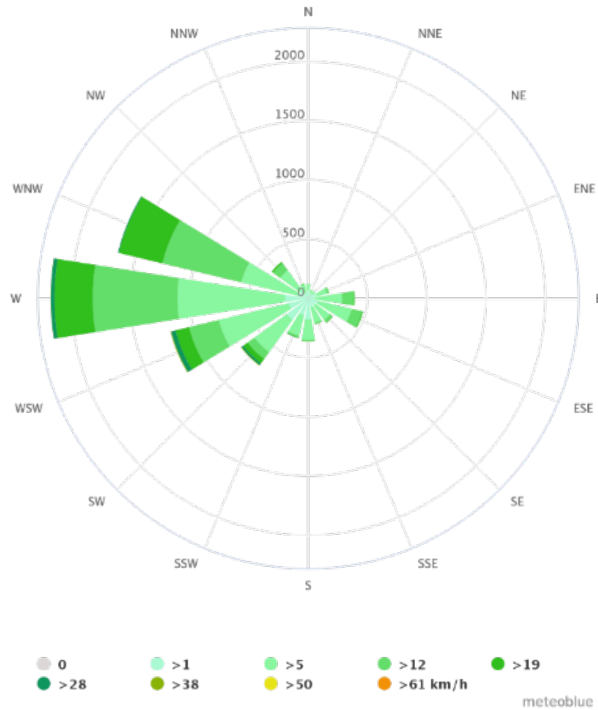


Figure 6-15: Karak Wind Rose [23]

The prevailing climate in Amman is known as a local steppe climate. The average annual temperature in Amman is 17.2 °C. The rainfall is around 187 mm per year [23]. Average temperatures and precipitation of Amman are presented in Figure 6-16 below and for 30 years duration while wind rose of Amman shows prevailing westerly winds.

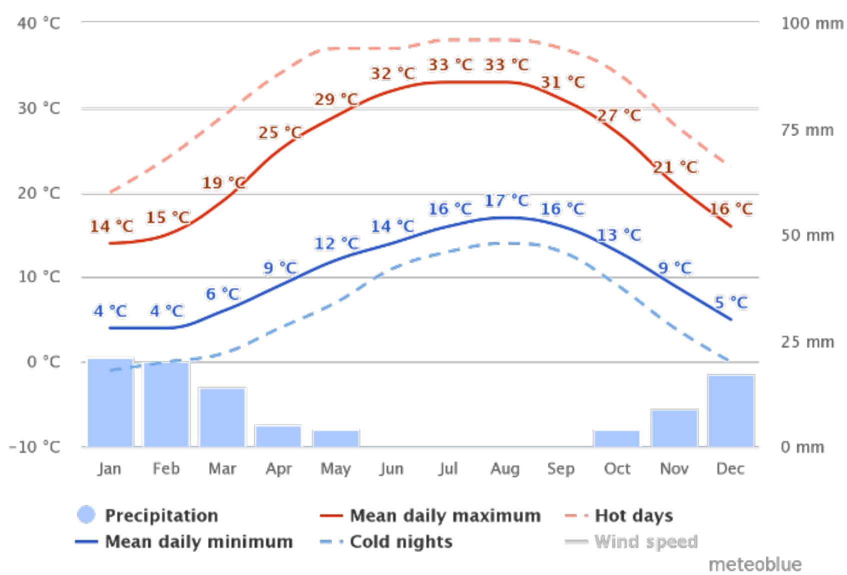


Figure 6-16: Amman Average Temperatures and Precipitation [23]

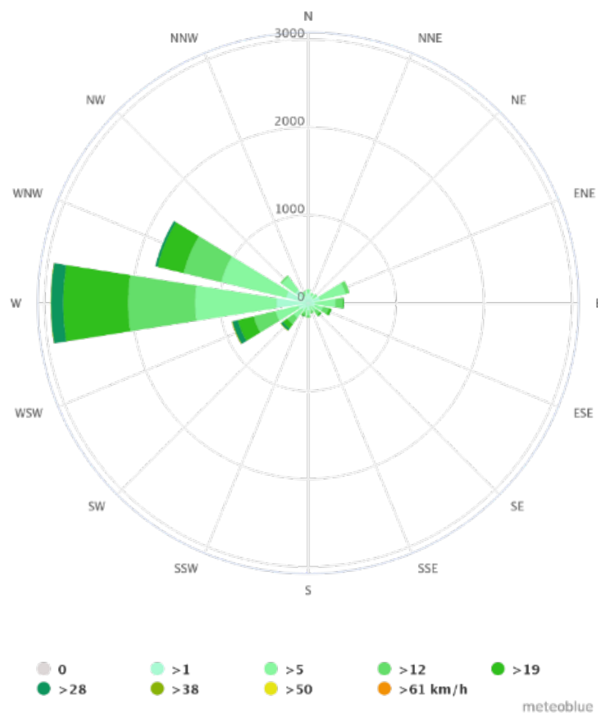


Figure 6-17: Amman Wind Rose [23]

6.1.5. Air Quality

Air quality data from ASEZA's New Port Air Quality Station was obtained in order to establish an indicative baseline for air quality in the area. This station is around 650m away from the IPS location and around 3.5 km away from the SWRO Desalination Plant (Figure 6-18).

Figure 6-18: Location of the New Port Air Quality Station with respect to the IPS and SWRO Desalination Plant Location

Table 6-1 presents the average daily air quality data obtained from ASEZA for the year of 2020 along with the Jordanian standard for ambient air quality (JS 1140/2006) for comparison.

Table 6-1: Air Quality Data from ASEZA Port Station for 2020

Parameter	PM_{10}	NO_2	SO_2	NH_3	H_2S	C_6H_6	C_7H_8	C_8H_{10}	MP-Xylene	O-Xylene
JS 1140/2006	120 μg/m^3	80 ppb	140 ppb	270 μg/m3	10 ppb	-	-	-	-	-
Jan-20	107.3	27	53.6	206.6	4.9	1	1.9	2.3	2.1	1.9
Feb-20	147.2	20.6	43.2	394.4	5.3	1.2	2.4	1	1.4	2.4
Mar-20	192.8	26.2	34.3	458.2	4.9	1.5	5.3	1.2	2.2	5.3
Apr-20	429	22.2	51.6	705.1	7.2	1.1	3.1	1.1	1.3	3.1
May-20	357.5	22.2	96.4	392.8	6.1	0.96	1.98	1.03	1.2	1.98
Jun-20	257.1	24.5	2.6	159.5	5.1	0	0	0	0	0
Jul-20	325.9	15.7	2.8	141.8	4.5	0	0	0	0	0
Aug-20	177.6	40.3	3.3	334.3	4.4	0	0	0	0	0
Sep-20	263	28.9	7	212	4.3	0	0	0	0	0
Oct-20	248.9	19.3	4.1	239.4	3.8	1.5	6.6	1.1	1.7	6.6

It can be noted that PM_{10} levels exceeded the JS 1140/2006 standards for all available months except for January. Moreover, concentrations of NH_3 were above the standard limits (JS 1140/2006) during several months of the measuring period. This exceedance is attributed to the presence of local transportation activities (i.e., ship, trucks) as well as industrial emissions within the area.

In addition, air quality data for the year of 2019 have been 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. Figure 6-19 presents the location of these five stations.

Figure 6-19: Location of MoEnv Monitoring Stations along the Conveyance Pipeline

Table 6-2 represents air quality data along the conveyance pipelines. For the Ma'an, Husaineyah, Qatraneh, and Sultani, the air quality data was obtained from the MoEnv air quality reports for the year 2019 when 6-day monitoring campaigns were conducted in those areas. Air quality data from the Sahab station were obtained from the 2019 Air Quality Assessment Report for Industrial Areas in Jordan conducted by the Royal Scientific Society. The data present average concentrations over a period of 1 year for some parameters.

Table 6-2: Air Quality Data along the Conveyance Pipeline

Parameter	Date	PM_{10}	$PM_{2.5}$	O_3	SO_2	H_2S	NO_2	NH_3	CO
JS 1140/2006		120 µg/m³	65 µg/m³	-	140 ppb	10 ppb	80 ppb	270 µg/m³	9000 ppb
Ma'an	20-Sep-2019	62	23	49.39	9.13	11.50	4.98	3.73	1167
	21-Sep-2021	52	18	41.42	7.62	11.70	4.25	4.70	1260
	22-Sep-2021	36	12	45.04	8.27	11.43	6.68	2.42	1288
	23-Sep-2021	49	17	45.88	8.59	11.87	8.58	2.14	1346
	24-Sep-2021	41	12	44.43	8.02	11.70	9.35	1.33	1343
	25-Sep-2021	41	13	51.00	9.56	11.25	9.49	1.17	1366

Parameter	Date	PM_{10}	$PM_{2.5}$	O_3	SO_2	H_2S	NO_2	NH_3	CO
JS 1140/2006		**120 µg/m³**	**65 µg/m³**	**-**	**140 ppb**	**10 ppb**	**80 ppb**	**270 µg/m³**	**9000 ppb**
Husaineyah	13-Sep-2019	33	9	54.2	11.91	10.7	2.55	5.68	241
	14-Sep-2019	53	19	47.5	8.44	11.2	2.4	7.31	221
	15-Sep-2019	49	18	56.7	7.1	11.6	1.87	5.94	163
	16-Sep-2019	40	17	55.3	8.48	11.4	2.98	5.44	139
	17-Sep-2019	44	15	48.8	10.43	11	4.9	5.04	-
	18-Sep-2019	51	14	49.9	8.47	11.3	4.92	4.14	-
Qatraneh	22-Jul-2019	43	-	34.1	50.5	11.6	17.4	12.6	1655
	23-Jul-2019	46	-	36.2	46.8	11.6	22.1	5.5	1595
	24-Jul-2019	43	-	34.5	46.6	11.7	26.7	2.4	1559
	25-Jul-2019	49	-	32	44.8	11.6	26.4	3.3	-
	26-Jul-2019	54	-	36.6	42.6	11.5	18.4	6.1	-
	27-Jul-2019	52	-	33.1	42.3	11.5	17.4	8	-
Sultani	29-Jul-2019	39	-	43.7	45.3	11.4	3.2	12.7	1370
	30-Jul-2019	44	-	44.9	46.6	11.2	9.1	7.1	1481
	31-Jul-2019	60	-	39.6	49.1	11.4	14.9	6.4	1560
	1-Aug-2019	77	-	42.5	42.4	11.8	4.9	9.6	1583
	2-Aug-2019	62	-	36.4	39.8	11.2	2.4	13	1609
	3-Aug-2019	55	-	38.4	37.8	11.5	2.6	12.1	1628
Sahab	1-Jan-2019 till 31-Dec -2019	-	96	-	36		89		4480

From the results above it can be notices that all tested parameters by MoEnv were within the Jordanian standards for air quality (JS 1140/2006) except for H_2S, for which concentrations were slightly above the standards for all locations. This is attributed to the presence of wastewater treatment plants and animal feed manufacturing industries.

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 them. This is likely due to the presence of an industrial wastewater treatment plant next to this station, as well as to its proximity of several stone cutting industries. In addition, the industrial area of Sahab is considered the largest industrial area in Jordan including more than 467 industrial facilities of different manufacturing categories (food production, pharmaceuticals, plastic and rubber production, chemical production, tanneries…).

6.2. Marine Environment

6.2.1. Seabed Morphology

The coastal area where the IPS is located is mainly a rocky reef structure extending to 45 m depth contour (Figure 6-20). It is a well-developed coral reef with relatively high live percentage cover in the centre down to 25 m. The reef structure continues to extend between 25 m and 45 m contours, but with much less live cover, not exceeding 5%. Beyond 45 m the reef structure disappears and the bottom drops rapidly to 50 m after which exists a gently sloping consolidated sand area. The bottom slopes steeply from east to west and gently from south to north, i.e. the points of similar longitude are deeper at the northern end than at the southern.

Figure 6-20: AAWDC Coastal Site Bathymetry

Figure 6-21 presents an illustration of the AAWDC coastal site bottom structure grasped from the two diving video surveys **(Annex 11).** The first diving video survey covered the entire area from the shoreline to 35 m depth and the second diving video survey covered 10 m wide belts along the proposed outfall pipeline and diffusers up to a seabed depth of 50 m.

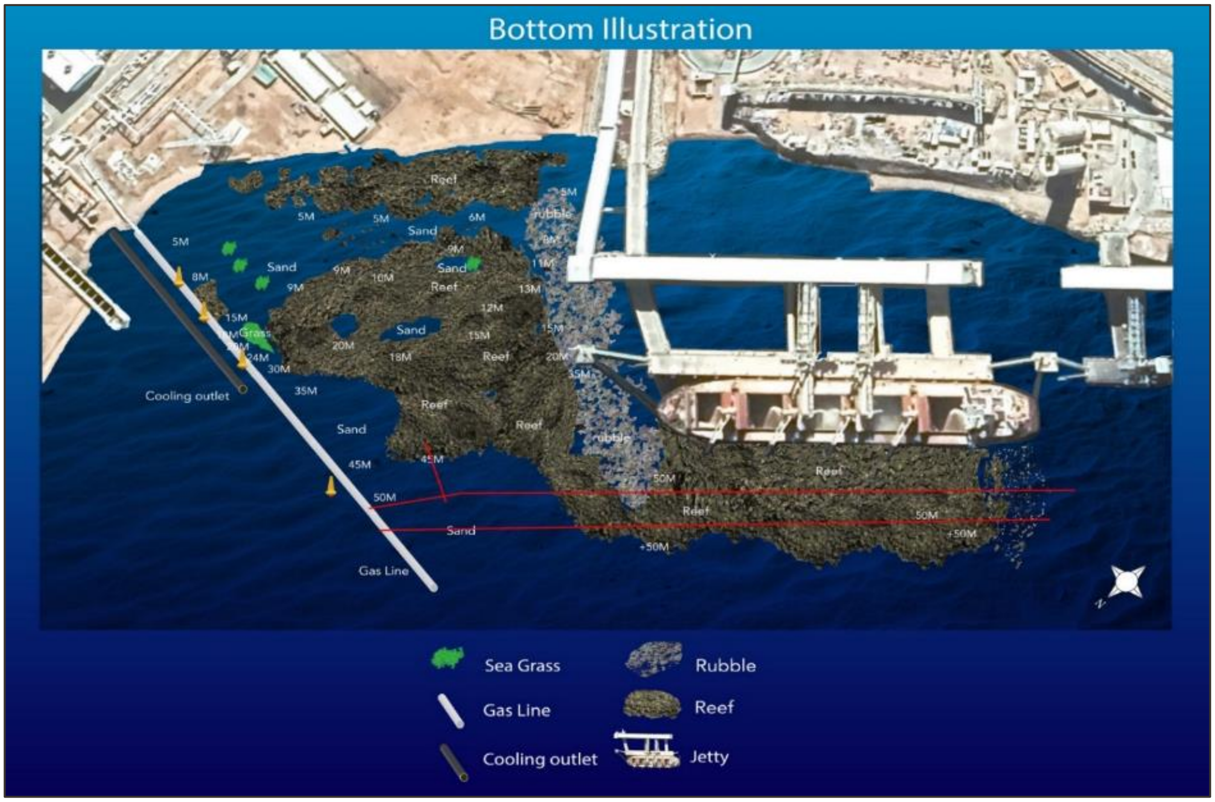


Figure 6-21: Illustration of the Seabed Configuration at the AAWDCP Suggested Intake, Outfall Pipeline and Diffusers Area

Characterising features of this area outlined in the video surveys are:

- The northern side that accommodates a Gas Pipeline is a sandy valley.
- The sandy valley is of an average width of about 30 m and extends beyond the 50 m contour.
- The southern side next to the JPMC LB is mostly rubble of damaged corals.
- Between depth contours 25 m and 45 m, the reef consists of mainly dead corals and coral rock.
- At the end of the reef structure at 45 m depth the bottom drops abruptly to 50 m.
- At 50m depth, the bottom consists mainly of consolidated sand for a width of about 100 m and continues sloping to the west but much less steep than between the shoreline and 50 m depth.
- After about 100 m of consolidated sand from the gas pipeline at 50 m reef structure with very poor live cover appears at (29°22'19.04"N, 34°57'46.27"E). Towards the end of the 50 m depth belt, the depth decreases rapidly, still consisting mainly of rubble and consolidated sand.

6.2.2. 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. According to a recent study by Omar et al [24] reporting on a number of point-by-point investigations of seismology and geophysics in the Gulf of Aqaba during the period 1998–2017, the vast majority of the ongoing seismic action revolving around the Gulf of Aqaba is portrayed by the contribution of moderate central quakes and an immediate after-effect of the relative development between the plates of Africa, Sinai, and the Arabian Peninsula. The connection between the dispatch and magnitude of quakes in the Gulf of Aqaba demonstrated that the vast majority of the Seismic Energy discharge originating from the biggest events is packed in the inside, while it is moderately low in the southern and northern parts of the Gulf.

According to the earthquake track site [25] in the last 24 years, 21 earthquakes were recorded around the Gulf of Aqaba, none of which were in Aqaba and they were mostly of magnitude below 5 and at depths exceeding 10 km.

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 the recent *history. Figure* 6-22 *shows* a map of earthquakes near Aqaba in the last 10 years.

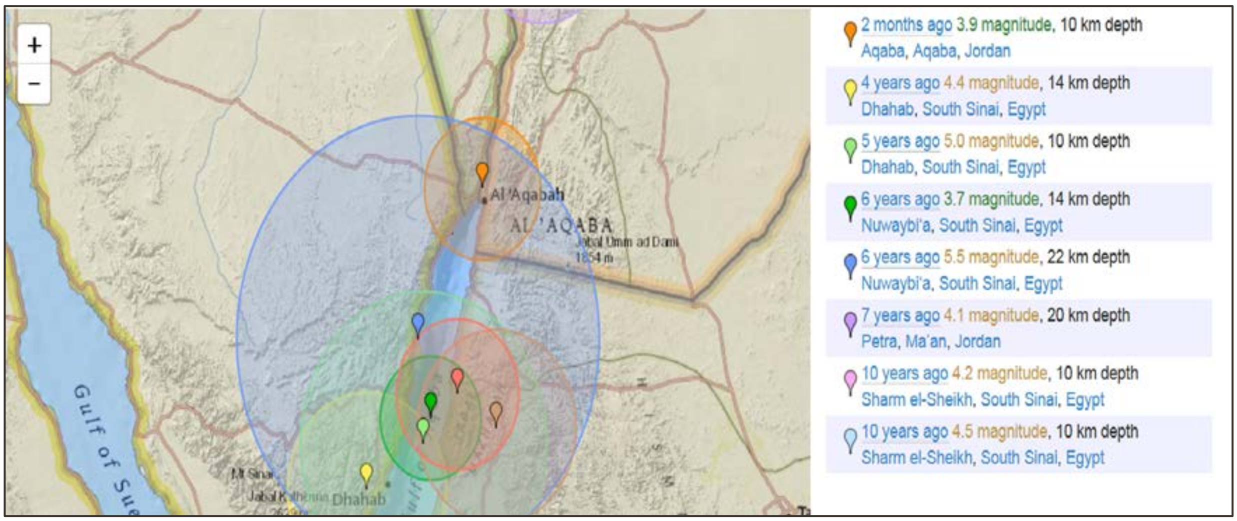


Figure 6-22: Earthquakes Near Aqaba in the Last 10 Years

6.2.3. Seawater Hydrology

The Gulf of Aqaba forms with the Gulf of Suez the two northern terminal basins of the Red Sea. The two basins (Figure 6-23) are significantly different in their natural characteristics. While the Gulf of Aqaba is deep and narrow, about one tenth the width of the Red Sea but close in depth, the Gulf of Suez is wider and much shallower. Besides, the Gulf of Suez has been artificially connected with the Mediterranean Sea through the Suez Canal. This has not been reported to seriously affect the hydrology but may result in considerable exchange of biodiversity. However, both the Gulf of Aqaba and Gulf of Suez have been reported to significantly affect formation of the northern Red Sea intermediate depth water [26] [27] [28].

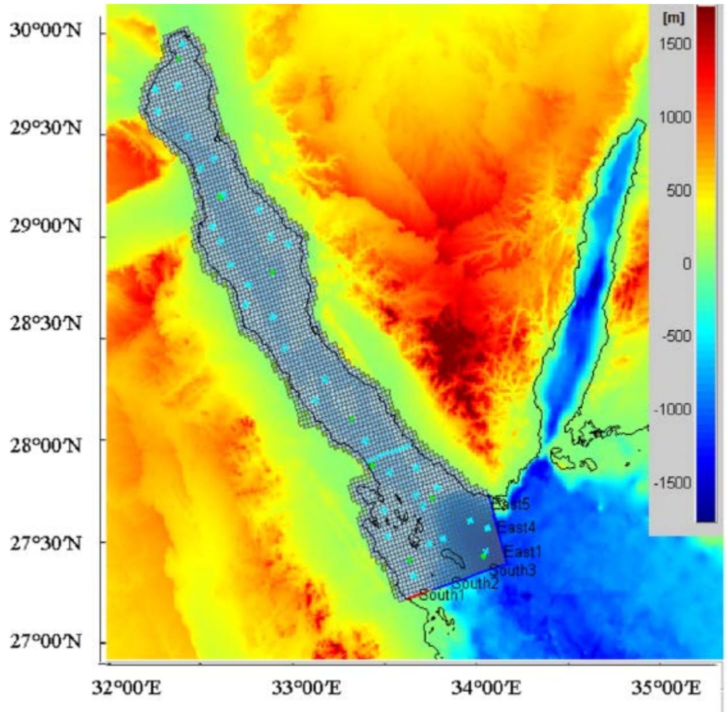


Figure 6-23: Northern Red Sea and the Gulfs of Suez and Aqaba [26]

The Gulf of Aqaba is connected to the Red Sea through the shallow strait of Tiran. It is about 6 km wide and has two channels of about 290 m and 75 m depths. Exchange between the Gulf of Aqaba and the Red Sea through the Strait defines most of the hydrology of the Gulf of Aqaba.

The Gulf of Aqaba lacks any regular freshwater surface inflow and its waters are generally warm (21-27C^o). It is subject to dry winds most of the year. This results in the Gulf experiencing high evaporation rates which are according to recent estimates about 0.5 cm/day. Given a surface area of the Gulf of about 3.2 x 10^9 m^2 this implies a net inflow to the Gulf of about 16,000,000 m^3/day, which is about three times the abstraction rate proposed previously for the RSCDC [14] and about 23 times the ultimate product water abstraction rate proposed for the AAWDCP. Seawater exchange between the Gulf of Aqaba and the Red Sea occurs through surface inflow of the Red Sea water into the Gulf of Aqaba and subsurface inflow of the higher salinity denser waters of the Gulf of Aqaba into the Red Sea. Total exchange is estimated to range between a minimum of about 432,000,000 m^3/day in September-November and a maximum of about 3,456,000,000 m^3/day in March-April, with an annual mean of about 1,555,200,000 m^3/day. Figure 6-23 and Figure 6-24 illustrate the seawater exchange between the Gulf of Aqaba and northern Red Sea through the Strait of Tiran.

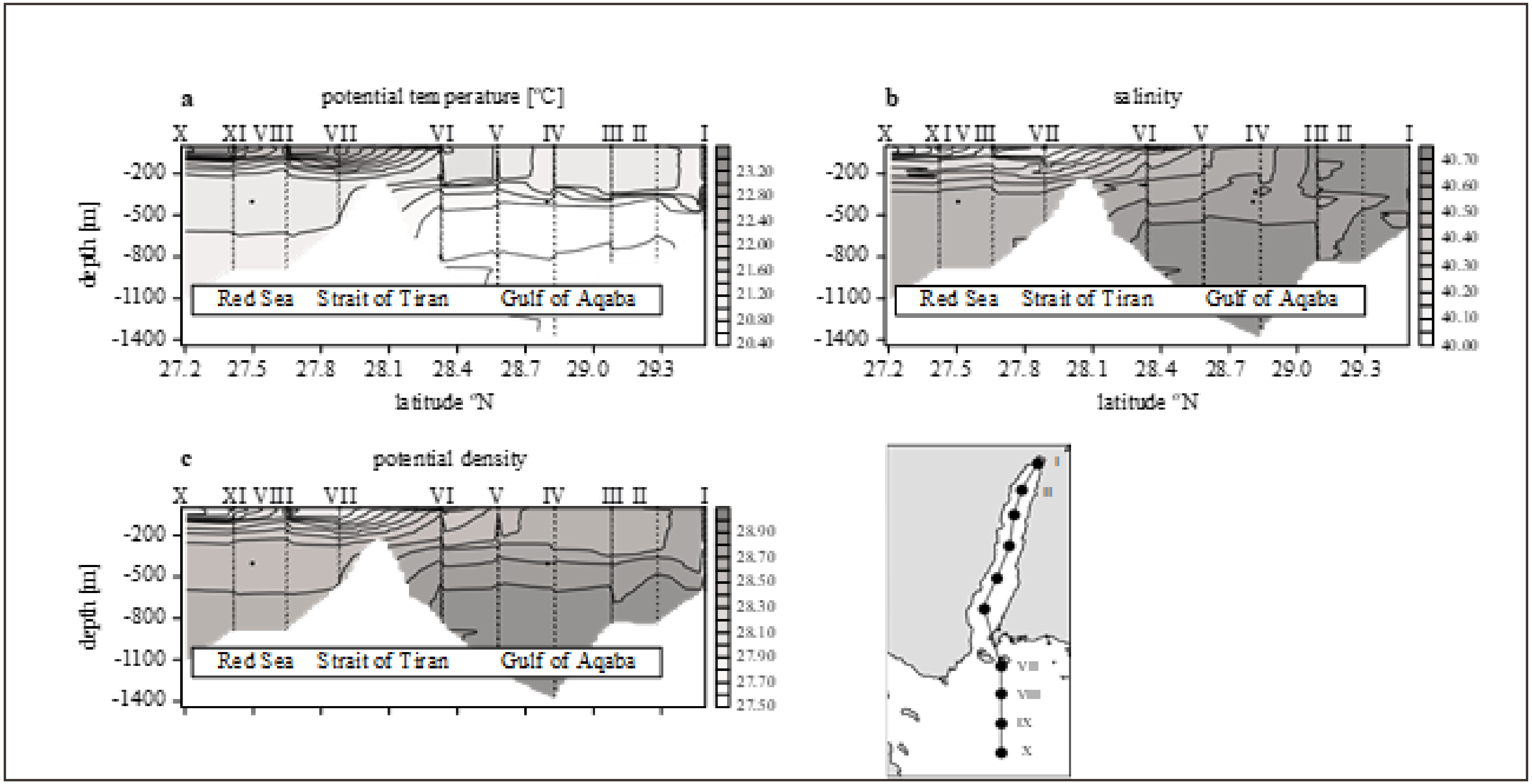


Figure 6-24: Long section distribution of Potential Temperature [◦C], Salinity and Potential Density in the Gulf of Aqaba and northern Red Sea from February 21st to March 7th, 1999 [29]

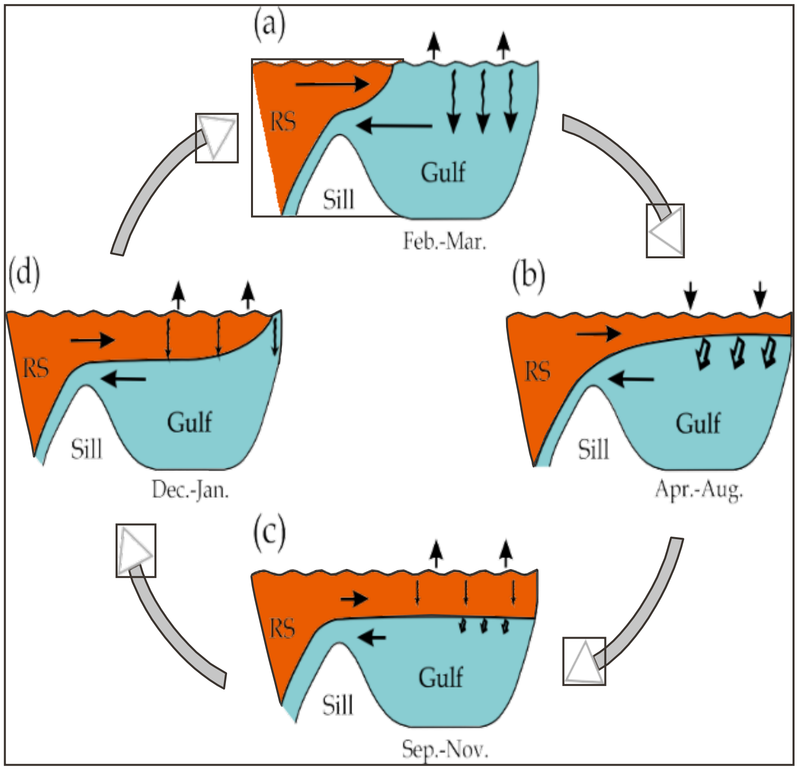


Figure 6-25: Schematic Representation of Different Stages in the Gulf of Aqaba Seasonal Evolution of the Deep/Intermediate Water Balance [30]

Notes: (a) the wintertime mixing conditions, (February–March); (b) the re-stratification period during April–August; (c) quasi-steady conditions in the intermediate water level/volume (September–November); and (d) the transition stage, when thermally driven vertical mixing creates a new intermediate water mass along the Gulf starting at the north

6.2.4. Seawater Level and Tides the in the Gulf of Aqaba

Tides in the Gulf of Aqaba are intimately affected by those in the Red Sea. Long-term sea level variations in the Red Sea are mainly influenced by water exchange through the Strait of Bab al-Mandab (at the bottom of the Red Sea), wind stress and evaporation [31]

Tides in the Gulf of Aqaba are minimal, with a range of about 1-1.5 m. They are semidiurnal displaying two highs and two lows every 24 hours. Tidal records in the northern Gulf of Aqaba have been measured intermittently by the Marine Science Station since the early 1980s. Regular and somehow continuous records have commenced in 2000 through the GEF-World Bank Project Aqaba Marine Peace Park. These records have been made at a fixed point with a frequency of 10-minute intervals adjusted to Global Mean Sea Level (MSL).

The yearly cycle of the sea level anomalies at the northern Gulf of Aqaba follows the corresponding sea level variations in the Red Sea. In general, during the period December-May, wind induced water movement driven by the north-east monsoon, has a net flow from the Indian Ocean to the Red Sea, which results in elevating the water level in the Red Sea and the Gulf of Aqaba. During the period July-October, the wind induced water movement, due to the south-west monsoon, has a net flow from the Red Sea to the Indian Ocean, which results in a lower water level in the Red Sea and consequently in the Gulf of Aqaba [31]. This phenomenon may in some years result in extreme low tide reaching about -0.7 m with reference to MSL, leading to over exposure of the intertidal zone during summer.

6.2.5. Waves

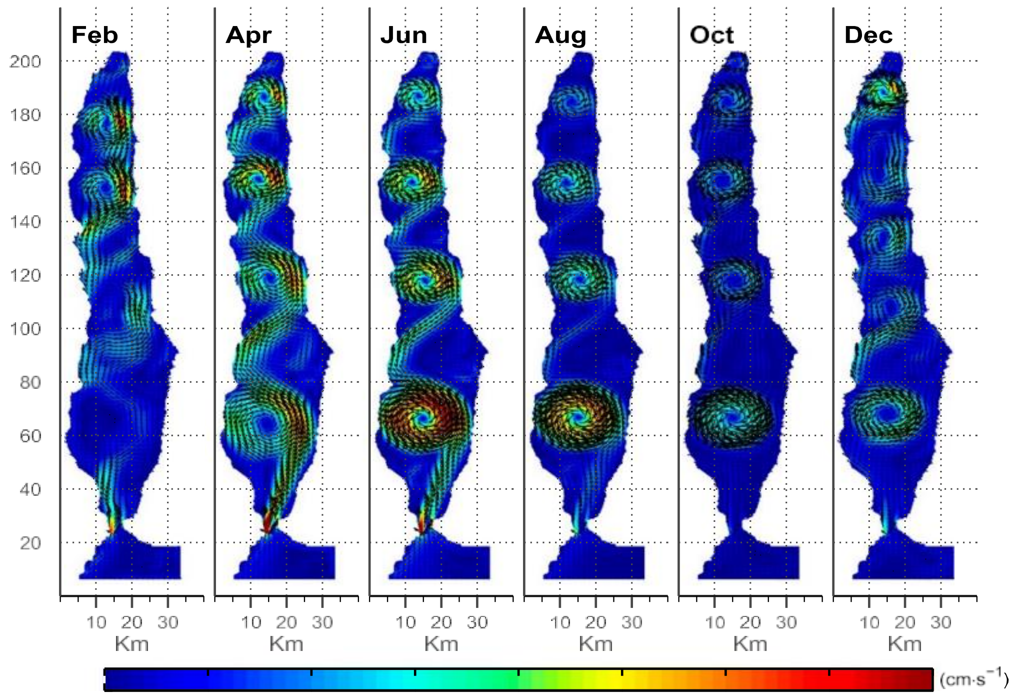
Wave heights in the Gulf of Aqaba are generally determined by the prevailing winds. The heights of sea waves depend on the distance from the land upwind, or the fetch, generally increasing in height the further the wind blows from the land. Wind generated waves and swell in the Gulf of Aqaba rarely exceed 1 m and in the northern Red Sea, as far south as 20°N are normally less than 2 m in height associated with north-north-west winds. But occasionally exceed 20m high associated with southern southern-western winds [31].

6.2.6. Currents

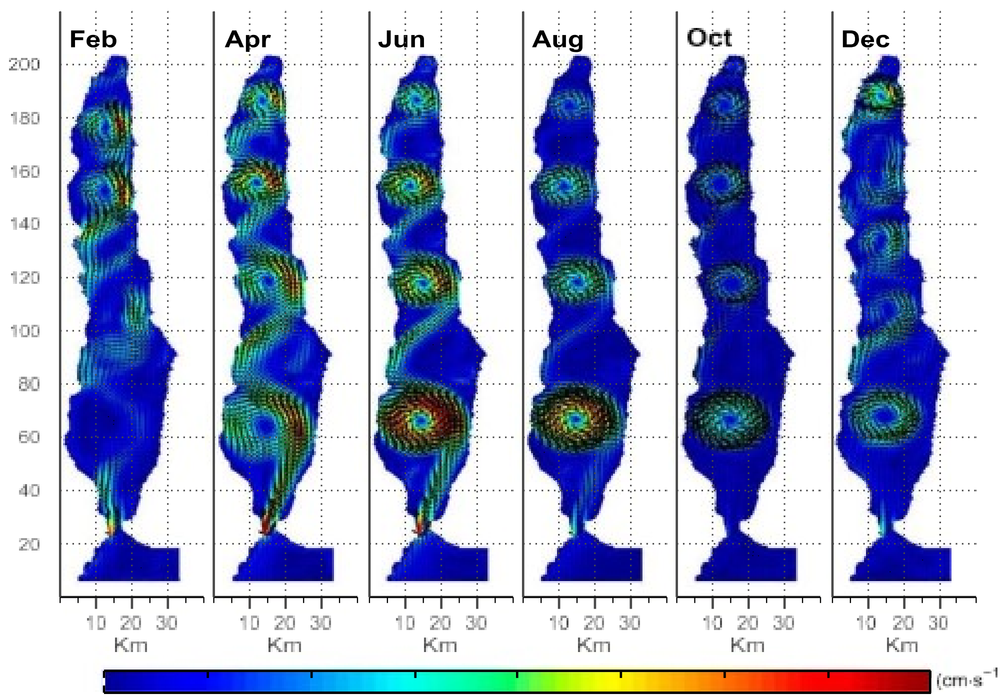
6.2.6.1. Currents in the Gulf of Aqaba

Current measurements covering the entire Gulf of Aqaba are rare and if exist they are mostly for short periods. One of the most recent scientific expeditions was the German RV Meteor which cruised the Gulf of Aqaba and northern Red Sea during the period February 21st to March 9th, 1999. Currents have been measured using a 150 KHz ADCP mounted on the ship. Analysing seawater exchange between the Gulf of Aqaba and the Red Sea and discussing intermediate depth water formation in the northern Red Sea Plaehn *et al*, 2002 estimated contribution of waters of the Gulf of Aqaba to be 1.5 times higher than that of the Gulf of Suez. Observations made along the entire Gulf of Aqaba by Manasrah *et al.* (2004) [29] revealed a sequence of flow changes with time and space that did not match the basic tidal motion, and represented in some parts a phase difference in the horizontal current components of about 90°. The main flow appeared to consist of a chain of cyclonic and anti-cyclonic eddies positioned along the Gulf axis occupying at least the upper 300m of the water column. The diameter of eddies ranged from 5 km to 8 km with velocities ranging from 0 to 0.30ms^{-1}. This early spring data of the RV Meteor expedition revealed that currents in the upper 200 m in the western and eastern sides of the northern Gulf of Aqaba were dominantly directed to the NE, while in the centre the current was mainly SE. The authors observed further an anti-cyclonic circulation in the upper 150 m between the western and central parts. In the deeper water 200 to 300m the NE current still dominated in the western part, while a transition from NE to SE could be seen on the eastern side. These two opposite currents form a part of a larger anti-cyclonic circulation between the eastern and the western sides.

Following energy budget calculations Biton *et al.* (2016) [30] modelled the horizontal circulation in the of Gulf of Aqaba using the Massachusetts Institute of Technology General Circulation Model (MITgcm; Marshall *et al.* 1997b, a). The model encompasses the entire gulf and a small part of the northern Red Sea; 20 km south of the Strait of Tiran. The resolution along and across the model's domain was 300 m, and the vertical axis was divided into 32 levels. The study indicated that circulation in the Gulf of Aqaba is characterized by the existence of a chain of eddies along its main axis. The main source of kinetic energy is conversions from the available potential energy resulting from density gradients. The mean kinetic energy balance represents the coupling between the exchange flow at the Strait of Tiran and the winter time dense water formation. The dense water exits through the Straits while sinking adiabatically along the Gulf. The strong variation in the shoreline/bathymetry triggers a baroclinic instability that enhances the eddy activity in the Gulf. Thus, the baroclinic instability is an effective mechanism that transfers energy from potential to the kinetic. This energy conversion term involves vertical adiabatic motions that occur through the upwelling of relatively warm water in anticyclonic circulation regions and downwelling of colder water in adjacent regions with cyclonic circulation. The horizontal circulation is powered by the energy transferred through these processes. Current velocities predicted from these calculations were generally low and in general agreement with those reported by Manasrah et al. (2004) [29]. Figure 6-26 and **Figure 6-27**



below summarise current velocities along the main access of the Gulf of Aqaba at 105m depth in early spring and one year on bimonthly basis at the surface. [30] [29].



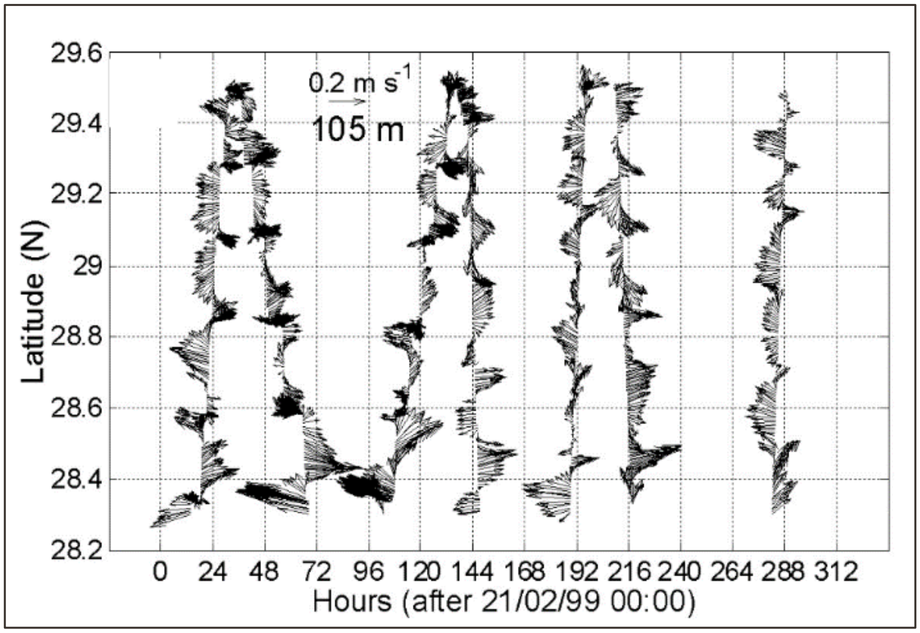


Figure 6-26: Time-Latitude Distribution of the Current Vectors Along the Axis of the Gulf of Aqaba at 105 M Depth on Repeated Tracks During February 21st-March 6th, 1999 [29]

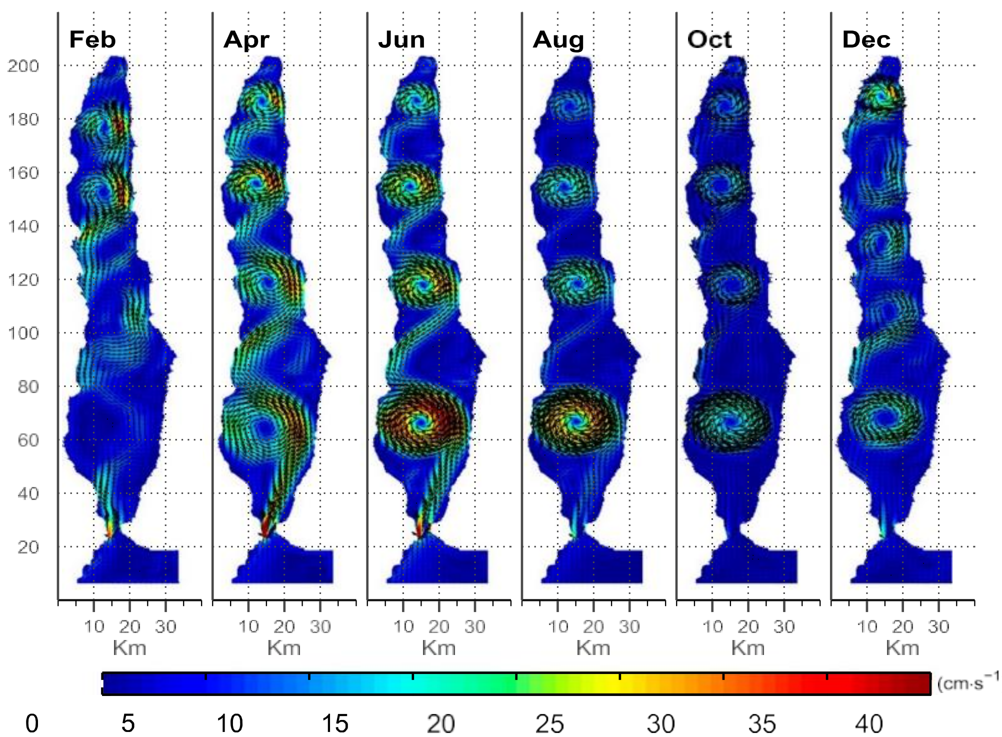


Figure 6-27: Modelled Monthly Mean Sea Surface Currents in the Gulf of Aqaba (Indicated By Arrows) Overlaid on a Map of Sea Surface Speed [30]

Note: In these plots, the positive directions of the Y and X axes are pointed approximately to the north and to the east, respectively

6.2.6.2. Currents in the Northern Gulf of Aqaba and AAWDC Coastal Site

Currents in the Jordanian section of the Gulf of Aqaba are relatively weak with an annual average in the upper 40m rarely exceeding 5cms^{-1}. The dominant direction is south-east parallel to the predominant wind direction in the northern Gulf. Currents are stronger at the surface with an average of 10.3 ± 9.0 cms^{-1} at 2 m depth than at depth 5-30m with an average speed of 2.1 ± 1.4 cms^{-1}. The average direction of the current recorded at 2 m and between 5-30 m depth is 246 ± 83°N and 153 ± 82°N, respectively [31].

Currents are recorded regularly on a monthly basis through the Coastal Environment National Monitoring Program at six locations spread from the northern edge of the Gulf of Aqaba to about 20 km south on the Jordanian coast (Figure 6-28). At the Marine Science Station (MSS), which is about central of the Jordanian coast currents are measured more frequently.

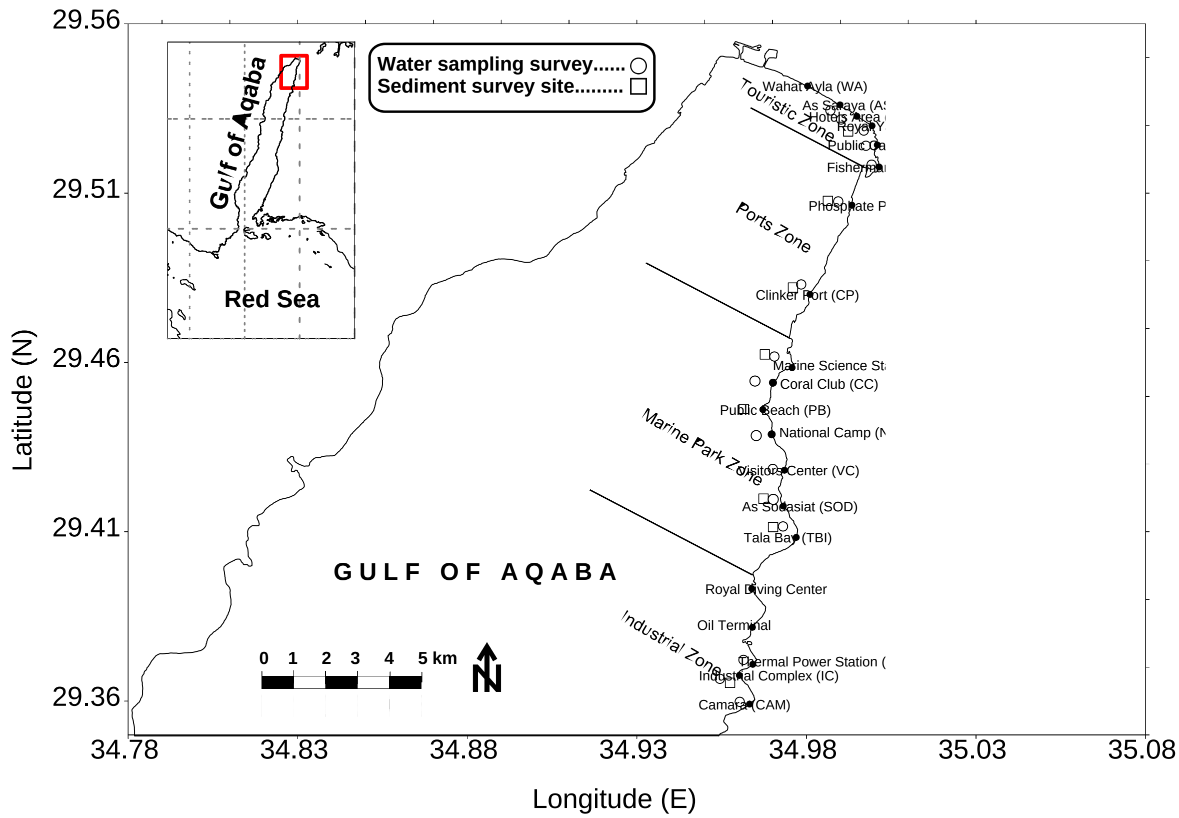


Figure 6-28: Field Survey and Sampling Stations of the Coastal Environment National Monitoring Program 2010-2020

Table 6-3 summarises currents speed and direction at the six monitored sites in 2015. Certainly there are inter-annual and month to month changes in the currents velocity. Discussion of the long term records at the MSS however gives an overview of the water circulation.

Table 6-3: Monthly Average Current Speed (cm s-1) and Direction (Degrees) at Six Coastal Stations [32]

Month	Current Speed (cms^{-1})						Current Direction (degrees)					
	WA	HA	PP	MSS	SOD	TBO	WA	HA	PP	MSS	SOD	TBO
Jan	5.84	6.17	7.73	10.13	10.13	7.76	63	60	58	205	205	213
Feb	5.48	4.67	7.00	8.83	10.20	8.91	50	61	57	202	204	216
Mar	3.97	3.39	5.56	7.99	9.67	8.24	54	48	310	212	201	210
Apr	3.74	4.71	6.32	8.46	9.75	7.54	53	297	57	220	197	205
May	6.70	6.46	4.44	6.21	7.68	6.21	33	314	120	149	200	145
Jun	5.40	7.83	7.89	6.08	12.85	5.85	49	234	204	144	198	148

Month	Current Speed (cms-1)						Current Direction (degrees)					
	WA	HA	PP	MSS	SOD	TBO	WA	HA	PP	MSS	SOD	TBO
Jul	4.53	6.17	7.67	8.14	14.90	5.62	62	223	156	220	196	207
Aug	3.47	9.78	5.73	6.91	9.77	7.71	46	237	38	221	199	212
Sep	4.32	8.06	5.56	5.82	9.78	5.98	52	221	26	147	195	209
Oct	7.03	5.58	8.90	7.80	6.71	6.59	297	54	46	148	201	219
Nov	5.06	3.86	6.72	8.17	6.55	6.93	295	56	44	152	203	224
Dec	5.56	5.57	6.28	7.45	6.00	7.32	293	51	44	148	149	226
Average	5.09	6.02	6.65	7.67	9.50	7.05	26.47	286.19	58.51	183.61	197.28	205.92
std. Dev	1.13	1.84	1.25	1.25	2.59	1.03	76.30	51.62	36.53	72.86	37.36	72.66

Notes: Wahat Ayla (WA), Hotels Area (HA), Old Phosphate Port (PP), Marine Science Station (MSS), As Sodasiat (SOD) and Tala Bay outside (TBO)

Current speed and direction measured continuously at 10 minutes interval in coastal waters (0-40m) in front of the MSS reveal percent frequencies of current speed less than 10 cms-1 over an annual cycle range from 70%-90% as recorded in most years. Records of stronger currents between 20-30 cms-1 the representing the maximum are few and represented only 1% to 12%. In general, current speed during summer is relatively weaker compared to the other seasons. The dominant current direction during all seasons, about 40%-75% of the current records, is between 180°-240° (south-southwest). The second dominant current direction is in the range 0-60° (north-northeast) represented about 9-40% of the current records [32].

Similar findings of low current velocity in the northern Gulf of Aqaba especially at depths exceeding 50m have been recorded during the RSDS studies. Figure 6-29 below shows records of an ADCP deployment at 500m for about 34 days during August-September 2010.

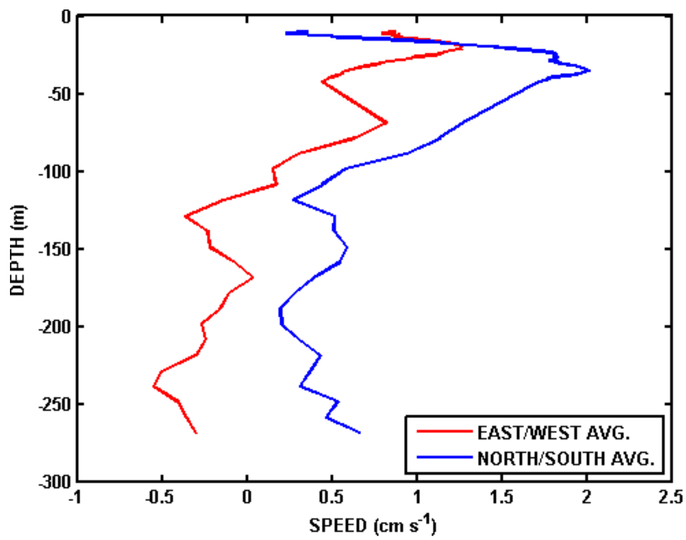


Figure 6-29: Current velocity in the upper 300m of The Water Column in the Northern Gulf of Aqaba during August – September 2010 [14]

Additional current measurements for the RSDS have been conducted during summer 2017. Figure 6-30 below shows seawater displacement in 3-m depth layers in the upper 50 m during the period June 21st–July 9th, 2017 at the northernmost area of the Gulf of Aqaba.

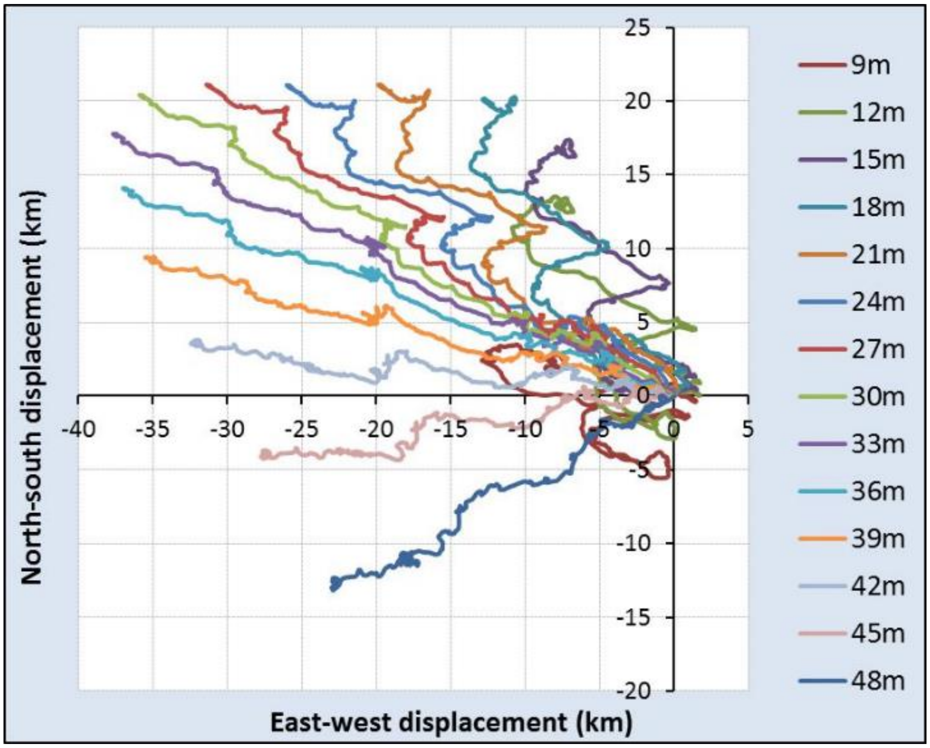


Figure 6-30: Progressive Vector Diagram of Water Current In 3m Depth Layers; 9-48m Water Column During the Period 21 June – 9 July 2017 at the Northernmost Area of the Gulf of Aqaba [33]

6.2.6.3. Currents based on the AAWDCP Field Invetigations

Based on the conducted sea water currents field investagations, the average daily current speed profile along the 25m water column depth varied slightly between 3-4 cm/s from the surface down to 22m depth with direction rotating from 80 to almost 0 degrees. Current speed suddenly increased at the end of the water column at 25m to reach 10 cm/s at the bottom, while its direction flipped occasionally to 240 degrees at 22m depth to reach 300 degrees then back to 100 degrees at the bottom.

While along the 50m water column, the behavior of the average daily seawater currents speed showed approximate gradual increase from 2cm/s to 4cm/s with changing direction clockwise starting from the surface down to 45m depth. At the bottom of the 50m water column abrupt increase of current speed and flipping of currents occured.

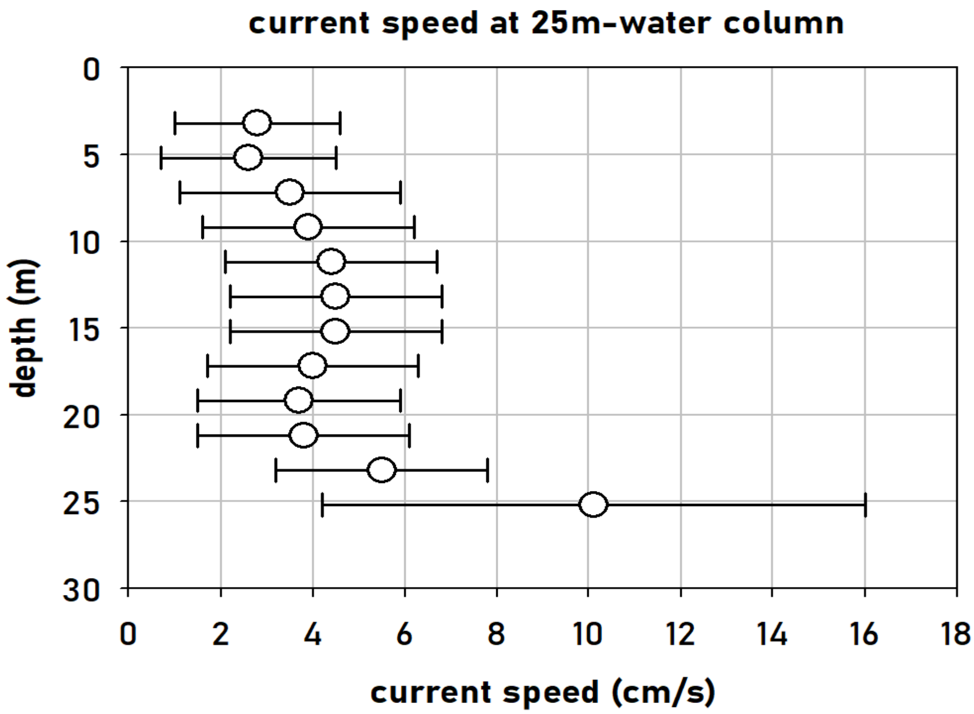


Figure 6-31: Average Seawater Current Speed at SWC1, 25 m Depth

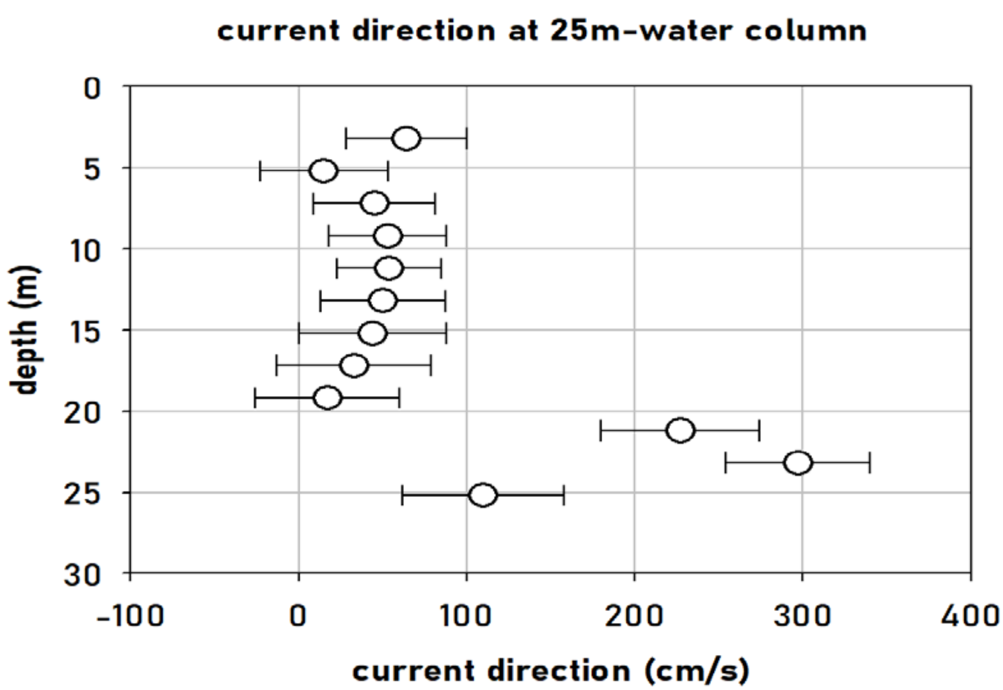


Figure 6-32: Average Seawater Current Directions at SWC1, 25 m Depth

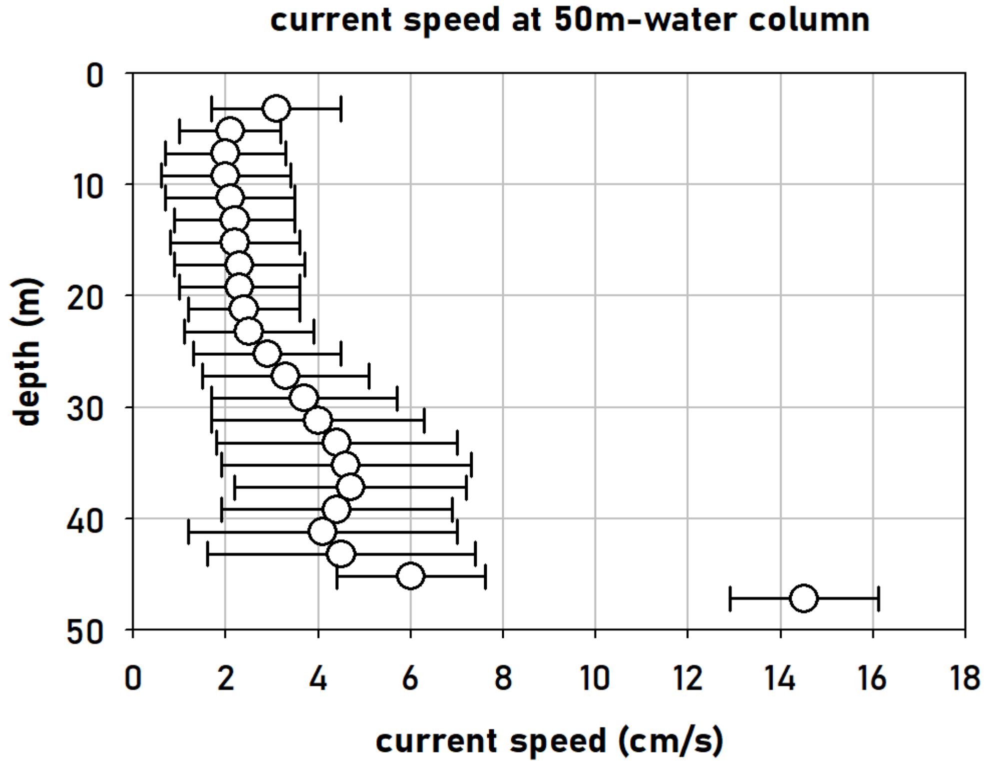


Figure 6-33: Average Seawater Current Speed at SWC2, 50 m Depth

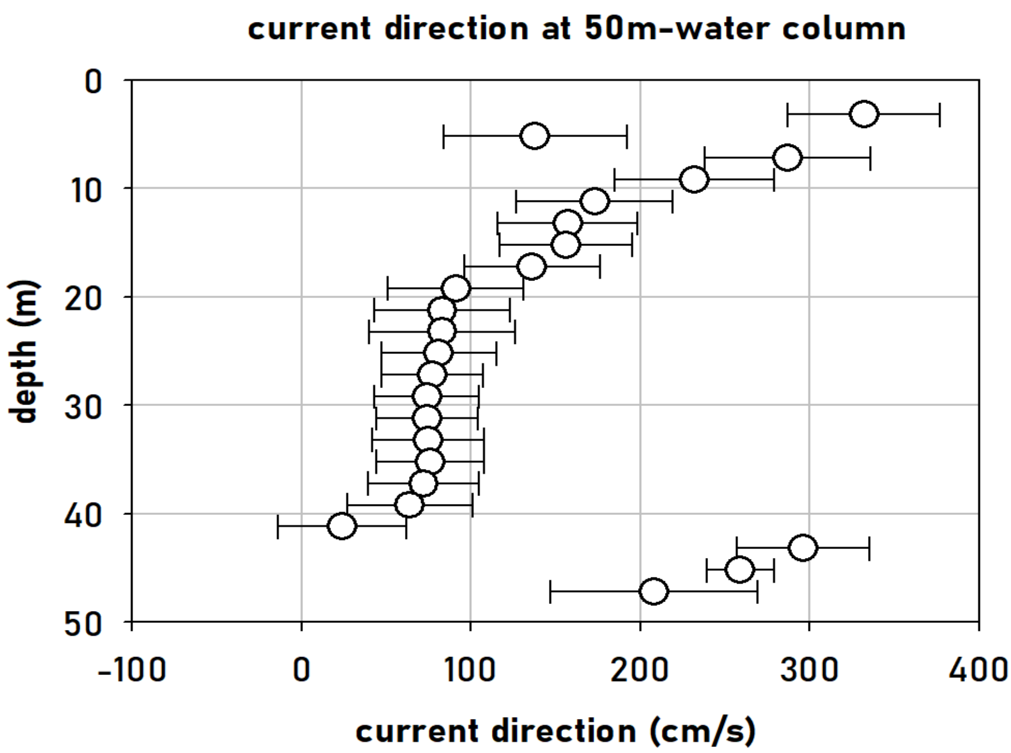


Figure 6-34: Average Seawater Current Directions at SWC2, 50m Depth

6.2.7. Seawater Column Characteristics in the Gulf of Aqaba

6.2.7.1. Seawater Density / Thermohaline Structure

Seawater column characteristics in the Gulf of Aqaba have a pronounced influence on both its physical and biogeochemical processes. As has been established earlier, that seawater density controls the exchange between the Gulf of Aqaba and northern Red Sea, this section illustrates the importance of density, which is mostly controlled by temperature in influencing the biogeochemical activities. Seawater column characteristics in the Gulf of Aqaba have been studied by several investigators. Manasrah et al (2006) [34] discussed the water column characteristics down to 450 based on six years of observations. Figure 6-35 shows potential temperature, salinity, and potential density profiles for the entire study period. 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). Variations in salinity in the upper 450m did not exceed 0.63 over the entire six years study period. The behaviour of seawater density followed basically that of the seawater temperature both in time and depth. According to the Authors this is in good agreement with previous findings, as numerous studies have documented a significant driving effect of seawater temperature in the Gulf of Aqaba on the biogeochemical cycles. The effect of seawater temperature of the water column structure is so pronounced to the extent that salinity inversion is noticed in summer where waters of higher salinity overlay waters of lower salinity.

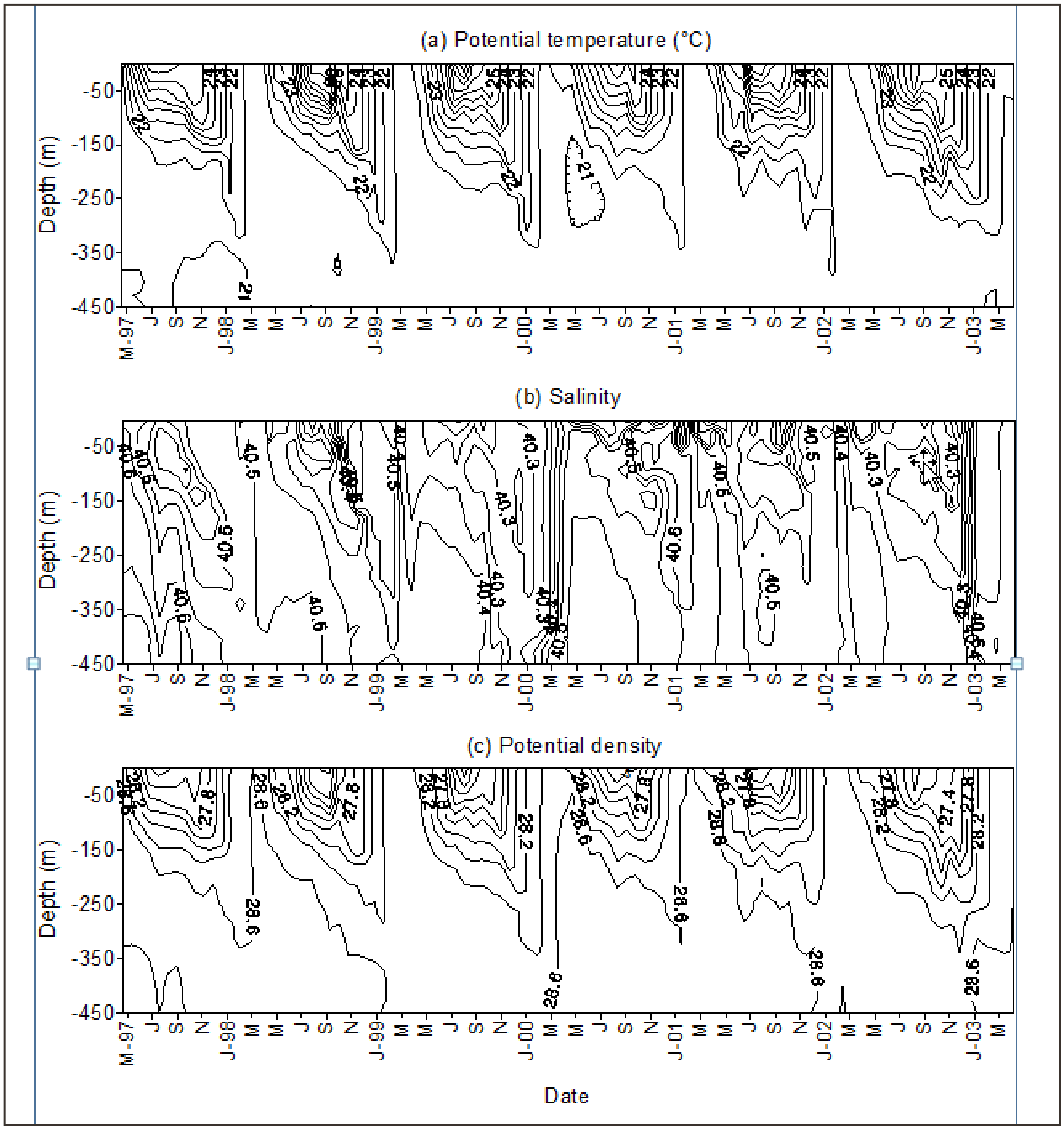


Figure 6-35: Seawater, Potential Temperature, Salinity and Potential Density Profiles for Six Years in the Upper 450m of the Water Column in the Northern Gulf of Aqaba [34]

According to the RSDS Red Sea Study Main Report Final July 2013 [14], three layers characterizing the water column in the Gulf of Aqaba can be distinguished: (i) a deep and quasi- stagnant layer; (ii) an intermediate water, and (iii) surface water. The deep layer is slightly colder than 21°C and fills the Gulf below approximately 700m. The intermediate water temperature slowly increases from 21°C to 21.9°C, and the surface layer has a temperature above 21.9°C. The two upper layers are highly active and undergo strong seasonal changes. The year can be divided into two phases, the re-stratification phase (April-August) and the mixing phase (September-March). During the re-stratification phase the surface layer is rebuilt, increases its temperature and volume, and pushes the 21.9°C isotherm from the surface down to ~200m. In August the temperature in the stratified surface layer at the northernmost of the Gulf increases almost linearly from 21.9°C at its base to surface temperature ~27°C comparably close temperature and subsequently density profiles exist throughout the entire Gulf of Aqaba.

6.2.7.2. Nutrients and Chlorophyll *a*

As indicated above and reported by a good number of scientific references seawater column biogeochemical characteristics follow the 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 30m during the summer stratification period and almost homogeneous in the upper and intermediate waters down to 500m during the winter mixing period. According to the RSDS Red Sea Study Main Report Final July 2013 [14], stratification of the water column during the summer months (April-November) causes recycled nutrients to accumulate in the deep reservoir (>250 m) and prevents them from being transported into the photic zone. 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 µmol.l^{-1}, respectively). While during winter deep convective mixing (>250 m) results in nutrient enrichment (2-3 orders of magnitude) of the open and coastal surface water. This enrichment supports phytoplankton and benthic macro algal blooms. During summer stratification the upper ~100m of the water column are almost completely depleted of inorganic nutrients and below this level a nutricline develops indicating the threshold between nutrient uptake by primary production in the photic zone and the supply of recycled nutrients from deep water across the thermocline. This pattern of repletion and depletion during summer stratification below 100m depth in is typical of nitrate, phosphate, and silicate. These seawater column indicators have been measured in the open and coastal water in the National monitoring programs in Aqaba and Eilat since 1999.

Figure 6-36 and Figure 6-37 show the annual average values of these indicators during 2015.

As documented in the RSDS Red Sea Study Main Report Final July 2013, chlorophyll *a* concentrations and primary productivity have been concurrently studied by Levanon- Spanier *et al*. (1979) [35]. The authors presented an annual cycle of the two indicators during 1976-1977 based on monthly measurements between the surface and 200 m in the north-western section of the Gulf of Aqaba. Phytoplankton succession has been studied by Kimor and Golandsky (1977) and more recently by Lindell and Post (1995) including the pico-fraction. Studies that included chlorophyll *a* concentrations along the eastern coast of the Jordanian coast of the Gulf are also numerous including. Many studies exist, it is difficult to have an exclusive list. From long term records of chlorophyll *a* concentrations 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 below 0.1µgl^{-1} during summer to about 1.0 µgl^{-1} during the spring end of mixed layer deepening end of March and beginning of April. During the summer stratification a typical deep chlorophyll *a* maximum develops at 60 –100m depth near the limit of light penetration and across the nutricline. Chlorophyll *a* concentration at this summer subsurface maximum is relatively constant at about 0.50µgl^{-1} and repeated annually. Nonetheless, the depth integrated concentration of chlorophyll a is greater by a factor of 2 Dec-Feb than the summer months Jun-Oct [36]. Figure 6-38 below shows chlorophyll a concentrations in the water column for multi years on the Jordanian sector of the Gulf of Aqaba.

Dissolved Oxygen mg l-1

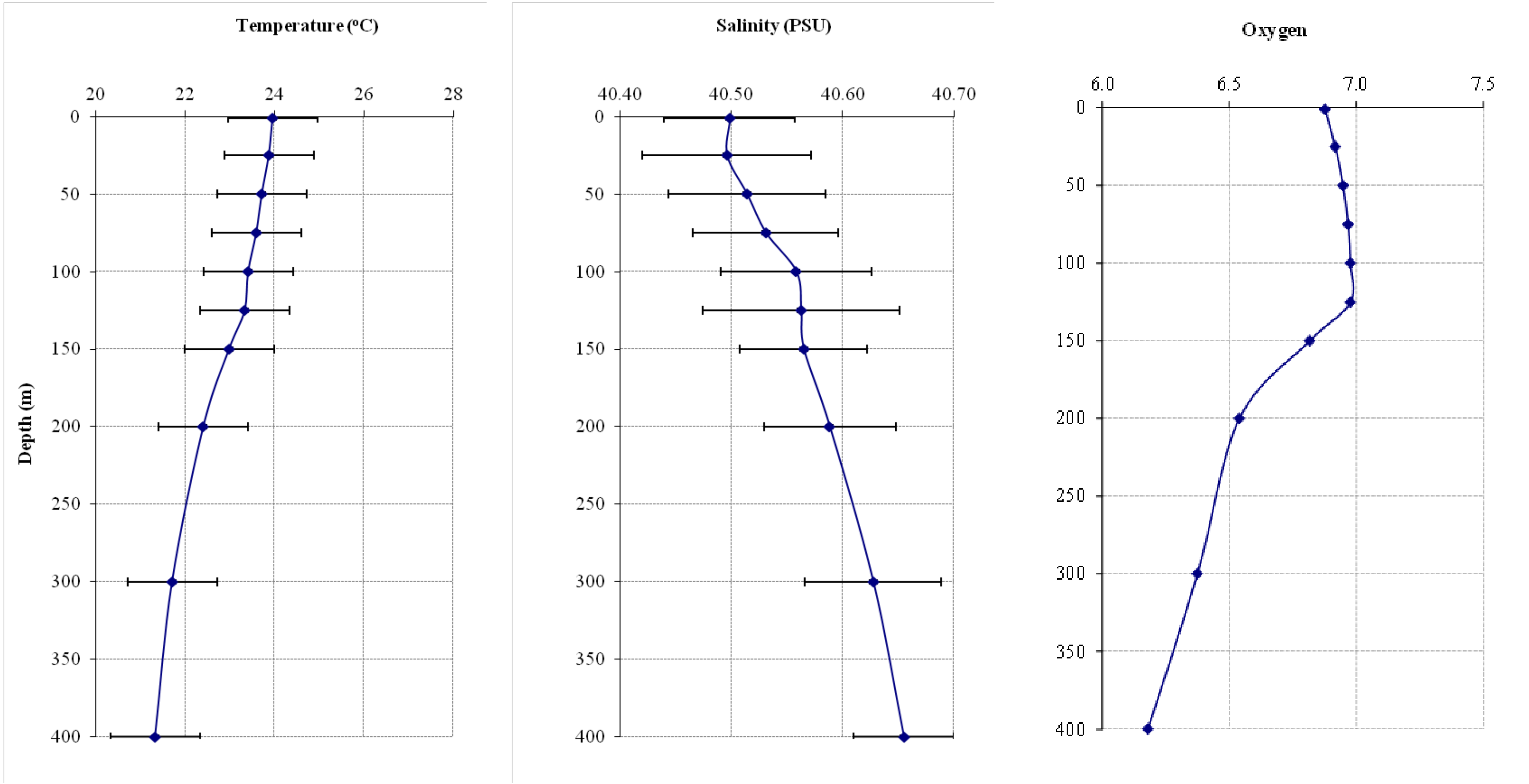
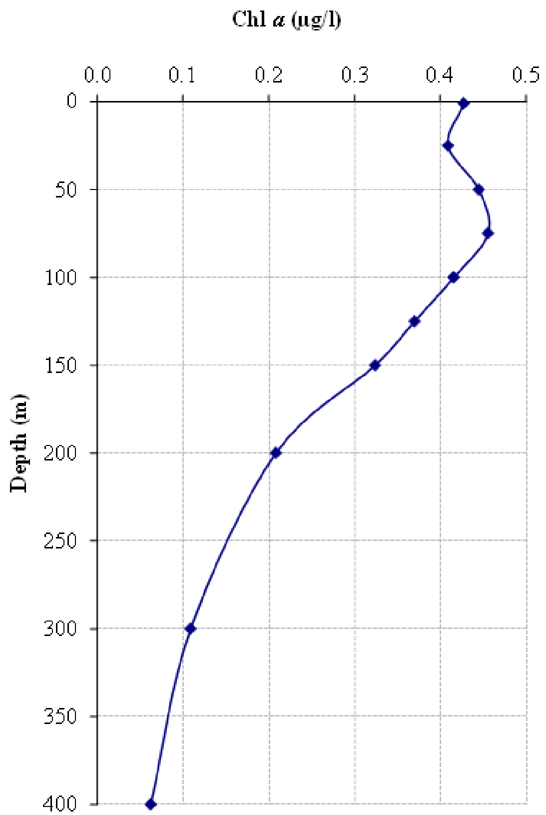


Figure 6-36: Annual Average Values of Seawater Temperature, Salinity, Salinity and Dissolved Oxygen During 2015 [32]



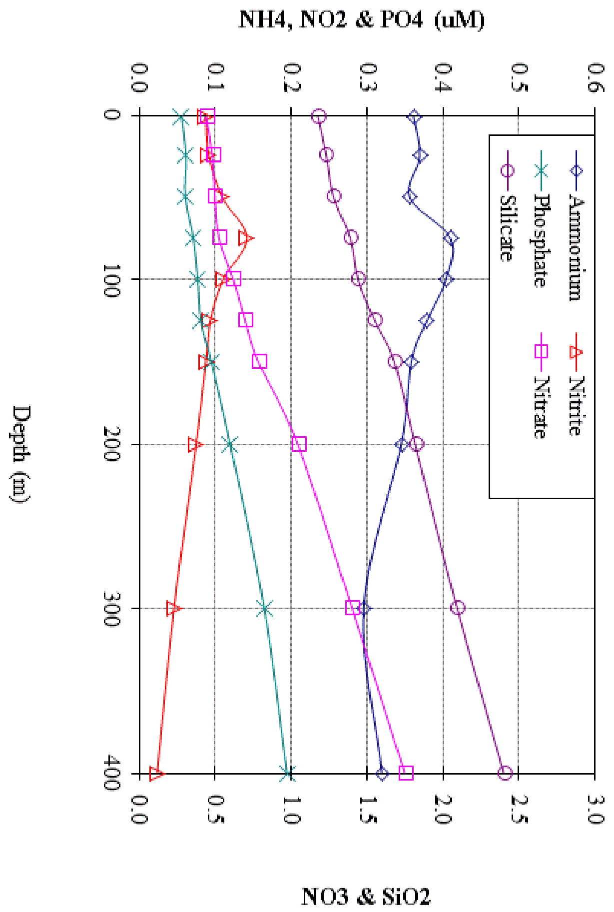
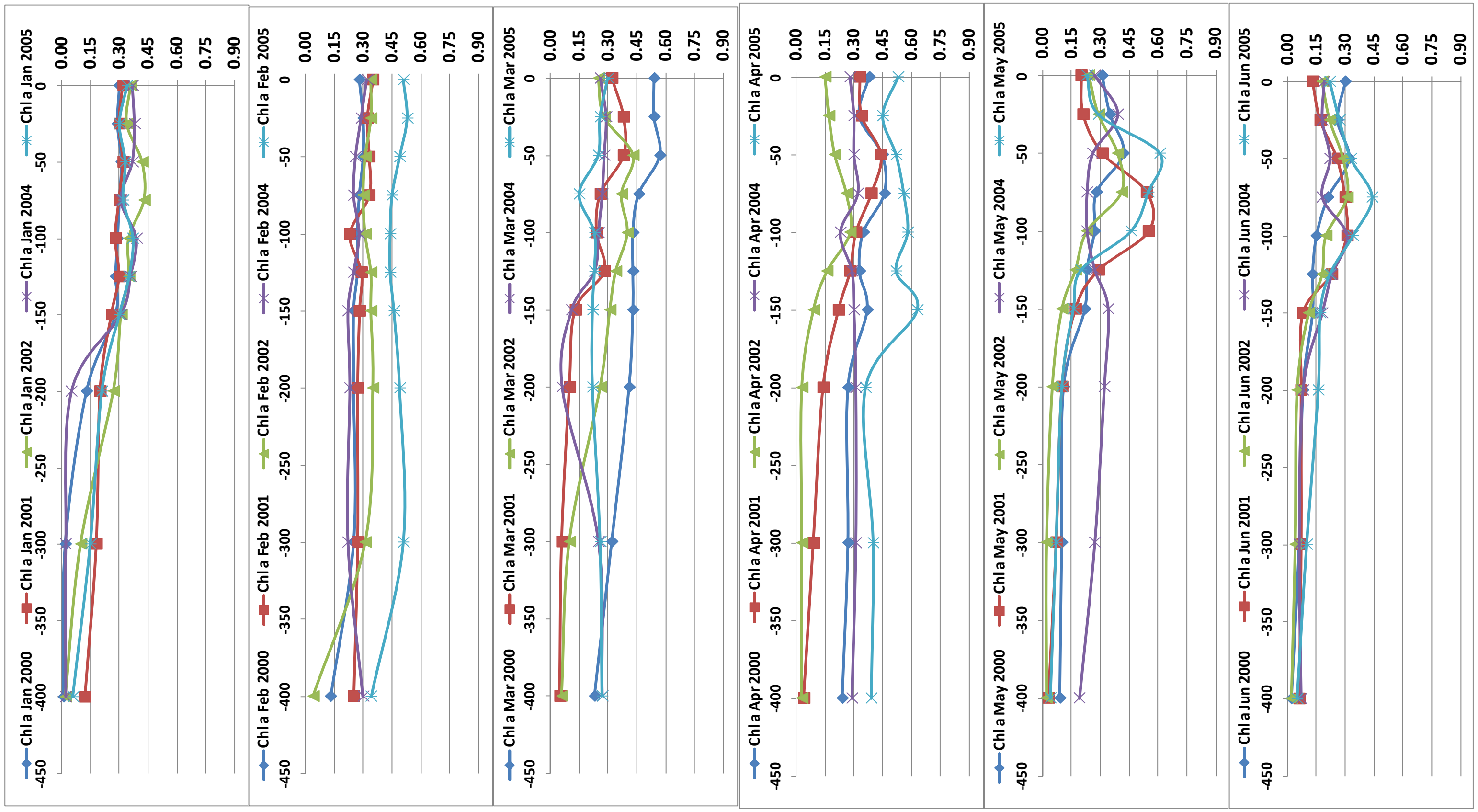


Figure 6-37: Annual Average Seawater Chlorophyll A, Ammonia, Nitrate, Nitrite, Phosphate and Silicate Concentrations During 2015 [32]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0 -50 -100 -150 -200 -250 -300 -350 -400 -450

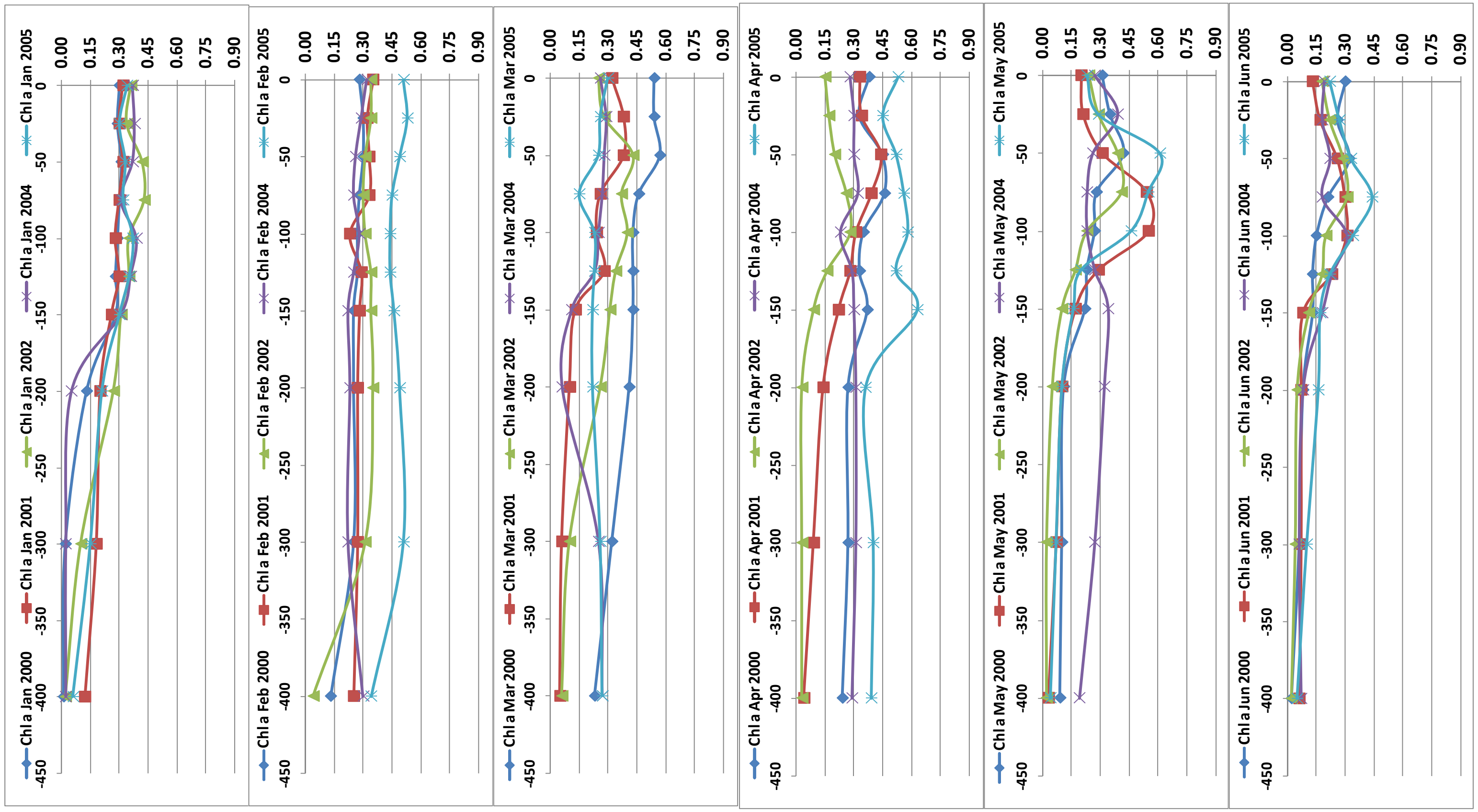
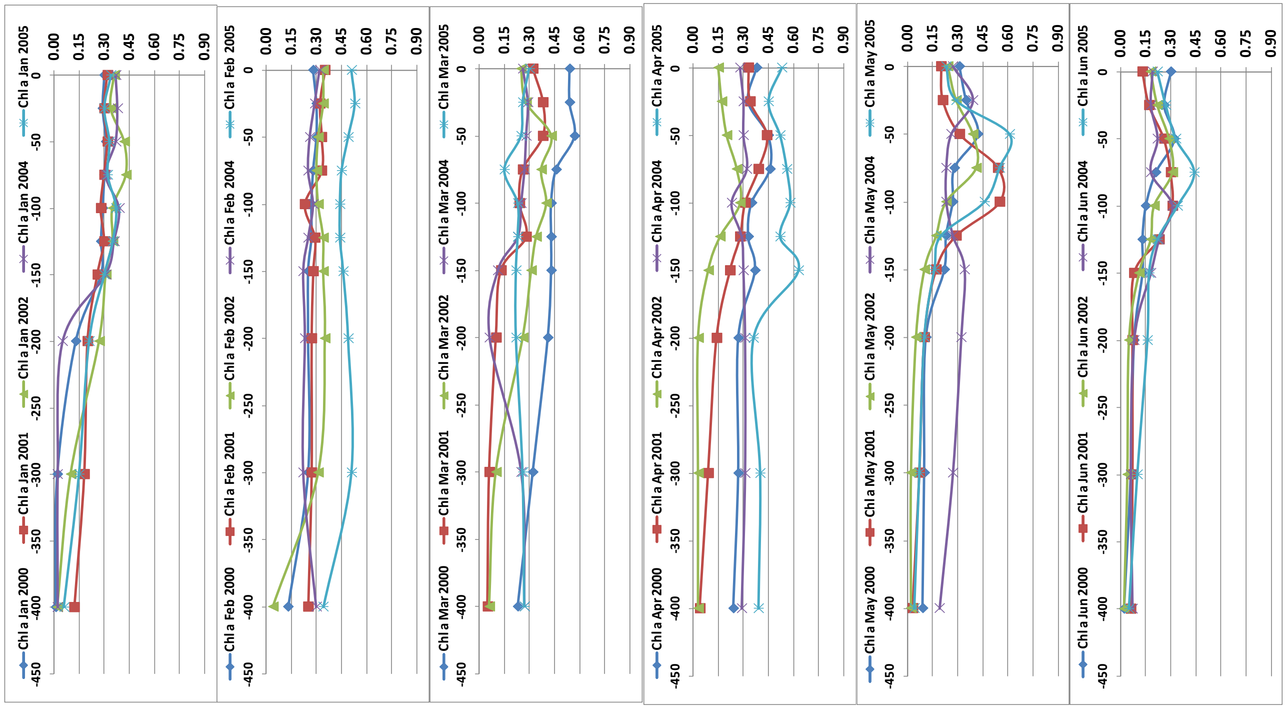


Figure 6-38: Shows Chlorophyll A Concentrations in the Water Column for Multi Years on the Jordanian Sector of The Gulf of Aqaba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Chl a Jun 2000

6.2.7.3. Plankton in the Gulf of Aqaba

a. Primary Productivity and Phytoplankton

According to Levanon- Spanier *et al*. (1979) [37] the photic zone in the Gulf of Aqaba extends to a great depth of 170m during most of the year (April–November). The Gulf is oligotrophic (chl. *a* 16 to 54 mg m^{-2}, primary production 200 to 900 mg C m^{-2} day^{-1}). 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 g C m^{-2} $year^{-1}$.

Based on high-resolution long-term records of 5 years in the upper 200m of the water column Badran *et al*. (2005) [38] calculated nitrogen flux across the summer thermocline for the period May-November. The main thermocline was considered to exist between 50 and 150m. Using a simple diffusion model that incorporates physical stress eddy diffusivity and biological stress, the authors estimated total nitrogen flux during the seven summer months (May–November) at 0.52 mole N m^{-2}. This flux in relation to established primary productivity values (75.5 gC m^{-2} $(\text{May-November})^{-1}$) and the generated chlorophyll *a* records, yields an *f* fraction of new to total primary production of 0.50. The authors suggested that the remaining regenerated 50% is accounted for by cross-sectional flow from the relatively nutrient rich coral reef coastal habitat and rapid recycling, triggered by high irradiance and Coastal density currents resulting from fine scale changes in the seawater temperature.

The primary productivity limiting nutrient has been discussed in several studies. Levanon- Spanier *et al*. (1979) [37] found that phytoplankton blooms followed peaks of the $NO_2 + NO_3 - N$ and of N/P ratios that suggest nitrogen is the major limiting factor. Badran (2001) and Badran *et al.* (2005) [38] analysed Redfield Ratios in the water column for multiple years and concluded that nitrogen was the limiting nutrient (Figure 6-39). Häse *et al*. (2006) also analysing Redfield Ratios in water samples from the northern Red Sea and entire Gulf of Aqaba collected on the RV Meteor also concluded that nitrogen is the direct limiting nutrient both in the Gulf of Aqaba and northern Red Sea.

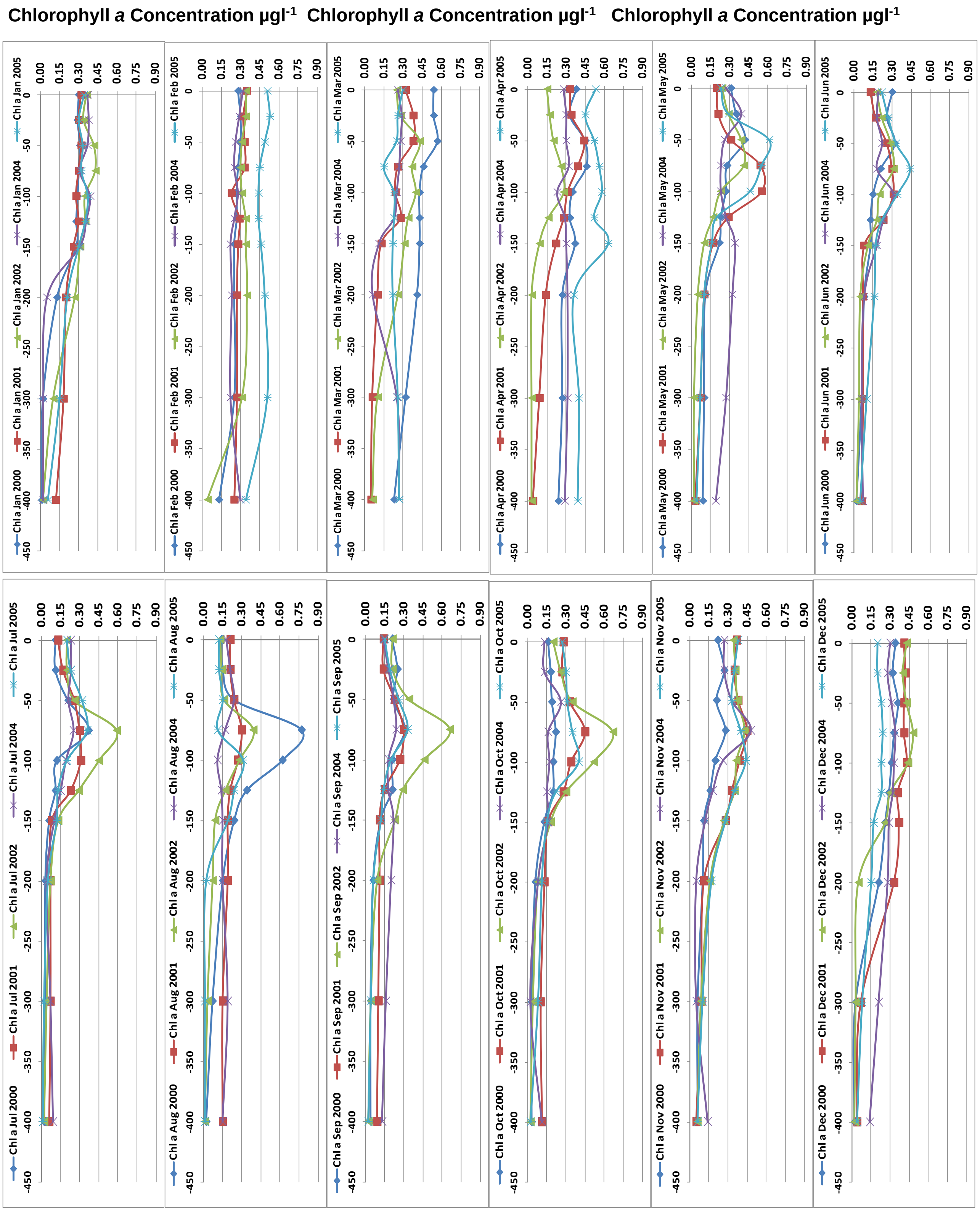


Figure 6-39: Chlorophyll a Concentration Profiles in the Upper 400 m of the Water Column in the Years 2000, 2001, 2002, 2004, 2005

Source: Data from published work of Dr. Mohammad Badran

According to Al Najjar *et al* (2007) [38] integrated (0–125 m) phytoplankton biomass as determined by HPLC pigment analysis of monovinyl Chlorophyll *a* was low during summer, fluctuating around 10 mg Chlorophyll *a* m^{-2}, with the major part of the biomass concentrated in the lower part of the euphotic zone (Figure 6-40). For the rest of the year (fall through spring), biomass underwent strong oscillations, with peak values up to 40 mg Chlorophyll *a* m^{-2}. During most of the latter period, Chlorophyll *a* was homogenously distributed in the water column except during spring, when a subsurface bloom developed, with a concomitant depletion of NO_3 in the top 0–75 m.

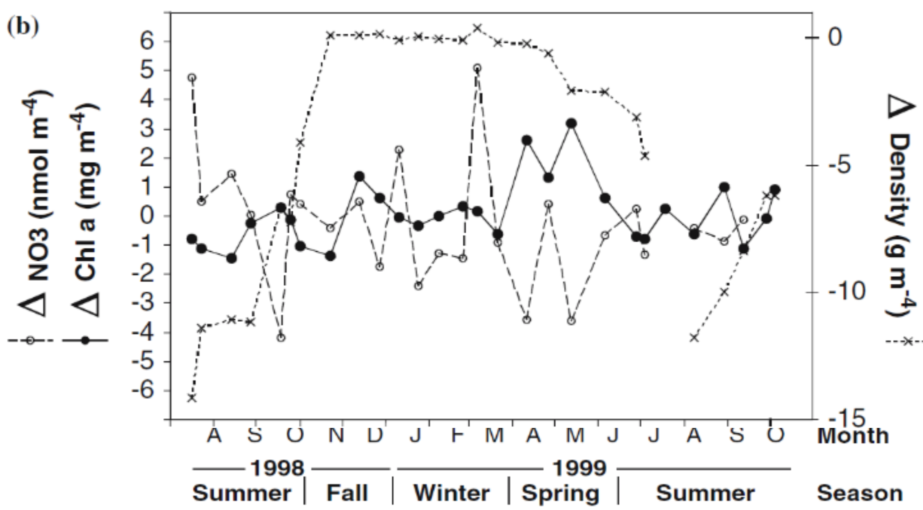


Figure 6-40: Plankton Biomass, Nitrate and Density Gradients with Respect to Depth in the Upper 125m of Waters in the Gulf of Aqaba [39]

b. Zooplankton

In an interesting study that captured onset of the rapid deepening of the mixed layer in the Gulf of Aqaba in February – March 1999 onboard the Meteor Research Vessel, Cornils *et al*. (2005) sampled mesozooplankton down to the sea bottom at different locations in the Gulf of Aqaba and northern Red Sea. A multiple opening– closing net system was used to sample mesozooplankton in stratified vertical hauls taken from near the bottom to the surface. The upper 100 m were sampled in 50 m steps while the lower depth intervals were chosen according to the depth of the water column, minimum 500 m and maximum 1300 m. The authors found that concomitant with the thinning of the mixed layer between the well mixed northern Gulf of Aqaba and the Red Sea proper, the mesozooplankton progressively concentrated in the upper 300, 200 and 50–100 m layer in the central Gulf of Aqaba, southern Gulf and northern Red Sea, respectively. In the northern Gulf of Aqaba the composition of the sample displayed an essentially homogeneous composition down to 400 m, which corresponded with the mixing depth.

Farstey *et al*. (2002) sampled zooplankton water column at the northern Gulf of Aqaba in vertical hauls collecting a 100 m layer from a depth of 600 m to the surface during December 1991, January, February and December 1992, January and February 1993, which represented mixing deeper than 100m, and August, September 1992, June 1993 representing summer stratification. Mixing depths during stratification did not exceed 30 m, which led the authors to pool the summer samples for the quantitative analyses in a single category, termed 'Summer'. The authors found 60 to 90% of the zooplankton existing in the in the upper 100 m of the water column during the summer stratification conditions with less than 16% in the layer just below it (100 to 200 m). In December, when vertical mixing reached ca. 150 to 200 m, only 54 to 64% of the zooplankton resided in the upper 100 m, with 22 to 31% in the 100 to 200 m layer. When mixing exceeded 300 m, over 90% of the zooplankton in the water column was evenly distributed within the mixed layer. A nearly uniform distribution of zooplankton was observed throughout the upper 400 to 500 m in February. This pattern was evident in both day and night and in different years despite substantial inter-annual differences in the overall abundance. It is worthy to note here that upper 100 for the authors was not sub-sampled in smaller fractions. It is therefore very likely that most of the plankton in the upper 100m was just close to the 100 m depth associated with chlorophyll a concentration as Figure 6-41 of the manuscript shows. It can be inferred from this study that for six months in the year zooplankton is homogeneously distributed in the upper 200 m of the water column. During the summer stratification zooplankton is mostly in the upper 100m but most likely below the summer mixed layer between 30–100m.

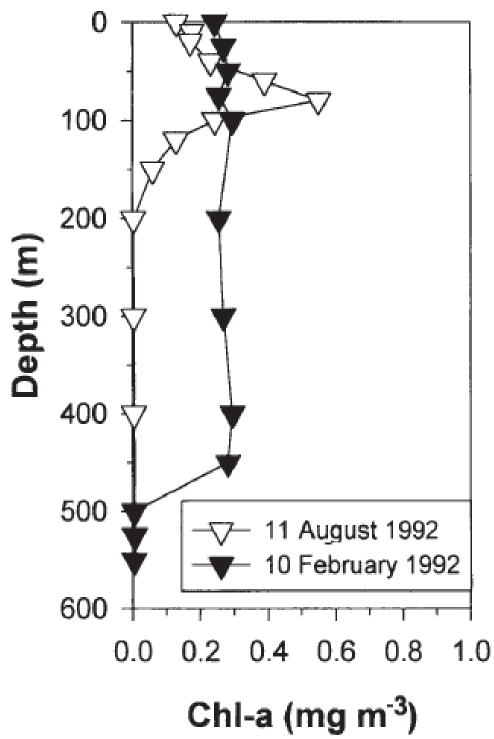


Figure 6-41: Vertical Profiles of Chl A Collected with Niskin Bottles at Station a in Winter (February) and in Summer (August) 1992 [40]

According to the RSDS Red Sea Study Report Final July 2013 [14], larvae of mollusks (gastropods and bivalves) were by far the most dominant zooplankton group, comprising together 91% of the total larvae counted. At the other extreme, planulae (larvae of corals and other cnidarians) were extremely rare, with an average of 0.3 m^{-3}, comprising 0.16% of the total larvae. This is illustrated in Figure 6-42.

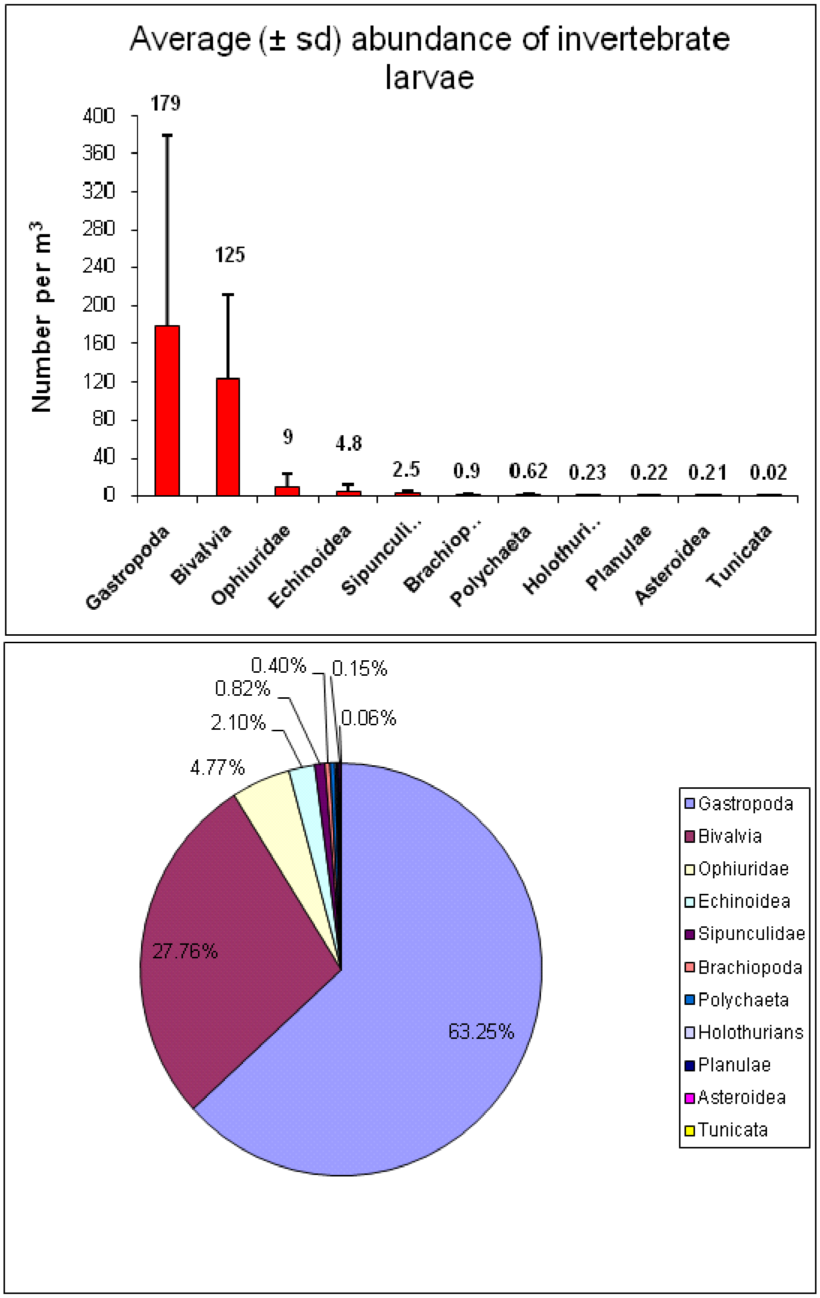


Figure 6-42: Abundance (Absolute- Upper Panel, Relative- Lower Panel) of Different Taxa of Invertebrate larvae in samples [14]

Notes: Absolute values (upper panel) are indicated as the average (±sd) density in all the samples sorted so far (N=89). Note dominance of gastropods and bivalves and the rarity of planulae

Additional studies were needed in the RSDS concept to resolve the issue of intake depth. Those were mainly on modeling and plankton. The plankton survey was conducted in the summer months of June and July 2017. Samples have been collected by vertical plankton net hauls from bottom depths of 25m, 50m, 75m, 100m, 130m and 160m along three suggested seawater intake pipeline tracks. Samples at 25m were collected from the bottom to surface and 15m to surface. For all other depths samples were collected from bottom to surface, 10m above bottom to surface and 25m above bottom to surface. Illustration of sampling hauls is shown in Figure 6-43.

Figure 6-43: Illustration of the Vertical Depths Hauls of the Plankton Survey 2017 [33]

The Plankton Survey Report indicates that there was no general trend in plankton biomass maximum or minimum values. However, the maximum plankton biomass of 0.064 $g.l^{-1}$ (the unit should be corrected to $g.m^{-3}$) was found at the depth of 160 m in the haul 25 m above seabed to surface, i.e., from 135 m to surface. Statistical analysis revealed that there were no significant differences among the different sea bed depths and among the three suggested pipeline tracks. But there was a clear significant difference of plankton biomass among the vertical depth ranges. Considering the non-significant difference among the different seabed depths and the pipeline tracks and to simplify the results of this survey, Figure 6-44 below is constructed using the survey data and compiling the same depth range from the different hauls. Table 6-4 below summarises how data for the illustration is rearranged.

Table 6-4: Summary of the Data Rearranged for Illustration of Plankton Biomass in the Water Column

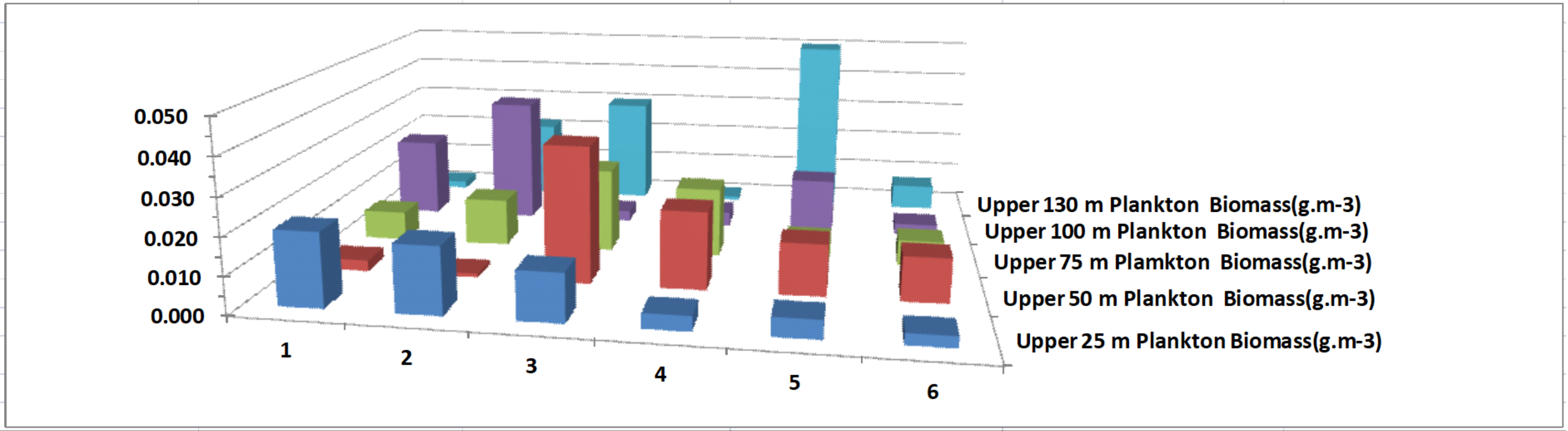
25m to Surface	50m to Surface	75m to Surface	100m to Surface*	130m to Surface**
Three Pipeline Tracks: Bottom at 25m + 25m above bottom at 50m bottom	Three Pipeline Tracks: Bottom at 50m + 25m above bottom at 75m bottom	Three Pipeline Tracks: Bottom at 75m + 25m above bottom at 100m bottom	Three Pipeline Tracks: Bottom at 100m + 25m above bottom at 130m bottom	Three Pipeline Tracks: Bottom at 130m + 25m above bottom at 160m bottom

**Half the samples are from 105m to surface; ** Half the samples are from 135m to surface. Approximation should be acceptable, as the Report states that the haul depths were approximate.*

The Plankton Survey (2017) concluded that the community structure of the different plankton taxa gained by the study represents the normal community taxa of the Gulf of Aqaba typical of summertime from May to August, in which gastropod and bivalves dominate the plankton community over the other taxa. In addition, the copepod is a major component of the holoplanktonic community of the Gulf of Aqaba. There was no significant difference between plankton communities along the three suggested pipeline tracks, but there were among the vertical water column depths. Fish larvae and fish eggs showed a significant difference with depth. The least abundance was observed between 10-25m [33].

6.2.8. Seawater Characteristics at the AAWDC Coastal Site

The AAWDC coastal site is just in front of the JPMC IC (Sec. 6.1), which has been subject of a regular long-term monitoring since 1996. Figure 6-22 shows annual chlorophyll *a* concentration in the surface water at 11 sites on the Jordanian coast including the Industrial Complex for 5 years. It is evident that the seawater chlorophyll a concentration at the JPMC IC is comparable to the other open water locations. Worth mentioning is that TB and RYC are enclosed marinas and cannot be compared to the other sites.



Replicate	Upper 25 m Plankton Biomass(g.m^{-3})	Upper 50 m Plankton Biomass(g.m^{-3})	Upper 75 m Plamkton Biomass(g.m^{-3})	Upper 100 m Plankton Biomass(g.m^{-3})	Upper 130 m Plankton Biomass(g.m^{-3})
1	0.020	0.003	0.008	0.022	0.002
2	0.018	0.001	0.013	0.035	0.022
3	0.013	0.037	0.023	0.003	0.030
4	0.004	0.021	0.019	0.004	0.001
5	0.005	0.014	0.006	0.015	0.064
6	0.003	0.012	0.007	0.003	0.007
Average	**0.011**	**0.015**	**0.013**	**0.014**	**0.021**
STDV	**0.008**	**0.013**	**0.007**	**0.013**	**0.024**

Figure 6-44: Illustration of Plankton Biomass based on the Plankton Survey (2017) In Water Column Different Depths at the Northern Jordanian Sector of the Gulf of Aqaba [33]

Rasheed *et a*l. (2012) [41] studied the seawater quality at the JPMC IC coastal area based on 12 years results (1998-2010) of the dedicated coastal environment monitoring program. Samples in the JPMC IC are collected monthly at 6 nearshore stations and one offshore station about 4 km from the intertidal zone. Indicators studied include seawater temperature, salinity, transparency, dissolved oxygen, pH, ammonia, nitrate, nitrite and phosphate. All indicators, both nearshore and offshore, displayed typical seasonal cycles of the Gulf of Aqaba. Statistical comparison between the nearshore and the offshore records on seasonal basis revealed no significant difference in any of the studied indicators (Figure 6-45). Figure 6-46, Figure 6-47 and Figure 6-48 illustrate time series records of the seawater temperature and dissolved oxygen concentration, ammonia and nitrite concentrations, and nitrite and phosphate concentrations respectively over the study period. Table 6-5 summarises key seawater quality indicators per month for five years (2014-2019) at the Industrial Complex and at an offshore reference site 3km off the coast based on seawater quality monitoring records obtained by the ESIA team from ASEZA. Table 6-5 is also coupled with the ESIA team's observations per examined quality indicator.

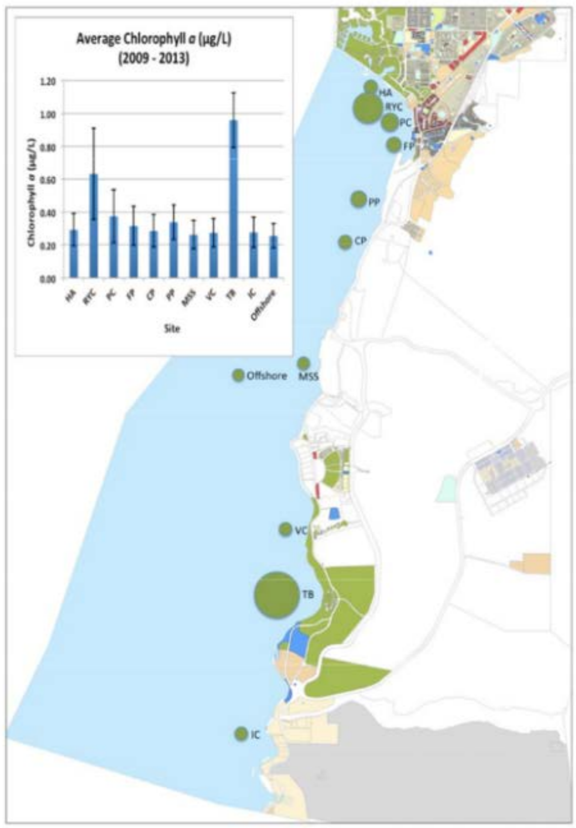


Figure 6-45: Annual average Chlorophyll a Concentration (µg.L-1) Over the Years (2009-2013) at 10 Coastal and a Reference Offshore Stations on the Jordanian Coast of the Gulf of Aqaba [31]

Note: HA: Hotels Area, RYC: Royal Yacht Club, PC: Public Beach, FP: Fishers Port, CP: Clinker Port, Passengers Port, MSS: Marine Science Station, VC: Visitor Centre, TB: Tala Bay, IC: Industrial Complex, Offshore: Offshore Control Station. Notice that RYC and TB are Enclosed Marinas

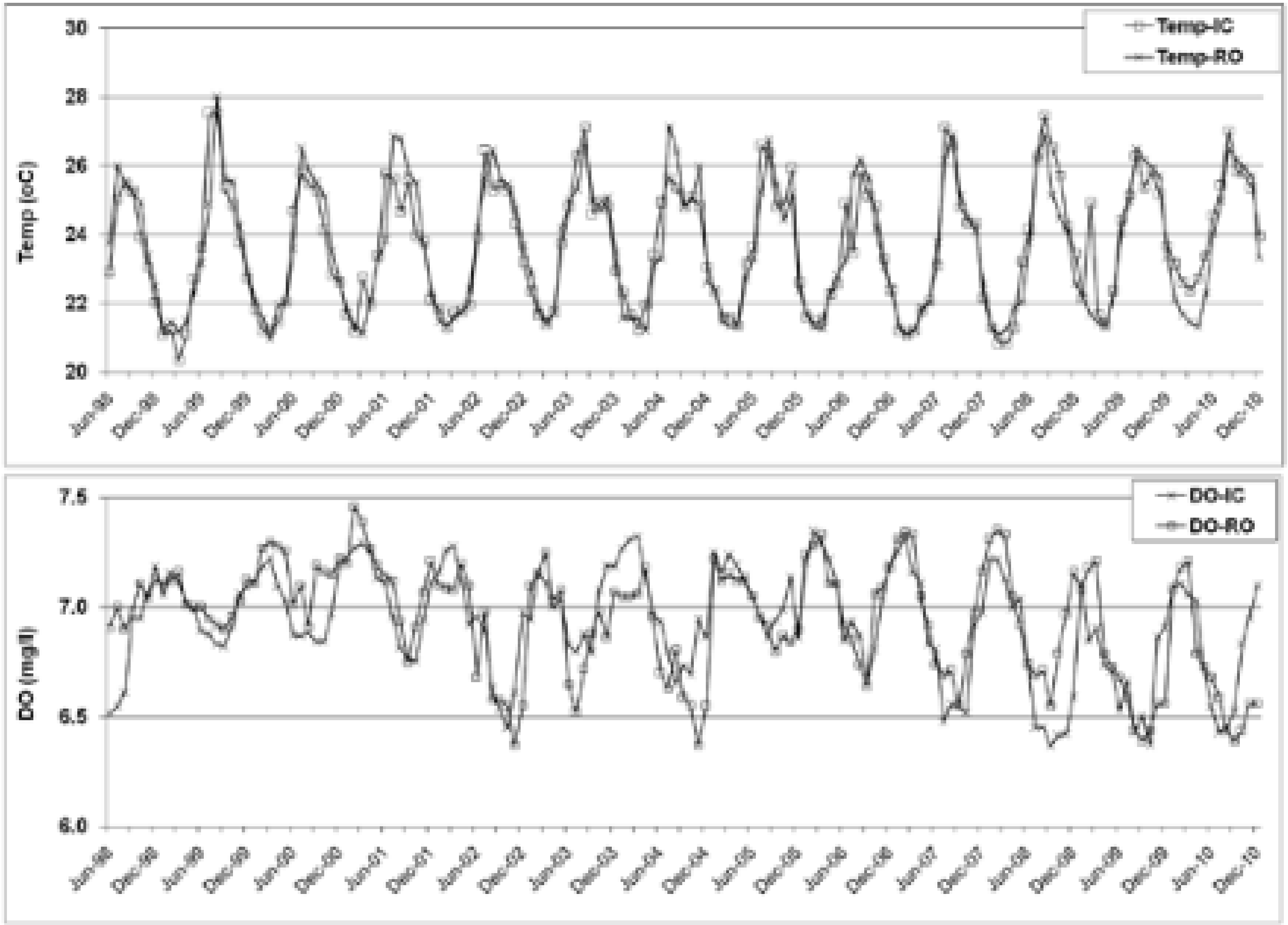


Figure 6-46: Sweater Temperature and Dissolved Oxygen Concentration Time Series (1998- 2010) in Nearshore and Offshore Waters in Front of the JPMC IC [41]

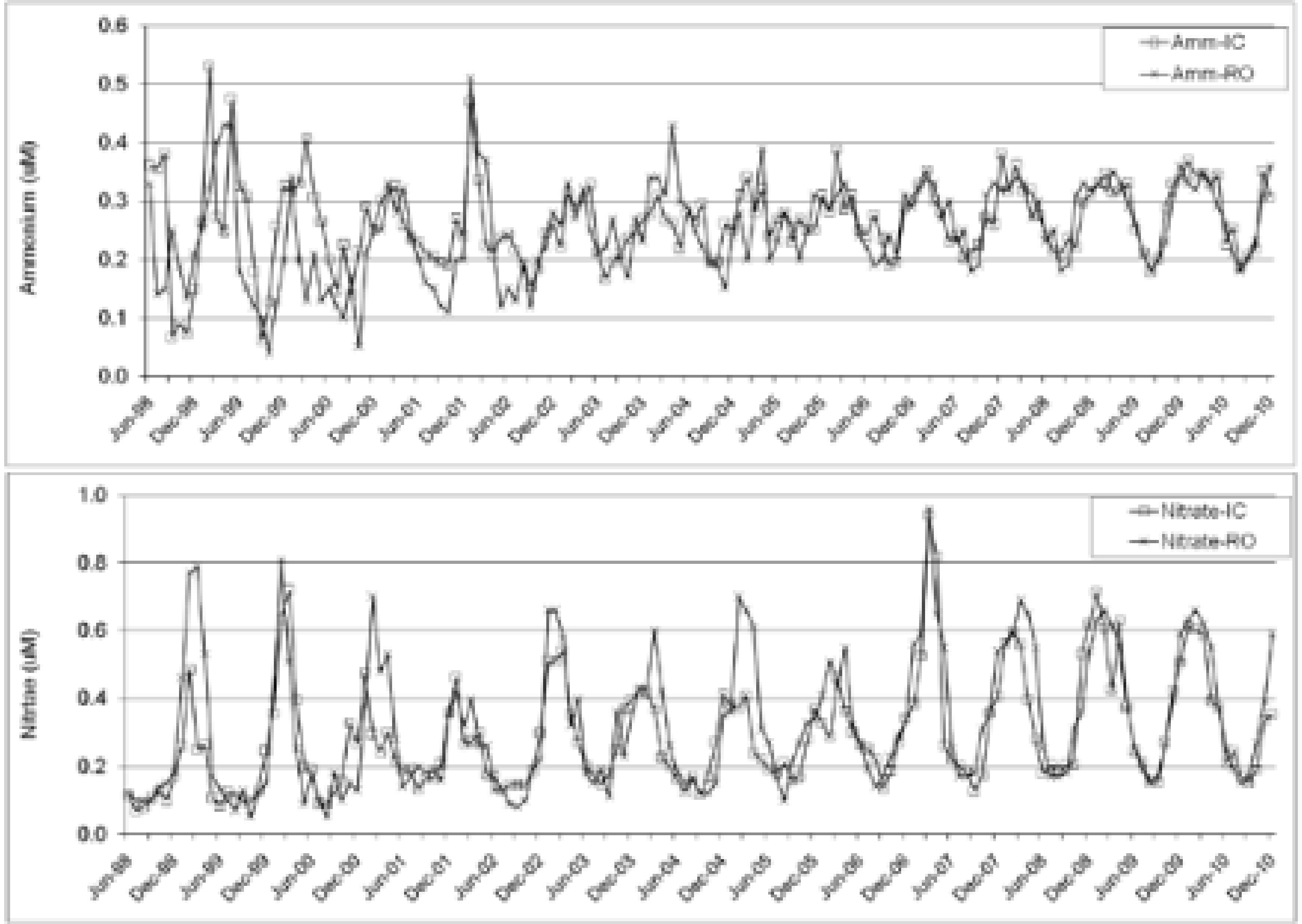


Figure 6-47: Seawater Ammonia and Nitrate Concentration (µM) Time Series (1998-2010) in Nearshore and Offshore Waters in Front of the JPMC IC [41]

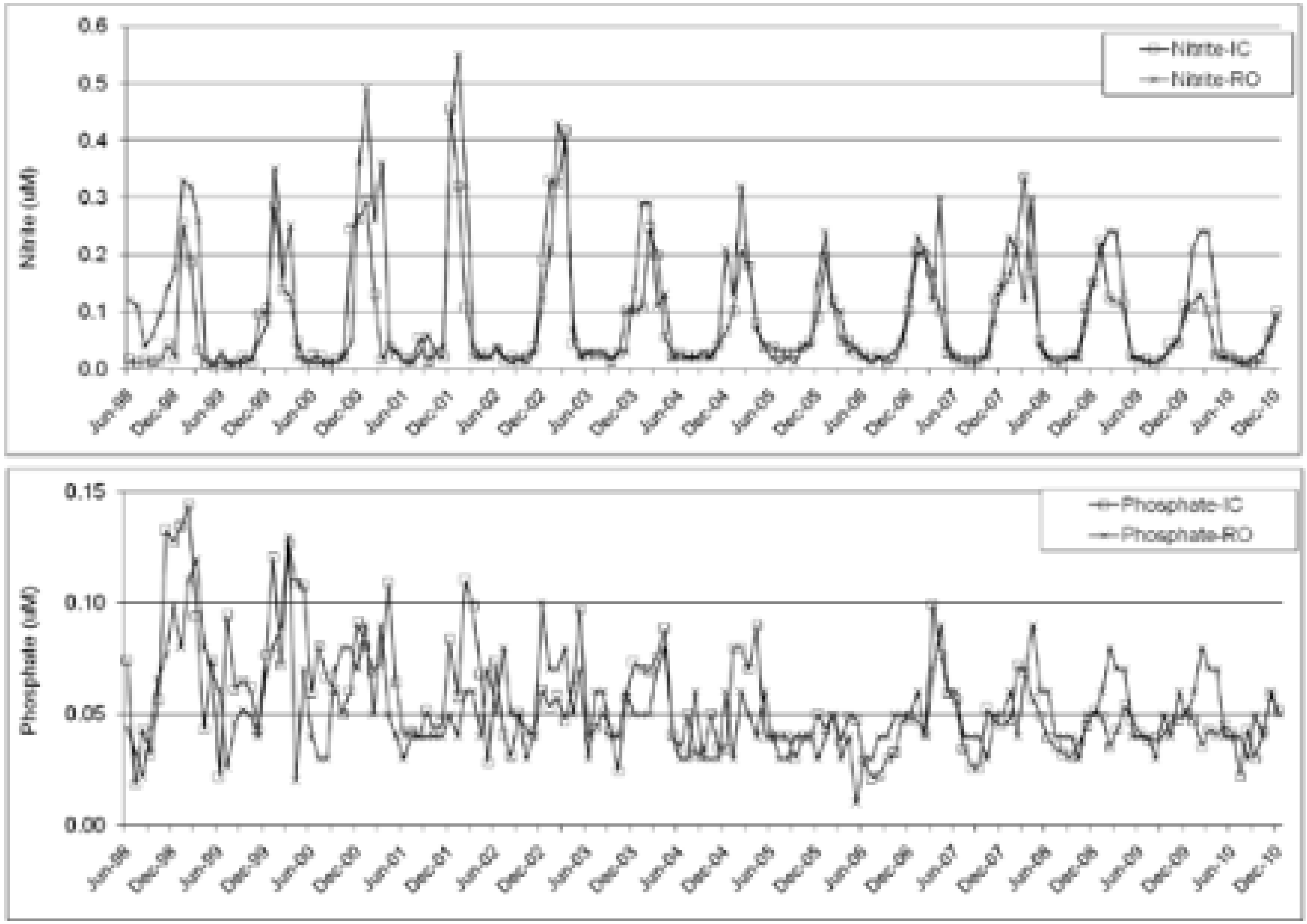


Figure 6-48: Seawater nitrite and Phosphate Concentration (μM) Time Series 1998-2010) in Nearshore and Offshore Waters in Front of the JPMC IC [41]

Table 6-5: Coastal Water Quality Data at the Industrial Complex and Offshore (Cumulative Monthly Average 2014-2019)

Month	Parameters																							
	T (^{0}C)		Salinity (PSU)		Conductivity (mS)		pH		DO (mg/l)		Ammonia (uM)		Nitrate (uM)		Nitrite (uM)		Phosphate (uM)		Silicate (uM)		Chl a (ug/l)		HC (mg/l)	
	IC	Offshore	IC	Offshore	IC	Offshore	IC	Offshore	IC	Offshore	IC	Offshore	IC	Offshore	IC	Offshore	IC	Offshore	IC	Offshore	IC	Offshore	IC	Offshore
January	22.43	22.13	40.62	40.59	57.51	57.17	8.33	8.33	7.10	7.11	0.60	0.35	0.76	0.59	0.33	0.18	0.06	0.08	1.42	1.17	0.43	0.34	0.002	0.001
February	21.68	21.62	40.57	40.54	47.24	45.28	8.34	8.34	7.17	7.18	0.55	0.36	0.63	0.53	0.14	0.15	0.09	0.07	1.66	1.31	0.30	0.35	0.004	0.001
March	22.07	21.72	40.53	40.59	56.99	45.32	8.35	8.34	7.14	7.18	0.54	0.44	0.49	0.56	0.13	0.16	0.06	0.06	1.26	1.38	0.37	0.43	0.002	0.001
April	22.45	22.29	40.56	40.54	57.46	57.23	8.32	8.33	7.08	7.18	0.72	0.47	0.46	0.52	0.07	0.12	0.08	0.07	1.34	1.22	0.40	0.40	0.001	0.002
May	23.66	23.40	40.51	40.37	58.84	58.17	8.34	8.35	6.96	6.96	0.52	0.56	0.45	0.42	0.05	0.07	0.09	0.06	1.34	0.98	0.29	0.40	0.002	0.001
June	25.22	25.20	40.47	40.58	60.59	60.82	8.31	8.31	6.70	5.64	0.59	0.37	0.76	0.25	0.05	0.04	0.05	0.06	1.17	1.25	0.27	0.20	0.001	0.001
July	26.69	26.18	40.59	40.60	62.32	61.91	8.28	8.27	6.68	6.65	0.54	0.36	0.26	0.20	0.03	0.03	0.07	0.04	1.74	1.20	0.19	0.17	0.001	0.001
August	26.97	26.85	40.57	40.57	62.93	62.62	8.30	8.30	6.59	6.56	0.57	0.47	1.99	0.22	0.06	0.03	0.07	0.05	3.81	1.23	0.16	0.13	0.001	0.001
September	25.69	25.64	40.52	40.54	61.24	61.20	8.30	8.29	6.63	6.61	0.61	0.44	0.29	0.25	0.04	0.03	0.05	0.05	1.30	1.35	0.17	0.18	0.001	0.001
October	20.84	19.90	40.70	40.60	50.37	48.27	8.31	8.29	5.58	5.35	0.39	0.36	0.29	0.21	0.05	0.05	0.06	0.06	0.99	0.90	0.20	0.21	0.001	0.001
November	24.52	24.20	40.60	40.62	59.96	39.81	8.30	8.29	6.76	6.76	0.68	0.49	0.35	0.25	0.09	0.10	0.07	0.06	1.09	1.16	0.28	0.22	0.001	0.001
December	23.32	23.18	40.66	40.63	58.62	47.02	8.30	8.31	5.56	6.96	0.59	0.34	1.15	0.44	0.21	0.18	0.07	0.05	1.57	1.03	0.33	0.33	0.001	0.002

With reference to the table above, the ESIA team's observations relative to seawater quality at the IC areas are as follows.

Reportedly, the trophic status of a water body can be assessed by measuring levels of several parameters including concentrations of dissolved oxygen (DO), nutrients and chlorophyll a (Chl-a). Eutrophication refers to the process of enrichment of relatively closed and slow-flowing water bodies with an excess concentration of nutrient, thus stimulating the proliferation of algae and other plankton in the water, resulting in lower DO, increased Chl-a content and the degradation of water quality. DO concentrations within eutrophicated systems exhibits diurnal variations. In fact, DO concentrations increase drastically during the daytime when light is available and drops down sharply during night when there is no photosynthesis. This diurnal DO variation indicates that excessive algae growth have caused a significant impact on DO production and consumption during the day and night, respectively. DO concentration is critical for marine ecosystems as it affects most marine biogeochemical processes as well as the survival and distribution of marine organisms. Its depletion causes hypoxia or anoxia in the aquatic ecosystems thus decreasing its ability to maintain a healthy aquatic life.

Whereas inorganic compounds (ammonia, nitrate, nitrite, phosphate and silicate) are essential nutrients for marine phytoplankton productivity and growth in excess, they may lead to eutrophication, whereby high-water fertility allows for a rapid blooming of phytoplankton with initial over production of oxygen, ending with decomposition of dead plants that reduces the level of oxygen in the water. Eutrophication occurs in areas where water circulation is restricted, allowing for nutrient build up due to low dilution.

The Gulf of Aqaba is a partially enclosed, narrow and deep coastal water body [34]. In addition, it is influenced by predominant subtropical conditions with extremely high temperatures, high evaporation rate and negligible rainfall. These conditions lead to a high salinity in surface water layer. The waters of the Gulf of Aqaba are well balanced and oxygenated with redox indicators of oxidizing conditions. This is mainly due to the annual deep water mixing which reaches complete saturation [42] [43]. As such, the two main factors controlling the DO concentrations in Gulf of Aqaba are temperature and salinity knowing the strong dependence of the oxygen solubility on these two variables [44].

pH: Aquatic species are sensitive to a change in pH and their productivity and community structure may be severely affected by a decrease of about 0.5 to 1.0 pH units in natural surface waters with pH normally within the range of 6.5 to 8.5 units [31]. Table 6-5 shows that, in the last 5 years, pH hovered around 8.3 with no significant difference between the coastal and offshore sites or during various seasons.

Salinity: Salinity in the area sampled has maintained a relatively constant concentration variation of around 40.57 to 40.63 PSU between seasons and locations.

Dissolved Oxygen: Dissolved oxygen (DO) is used as an indicator of the aquatic life supporting capability of a water body. Even though each organism has a specific DO tolerance, DO levels under 3 mg/L are considered of concern while levels below 1 mg/l are considered hypoxic and generally devoid of life (https://www.epa.gov/national-aquatic-resource-surveys/indicators-dissolved-oxygen). Table 6-5 shows that DO levels at both sites (IC and off-shore) were proportional to that of temperature with a range of 5.35 to7.18 mg/l. With the exception of June and December, DO levels were almost identical on the coast and offshore.

Ammonia: Ammonium concentration is an important ecosystem variable in water monitoring because of its high reactivity in the biogeochemical processes and the relatively high uncertainty in its analysis when compared with other environmental variables [42]. Table 6-5 shows that ammonia concentrations fluctuated between 0.34 and 0.72 µM, with higher concentrations at the coastal site than the offshore one and no clear seasonal difference.

Nitrate and Nitrite: Table 6-5 shows that both nitrate and nitrite concentrations during the last five years showed a clear shift from a summer low (except for August, which for the year 2018 registered an abnormally high nitrate concentration) to relatively higher winter values. Deep winter mixing, between

January and April, has been reported to introduce new nutrients into the surface water, such that nitrate concentrations in deep water were found at more than 2 µM [34] [43].

Phosphate: It is generally accepted that rather than phosphorus, nitrogen is the primary productivity limiting nutrient, implying that anthropogenic phosphorus can be assimilated only if surplus nitrogen is available. Phosphate concentrations reported in the last 5 years did not present any clear seasonal pattern and there was no discernible differences between coastal and offshore sites.

Silicate: The main source of silicate in the Gulf of Aqaba is the deep-water reservoir, which introduces silicate during mixing conditions [31].In addition, silicate carried by the desert winds in the atmosphere may be another source. Table 6-5 shows that silicate concentrations did not present any clear seasonal patterns and offshore concentrations tended to be lower than coastal ones.

Chlorophyll a: Table 6-5 shows that higher concentrations of chlorophyll were generally reported during the colder seasons in the last 5 years. This may be attributed to deep water vertical mixing during winter and water column stratification and high irradiance during summer, which result in the depletion of inorganic nutrients in the upper waters [31]. No clear differences between the coastal and offshore concentrations were recorded.

6.2.9. Ecological Features of the Jordanian Section of the Gulf of Aqaba

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 conditions. 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 [31].

A rich source of information on coastal habitats on the Jordanian coast of the Gulf of Aqaba is the long-term ongoing monitoring program commenced in 1999. Habitats monitoring focus on the coral reef ecosystem. Indicators monitored include percent cover and diversity of corals, associated marine life such as fish, sponges, algae and macro-invertebrates. According to UNDP (2015) [31] based on the national monitoring program results, the benthic habitat in the Jordanian Gulf of Aqaba can be generally described as follows:

- Southern sites of the Jordanian coast have more coral cover compared with the northern sites.
- Deeper transects in all sites have more percent cover of corals compared with the shallower transects. The program is conducted at two depths 8m and 15m.
- The deep transects contain higher percent cover of healthy corals
- Other species such as sponges, clams, sea anemone, ascidians, algae and others are less significant in terms of their distribution along the Jordanian coast of the Gulf of Aqaba.
- Recently killed corals, as the most important indicator for reef destruction were low in all sites with a percent cover of less than 1%.
- Fish larval abundance varies seasonally, reaching maxima during July and minimal during winter; November-February. This implies that most fish spawn between April and June.
- The family Scombridae represent the most important commercial species in Aqaba. It represents more than 70% of the Jordanian marine fish catch, particularly the most abundant migratory species Katsuwonuspelamis and Euthynnusaffinis. The family Carangidae comes in the second place represented by the species are Decapterusmacarellus and Decapterusmacrosoman. In the third and fourth places come the families Xiphiidae and Istiophoridae respectively.
- Turf algae exhibits higher cover in the shallower depth (8 m), and more live corals occur at the deeper water (15 m).
- Sites with the highest turf algae and least live coral cover are within close proximity to heavy industrial developments, while the site with the least turf algae and most live coral cover lies within a public beach, inside the Aqaba Marine Park.
- The average turf algae cover in relation to the total reef area for all the sites is 28%

- Bare dead coral to total reef proportion constitutes greater percentage (40%). This may indicate that the potential phase-shift from coral reef to turf algae is not yet incurable; but with more careful management, it might be slowed, halted, or even reversed
- Eighteen genera of benthic macroalgae have been identified in the Gulf of Aqaba coast including seven chlorophytes, eleven rhodophytes, and ten phaeophytes.
- Both biomass and mean absolute cover (MAC) are high for the brown algae (Phaeophyceae).
- The industrial complex exhibited the highest brown algae cover and biomass and is significantly different from those observed at the old phosphate port in the north. The highest cover and biomass are in spring.
- Several types of man-made litter are found in areas of the coast with intense human activities.

6.2.10. Ecological Features at the AAWDC

A dedicated coastal environmental monitoring program has been running at the site since 1996. Bottom habitat is a basic component in this monitoring program. Zibdah *et al.* (2007) [45] conducted a detailed ecological study in the framework of this monitoring program for three years (2001-2003) on a 5 km stretch of well-developed coral reef facing the JPMC IC. The status of prevailing ecological factors was assessed with respect to species diversity and abundance of the major groups of the macrobenthic community: corals, bivalves, hydrozoans, echinoderm, sponges and macroalgae. Three locations of two depths each: 6 & 12 m were selected and surveyed using the visual census point-intercept method (Figure 6-49).

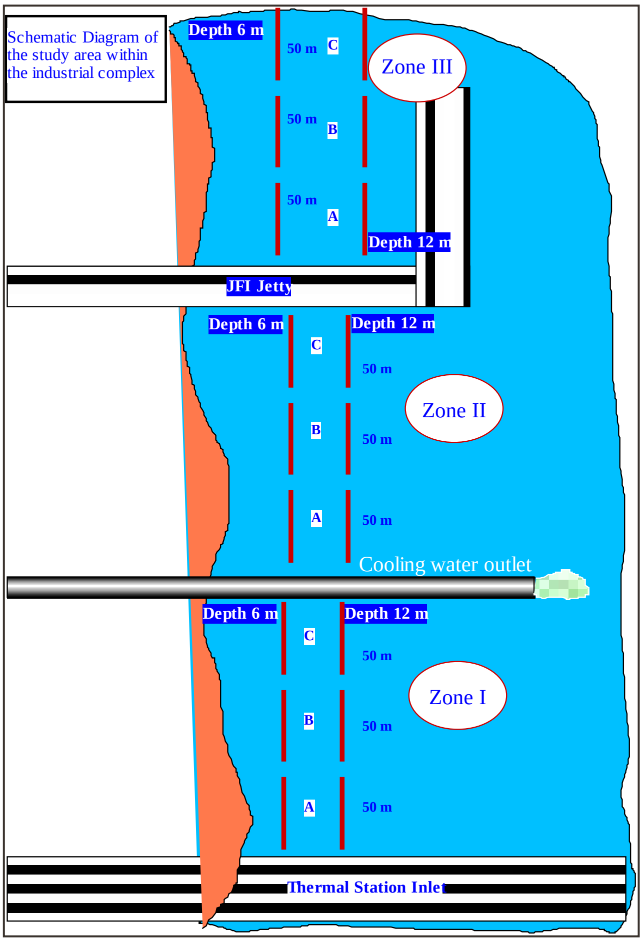


Figure 6-49: Bottom Habitat Study Sites in the JPMC IC Environmental Monitoring Program [45]

The number of species of existing hard coral species counted entire survey totalled 46 hard coral species belonging to the families *Acropora sps.*, *Montipora sps*., *Favia sps and Fungia sps.*. The bottom habitat was mainly rocky typical of coral reef sites. Structural modifications were noticed at certain places of the study site mainly due to construction activities where hard coral abundance and cover were slightly perturbed. The manoeuvring of ships and port activity may have also contributed to the observed impacts. However the main pattern noticed on other sites along the Jordanian sector of the Gulf of Aqaba dominated also at the IC site. Corals and other biotic indicators except seagrass showed higher abundance at the deeper transects as compared to the shallower. Figure 6-50 and Figure 6-51 below demonstrate these findings.

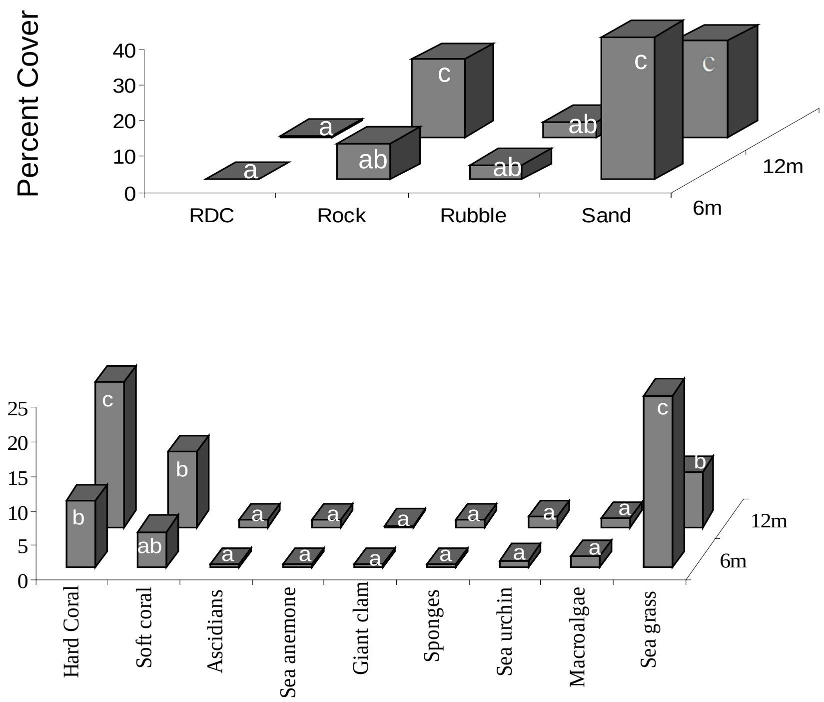


Figure 6-50: Percent Cover of Biotic and Abiotic Indicators at the Study Area [45]

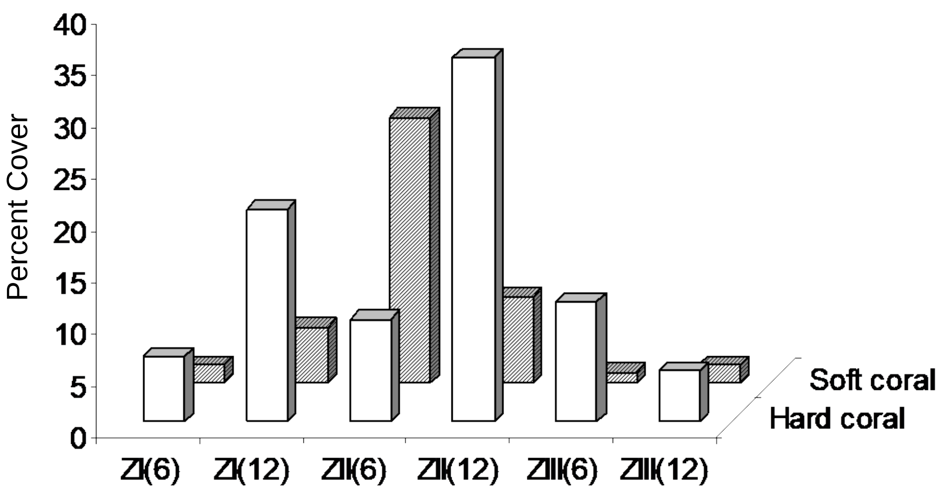


Figure 6-51: Percent Cover of Hard Corals and Soft Corals at the Study Area [45]

Fish assemblages at the JPMC IC coral reef according to the Monitoring Program reports are comparable with those at other coral reef sites on the Jordanian coast. Recorded species represent a fairly complete list of some of the reef associated families such as chaetodontidae, pomacanthidae, labridae and pomacentridae. Cotal Reef fish are important players in the Reef ecosystem as they influence the zonation of various parts of the reef through their grazing activities, which keeps algae in check and prevents them from out competing the corals.

6.2.11. Coral Reproduction

Corals reproduce in two ways asexual and sexual. Asexual reproduction, budding occurs when a new zaygot grows on another one and remains attached to it until maturity. Sexual reproduction, fertilization also occurs in two ways. Fertilization may occur within the coral known as brooding or outside the coral known as broadcasting (Figure 6-52). About 75% of hermatypic corals are hermaphrodite capable of producing both eggs and sperms while about 25% are capable of producing eggs or sperms only.

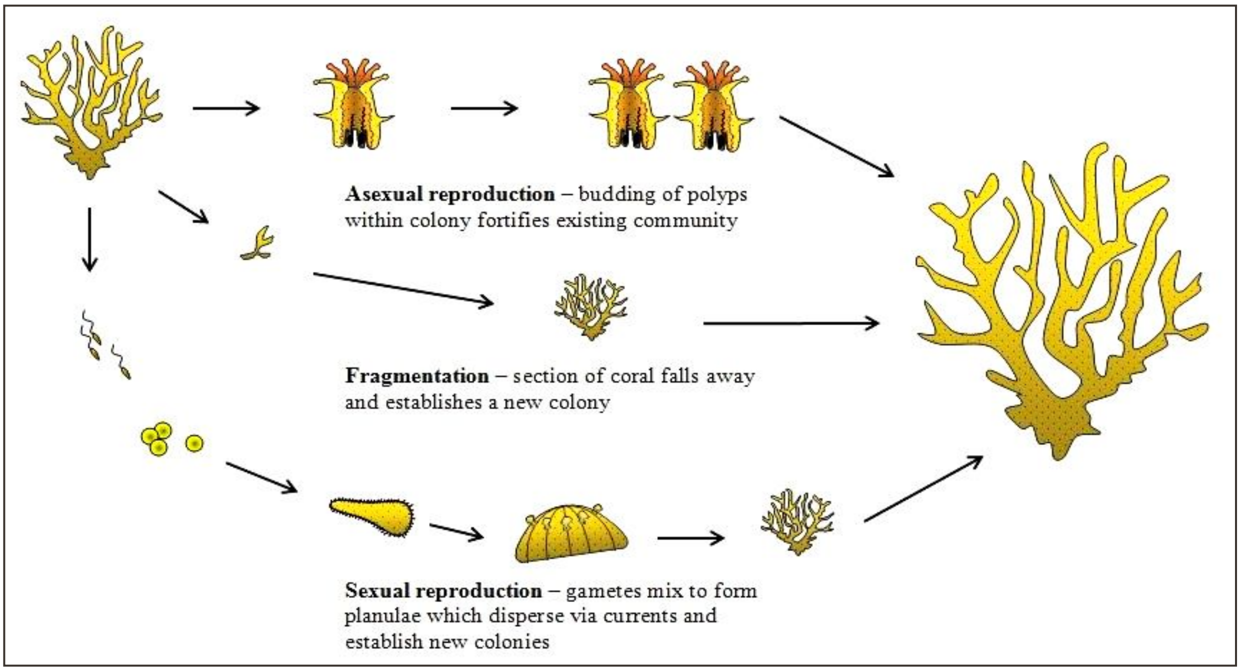


Figure 6-52: Coral Reproduction Scheme [46]

Corals are unique in their broadcasting reproduction. Almost all corals in a specific ecosystem shed their eggs and sperms in the water column where fertilization takes place on specific full moon nights. According to Bouwmeester and Berumen (2015) [47] coral broadcasting spawning in the northern Gulf of Aqaba has been reported to be highly synchronous, making it almost unique when compared to other regions in the world. Similar findings have been reported by Rapuano *et al.* (2017) [48]. Corals Spawning in the northern Gulf of Aqaba is about 2 months later than in the Red Sea proper. This has been attributed to seawater temperature. Corals in the Gulf of Aqaba spawn repeatedly every year on the full moon during June and July. Maturity can be easily noticed about a week before full moon and the spawning night can be predicted with very high confidence. This phenomenon makes it possible to collect the eggs and sperms during the spawning event and complete fertilization under controlled laboratory conditions [49]. This is very important for the AAWDC Project because on top of best practice design considerations to minimise adverse impacts from entrainment of coral eggs at the intake system, the particular phenomenon enables further minimisation of entrainment impacts through scheduled shut-down of the plant during the night and day after of this critical spawning event.

6.2.12. Baseline Findings of the Video Recording Survey at the Intake Area

The AAWDCP intake area has been covered by 37 diving belts about 5m wide each. At every belt, a video recording (**found in Annex 11**) and some indicative still photos have been taken. Figure 6-53 shows the video diving belts coordinates and extensions. Table 6-6 summarizes the information on the diving belts and explains the way folders and files names have been given. Figure 6-54 shows an illustration of the AAWDC intake area bottom composition. It is important to note in Figure 6-54 that "Reef" does not mean live corals. It is just a reef structure, which has flourishing live corals in some parts as can be seen in the videos and dead corals and coral rock in other parts. Towards the deep end, deeper than 25m very limited numbers of live corals could be found. Live cover would not exceed 5%. Dead reef structures are still important habitats as they still have the caves and crevices that provide shelter and protection to marine organisms, but not as much food as can be provided by high live coral cover reefs. The gas pipeline runs on a sandy bottom, but coral heads can be seen growing on the Pipeline, which is also common for fixed introduced structures to play the role of artificial reefs or providing the solid substrate needed for corals to settle and regenerate.

Some fish have been seen during the survey. A Barracuda (Figure 6-55), a Napoleon wrasse (Figure 6-56) and a spotted stingray (Figure 6-57) appear to inhabit the site. A hawksbill turtle has also been seen in the area (Figure 6-58). It appears to dwell under the phosphate loading berth. It is noted that the barracuda is not listed as endangered or vulnerable with the World Conservation Union (IUCN). On the contrary, (a) hawksbill turtles are currently classified as Critically Endangered by the IUCN, (b) Napoleon wrasse is listed as Endangered on the IUCN Red List and included in CITES Appendix II in 2004, and (c) stingrays are not listed under CITES, the Convention on International Trade in Endangered Species and generally range from Least Concerned (not endangered) to Endangered. Considering their conservation status and potential sensitivity to toxicity exposure, these species is recommended to be included in the design of the Whole Effluent Toxicity (WET) tests to be undertaken by the AAWDC project developers. The same applies for endemic coral species.

According to the JPMC IC environmental monitoring program, the seafront which is the AAWDC Intake area is rich in fish abundance. This is common in no reach sites where the restriction of access plays a role of a protected area. Table 6-7 from the JPMC IC environmental monitoring program (2019) shows frequency of appearance and relative abundance of fish species at two depths 8 and 15m. The table has been adapted to also present conservation status of each listed species, which indicates that most of the documented fish species (a total of 52) are of Least Concern. However, only one, the Chaetodon itrifascialis is considered Near Threatened and Dascyllus trimaculatus has a Vulnerable status (pursuant to MSS/UoJ/YU, 2019). In addition, Figure 6-59 shows temporal trend of the frequency of appearance of the different fish families at two zones, 15m deep in front of the Industrial Complex, North (a) and South (b).

Figure 6-53:Video Survey at the AAWDC Seawater Intake Diving Belts' Coordinates and Extensions

Table 6-6 Summary Information on the Diving Belts, Explaining the Way Folders and Files Names Have Been Given

Folder Serial Number	Folder / File Name*	Northern End			Southern End			Direction	Duration Minutes	Comments
		Depth m	Latitude N	Longitude E	Depth m	Latitude N	Longitude E			
1	1NS20191135	35	29.3723407	34.9645122	35	29°22'17.21"	34°57'47.48"	N-S	06:20	Most of the reef at these depths consisted of dead corals and coral rocks
2	2NS20111930	30	29.3718963	34.9646762	30	29°22'17.05"	34°57'47.62"	N-S	05:29	
3	3NS20111630	30	29.3722721	34.9643912	30	29°22'17.02"	34°57'47.86"	N-S	07:00	
4	4NS20111725	27	29.3722743	34.964509	18	29°22'16.94"	34°57'48.08"	N-S	06:36	
5	5NS20111725	25	29.3723889	34.9647778	20	29°22'16.85"	34°57'48.14"	N-S	08:29	
6	6NS20111824	24	29.3723889	34.9648056	17	29°22'16.76"	34°57'48.25"	N-S	07:34	
7	7NS20111823	23	29.371891	34.9649034	16	29°22'16.66"	34°57'48.35"	N-S	6:23	
8	8SN20111822	22	29.3722088	34.9649348	13	29°22'16.51"	34°57'48.52"	S-N	7:24	
9	9SN20111821	21	29.3723021	34.9649755	11	29°22'16.29"	34°57'48.69"	S-N	06:26	
10	10NS20112020	20	29.3720856	34.9648682	11	29°22'16.14"	34°57'48.83"	N-S	08:32	
11	11NS20112118	18	29.3723387	34.9649482	10	29°22'15.95"	34°57'48.98"	N-S	07:41	
12	12SN20112115	15	29.3720378	34.9647016	12	29°22'15.85"	34°57'49.16"	S-N	07:57	
13	13SN20111811	11	29.3716788	34.9646909	11	29°22'15.69"	34°57'49.36"	S-N	06:42	
14	14NS20111710	10	29.3719569	34.9648698	10	29°22'15.58"	34°57'49.51"	N-S	10:36	
15	15NS20111809	9	29.3716978	34.9647543	9	29°22'15.41"	34°57'49.62"	N-S	07:32	
16	16NS20111809	9	29.3723056	34.9654722	5	29°22'15.13"	34°57'49.74"	N-S	08:21	
17	17NS20111809	9	29.3718611	34.9652778	4	29°22'14.96"	34°57'49.81"	N-S	08:53	
18	18NS20111808	8	29.3721725	34.9649873	4	29°22'18.40"	34°57'54.92"	N-S	02:43	
19	19SN20112308	8	29.3722138	34.9653744	5	29°22'18.30"	34°57'55.11"	S-N	08:27	
20	20NS20111807	7	29.3720343	29.3720343	3	29°22'18.16"	34°57'55.25"	N-S	01:58	
21	21SN20111807	7	29.371976	34.9651255	3	29°22'18.02"	34°57'55.32"	S-N	03:08	
22	22SN20111805	5	29.3719879	34.9651244	3	29°22'18.24"	34°57'55.61"	S-N	02:04	
23	23NS20111804	4	29.3722309	34.9654921	2	29°22'18.29"	34°57'55.80"	N-S	03:25	
24	24NS20111803	3	29.3721755	34.9656281	1	29°22'18.33"	34°57'55.97"	N-S	03:25	
25	25SN20111801	2	29.3717827	34.964737	2	29°22'18.30"	34°57'56.12"	S-N	06:37	
26	26SN20111801	1	29.3721413	34.9656542	1	29°22'18.27"	34°57'56.25"	S-N	01:52	
27	27SN201118BR	Backreef	29.3720823	34.9655912	Backreef	29°22'18.24"	34°57'56.37"	S-N	02:05	
28	28NS201118BR	Backreef	29.3720464	34.9657718	Backreef	29°22'14.80"	34°57'49.93"	N-S	01:39	
29	29NS201118BR	Backreef	29.3721441	34.965777	Backreef	29°22'14.55"	34°57'50.11"	N-S	03:38	
30	30NS201118BR	Backreef	29.3719346	34.964425	Backreef	29°22'14.37"	34°57'50.29"	N-S	08:48	
31	31SN201119BR	Backreef	29.3716066	34.9649122	Backreef	29°22'14.25"	34°57'50.42"	S-N	04:57	
32	32SN201119BR	Backreef	29.3716633	34.9652501	Backreef	29°22'14.11"	34°57'50.57"	S-N	04:53	
33	33NS201119BR	Backreef	29.3716893	34.9653834	Backreef	29°22'13.97"	34°57'50.72"	N-S	04:25	
34	34NS201119BR	Backreef	29.3716893	34.9653834	Backreef	29°22'17.89"	34°57'55.59"	N-S	04:49	

Folder Serial Number	Folder / File Name*	Northern End			Southern End			Direction	Duration Minutes	Comments
		Depth m	Latitude N	Longitude E	Depth m	Latitude N	Longitude E			
35	35NS201121BR	Backreef	29.371709	34.9655442	Backreef	29°22'17.71"	34°57'55.68"	N-S	01:13	
36	36SN201121BR	Backreef	29.371709	34.9655442	Backreef	29°22'14.90"	34°57'49.87"	S-N	01:12	
37	37 NEW SWE	The Folder contains two diving belts covering the northern side from east to west (0-35m) and the southern side from west to east (35-0m)								

**The Folder and the video inside have the same name. The folder and file name consists of serial number, direction, date yy/mm/dd and depth at the northern end*

Figure 6-54: Illustration of the AAWDC Intake Area Bottom Composition

The shallow part of the site 8m and 15m depths are covered in a regular monitoring program for the JPMC Industrial Complex. According to the results of the monitoring program the shallow part hosts good live cover of healthy corals. Figure 6-60 from the JPMC IC Monitoring program 2019 shows live percent cover of hard and soft corals, which collectively comprise 50%-60% with a tendency of higher live cover at 15 m than at 8 m. Figure 6-62 to Figure 6-64 are taken from the AAWDC Intake Area Bottom Video Survey and present illustrative plates of the high live cover healthy habitat in the shallow area below 20 m depth.

Figure 6-55:Barracuda Seen During the Video Survey on Poor Reef at 30m depth

Figure 6-56: Napoleon Wrasse Seen on Poor Reef at 25m Depth Close to the IC Cooling Water Outlet

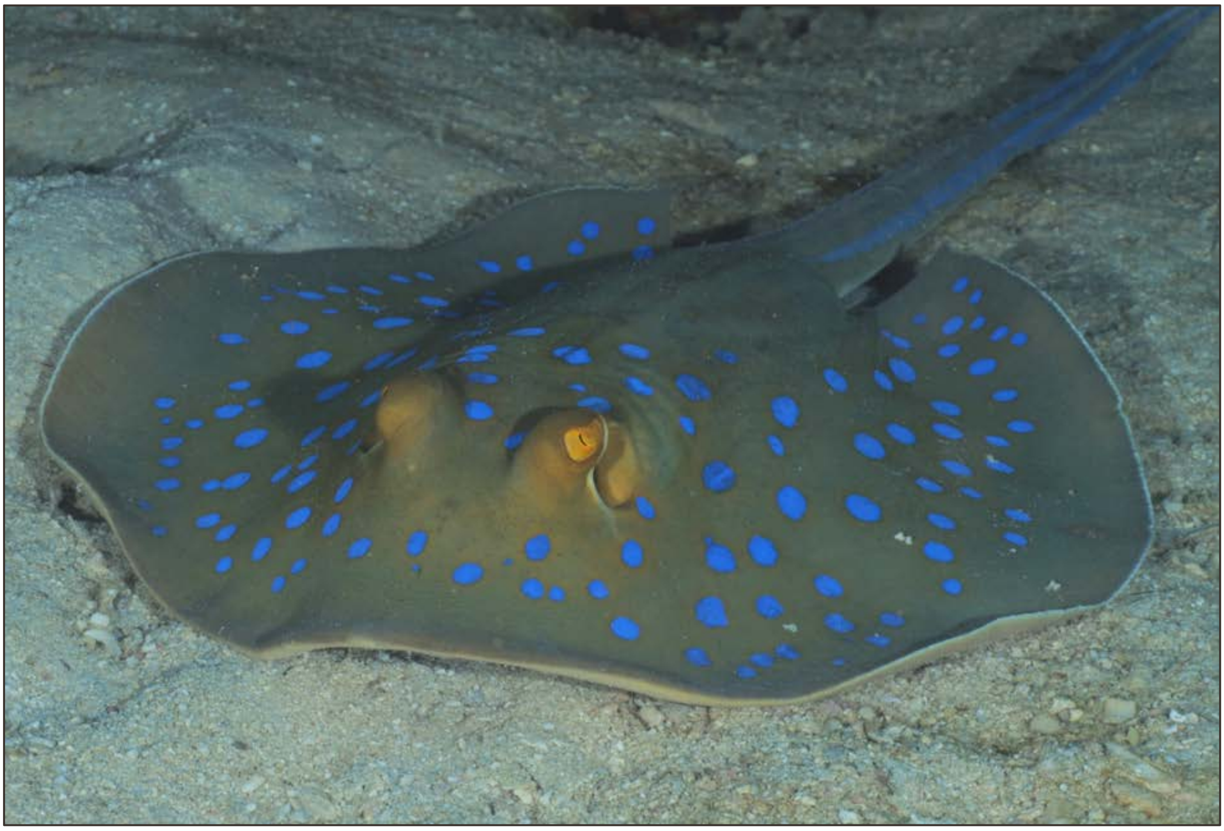


Figure 6-57: Spotted Stingray Seen on Sandy Seabed at 15 Depths Close to the Gas Pipeline

Figure 6-58: Hawksbill Turtle Under the Phosphate Loading Berth at 10m depth (Appears To Dwell There)

Table 6-7 Frequency of Appearance (FA) and Relative Abundance (RA) of all Fish Species at Two Zones (South and North) and at Two Depths of the Industrial Complex (December 2019) and their Conservation Status

Fish Species	Conservation Status	FA		RA	
		North	South	North	South
Sargocentron diadema	Least Concern	100.0	100	0.7	0.50
Epinephelus fasciatus	Least Concern	0.0	17	0.0	0.01
Variola louti	Least Concern	100.0	100	0.1	0.10
Pseudanthias Squamipinnis	Least Concern	100.0	100	24.2	24.85
Pseudochromis fridmani	Least Concern	66.7	83	0.0	0.05
Pseudochromis olivaceus	Least Concern	100.0	83	0.1	0.09
Pseudochromis springeri	Least Concern	100.0	100	0.1	0.14
Caesio varilineatus	Least Concern	100.0	100	0.1	0.11
Parupeneus forssky	Least Concern	83.3	87	16.9	83.3
Parupeneus macronemus	Least Concern	100.0	100	0.5	0.36
Lethrinus borbonicus	Least Concern	100.0	100	0.1	0.11
Chaetodon auriga	Least Concern	83.3	67	0.1	0.03
Chaetodon austriacus	Least Concern	16.7	0	0.1	0.00
Chaetodon fasciatus	Least Concern	66.7	83	0.0	0.05
Chaetodon melannotus	Least Concern	83.3	100	0.1	0.13
Chaetodon paucifasciatus	Least Concern	100.0	100	0.1	0.13
Chaetodon itrifascialis	Near Threatened	16.7	50	0.0	0.02
Heniochus diphreatus	Least Concern	50.0	100	0.0	0.06
Heniochus intermedius	Least Concern	100.0	83	0.4	0.23
Apolymichthrys xanthotis	Least Concern	0.0	33	0.0	0.13
Centropyge multispinis	Least Concern	66.7	33	0.0	0.01
Pomacanthus imperator	Least Concern	83.3	83	0.5	0.36
Pygoplites diacanthus	Least Concern	100.0	83	0.1	0.07
Amphiprion bicinctus	Least Concern	100.0	100	0.1	0.08
Chromis dimidiata	Least Concern	100.0	100	0.2	0.26
Chromis viridis	-	66.7	67	0.0	0.02
Chromis pelora	-	66.7	67	0.0	0.02
Dascyllus anuanus	-	100.0	100	0.7	0.88
Dascyllus marginatus	Least Concern	100.0	100	0.4	0.71
Dascyllus trimaculatus	Vulnerable	100.0	100	0.7	0.71
Neopomacentrus miryae	-	100.0	83	21.7	14.55
Pomacentrus suifureus	-	100.0	100	6.0	10.42
Promacentrus trichourus	-	100.0	100	0.1	0.10
Anampses twistij	Least Concern	1.00.0	100	0.3	0.39
Oxycheilinus mentalis	Least Concern	100.0	100	0.2	0.16
Cheilinus trilobatus	Least Concern	0.0	50	0.0	0.03
Chelinus trilobatus	Least Concern	0.0	50	0.0	0.3
Gomphosus caeruleus klunzingeri	Least Concern	83.3	100	0.1	0.07
Labroides dimidiatus	Least Concern	83.3	67	0.1	0.04
Larabicus quadrilineatus	Data Deficient	100.0	100	0.1	0.15
Parachellinus octotania	Least Concern	100.0	100	18.7	30.87
Thalassoma klunzingeri	Least Concern	100.0	100	1.2	1.61

Fish Species	Conservation Status	FA		RA	
		North	South	North	South
Chiorurus sordidus	Least Concern	100.0	83	0.1	0.08
Scarus gibbus	Least Concern	0.0	17	0.0	0.04
Acanthurus nigrofuscus	Least Concern	0.0	17	0.0	0.05
Ctenochaetus striatus	Least Concern	100.0	100	0.1	0.08
Zebrasoma xanthurum	Least Concern	100.0	100	0.8	0.57
Siganus luridus	Least Concern	0.0	0	0.0	0.00
Siganus rivulatus	Least Concern	100.0	100	0.4	0.28
Sufflamen albicaudatus	-	66.7	67	0.0	0.04
Cantherhns pardalis	Least Concern	100.0	100	0.1	0.08
Canthigastr coronata	Least Concern	83.3	50	0.8	0.20

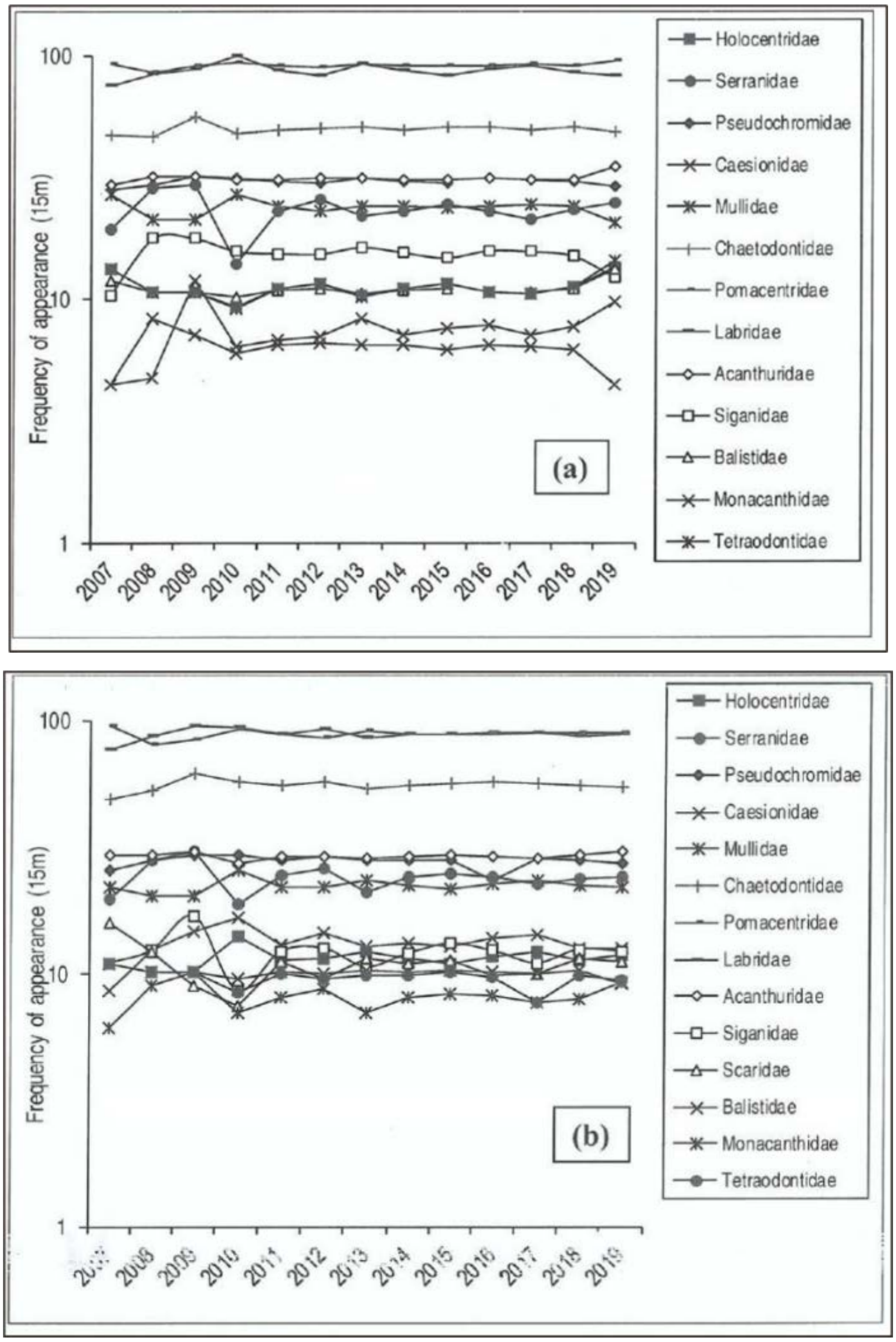


Figure 6-59: Temporal Trend of the Frequency of Appearance of the Different Fish Families at Two Zones, 15m Deep in Front of the Industrial Complex, North (a) and South (b)

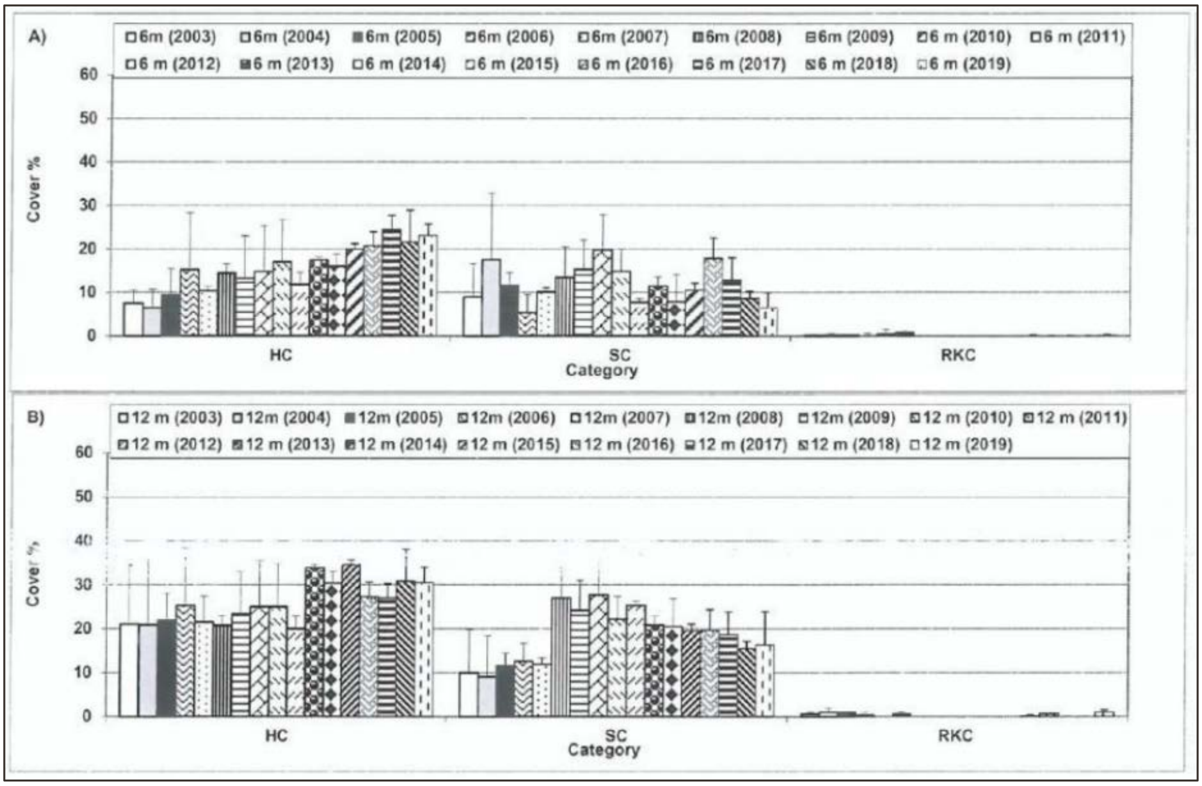


Figure 6-60: Live Percent Cover of Hard and Soft Corals at 6m and 12m Depths in the Intake Area for Years 2003-2019

Figure 6-61: High Live Cover Healthy Corals at About 10 m Depth (Intake Video Survey)

Figure 6-62: Healthy Corals and Rich Fish Abundance at The Back Reef About 1m Depth

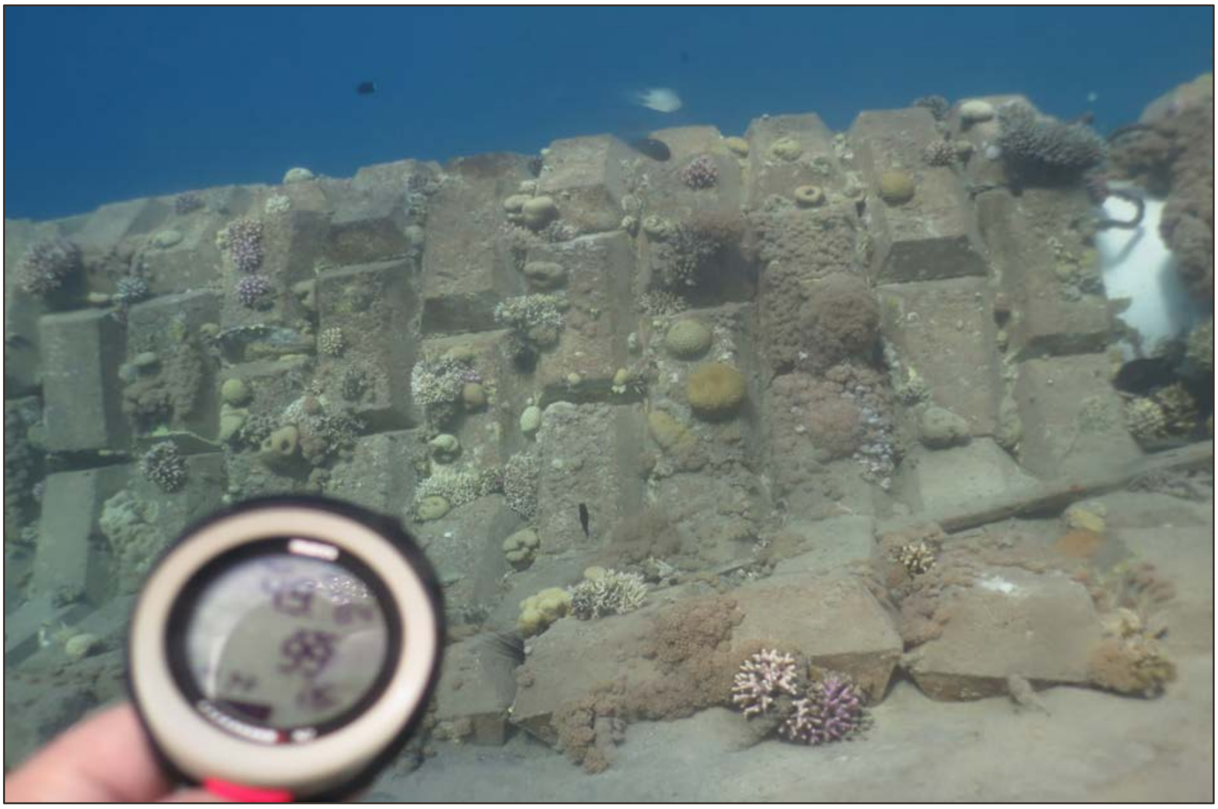


Figure 6-63: Coral Settlement on Building Material Covering the Gas Pipeline at 2m Depth

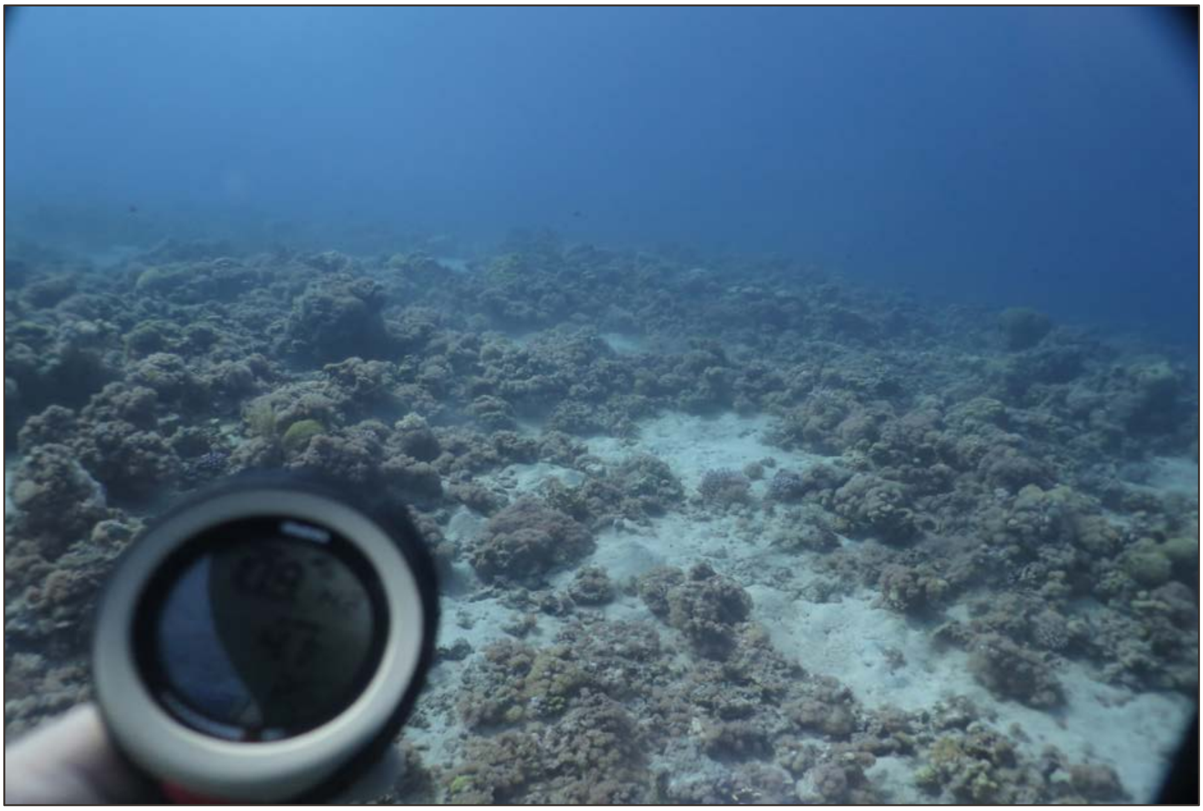


Figure 6-64: Healthy Dispersed Corals at 19m Depth

Figure 6-65: Abundant Fish Assemblages at About 20m Depth Under the Phosphate Loading Berth

6.2.13. Baseline Findings of the Video Recording Survey at the Outfall Area

After the horizontal position-elevation verification and filming a third video, there was still an offset between the planned 50m diffusers depth that was based on the available bathymetric maps and the actual ground-truthing by on the spot depth measurements. The offset was about 35 m at the northern end of the planned diffusers location and 25 m at the southern end of the planned diffusers location. This horizontal offset corresponds to about 5m in elevation. It is noted, however, that this offset does not indicate an error in bathymetry maps or surveyed belts and it is mainly attributed to the fact that divers can only stay at 50 m depth for a limited period during which they captured their first reading (at 50 m depth and at 52 m depth) and then they move back to shallower waters without being able to cross check how much further this depth is extended. The limit of the survey was set at 50 m depth and the survey profiles indicate where such depth was encountered. The change in slope further to the west was not possible to be determined but the mild topography between the 50 m and 55 m depth contours as shown in the bathymetry map was confirmed. In any case, the seabed video recording reports as appended to this Report **(Annex 11)** can be provided to the developers as non-warranted project information that requires confirmation from their end during project design. This is typical in SWRO BOT scheme projects, where developers are required to take full responsibility for all survey works, including bathymetry, whereas survey work provided in RFPs is considered as non-warranted project information.

As mentioned above, the AAWDC Outfall Pipeline Path and Diffusers' Area has been covered by 4 diving belts about 10 m wide each. At every belt, a video recording and some indicative still photos have been taken. It is important to note in the Figure that "Reef" does not mean live corals. It is just a reef structure. As can be seen in the videos the Reef structure in the deep area is mainly dead corals and coral rock continuing the conditions that prevailed between 25 m to 35 m in the shallow intake area video survey. Live coral cover is clearly very low, almost unnoticeable.

General features that could be observed from the videos are as follows:

- Belt 1EW20210105 that extends east west displays rocky steep sloping reef structure between 35 m and 45 m depths that ended at 45m dropping abruptly to 50m depth to a gently sloping consolidated sand area. At the end of the video the diver rotated 360º with the camera. The reef that appears at the end of the video is that extending between 35 m and 45 m.
- Belt 2NS20210106-7 displays a reef that appears in the video is 5-10m east of the line at 45m depth. At minute 3:30 of the video reef appears at 50m depth (29°22'19.04"N, 34°57'46.27"E). At minute 5:30 the reef structure ends with rubble and consolidated sand. Towards the end of the belt the 50m depth contour ends and the depth decreases rapidly, still consisting mainly of rubble and consolidated sand.
- Belt 3NS20210109-10 and Belt 4SN20210130 are west of the previous belt and about 5 m interspaced. The bottom here consists mainly of rubble, consolidated sand, and dead reef structure.

Figure 6-66 shows examples of the bottom features at 50 m depth.

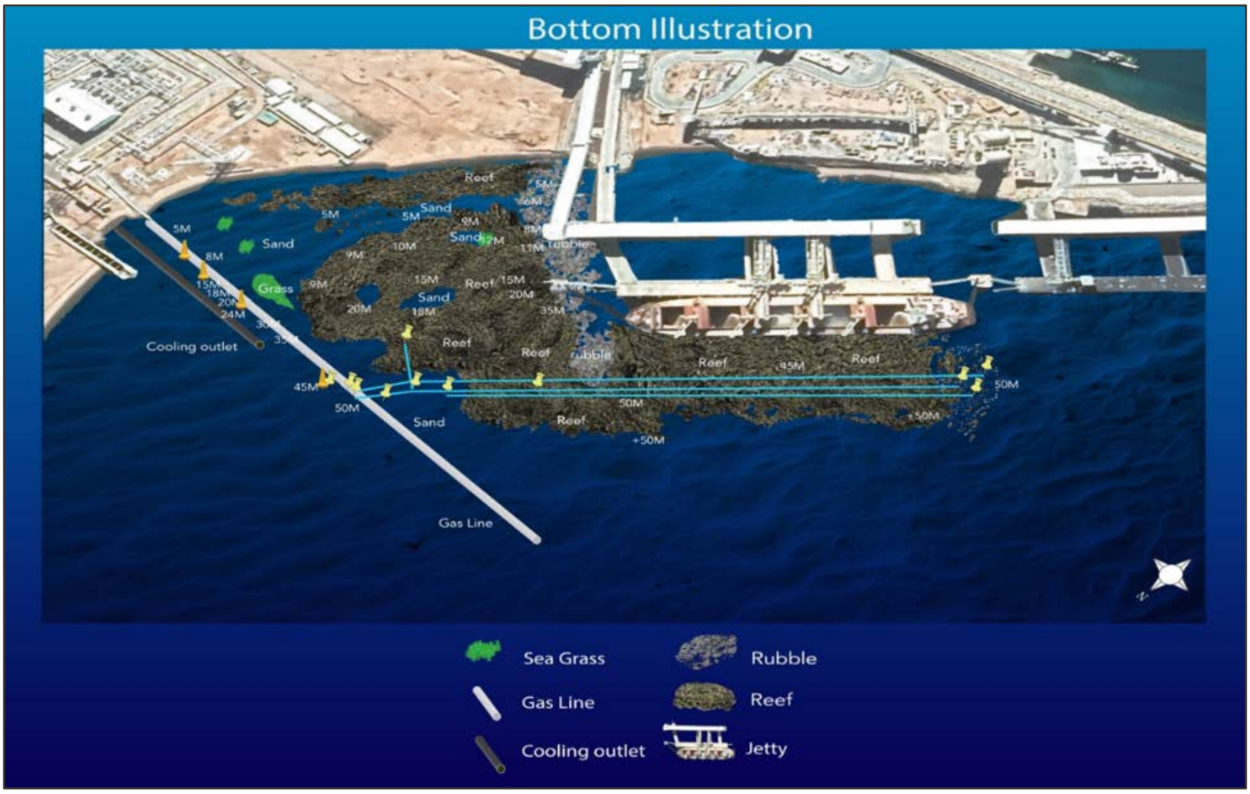


Figure 6-66: Illustration of the AAWDC Intake, Outfall Pipeline Path and Diffusers Area Bottom Composition

Figure 6-67: Examples of the Seabed Structure at 50 m Depth

Table 6-8: Video Survey at the AAWDC Brine Outfall Pipeline Path and Diffusers Diving Belts' Coordinates and Extensions

Folder Serial Number	Folder / File Name*	Northern End			Southern End			Direction	Duration Minutes	Comments
		Depth m	Latitude N	Longitude E	Depth m	Latitude N	Longitude E			
1	1EW20210105	35	29°22'19.57"	34°57'49.45"	50	29°22'20.40"	34°57'48.34"	E-W	2	Reef 35-45m. Drops sharply to 50m consolidated sand bottom
2	2NS20210106-7	50	29°22'21.49"	34°57'49.73"	50	29°22'13.57"	34°57'39.14"	N-S	11	Start: consolidated sand. Middle: reef with mostly dead corals. End: consolidated sand and rubble
3	3NS20210109-10	50+	29°22'21.54"	34°57'49.59"	50	29°22'14.13"	34°57'39.40"	N-S	9	Mostly consolidated sand, dead reef structure and rubble
4	4SN20210130	50+	29°22'20.10"	34°57'47.70"	52	29°22'14.30"	34°57'38.90"	S-N	7.5	Mostly consolidated sand, dead reef structure and rubble

**The Folder and the video inside have the same name. The folder and file name consists of serial number, direction, date yy/mm/dd and depth at the starting point*

6.2.14. Baseline Findings of the ROV Survey

The ROV survey found (**Annex 12**) that the seabed at the surveyed area consists of a continuous sandy strip 20-40 m wide extending east to west next to the gas pipeline. Next to the south extends an aggregated rocky bottom partially covered with live coral tissue. These naturally formed coral rocks seem to be stressed by the prevailing environmental conditions in survey area. This is inferred from partially lost live coral tissues on the rock surface. However, at these great depths natural conditions may also contribute to poor coral cover. Coral distribution and cover percentage increase with depth to a certain extent, where the best coral cover with healthy corals on the Jordanian coast of the Gulf of Aqaba is found at depths ranging between 15 m and 30 m. Below this depth, coral heads become subject to impacts by deposited sediments that fall down from the surface and lay down on the coral surfaces. The sediment particles cause the live tissue abrasions, suffocation and final death. Therefore, it could be noticed that the corals on the deeper sections of the reefs are not fully covered by healthy coral tissues.

It is also generally known that corals in the deep contours of the reef ecosystems suffer from light attenuation, where the surface light cannot penetrate deep due to suspended particles in the water body. This result in the intensity of light greatly reduced in the deep water. This effect is added to the light filtration effect, where only short wavelengths can penetrate deep in the sea because of their wavelength energy. These two factors can easily be detected from the quality of photos obtained in the study transects done at 60 m and 70 m, where the photo contrast was poor. This was noticed when videos and photos were taken from few meters away from the camera. As ambient natural light was not enough to supply the full light spectrum to the photo, when clear photos were desired, the ROV needed to be brought too close to the target object and full light supply of the ROV used.

The two depth contours surveyed at 60 m and 70 m, starting from the gas pipeline had sandy bottom cover on the two pipeline sides. This formed a stripe about 20-40m wide along the surveyed southern side of the pipeline (Figure 6-68). Next to this stripe extended batches of rocks and aggregates of small reefs.

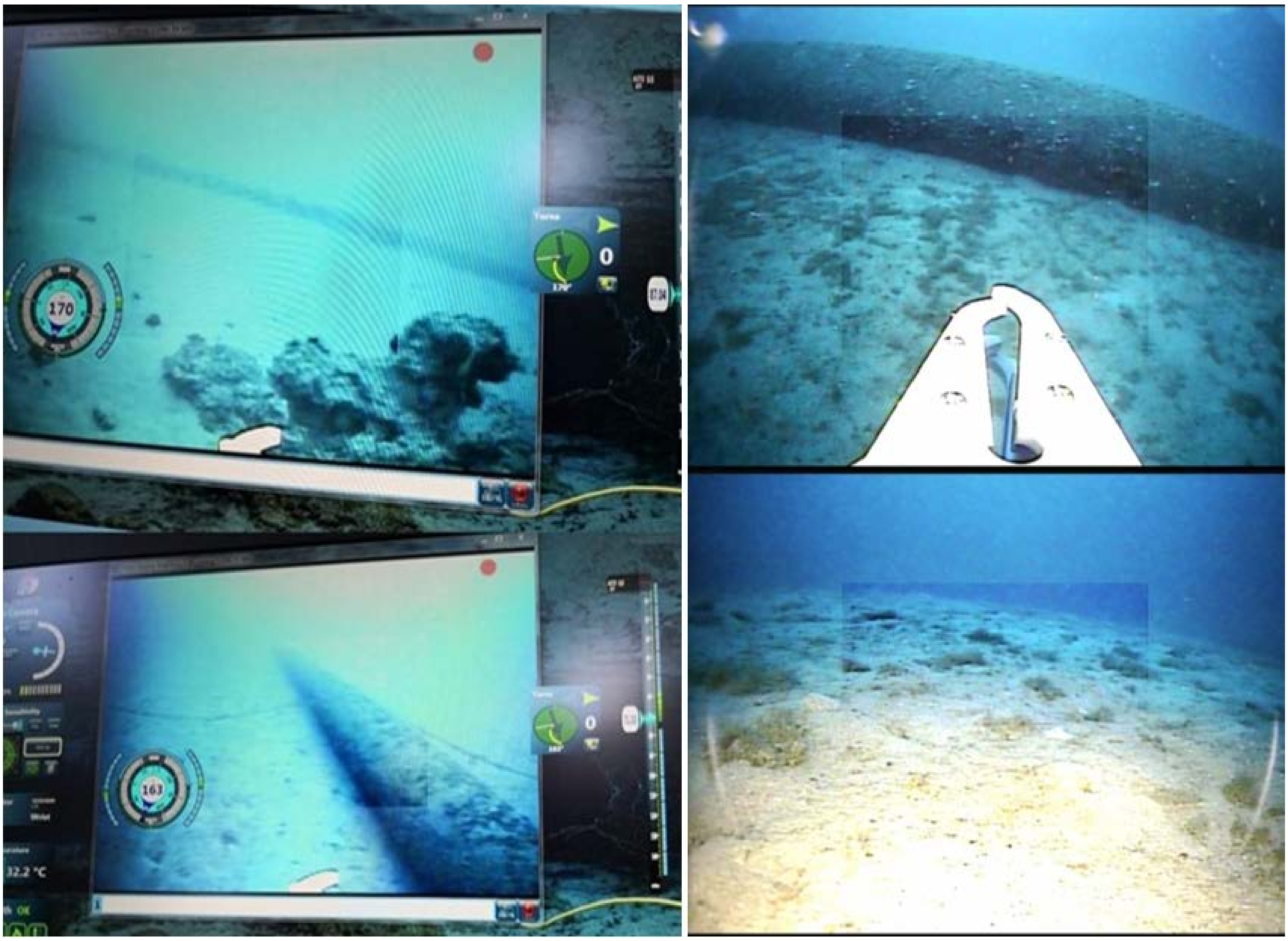


Figure 6-68: Sandy Bottom Habitat Characterized the Area Around the Gas Pipe Line

With respect to bottom percentage cover, the batch rocky with aggregated coral live tissue seabed was interspersed with sandy areas. It was not possible from the survey to give a precise percentage cover. However, from the videos and digital photos obtained the rocky parts were partially covered with live coral tissue, which may reach up to 20-30%, based on a visual observation. This live coral tissue could not be identified, but from close-up shots it appears to belong to different coral species (Figure 6-69 and Figure 6-69).

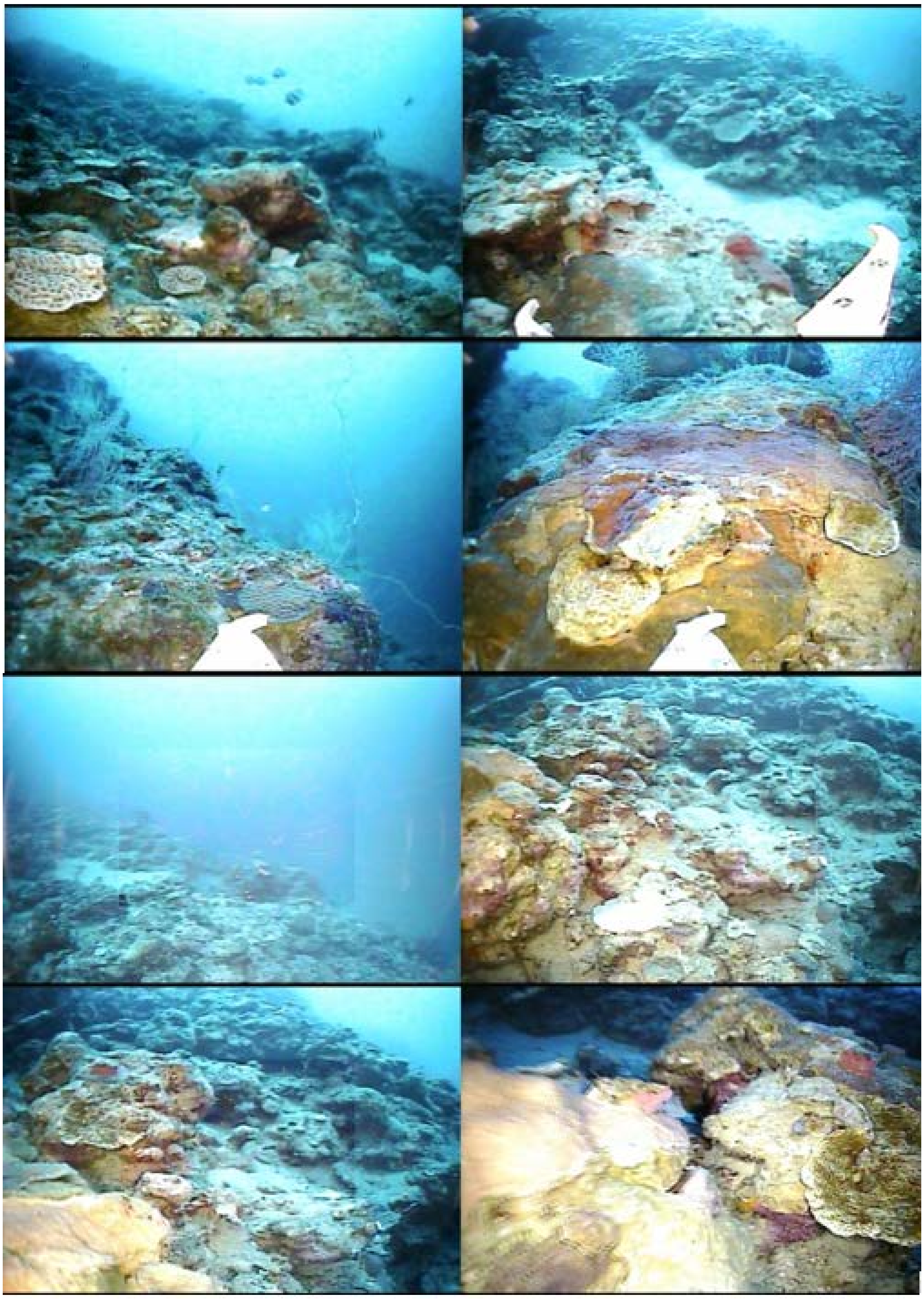


Figure 6-69: Selected Photos from the Rocky Part of the Benthic Habitat in the Study Area

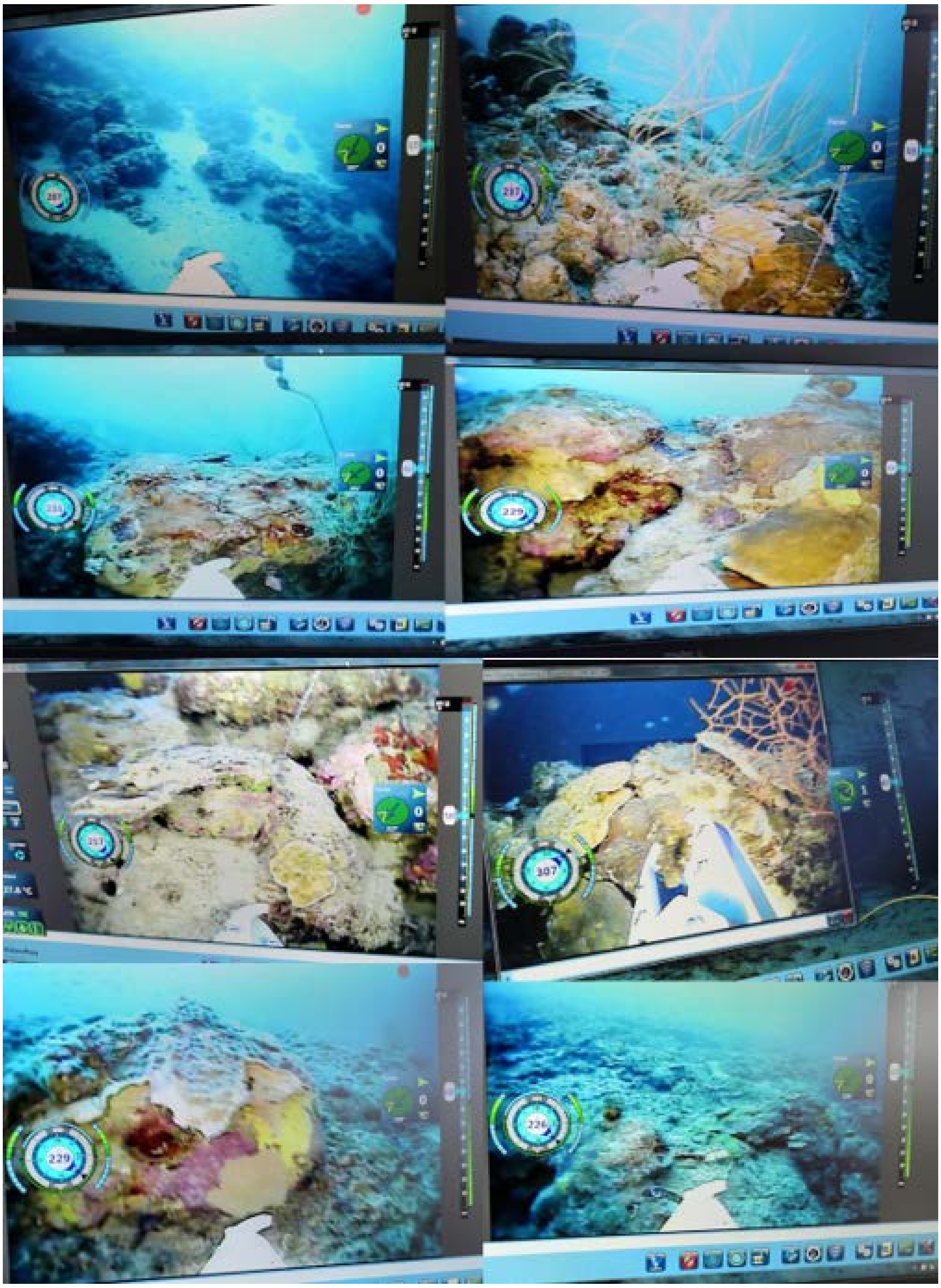


Figure 6-70: Selected Photos from the Rocky Part of the Benthic Habitat in the Study Area

6.2.15. Trihalomethanes and Residual Chlorine Analysis

The results of the Residual Chlorine and THMs analysis report indicate 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 our information. The analysis was conducted by BEN HAYYAN - Aqaba International Laboratories and the results are included in **Annex 13** of this report.

6.2.16. Seawater Charactertics based on the ESIA of AAWDCP Field Investigations

Annex 14 of the ESIA report includes data of the investigations, sampling and analysis related to seawater characteristics. Those investigations have been conducted through the ESIA study of the AAWDCP and a conclusion of the investigations are provided in sub-sections below.

Temperature and Salinity

The maximum value of seawater temperature 25.20^{0}C was recorded in surface at site (SSA2), which was higher of about 0.22^{0}C than the average value at 25m depth in the same site (Figure 6-71). In contrast, the minimum value of seawater temperature of 24.75^{0}C was recorded in 50 m depth at site (SSA3), which was lower of about 0.23^{0}C than the average value within 25 m depth at SSA2 site.

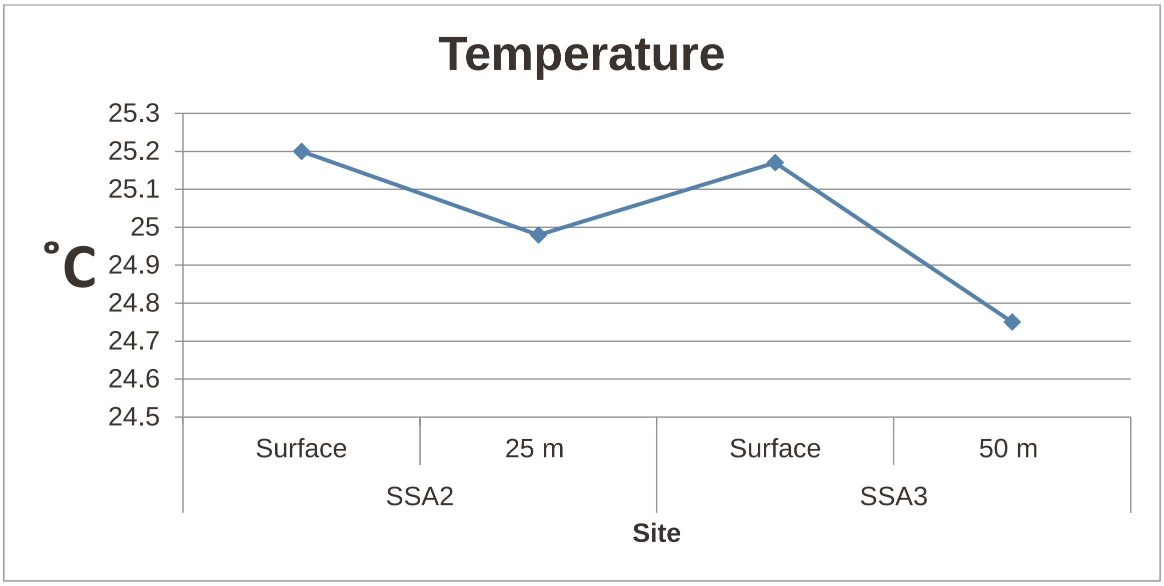


Figure 6-71: Average Seawater Temperature Measurements at Different Depth

The maximum value of seawater salinity 40.58 PSU was recorded in the surface all sites (SSA2 and SSA3), which was higher of about 0.03 and 0.08 PSU than the average value at the surface of SSA2 and SSA3 sites respectively (Figure 6-72). As it can be seen in these Figures, 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.

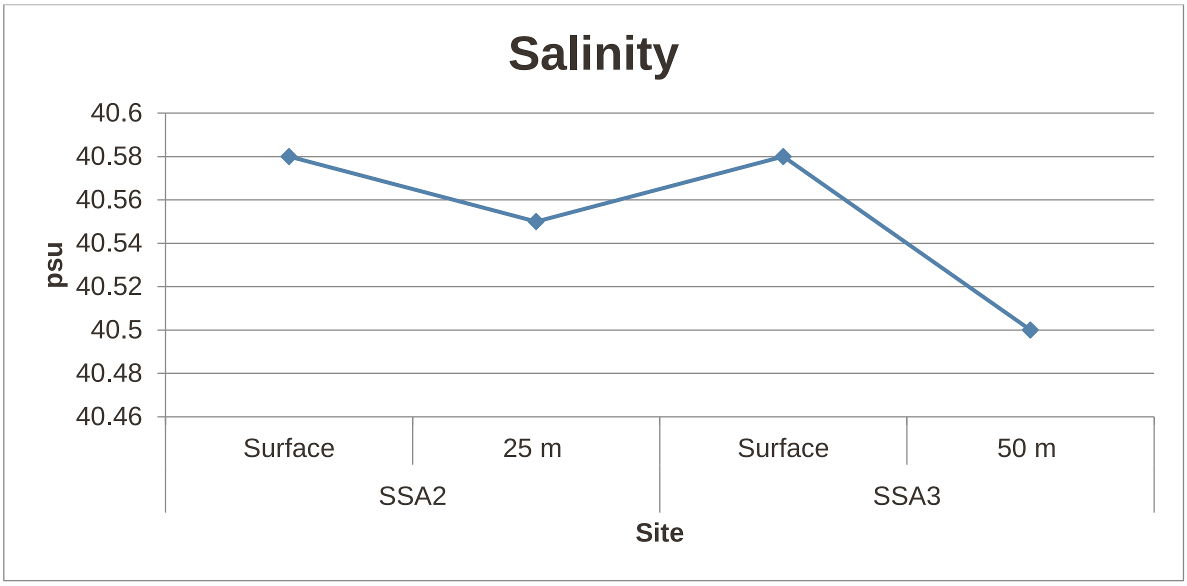


Figure 6-72: Average Seawater Salinity (psu) Measurements at Different Depth

Inorganic nitrogen nutrients

No clear difference was noted between ammonium concentrations in surface and bottom water at SSA1. Whereas some differences were reported at SSA2 and SSA3 within 25 m and 50 m deepth, respectively, as compared to the surface at the same sites (Figure 6-73). However, the measured concentrations were generally acceptable when compared with other sites in the Gulf of Aqaba and with the Jordanian and International standards. As for nitrate and nitrite, there were no major differences between concentrations in the selected sites (Figure 6-74andFigure 6-75).

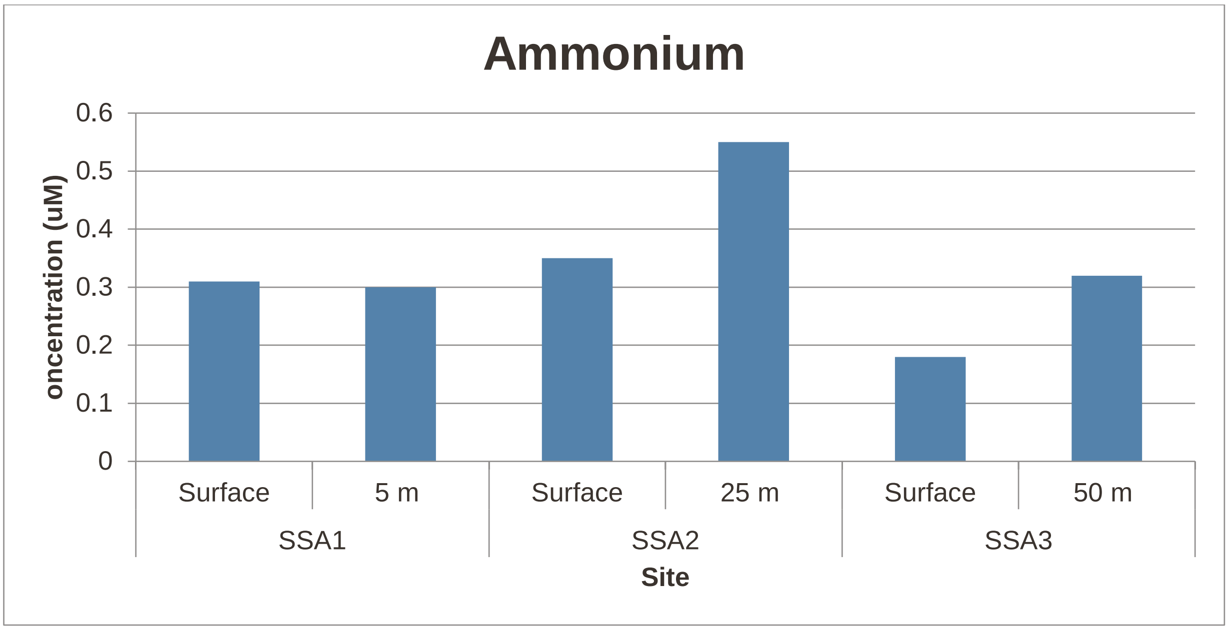


Figure 6-73: Average Ammonium Concentrations (uM) at Selected Sites

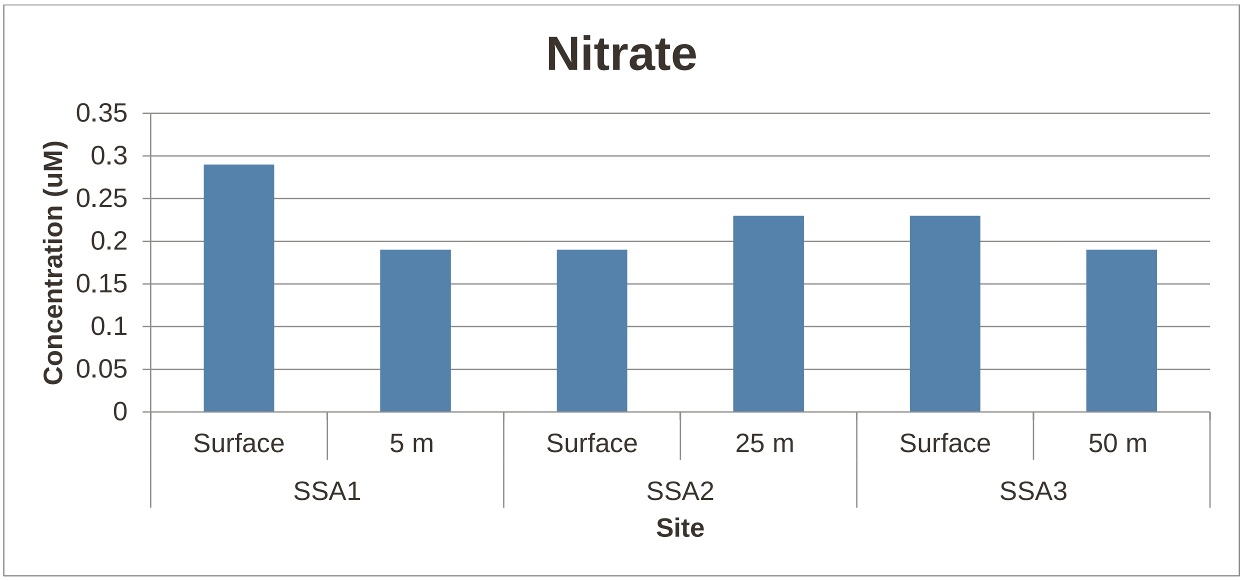


Figure 6-74: Average Nitrate Concentrations (uM) at Selected Sites

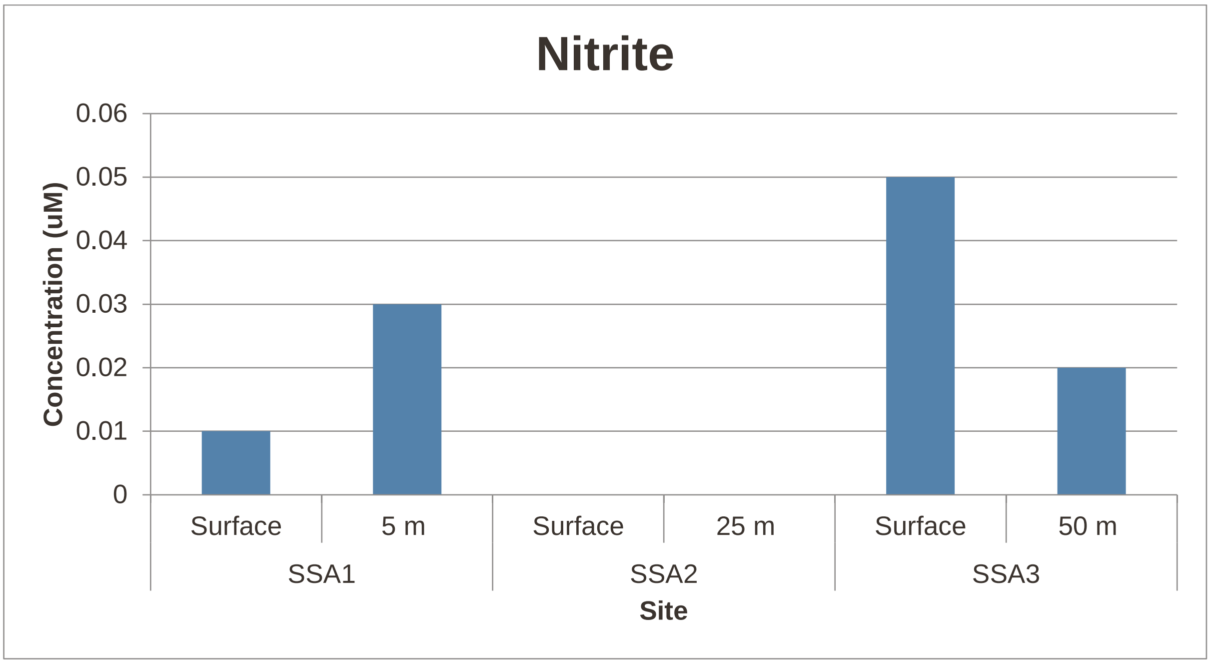


Figure 6-75: Average Nitrite Concentrations (uM) at Selected Sites

Phosphate

Typical of the oligotrophic waters, phosphate concentrations were fluctuated around 0.065 µM (Figure 6-76). Records of phosphate at the selected sites and reference sites in the Gulf of Aqaba showed always low values (less than 0.10 µM).

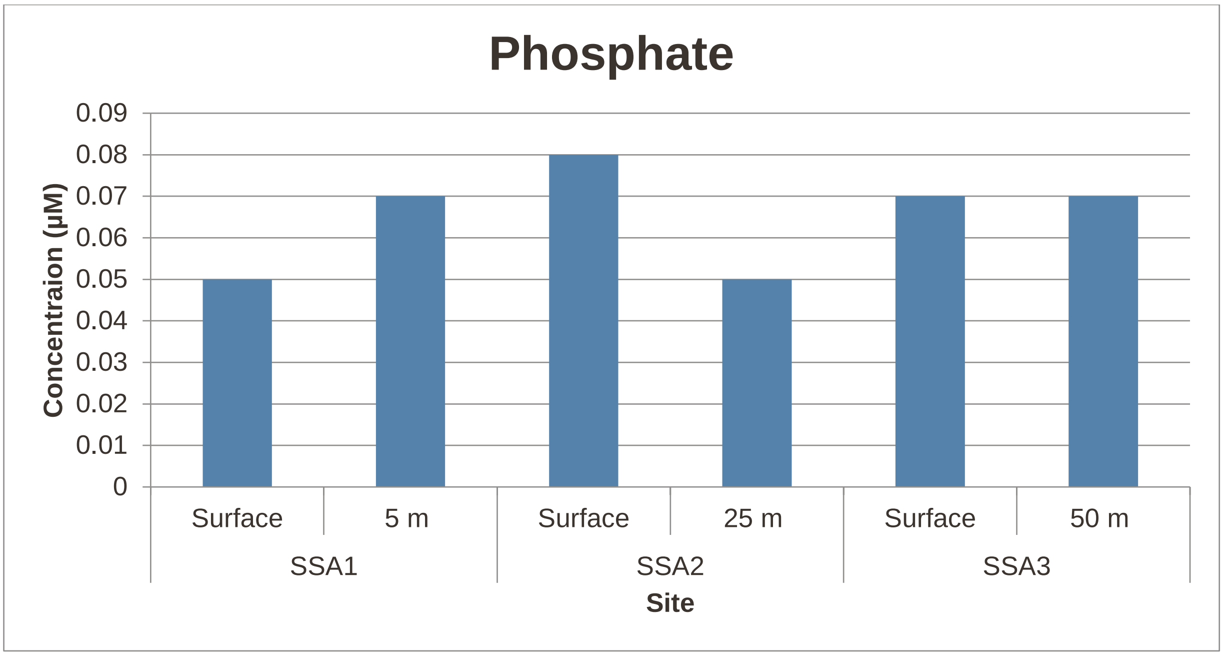


Figure 6-76: Phosphate Concentrations (uM) at Selected Sites

Silicate

Silicate concentrations (Figure 6-77) varied between 1.31 µM to 1.65 µM. There were no major differences between concentrations in the selected sites and the reference sites in the Gulf of Aqaba waters.

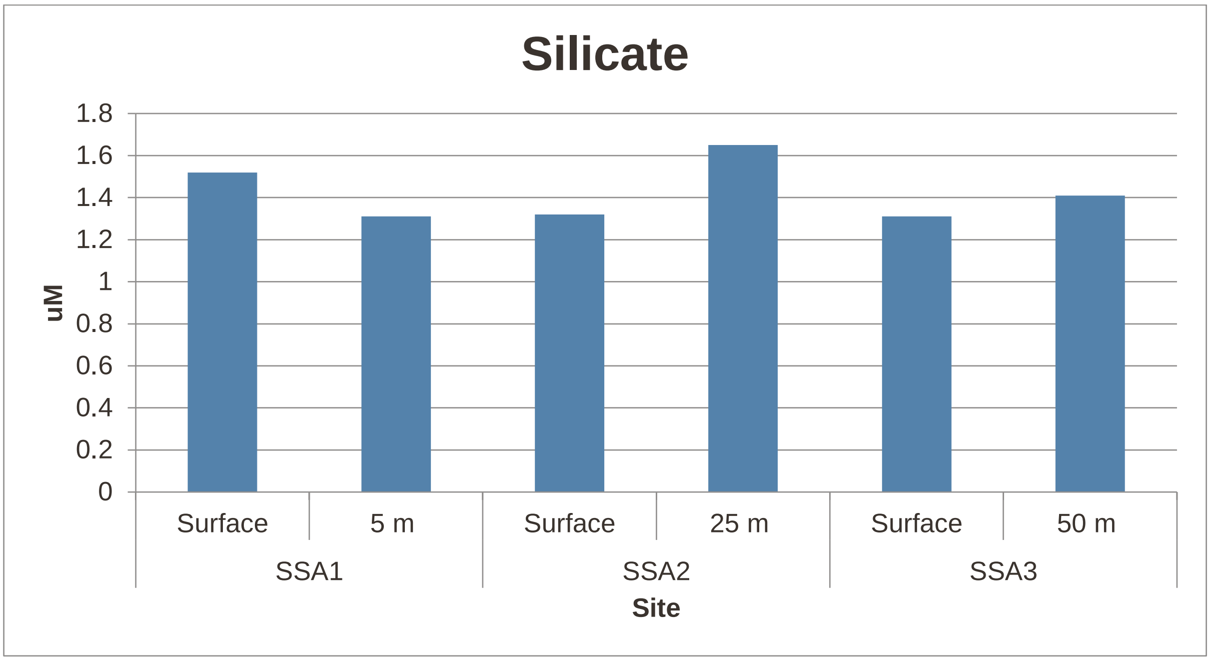


Figure 6-77: Silicate Concentration (uM) at Selected Sites

Chlorophyll a

Records of chlorophyll a concentration ranged from 0.17 µg/l in to 0.22 µg/l with no major difference between the selected sites and the reference site at the Gulf of Aqba waters (Figure 6-78). Chlorophyll a values which considered as the main indication of eutrophication were below 1 µg/l; which is commonly considered as the limiting concentration for Eutrophication threshold in oiligotrophic waters.

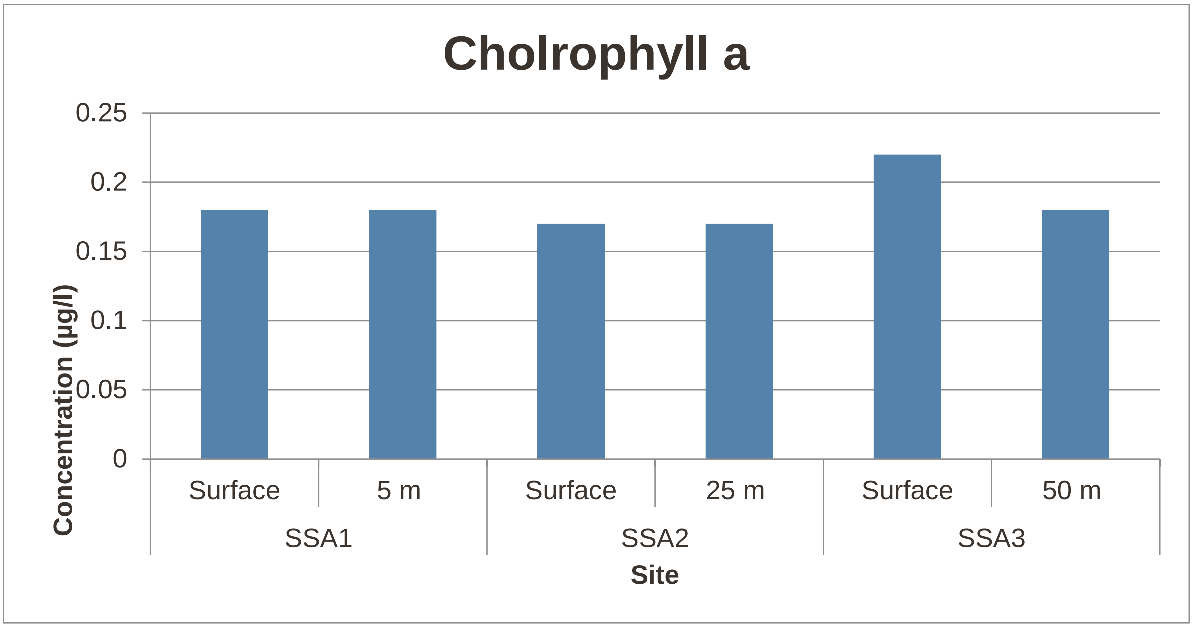


Figure 6-78: Average Cholrophyll a Concentrations (µg/l) at Selected Sites

pH

Records of pH, in all selected sites fluctuated around 8.2 (Figure 6-79) showing no difference between the surface and bottom at each site and between selected sites. The strongly stable pH values can be attributed to what is so called aragonite saturation of the waters of the Gulf of Aqaba, which are always saturated with calcium carbonate that acts as a buffer and resists to any change in the pH.

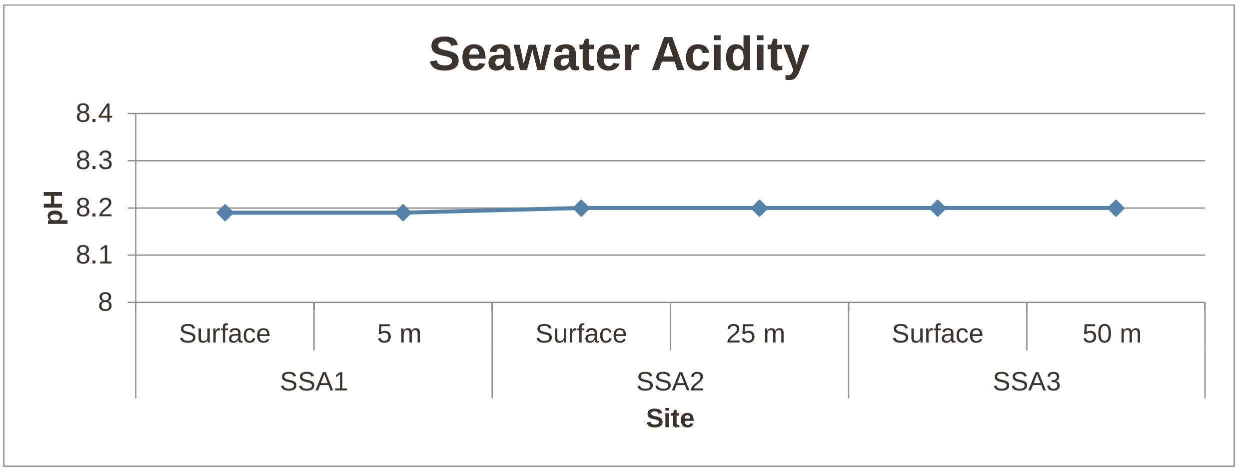


Figure 6-79: Average Seawater Acidity Measurements at Selected Sites

Dissolved Oxygen

The dissolved oxygen concentration at all sites showed a regular pattern inversely proportional to that of temperature with a range of 6.53 to 6.6 mgl-1 (Figure 6-80), indicating the effect of temperature. The solubility of oxygen in seawater usually increases as temperature decreases. These are typical 100% dissolved oxygen saturation concentrations, typical of all the year around of the upper waters of the Gulf of Aqaba.

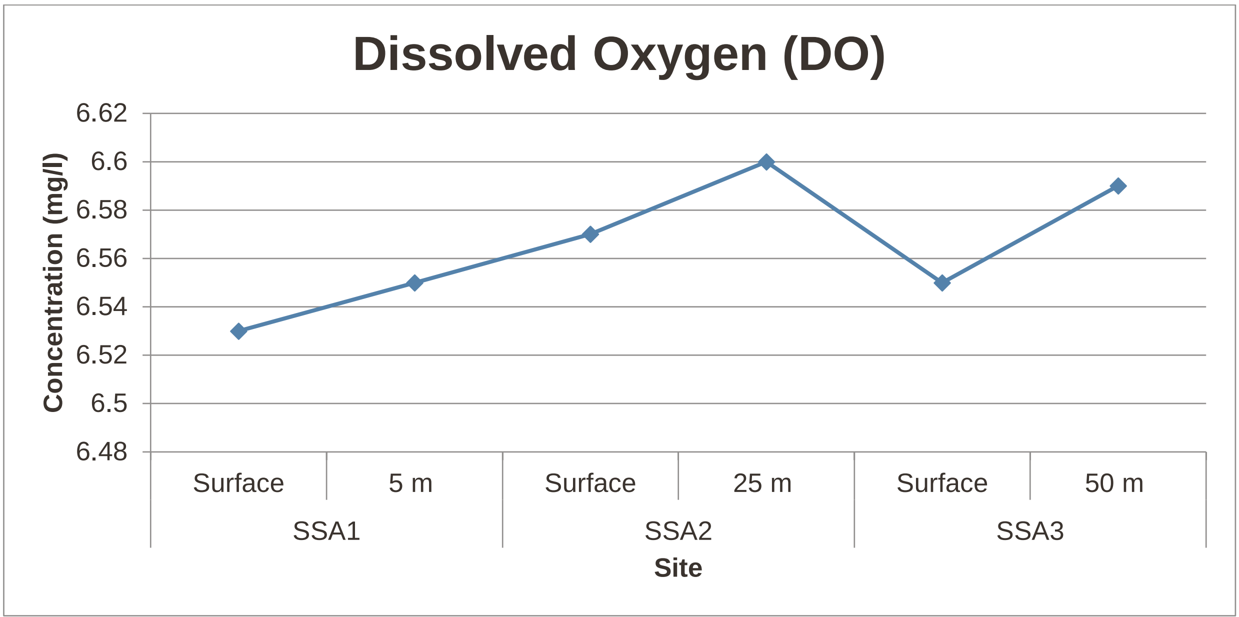


Figure 6-80: Average Dissolved Oxygen Concentrations (mg/l) at Selected Sites

Total Suspended Solids (TSS)

TSS records at the selected sites (Figure 6-81) ranged from 2.6 mg/l to 8.6 mg/l. There were no differences between surface and bottom measurements at all sites.

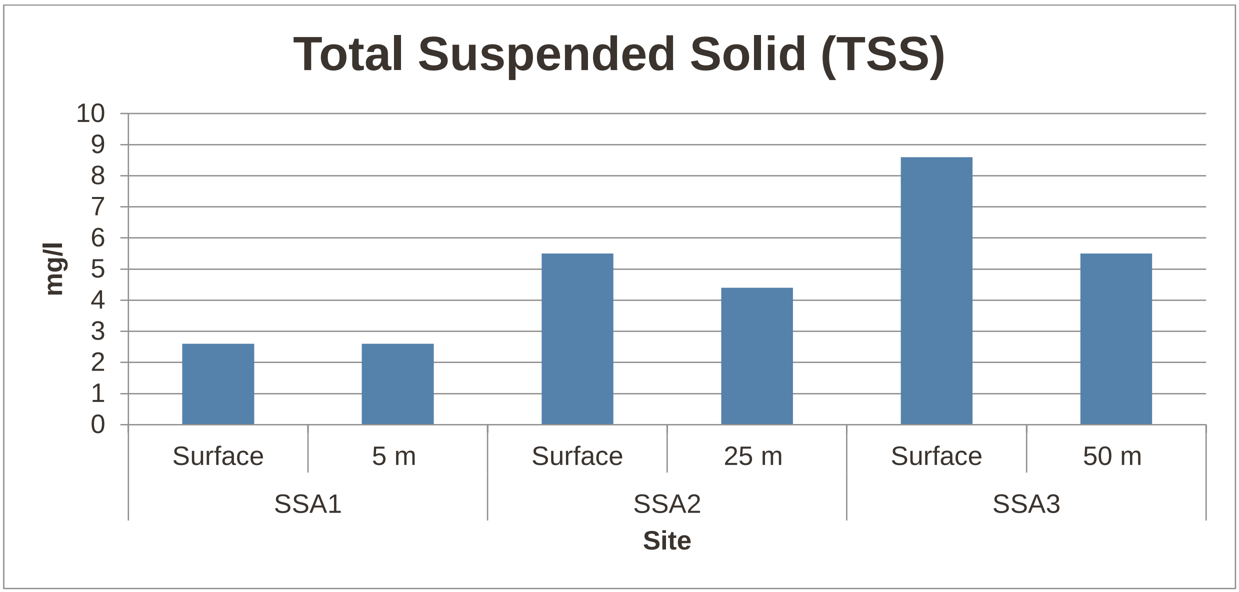


Figure 6-81: Average Total Suspended Solid Concentration (mg/l) at Selected Sites

Total Hydrocarbons

Hydrocarbon concentrations were always even at 0.001 mg/l for all sites. These low concentrations indicate that there is no oil pollution at all examined sites (Figure 6-82).

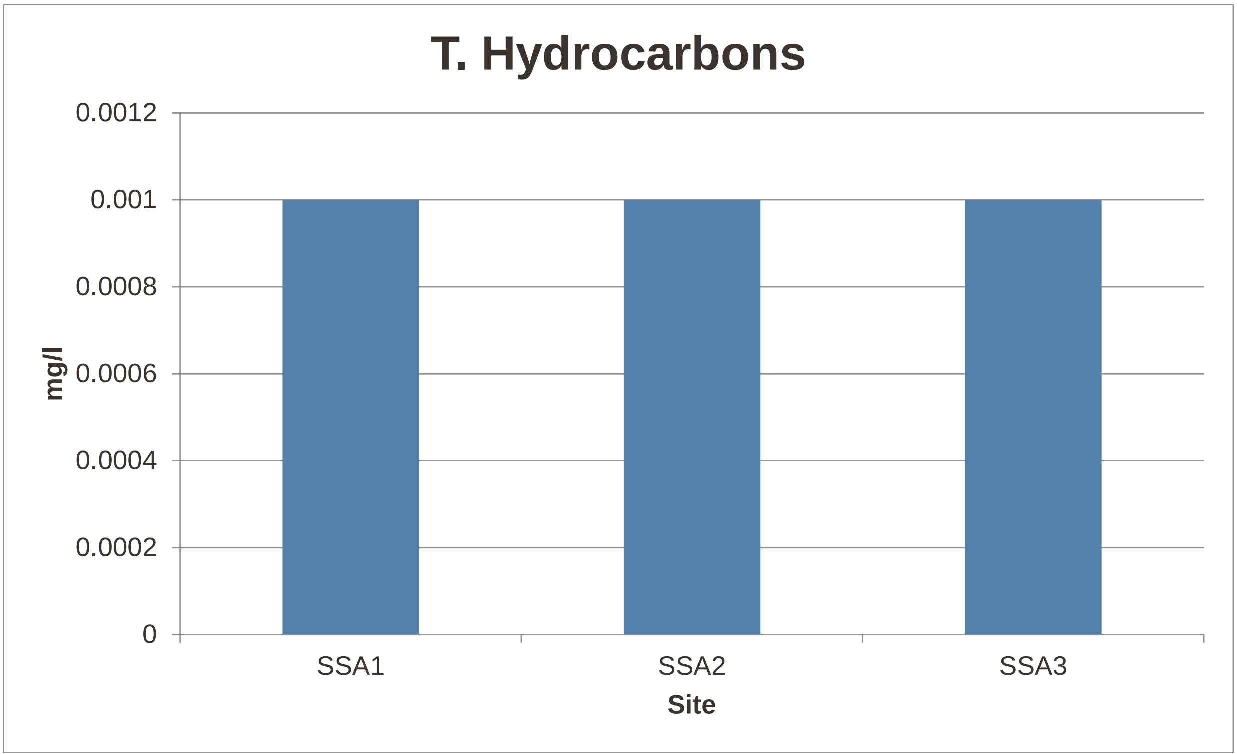


Figure 6-82: Average Total Hydrocarbons Measurements (mg/l) at Selected Sites

Zooplankton biomas

The measurements of biomass zooplankton is important to evaluate the distribution of the zooplankton biomass abundance through the water column; this provides an indirect indication to the relative status of eutrophication at the different selected sites. The results of the zooplankton biomass in the water column (25 m to surface) for the sampling stations (SSA2 and SSA3) did not show any remakable differences (Figure

6-83). However, slightly lower biomass was found in the water column (50 m to 25 m) at site SSA3 with mean concentration of 0.22 mg/l. Zooplankton biomass can be very patchy. Therefore, extra care needs to be practiced during the field and laboratory analysis and in the interpretation of results.

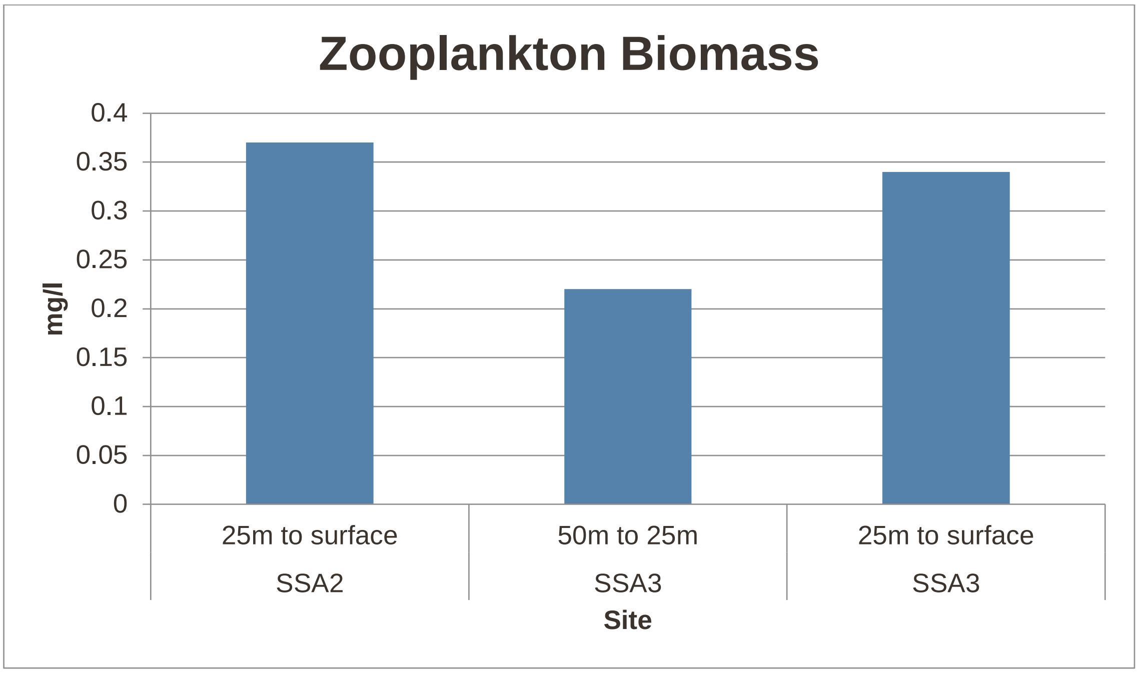


Figure 6-83: Average Zooplankton Biomass (mg/l) at Selected Sites

Siltation and Bio-fouling Potential

The following tables illustrate the analyses results relative to siltation and biofouling potential at the examined sites.

Table 6-9: Particulate Fouling Potential at Selected Sites

Site	Depth	SDI5	SDI10	SDI15	MFI-0.45
SSA1	Surface	7.4954	5.06518	3.86204	2.6596
SSA2	Surface	6.61439	4.62363	3.58635	1.92514
SSA3	Surface	6.45572	4.54106	3.53384	1.98551
Site	**Depth**	**SDI5**	**SDI10**	**SDI15**	**MFI-0.45**
SSA2	25 m	11.9412	7.01437	5.01273	8.002
SSA3	50 m	7.78879	5.2071	3.94922	2.93127

SDI= silt density index, MFI= modified fouling index

Table 6-10: Bio-fouling Potential at Selected Sites

Site	Depth	[ATP] ng-ATP/L
SSA1	Surface	142989703.9
SSA2	Surface	144957774.5
SSA3	Surface	147241627.4
SSA2	25 m	112989075.1
SSA3	50 m	52862028.68

Benthic Habitat at 10m Bottom (BHS1) The study of the benthic habitat in the BHS1 (Transect A and Trabsect B, 10m depth) showed that the bottom habitat in this area was mainly sand with a cover percentage that exceeded 49% and 43%, respectively (Figure 6-84and Figure 6-87). However, the mean percentage of living cover was about 36 % (Transect A, Figure 6-85) and 49 % (Transect B, Figure 6-88).

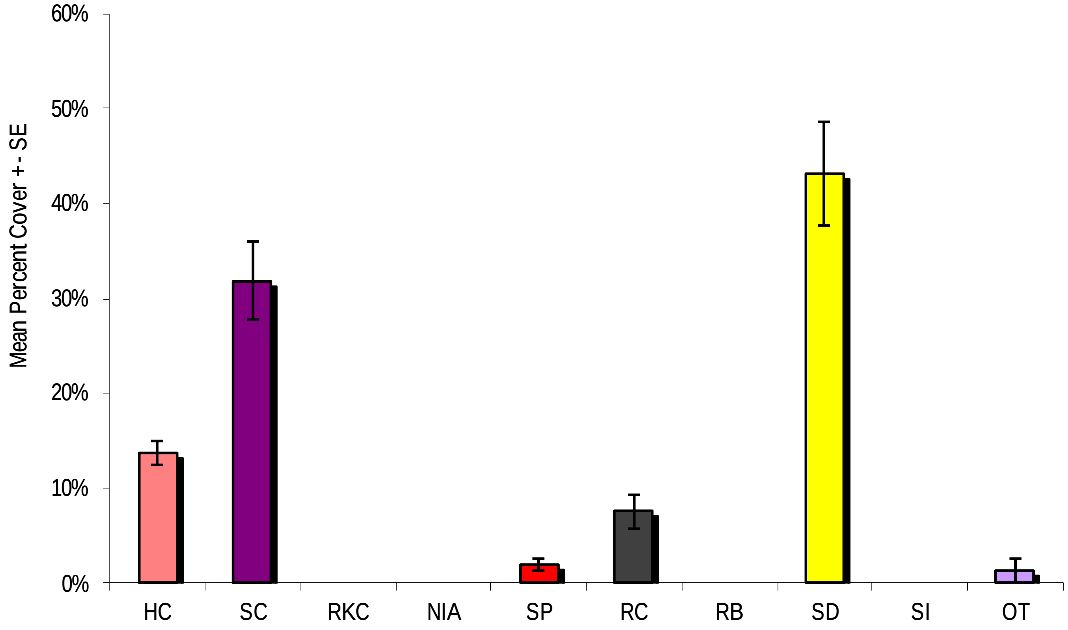


Figure 6-84: Mean Percent Cover for Transect A at BHS1, 10m Depth

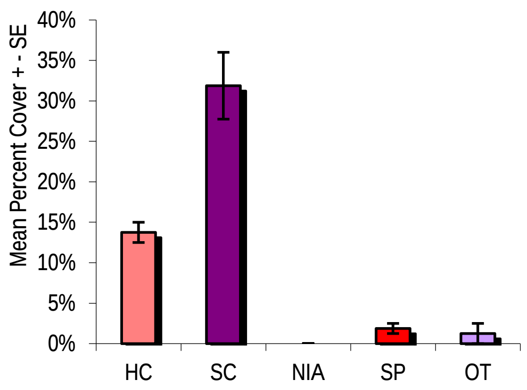


Figure 6-85: Mean Percent Living Cover at BHS1, Transect A

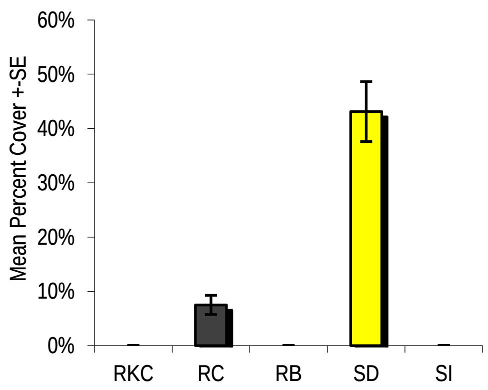


Figure 6-86: Mean Percent Non-Living Cover at BHS1, Transect A.

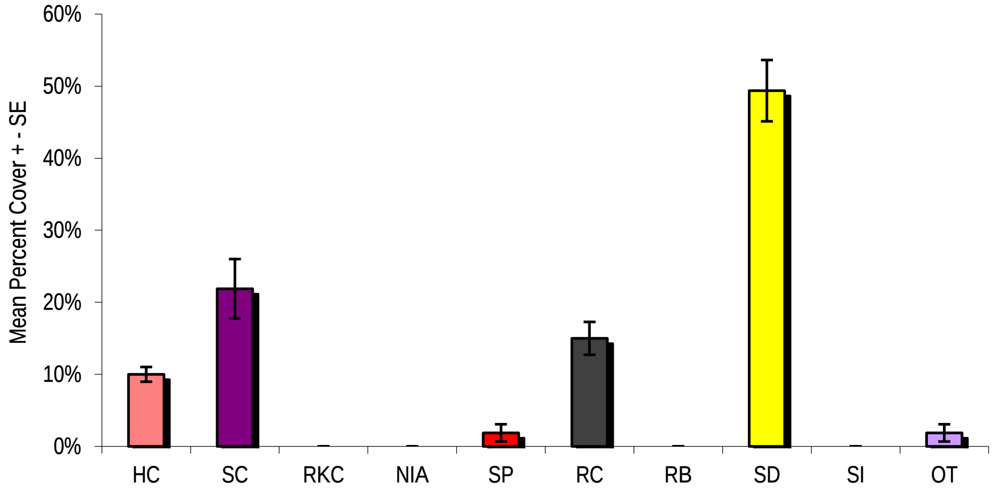


Figure 6-87: Mean Percent Cover for Transect B at BHS1, 10m Depth

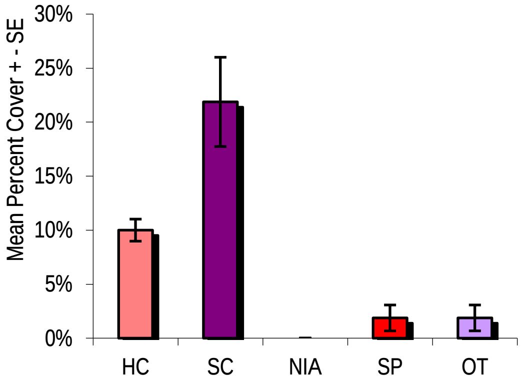


Figure 6-88:Mean Percent Living Cover at BHS1, Transect B.

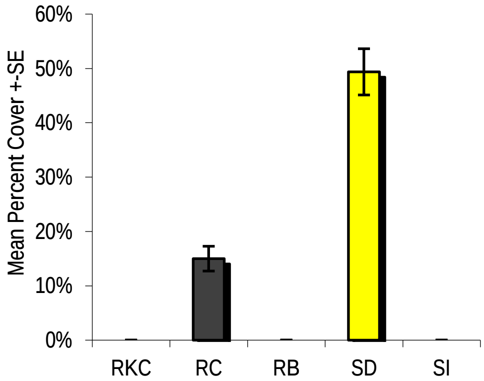


Figure 6-89:Mean Percent Non-Living Cover at BHS1, Transect B.

Benthic Habitat at 20m Bottom (BHS2)

The study of the benthic habitat in the BHS2 (20m depth) showed that the bottom habitat in this area was mainly hard coral and rock with an even cover percentage of about 34% (transect A and B, respectively) (Figure 6-90andFigure 6-93). However, the mean percentage of living cover was about 63 % (Transect A, Figure 6-91) and 55 % (Transect B, Figure 6-94).

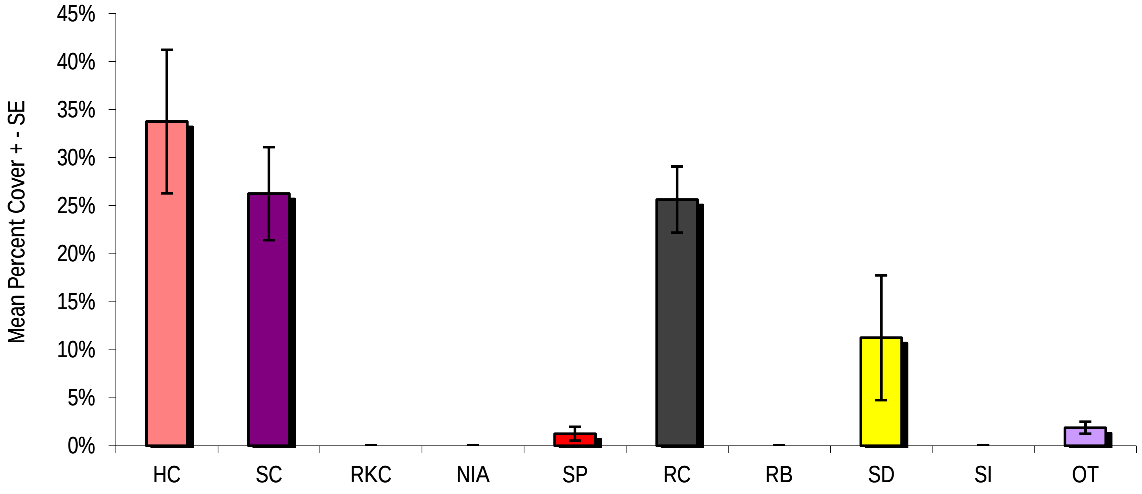


Figure 6-90: Mean Percent Cover for Transect A at BHS2, 20 m Depth

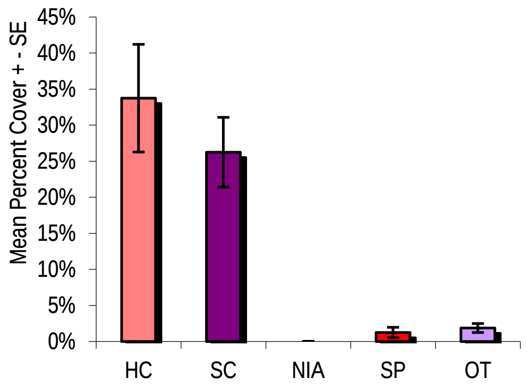


Figure 6-91:Mean Percent Living Cover at BHS2, Transect A.

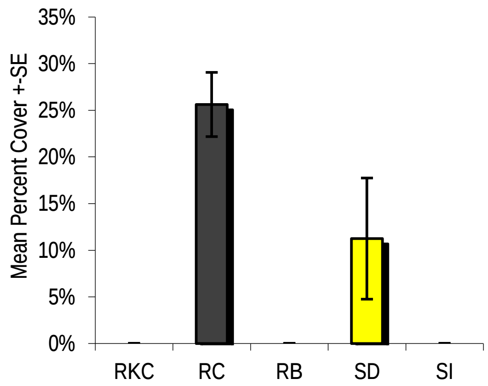


Figure 6-92: Mean Percent Living Cover at BHS2, Transect A.

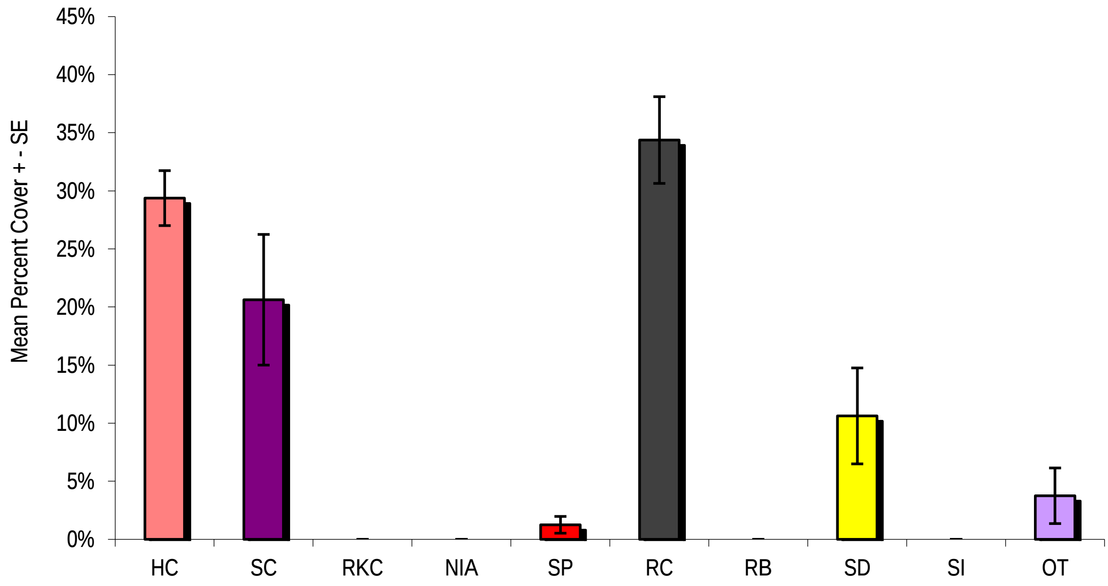


Figure 6-93: Mean Percent Cover for Transect B at BHS2, 20 m Depth

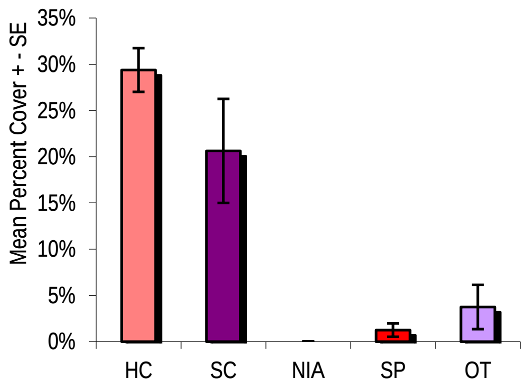


Figure 6-94: Mean Percent Living Cover at BHS2, Transect B.

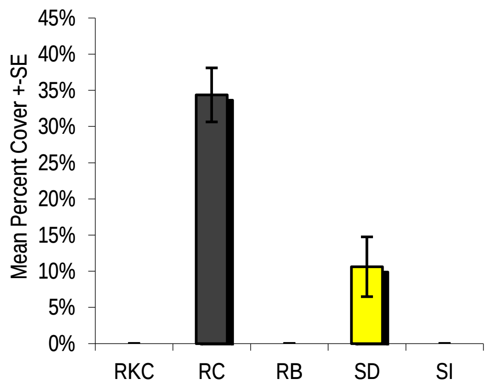


Figure 6-95: Mean Percent Living Cover at BHS2, Transect B.

Fish community structure

A total of 47,637 fish individuals were counted in the present survey at the selected sites; BHS1 (10m bottom) and BHS2 (20m bottom), representing 47 shallow-water species at each site belonging to 14 fish families. In terms of relative abundance per families at site BHS1, the results revealed that the family Serranidae constituted (RA=45.83%) of the total fish population. Followed by Caesionidae (RA=22.48%), Labridae and Pomacanthidae (RA=16.72%, RA=7.36%, respectively). These 4 fish families represented (RA=92.39%) of the total fish population at BHS1 site. Whereas, at site BHS2, the family Caesionidae constituted (RA=38.08%) of the total fish population. Followed by Serranidae (RA=28.34%), Pomacanthidae (RA=14.35%), and Labridae (RA=13.87%). These 4 fish families represented (RA=94.64%) of the total fish population at BHS2 site (Table 6-11).

Table 6-11: Fish Family Relative Abundance per 75 m² at 10m Depth (BHS1), and 20m Depth (BHS2)

Family	10m depth Relative Abundance %	20m depth Relative Abundance %
Holocentridae	4.08	2.89
Serranidae	45.83	28.34
Pseudochromidae	0.31	0.27
Caesionidae	22.48	38.08
Mullidae	0.43	0.29
Lethrinidae	0.15	0.08
Chaetodontidae	0.25	0.20
Pempheridae	0.75	0.41
Pomacanthidae	7.36	14.35
Labridae	16.72	13.87
Scaridae	0.23	0.17
Acanthuridae	0.52	0.51
Siganidae	0.66	0.41
Tetraodontidae	0.24	0.15

Interstitial Living Assemblage

The investigation demonstrated that the encountered taxon groups were generally four. Namely, bivalves, snails, polychaets and foraminifera. The four taxa of meiofauna were recorded in the selected sites (BHS1; 10m depth and BHS2; 20m depth). The abundance of foraminifera illustrated an increase at 20m compared with values observed at 10m depth. Moreover, bivalves were found slightly increased in sediment samples at 20m depth. On the other hand, the abundance of polychaeta and snails illustrated a slight decrease at 20m when compared with values observed at 10m depth (Figure 6-96).

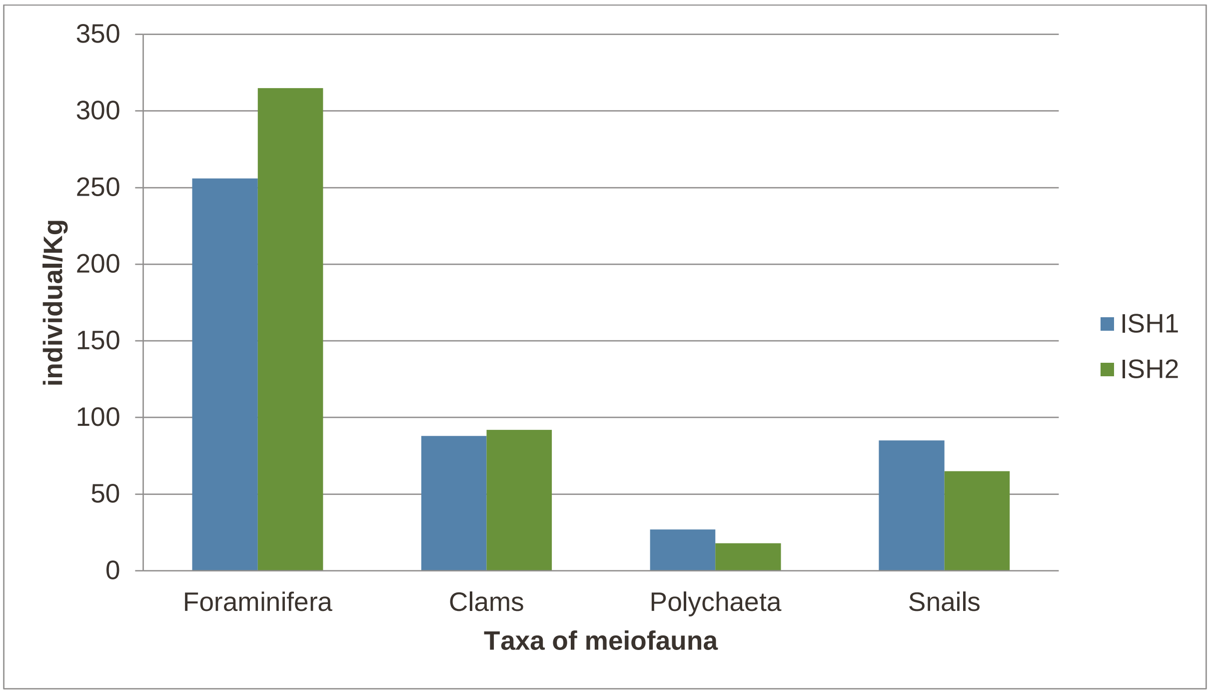


Figure 6-96: Interstitial Living Assemblages at 10 Depth (ISH1), and 20 m Depth (ISH2)

Sediment physical properties (particle size analysis, PSA)

All sediments from the selected sites (BHS1 and BHS2) had almost similar textural composition. The most dominant fractions were the sand (250-500µm) which comprised more than 32% of all sizes. The mud fraction (<63µm) in the two sites sediments (average 1.11 %) which was lower than that from the offshore shallow station (4.07%).

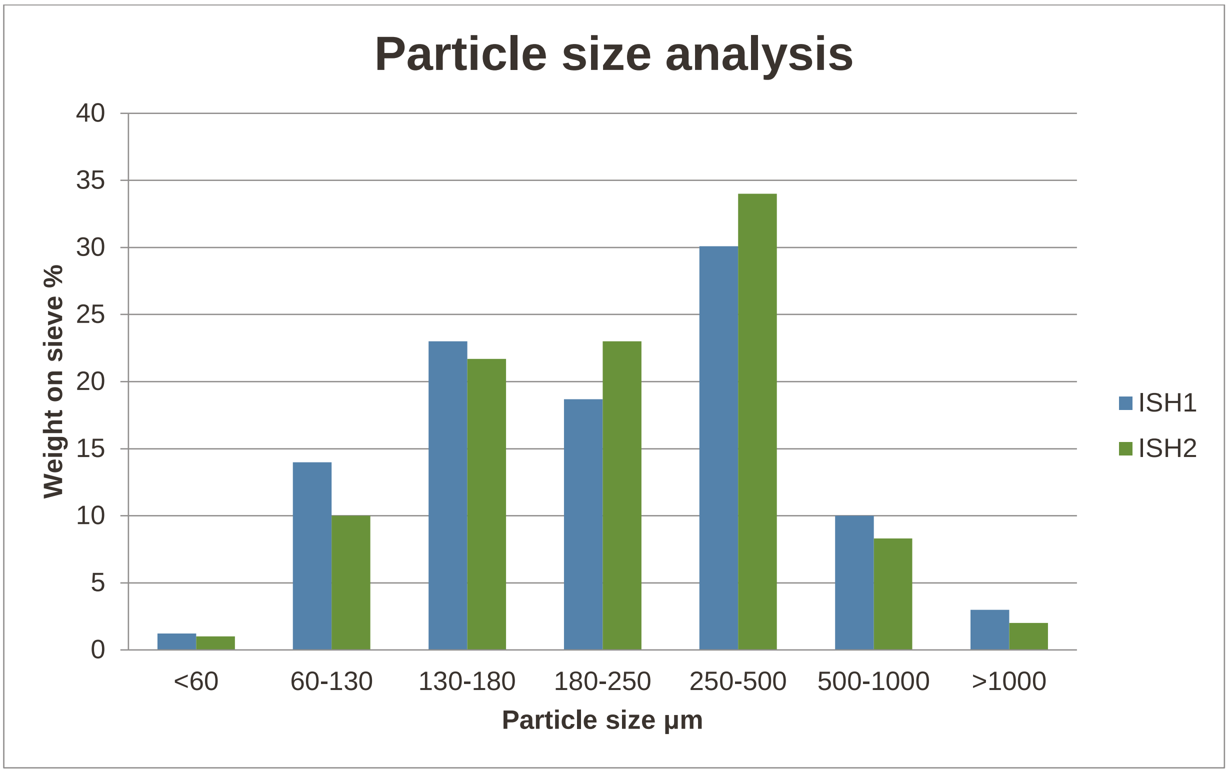


Figure 6-97: Bottom Sediments Particle Size Analysis (PSA) at 10 M Depth (ISH1), and 20 m Depth (ISH2)

6.2.17. Marine Habitat

The AAWDC Project site being an Industrial Site is classified as "modified" according to the IFC Performance Standard 6 and as 'Urban Habitat' according to EIB Biodiversity Standards. However, the bottom photographic and video surveys and the benthic habitats survey conducted at the shallow depths where the intake towers will be built revealed that some coral species do exist. Some of the coral species encountered in the human diving surveys are listed in Table 6-12. The ROV deep video survey reported presence of coral rock partially covered by live tissue but did not provide coral classification.

Table 6-12: Coral Species Encountered in the Seabed Photographic and Video Survey

Taxa	Growth Form	Genera	IUCN Category
Hard Coral	Massive	Platygyra	Least Concern - Near Threatened
Hard Coral	Massive	Favia	Least Concern - Near Threatened
Hard Coral	Massive	Favites	Near Threatened
Hard Coral	Massive	Hydnophora	Least Concern - Near Threatened
Hard Coral	Massive	Montipora	Least Concern - Vulnerable
Hard Coral	Massive	Porites	Least Concern - Near Threatened
Hard Coral	Branched	Acropora	Data Deficient - Least Concern
Hard Coral	Branched	Pocillopora	Least Concern
Hard Coral	Branched	Stylophora	Least Concern - Near Threatened
Soft Coral	Branched	Nephthya	No Result

EIB Standards indicate that Critical Habitat are defined by different criteria, including the presence of a population of critically endangered, endangered or vulnerable species, as defined by the IUCN Red List of threatened species and in relevant legislation. Due to the potential presence of vulnerable coral species (Genera Montipora) within the proposed site for the intake and brine discharge pipelines and the intake itself, the area shall be considered a Critical Habitat. As described later in the report, direct impacts to this habitat are linked to construction works (laying of pipelines and other infrastructure) and to operations (larval entrainment at intake level). Specific mitigation measures are proposed for both types of impacts to ensure no irreversible damage to the habitat and wider marine ecosystem. With the application of the proposed mitigation measures the residual impact is considered negligible. Nevertheless, specific requirements are included for the BOT Developer to ensure an overall net biodiversity gain in line with IFC and EIB standards requirements for Critical Habitats.

6.3. Terrestrial Environment

The terrestrial environment investigated in this study is based on field survey which was conducted to identify the various ecological properties, species and critical habitats occurring along the alignment, in addition to the review of several publications and studies by Jordanian and non-Jordanian Researchers, and national technical reports and studies.

The surveys covered occurring flora and fauna along the alignment as well as highlighting the regional ecology of the areas crossed by the conveyance alignment. Collected or observed specimens have been identified using several authoritative books and field guides available. International and local species conservation status of plant, fauna and avifauna species was assigned according to the IUCN Red List, and the recently published national red list publications. Furthermore, results of surveys are presented to cope with the alignment segmentation, which are the southern, middle, and northern segments.

6.3.1. Biodiversity in Jordan

The biodiversity in the Middle East is characterized by its location as the meeting point between three different faunal elements, namely: the Ethiopian, Oriental, and Palaearctic. The entire area underwent many geological changes in the past that resulted in the formation of very different habitats and ecological regions. This area has been influenced by different faunal and floral elements soon after the retraction of the Tethyus Sea. Animals of different origins passed through the natural corridors and spread through our area. This is exemplified by several terrestrial animals and plants that make up the major biodiversity assemblage of the region. Retraction of the post-glacial effect also created what is known as "*relict species*".

Jordan is located within the eastern margins of the eastern Mediterranean. Much of Jordan can be classified as semi-desert, with only the western high lands 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 ([50], [51]), Jordan is divided into four main biogeographical regions/zones (Figure 6-98).

1. **The Mediterranean:** This region extends from the northern mountains to the south near Petra. It is characterized by its distinctive terra rosa and rendzina soil types. Annual rainfall ranges 400-600 mm and the altitude ranges 900-1,700 m. Oak (*Quercus sp.*), juniper (*Juniperus phoenica*) and pine forests (*Pinus halepensis*) are found along these relatively narrow mountain strips.
2. **The Irano-Turanian:** surrounds the Mediterranean one. It extends over about the lower half of the Jordan valley and reaches Ras An Naqab in the south. The annual rainfall varies through 150-250 mm at altitudes ranging 400-700 m. The soil is loess and/or calcareous and supports poor scattered vegetation (e.g. *Artemesia herba-alba*, *Anabasis sp.* and *Retama raetam*). The vegetation type under thisbiogeographical zone is commonly referred to as the steppe vegetation.
3. **The Saharo-Arabian:** occupies the largest portion of the area of Jordan. The soil is extremely poor and comprises Hamada, saline, sandy loam or mud flats. The surface is covered by sand-dunes, gravel or pebbles and black Laval rocks. The annual rainfall is 50-100 mm. *Artemesia herba-alba, Achillea fragrantissma* and *Trigonella sp*. are among the most common plant species.
4. **The Sudanian penetration:** covers Wadi Araba, the eastern borders of the southern end of the Dead Sea and southern Jordan. In Wadi ‘Araba altitudes range from 400 m below sea level to sea level near Aqaba and 200 m above sea level at Ar-Rishah. Soil is predominantly alluvial, saline sand with scattered sand-dunes, lisan marls and others. The annual rainfall ranges 50-100 mm. Vegetation is exemplified by *Haloxylon persicum*, *Acasia sp*., *Calotropis procera* and *Nitraria retusa*.

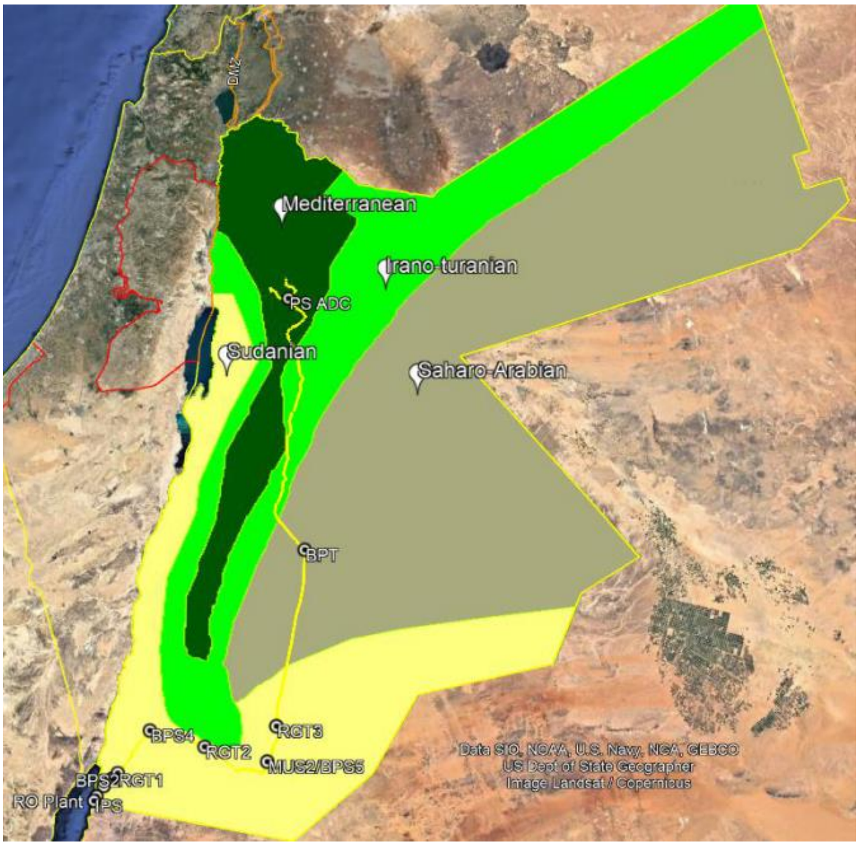


Figure 6-98: Project Location within Biogeographic Zones of Jordan

6.3.2. Biogeographical Areas along the Conveyance Route

Biogeographically, the alignment crosses the four different bio-geographic regions recognized in Jordan as shown in Figure 6-98. The dominant habitat type in the project area is the Hamada type and specifically the gravel Hamada. However, sandy and runoff Hamada are also common. Hamada areas are usually devoid of vegetation. But since the area is interspersed with many run offs and wadis of various sizes, substantial vegetation can be supported. These areas are usually suitable sites for grazing herds in the Jordanian desert.

The Mediterranean biogeographic region is observed in Segment C and in the northern part of Section B-2, specifically in the alignment between Al Jiza (Section C1) to Al Zumayla village, which are mainly the non-forest Mediterranean type that is devoid of naturally occurring forest elements. Human plantations, forestations and private farms occur for the existing tree stands in the area. Main plant species are *Nerium oleander, Cuppressus* spp. *Pinus* sp. Other species include: *Euphorbia heirosolymitana, Plantago* spp. *Urginea maritime, Notobasis syriaca, Inula viscosa Anchusa* spp. *Erodium* spp. and many other annuals.

The Irano-Turanean realm is evident at the alignment part that extends along the Desert Highway starting from Al Zumayla village (Section C-1) throughout the remaining alignment in Segment B. The soil is mostly poor, eroded and has the calcareous or loos type. This soil is moderately productive and is best used for moderate grazing. The Irano-Turanean parts are treeless zones where steppe grassland vegetation dominates. Substantial green stands occur at large wadis such as wadi Al-Abyad and wadi Al-Hasa dominated by *Tamarix nilotica* shrubs.

The Saharo Arabian on the other side is present along the alignment that crosses the desert areas starting from the northern most part of Section A-4 (i.e., slightly to the east of the cross point of the alignment with the desert highway between Jurf Al-Drawish and Al Hasa) further to the south until about 30 kms to the north of RGT4. The soil is very poor and mostly of the Hamada type with some sandy, saline soils or mud flats. The vegetation is very poor, and is restricted to watersheds and water runoffs where enough moisture is available to support some vegetation. These have been described as a monotonic segment in terms of ecological features being generally of desert character. The vast stretches of the deserts covering the upper two segments can be described as Flintstone desert (Al-Hammad); with flat or hilly desert areas that are often intersected by broad wadis and large mudflats (Qa's), which are seasonally flooded according to the amounts of rainfall. The most common species found there are *Artemisia herba-alaba, Achillea fragrantissima, Astragalus spinosa, Zilla spinosa, Matthiola* spp. *Rumex vesicularis, Rheum palaestinum, Reichardia tengitana, Retama reatam, Anabasis syriaca, Plantago* spp*. Schismus barbatus.*

The Sudanian realm is evident in the area starting from about 30 km to the north of RGT4 moving south and south-west within Hizma basin (Wadi Rum and Disi) and includes the remaining sections in segement A. The soil is mostly sandy. Saline soils occur discretely in this region. There are also hilly limestone regions, the high mountains of wadi Rum as well as the sand dunes of Al-Mudawarra desert in the south. Vegetation is related to tropical varieties like *Acacia* spp. *Cleome africana, Halocnemum strobiulaceum, Hamada salicornica*.

6.3.3. Vegetation Types

Much of the country's diversity is due to the formation of the Great Rift Valley. The Rift Valley produced the high western mountains ranging in altitude from 400m below sea level to 1854m above sea level. While the rest of the country is arid, composed of either basalt or Hamada; an ecologically rich ecosystem is present which is unique to Jordan and Syria. Within the before mentioned bio-geographic zones, there are 13 different vegetation types each representing different elements of flora and fauna [50]. Mapping of vegetation types distribution in Jordan was undertaken by Albert et al (2003) [51].

The review of available literature and vegetation maps indicate, as illustrated in Figure 6-99, that the northern segment of the alignment between Abu Alanda and Al Qatraneh is mostly falling within the grassland vegetation type, except for the PSAA to Muntazah preliminary section which also cross the Batha-stepe and the Mediterranean non-forest vegetation-Batha vegetation types.

The middle segment between Al Qatraneh and slightly to the south of RGT4 is almost entirely falling within the Chert-hamada vegetation types except for a small section (about 15 km section to the north of Al Hasa) falling within the Grassland steppe.

In the southern segment, the following vegetation types can be observed:

- Sand dune vegetation, mostly between RGT4 and RGT2;
- Weathered sandstone and granite scrub, mostly between RGT2 and BPS4;
- Acacia woodlands, mostly along the alignment between BPS4 and the intake, except the alignment extended about two kilometres to the north of RGT1 and two kilometres to the south of BPS3; and
- Sandy hamada, which is located along the alignment extended few kilometres to the north of RGT1 and few kilometres to the south of BPS3.

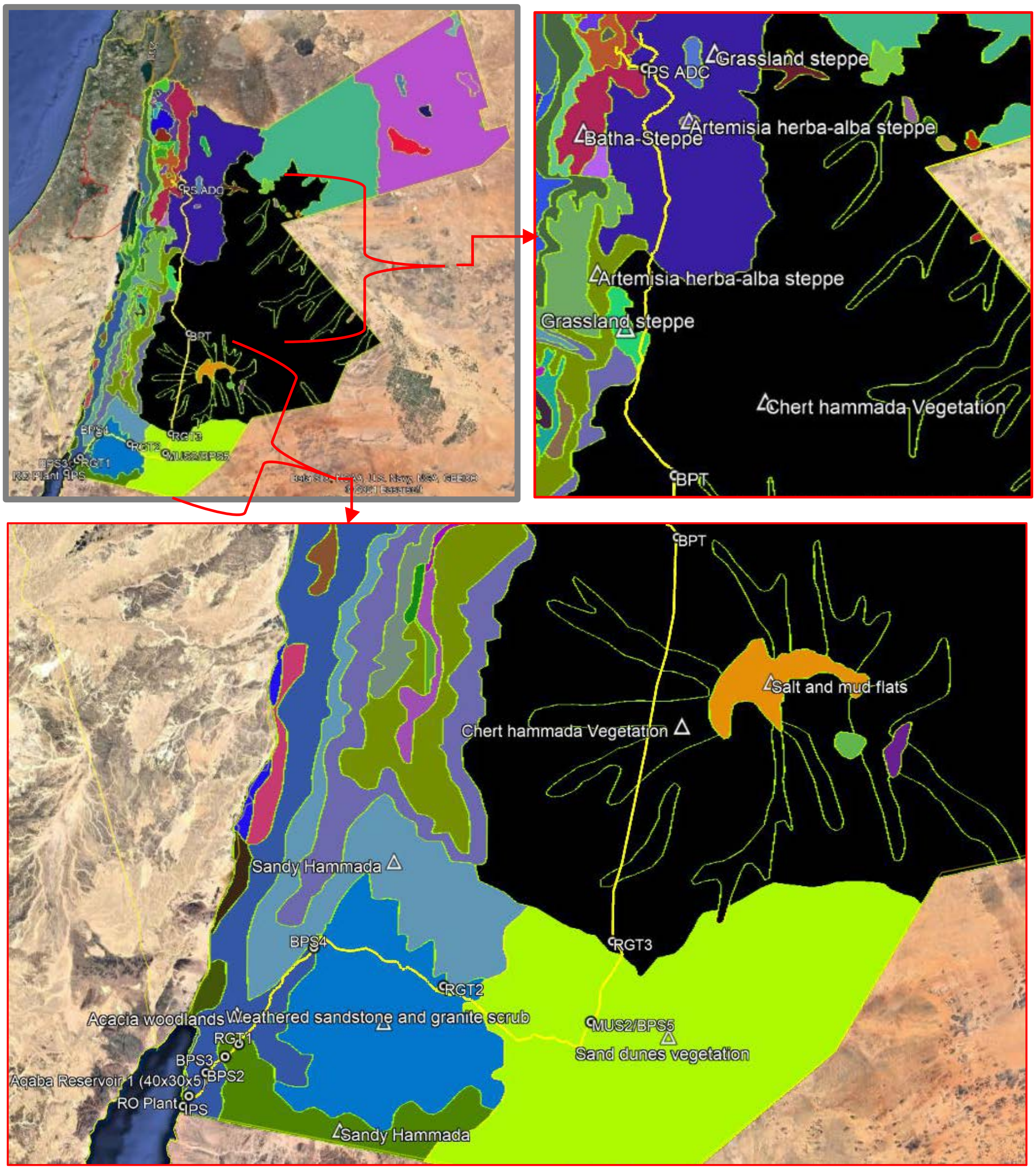


Figure 6-99: Vegetation Types Along the Proposed Alignment

6.3.4. Protected and Designated Areas

Currently, 10.9% of total land areas are established as protected areas including seven nature reserves managed by the RSCN, forming about 1.6% of Jordan area, in addition to national parks, one marine reserve, and 28 grazing reserves. Currently 12 terrestrial and one marine reserve have been established, more terrestrial reserves are proposed to be established. Several grazing reserves have also been established in the eastern Badia. The border areas are considered partially protected since human activities within these sites are controlled and limited. Up to date, 28 grazing reserves have been established all over the country.

Figure 6-100 below shows existing and proposed protected areas in Jordan.

Figure 6-100: Map Showing the Existing and Proposed Protected Areas in Jordan [52]

Key Biodiversity Areas (KBAs) include (1) areas supporting habitats of unique, rare or sensitive characteristics, or (2) areas providing habitats for floral and faunal species of particular concern and do not have any protection designation. For this purpose, the network of proposed protected areas and the network of Important Bird Areas (IBAs) reported by the Royal Society for the Conservation of Nature (RSCN) and endorsed by the Ministry of Environment have been adopted for the identification of the Project areas of particular biological importance. Important Plant Areas and Jordan National List of KBAs are currently under the process of delineation.

IBAs area sites providing essential habitat to one or more species of breeding, wintering, and/or migrating birds. The sites vary in size but are usually discrete and distinguishable in character, habitat, or ornithological importance from surrounding areas. These areas were identified as ecologically important owing to their unique habitats and natural resources supporting a wide variety of faunal and avifaunal communities. The proposed project crosses two IBA's, namely Hisma Basin (Wadi Rum-Disi) and Aqaba Mountains (See Figure 6-102). Other IBAs are located on substantial distance from the proposed alignment.

A total of 27 Important Bird Areas (IBAs) have been identified, significant portions of which are protected since these portions are located in established protected areas, many (unprotected) IBAs are located in proposed protected areas and expected to be protected in the future, and few are not expected to be protected as protected areas at least in the short and medium runs. Also, 13 Important wetlands are identified according to the Directory of Wetlands including two Ramsar Sites: Azraq wetland and Fifa.

With regard to protected areas, the proposed project alignment does not cross any established one. Hence, the following are to be noted (Figure 6-103):

1. According to available data and maps, it is confirmed that the alignment does not penetrate the northern part of Wadi Rum Protected Area and World Heritage Site. Hence, it is apparent that the alignment passes through the buffer zone of the protected area.
2. The proposed alignment crosses Hizma and Aqaba IBA's.
3. The proposed project does not cross or interfere with any Ramsar site.
4. The alignment passes to the east of Abu Rukbeh proposed protected area.
5. The proposed alignment does not cross any rangeland/grazing reserve or special conservation area (See Figure 6-104). Hence, it is noted to run next to the border of Dab'a rangeland reserve.

To further explain the relationship between the proposed protected area at Abu Rukbeh and the alignment, it is important to note that the proposed pipeline alignment as shown in Figure 6-101 crosses a total length of 500 m of the east-south border of the PA, which affects a total area of about 900 square meters of the proposed PA. This section of the proposed PA is noted to cross and include the desert highway, and its habitat is considered degraded.

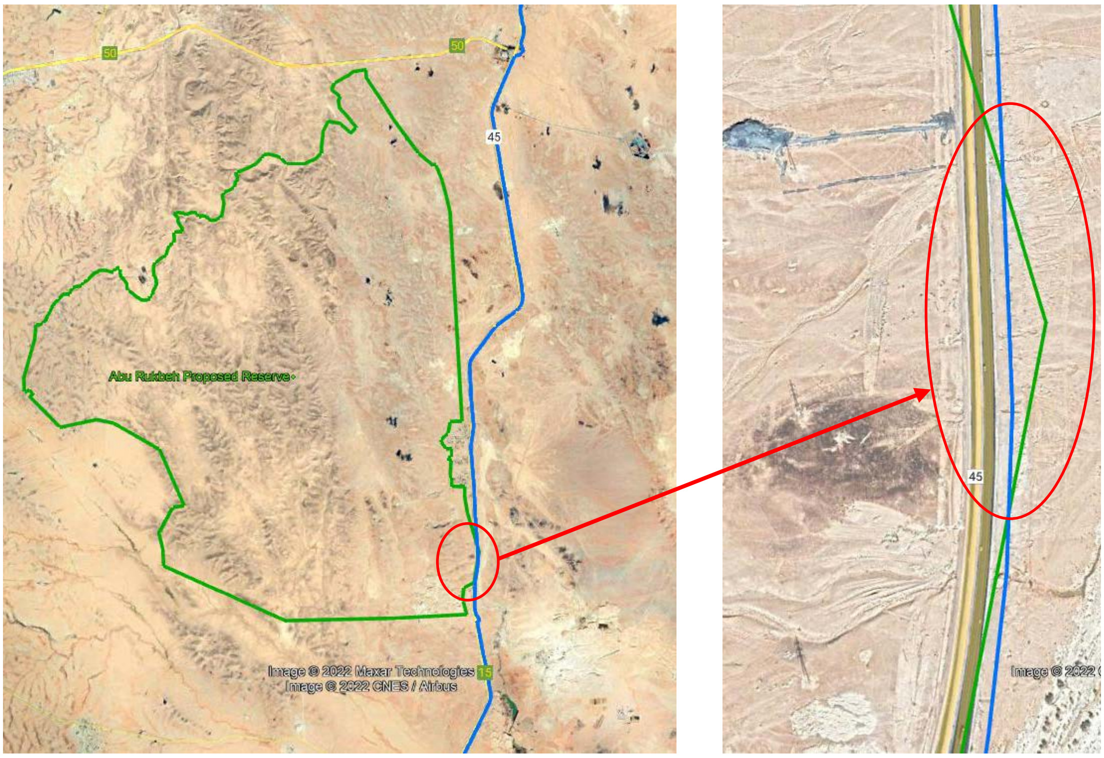


Figure 6-101: The Intersection Between the Proposed Pipeline and Abu Rokbeh Proposed PA

Abu Rukbah proposed protected area is not yet established and it is unmanaged as a protected area. As per regular practice, and when decision is made to proceed with the establishment and management of the site as a protected area, the RSCN will conduct several field surveys to investigate the biodiversity values of the site that was previously considered for its nomination as a proposed protected area. The surveys will also include evaluation of the biodiversity, environmental and social baseline conditions of the site, and accordingly revising its proposed boundaries, which can be adjusted based on the site evaluation findings.

Figure 6-102: IBAs Crossed or Nearby the Proposed Project Alignment

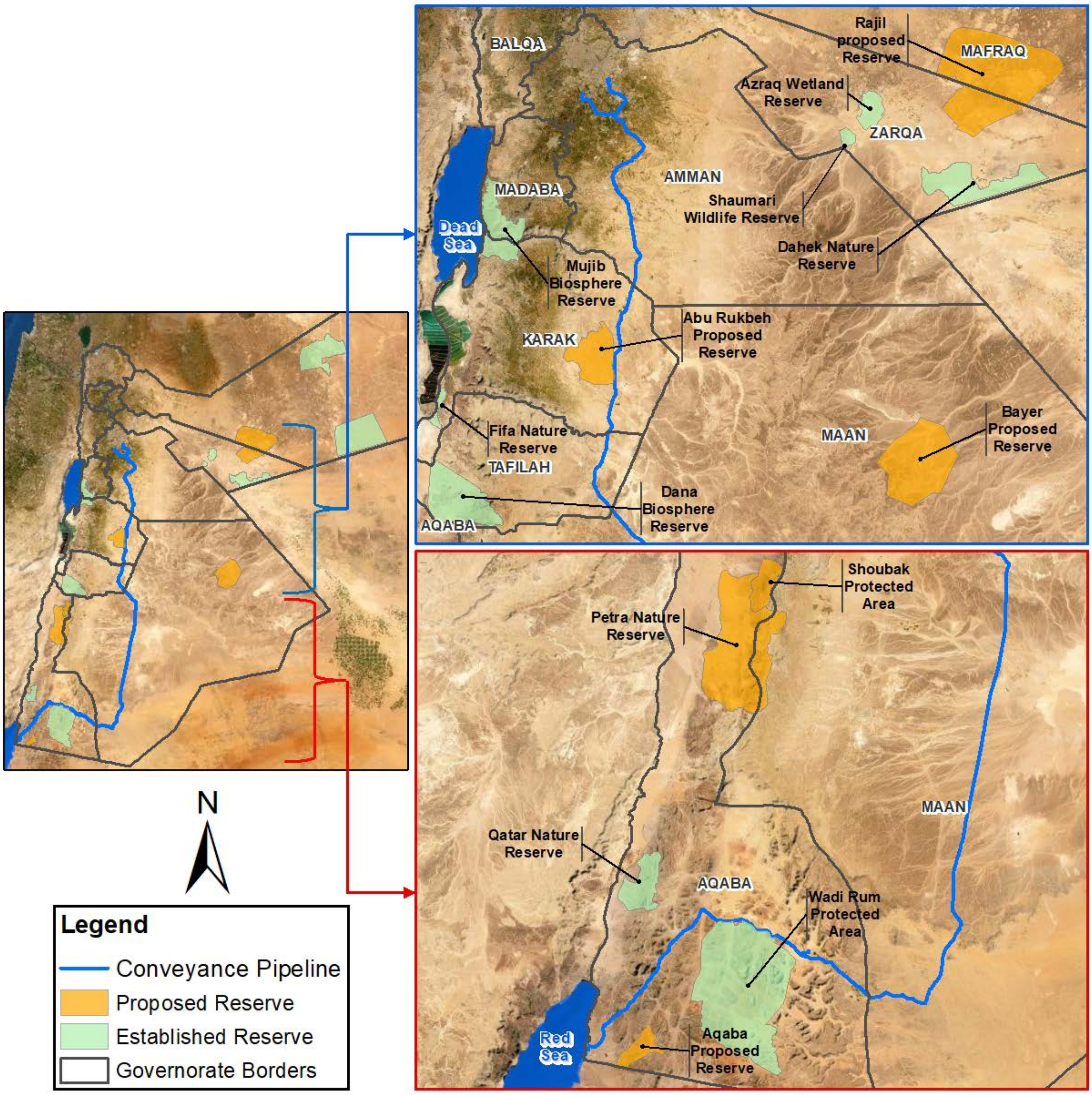


Figure 6-103: Protected Areas Crossed or Nearby the Proposed Project Alignment

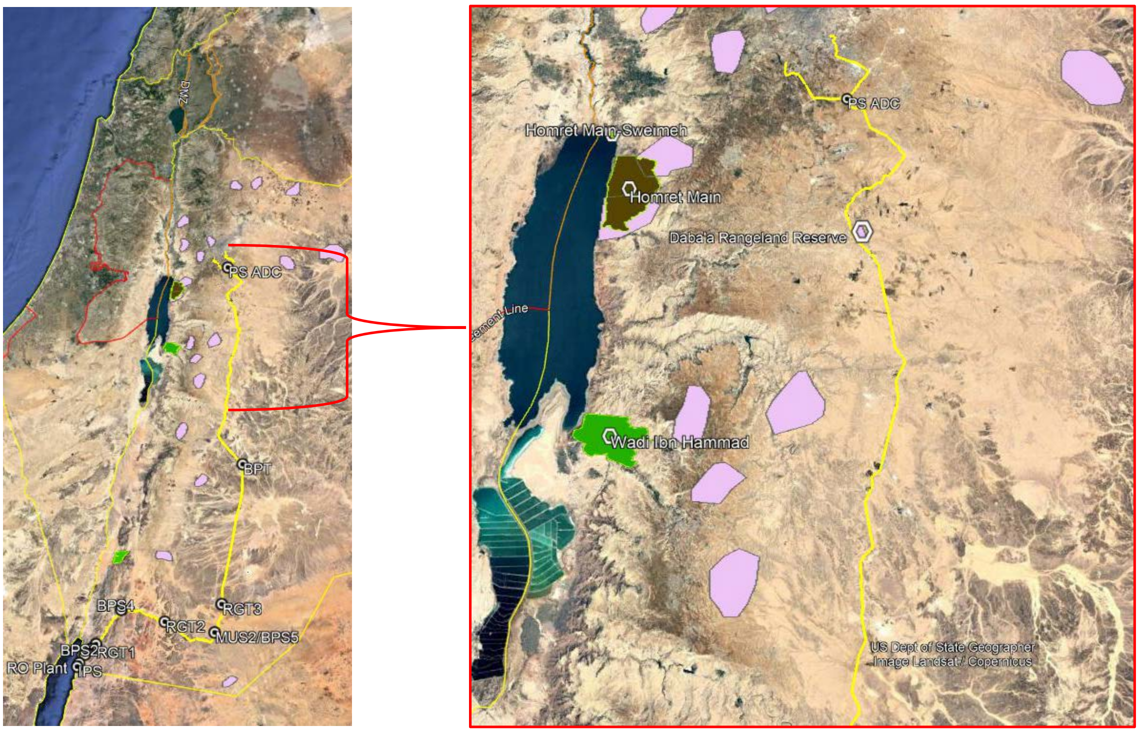


Figure 6-104: Project Alignment in Relation to Designated Special Conservation Areas and Rangeland Reserves

6.3.5. Biodiversity along the Conveyance Route

The following sections present the biodiversity within the project area and along the conveyance line.

6.3.5.1. Segment A (Southern Part) which extends from the Wellfield at Disi to Jurf Al Drawish - Qatraneh Junction (Desert Highway)

Section A-1: Intake/IPS to the RO Plant and to BPS4

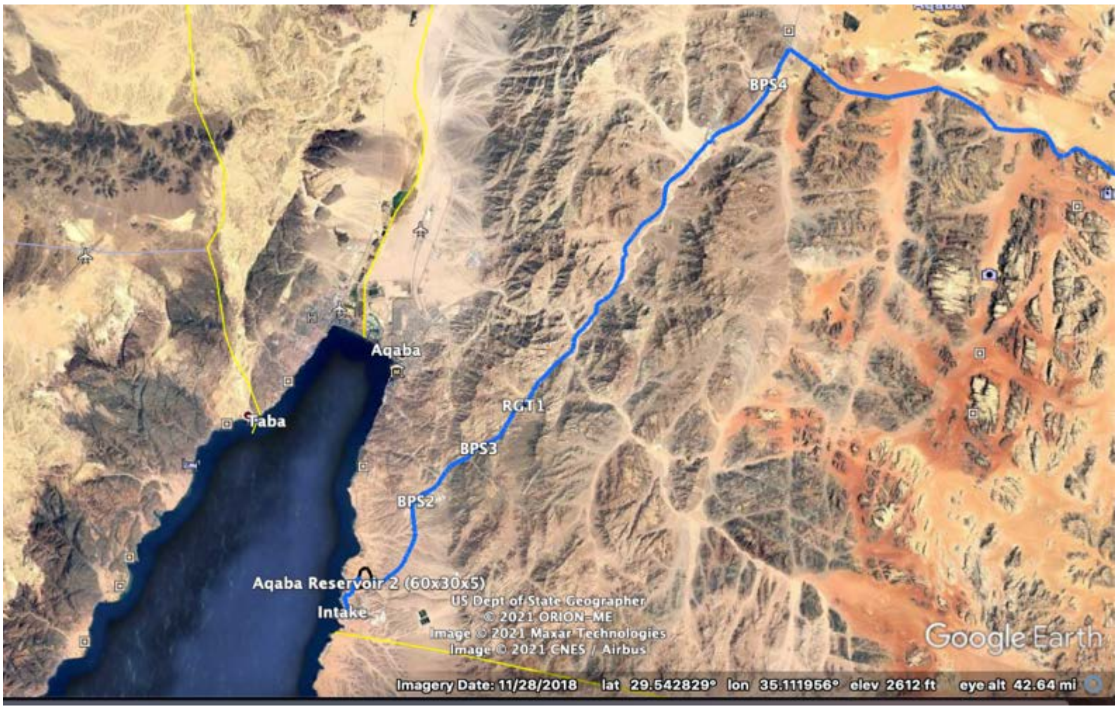


Figure 6-105: Map Showing the Proposed Project Alignment and facilities within Section A-1

Habitat Type and Conditions

This area surrounded by the granite mountains of Aqaba. Its most northern part is covered by wind-blown sand whereas the mid to southern portion has a hard substrate covered with course granite soil and rocks. The area has several wadi systems, most are relatively narrow with maximum width of about 4 km wide with scattered vegetation of *Acacia* sp., *Retama raetam*, *Anabasis* sp., and *Zilla spinosa*. Solid granite mountains with various altitudes are common. In terms of land use classification, the substrate in the area is mostly gravely and hard, especially in the southern half. Grazing is high and we observed many settlers with sheep and camels all through the area. Also, a relatively heavy traffic by vehicles was seen, since the area is used as a shortcut to reach Aqaba.

The RO site Aqaba reservoir area is mostly barren hard soil consisting of firm upper crust in most of the area, with ruins of old constructions that has been demolished. Only few scattered Acacia trees are located to the east, close to the road leading to the site. A sharp mountain ridge, Aqaba Mountains, is located about 2 km east to the site. The 4 pumping stations along the route are directly near the Aqaba backroad, all 4 sites are heavily disturbed and exhibit no biodiversity elements and pose no threat to the local diversity.

SWRO Plant Site

BPS3 Site

BPS4 Site

BPS2 Site

RGT1 Site

Vegetation Type and Floral Diversity

This section stretches from Al Rashidieh, then along the Aqaba back road to the intake location. Most of vegetation is restricted at wadi beds that are mostly sandy and alluvial. Acacia trees do occur on the wadi peripheries at the foot of the mountains or where hard substrate exists. More specifically, the representative habitats discussed above include weathered sandstone and granite scrub in the higher altitudes overseeing the proposed pipeline route, alluvial fans in the foothills, and Acacia woodland in the wadi bed.

The dominant species along this section are *Acacia tortilis and Zilla spinosa* in the areas closer to Wadi rum road to Al Rashdiyah, and *Acacia tortilis and Ochradenus baccatus* along the back road to the proposed desalination plant. The vegetation cover is limited, as mentioned above, to wadi beds, and within the wadi beds the vegetation cover is estimated to be between 10% and 15%. Other observed species are listed in

Table 6-13: Observed Flora Species in Section A-1

Genus	Species	Family	National Status
Zilla	*spinosa*	CRUCIFERAE	Common
Ochradenus	*baccatus*	RESEDACEAE	Common
Retama	*raetam*	PAPILIONACEAE	Common
Haloxylon	*salicornicum*	CHENOPODIACEAE	Common
Acacia	*tortilis*	MIMOSACEAE	Vulnerable
Acacia	*subsp. raddiana*	MIMOSACEAE	Vulnerable

Faunal Diversity

Results from the biodiversity assessment indicated the actual or potential presence of 18 species of mammals (3 carnivora, 1 artiodactyla, 1 hyracoidae, 8 bats, and 3 rodents) and 19 species of reptiles (12 lizards and 7 snakes). Some of the recorded species have global (e.g. striped hyena, ibex, Aqaba agama, and Sinai banded snake), regional or national conservation status and 4 species are considered habitat-restricted and unique to the cliffs, rocky slopes, and gravelly habitats that are prevalent in this zone.

This area is important for the Nubian ibex which uses its wades and cliffs as corridors between the mountains at the borders with Saudi Arabia and Wadi Araba mountains through Wadi Al Yutum. Wadi Al Yutum area is situated along the western border of Wadi Rum protected area with solid granite mountains at various altitudes. The remoteness of this area makes it important as refuge for large mammals such as the hyena and the ibex, also the finding of the Aqaba Agama is important, this species has limited distribution along Aqaba Mountains in Jordan, and certainly can be considered a species that requires more protection.

The flat gravelly areas east of the RO site contains a small population of the Egyptian Spiny–tailed Lizard, this species is of conservation status on both the local and the international level (listed as near threatened). Table 6-14 below shows reptiles of Wadi Al Yutum area.

Table 6-14: Reptiles of Wadi Al Yutum Area. Global and Regional IUCN Status in Parentheses ([53]

Species	Common Name
Family Gekkonidae	
Bunospus tuberculatu	The Baluch Ground Gecko
Hemidactylus mindiae	Mount Sinai-Gecko
Ptyodactylus hasselquistii	Hasselquist's Fan-footed Gecko
Stenodactylus sthenodactylus	Elegant Thin-Toad Gecko
Tropiocolotes nattereri	Natterer's Pigmy Gecko
Family Agamidae	
Stellagama stellio	Southern Starred Agama
Pseudotrapelus aqabansis	Aqaba Agama
Uromastyx aegyptia **(VU)**	Egyptian Spiny–tailed Lizard
Family Lacertidae	
Acanthodactylus boskianus	Bosk's Fringe-toed Lizard
Acanthodactylus opheodurus	Arnold's Fringe-fingered Lizard
Mesalina brevirostris	Blanford's Short-nosed Lizard
Mesalina guttulata	Small-spotted Lizard
Family Colubridae	
Platyceps elegantissimus	The Beautiful Whip Snake
Platyceps rhodorachis	Jan's Whip Snake
Platyceps Sinai **(NT)**	Sinai Banded Snake
Psammophis schokari	Forskål's Sand Snake
Spalerosophis diadema	Clifford's Snake
Telescopus dhara	The North- African Cat Snake
Family Viperidae	
Echis coloratus	The Arabian Saw-Scaled Viper
Species richness	**19**
# Globally threatened	**2**

Table 6-15: Mammals of Wadi Al Yutum area. Global and Regional IUCN Status in Parentheses (Mallon and Budd 2011), § Habitat Restricted, ‡ Nationally Threatened

Scientific Name	Common Name
Erinaceidae	
Paraechinus aethiopicus	Ethiopian Hedgehog
Hyaenidae	
Hyaena hyaena **(NT, EN)**	Striped Hyaena
Canidae	

Scientific Name	Common Name
Canis lupus **(LC, EN)**	Wolf
Vulpes vulpes	The Red Fox
Rhinolophidae	
Rhinolophus clivosus	Geoffroy's Horseshoe Bat
Rhinolophus hipposideros	Lesser Horseshoe Bat
Vespertilionidae	
Otonectris hemprichii	Hemprich Longeared Bat
Hypsugo ariel	Desert Pipistrelle
Barbastella leucomelas	Asian Barbastelle
Eptesicus bottae	Botta's Serotine Bat
Plecotus christii	African Long Ear Bat
Molossidae	
Tadarida teniotis	Free-tailed Bat
Muridea	
Acomys dimidiatus	Eastern Spiny Mouse
Gerbillus dasyurus	Wagner's Gerbil
Sekeetamys calurus	The Bushy-tailed Jird
Leporidae	
Lepus capensis **(LC, EN)**	Arabian Hare
Procaviidae	
Procavia capensis **(LC, EN)**	Rock Hyrax
Bovidae	
Capra nubiana **(VU, VU)**	Nubian Ibex
Species richness	**18**
# Globally threatened	**2**
# Nationally threatened	**5**

Avifauna

The habitat is characterized by barren granite mountains that have small runoff wadis intersecting these mountain ridges. The vegetation comprises of scattered trees and bushes of *Acacia raddiana* and *Retama raetam*. During the field study, the following species were recorded: Long-legged Buzzard, Rock Dove, Collared Dove, Palm Dove, Little Green Bee-eater, Bar-tailed Lark, Desert Lark, Blackstart, Yellow-vented Bulbul, Tristram's Grackle and House Sparrow.

Those recorded species are typical breeding assemblages of this area extending along the desert Highway from Aqaba to Rum Junction. The area is also important for migratory raptors utilizing this mountain ridges as part of their migration flyway especially in Spring migration.

Section A-2: from BPS4 to RGT2

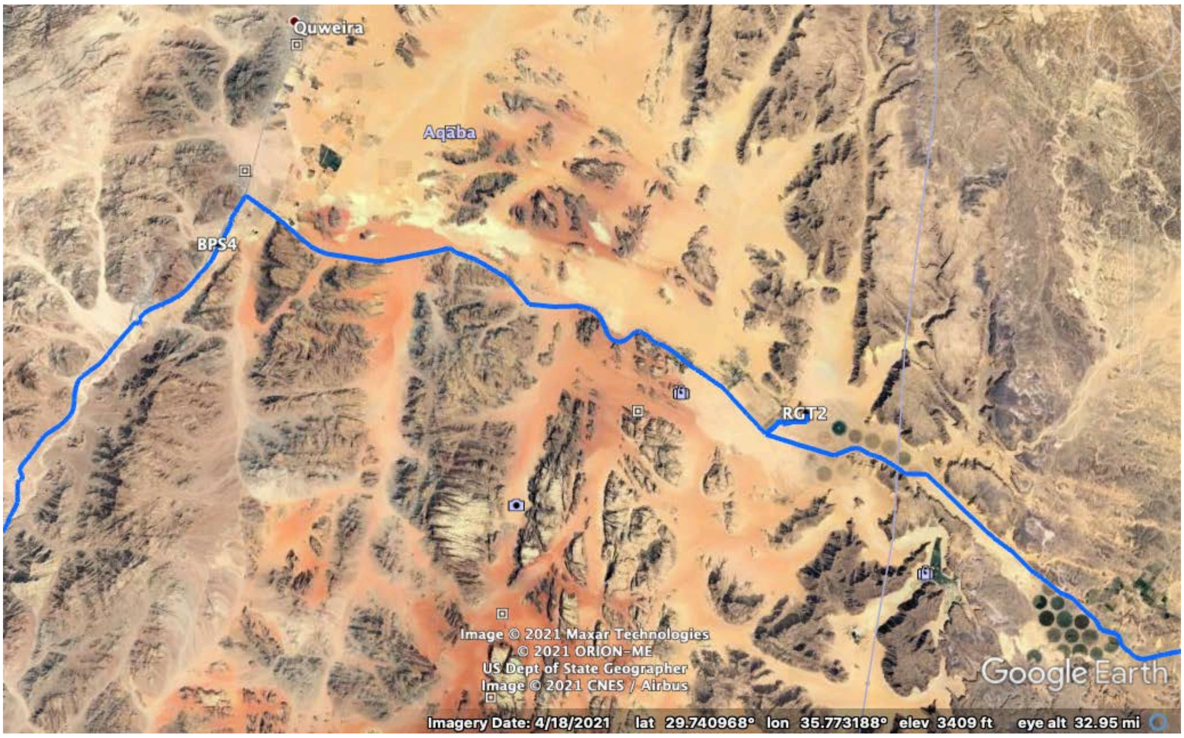


Figure 6-106: Map Showing the Proposed Alignment in Section A-2

Figure 6-107: Proposed Location for RGT2

Habitat Type and Conditions

Wadi Rum is characterized by a unique landscape of scenic sandstone mountains separated by vast open sandy valleys. According to vegetation types proposed by Albert et al. (2004) [54], Wadi Rum escarpment lies within three types of vegetation types. Sandy Hamada: This is the largest vegetation type by area within Jordan. In Wadi Rum Protected Area, this vegetation type is not dominant but nevertheless some of its components are present. The main species of this type that are present in the protected area include Anabasis articulate, Retama raetam, Tamarix spp., Achillea fragrantissima, Artemisia herba-alba and Zilla spinosa. Sand Dune: This vegetation type is only found in the Sudanian Vegetation Region. Wadi Rum area is one of the best representatives for it. It is made up of shrubs and bushes (sand dunes fixatives).

The main species that characterize this type include *Haloxylon persicum*, *Retama raetam*, *Calligonum comosum*, *Neurada procumbens* and *Hamada scoparia*. Weathered sandstone and granite scrub: This vegetation is limited to the rocky areas in the protected area. Sometimes it is found together with the Sand Dune Vegetation Type. The main species of this type that are present in the protected area include *Acacia raddiana*, *Anabasis articulata, Caralluma* spp., *Fagonia* spp., *Gymnocarpos decatidrum* and *Helianthemiim lippii*.

Soil is mostly alluvial (being transported by water and wind) of sandy, saline, and/or granite nature. According to soil maps of Jordan, Wadi Rum Protected Area includes two main soil types that vary in properties. Both types are shallow and contain moderate to high levels of soluble salts requiring high leaching to practice irrigated agriculture. Most of the area to the east is characterized by steeply slopes and eroded lands that include Torripsamment and some camborthids soil types, whereas the western and southwestern regions are located on a land region known as Wadi Araba Escarpment with aridic Torriorthent soil, this area is dominated by coarse-textured soils with very stony nature and calcic horizons

Small villages with semi-nomadic and resident Bedouins of the Howeitat Tribe are settled in Wadi Rum and the adjoining areas. They utilize the territories in the north and east edges of the reserve within the buffer zone. They include: Shakriyeh, Salihiyeh, Tuwaiseh, Mnnaishir, Al Ghal and Disi. Their local economy is mostly based on subsistence pastoralism, tourism, and limited agriculture. The Bedouins that depend on pastoralism lead their camels, goats and sheep throughout the region according to the presence of water and availability of vegetation. Most families have a house in one of the villages and a Bedouin tent in the desert where the livestock in kept. Figure 6-107 below shows the northern of Wadi Rum area.

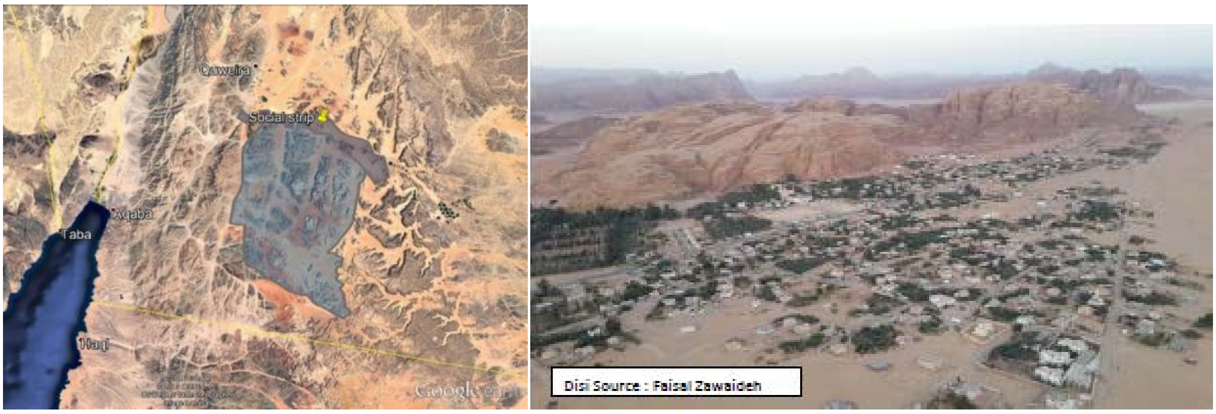


Figure 6-108: Map of Northern of Wadi Rum Area

Vegetation Type and Floristic Diversity

The dominant species along this section is *Halyxolon persicum*. The vegetation cover is limited, as mentioned above, the vegetation cover is estimated to be between 10% and 15%.

Faunal Diversity

Results from the biodiversity assessment indicated the actual or potential presence of 24 species of mammals (3 carnivora, 1 hyracoidae, 8 bats, and 9 rodentia) and 22 species of reptiles (14 lizards and 8 snakes). Five of the recorded species of mammals have regional or national conservation status (e.g. Hyena, Blanford's fox and rock hyrax) and 7 species are considered habitat-restricted and unique to the sandstone cliffs and canyons or the sand dune habitats that are prevalent in the study sites (Blanford's fox, rock hyrax, Cheesman's gerbil, bushy-tailed jird, sand fish, Blanford's gecko, Arabian horned viper).

Due to the rocky nature of wadi rum and presence of small-scale agricultural gardens and irrigation pools, the order Chiroptera is diverse with 11 species, followed by Order Rodentia with nine species. Carnivores are represented with three species, while the other orders are represented by a single or two species. The red fox is the most common carnivore species in the reserve. It was seen during the day and photographed at night with camera traps. It is well adapted to a wide range of habitats and exhibits the widest global and local distribution of all carnivores; however, it faces the threat of poisoning and illegal shooting throughout the country. 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.

Table 6-16: Reptiles of Northern Wadi Rum Area. Global and Regional IUCN Status in Parentheses [53], § Habitat Restricted, ‡ Nationally Threatened

Species	Common Name
Family Gekkonidae	
Hemidactylus mindiae	Mount Sinai-Gecko
Pristurus rupestris	Blanford's Semaphore Gecko
Ptyodactylus guttatus	Sinai Fan-fingered Gecko
Ptyodactylus hasselquistii	Hasselquist's Fan-footed Gecko
Stenodactylus doriae	Short-fingered Gecko
Stenodactylus sthenodactylus	Elegant Thin-Toad Gecko
Family Chamaeleonidae	
Chamaeleo chamaeleon	Chameleon
Family Agamidae	
Stellagama stellio	Southern Starred Agama
Phrynocephelus nejdensis	Arabian Toadhead Agama
Pseudotrapelus sinaitus	Sinai Agama
Family Lacertidae	
Acanthodactylus boskianus	Bosk's Fringe-toed Lizard
Acanthodactylus opheodurus	Arnold's Fringe-fingered Lizard
Acanthodactylus schmidti	Schmidt's Fringe-toed Lizard
Family Scincidae	
Scincus scincus	The Sandfish
Family Colubridae	
Platyceps elegantissimus	The Beautiful Whip Snake
Platyceps rhodorachis	Jan's Whip Snake
Platyceps Sinai **(NT, NT)**	Sinai Banded Snake
Psammophis schokari	Forskål's Sand Snake
Spalerosophis diadema	Clifford's Snake
Telescopus dhara	The North- African Cat Snake

Species	Common Name
Family Viperidae	
Cerastes gasperettii	The Arabian Horned Viper
Echis coloratus	The Arabian Saw-Scaled Viper
Species richness	**22**
# Globally threatened	**1**

Table 6-17: Mammals of Northern Wadi Rum Area. Global and Regional IUCN Status in Parentheses [55], § Habitat Restricted, ‡ Nationally Threatened.

Scientific Name	Common Name
Erinaceidae	
Paraechinus aethiopicus	Ethiopian Hedgehog
Canidae	
Canis lupus **(LC, EN)**	Wolf
Vulpes cana **(LC, EN)**	Afghan fox
Vulpes vulpes	The Red Fox
Rhinolophidae	
Rhinolophus clivosus	Geoffroy's Horseshoe Bat
Rhinolophus hipposideros	Lesser Horseshoe Bat
Vespertilionidae	
Otonectris hemprichii	Hemprich Longeared Bat
Hypsugo ariel	Desert Pipistrelle
Barbastella leucomelas	Asian Barbastelle
Eptesicus bottae	Botta's Serotine Bat
Plecotus christii	African Long Ear Bat
Molossidae	
Tadarida teniotis	Free-tailed Bat
Gliridae	
Eliomys melanurus	The Southwest Asian
Diplodidae	Dormouse
Jaculus jaculus	Three-toed Jerboa
Muridea	
Acomys dimidiatus	Eastern Spiny Mouse
Gerbillus nanus	Baluchistan Gerbil
Gerbillus cheesmani	Chessman's Gerbil
Gerbillus dasyurus	Wagner's Gerbil
Merionus crassus	Sand evall's Gerbil
Merionus libycus	Libyan Jird
Sekeetamys calurus	The Bushy-tailed Jird

Scientific Name	Common Name
Leporidae	
Lepus capensis **(LC, EN)**	Arabian Hare
Procaviidae	
Procavia capensis **(LC, EN)**	Rock Hyrax
Bovidae	
Capra nubiana **(VU, VU)**	Nubian Ibex
Species richness	**24**
# Globally threatened	**1**
# Nationally threatened	**5**

Famous for its scenery, desert adventure, Bedouin culture, and archaeology, Wadi Rum area is currently under intense impacts of tourism activity. Visitor activities include 4x4 tours, camel rides, hiking, camping, rock climbing and horse riding. Tourism activities represent a real concern for the well-being of the protected area, this is particularly true in relation to off road excursions and the number of camp site.

The area between Al Quweirah and the villages of Salihiyeh, Shakeriyeh and Disi are tourism zones. This particular area represents open sandy desert and large sandstone mountains that currently hosts minimum biodiversity elements. This area is already disturbed from busy traffic and human settlements. The area has little value for biodiversity and can be assigned for human activities with minimum number of impacts on wildlife and biodiversity. The majority of the Bedouin communities are settled in villages, while only a limited number of families change location throughout the year, moving with their livestock on a seasonal basis for foraging ground. The area hosts some house gardens with olive trees and a few irrigation systems and open pools where several records for bat species were made [56] and could also have significant value for species like the chameleon and garden doremouse due to its vegetation cover.

Avifauna

The Sudanian realm is evident in this area. The soil is mostly sandy. Saline soils occur discretely in this region. There are also hilly limestone regions, the high mountains of wadi Rum as well as the sand dunes habitats between scattered mountains of Wadi Rum. This section is home to restricted range breeding birds including: Sand Partridge, Chukar, Desert Owl, Hooded, Mourning and White-crowned Black Wheatears, Tristram's Grackle, Trumpeter Finch and Sinai Rosefinch. The mountains of Rum supports also the following breeding raptors: Short-toed Eagle, Barbary Falcon Sooty Falcons, and Lesser Kestrel (rare).

Winter visitors include Steppe Eagle, Desert Warbler and Pale Rock Sparrow, Honey Buzzard, Egyptian Vulture, Crane and White Stork are uncommon autumn migrants, but are quite common in the irrigated farms of Disi area.

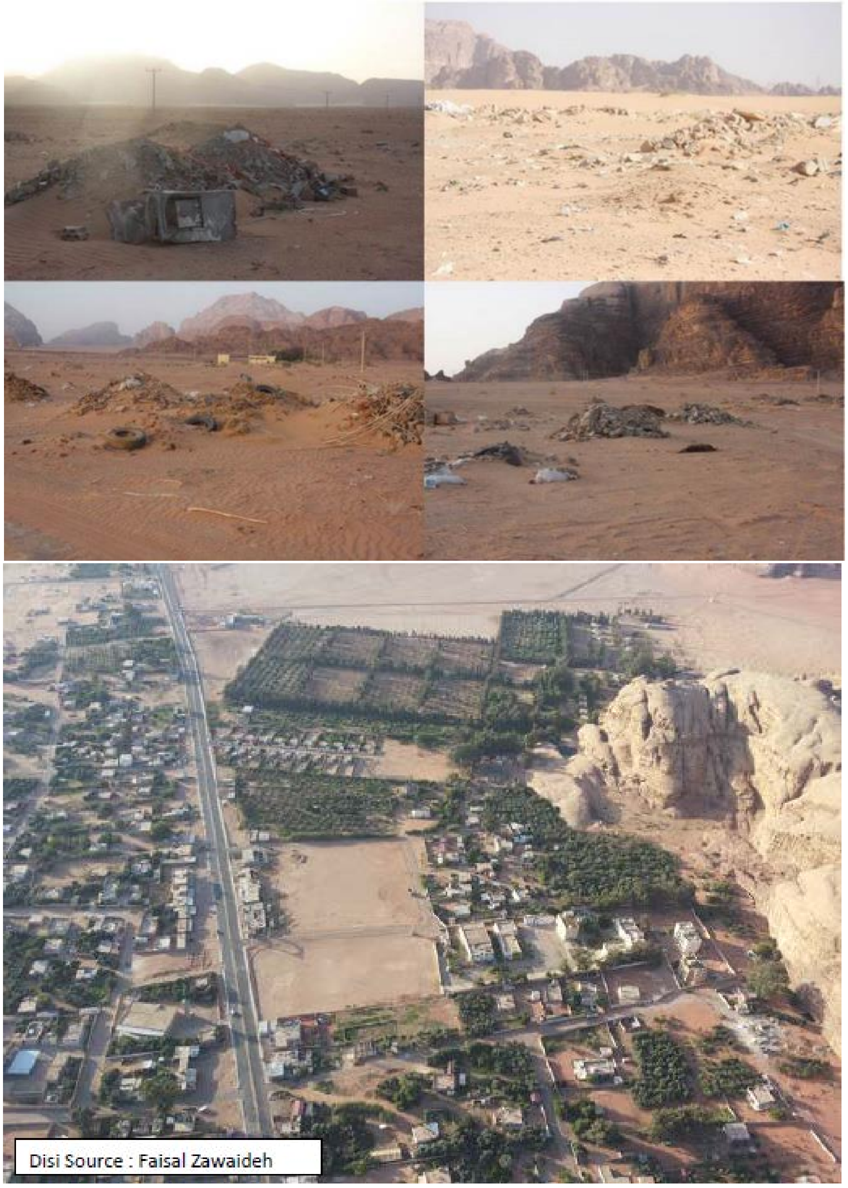


Figure 6-109: Images of Observed Habitat Disturbance and Small Scale Agriculture Around Disi/Rum Areas

Section A-3: from RGT2 to RGT3

Figure 6-110: Map Showing the Proposed Alignment of Section A-3

Figure 6-111: Image Showing The Proposed Location for the MUS2/BPS5

Figure 6-112: Image Showing the Proposed Location for the RGT3

Habitat Type and Conditions

This agricultural area extends southeast from the village of Disi to the wellfields and 'crop circles' of large-scale agricultural farms. The landscape is mostly open Hamada of gravely substrate.

This area lies to the east of Wadi Rum area, east of the villages of Disi, Tuwaiseh and Mnaishir. Irrigated agriculture in this area was developed during the last 15-20 years on the silt plains between Disi, Sahl as Suwwan and Al Mudawwara, which lie along the northern and eastern boundaries of Wadi Rum Protected Area. These farms are said to cover more than 50 km2 and are mainly large-scale, commercial enterprises which pump fossil water from huge aquifers to irrigate cereals, alfalfa, and fruit crops for export to the West and Far East, using intensive methods such as pivots, drip pipes and a high use of agrochemicals.

Vegetation Type and Floristic Diversity

The dominant species along this section are *Acacia tortilis, Anabasis articulata* and *Haloxylon persicum*. The vegetation cover is limited, as mentioned above, the vegetation cover is estimated to be around 5%. Other observed species are listed in Table 6-18.

Table 6-18: Observed Flora Species in Section A-3

Genus	Species	Family	Status
Haloxylon	*persicum*	CHENOPODIACEAE	Vulnerable
Schismus	*arabicus*	GRAMINEAE	Common
Seidlitzia	*rosmarinus*	CHENOPODIACEAE	Common
Anabasis	*articulata*	CHENOPODIACEAE	Common
Zilla	*spinosa*	CRUCIFERAE	Common
Acacia	*Tortilis*	MIMOSACEAE	Vulnerable
Ifloga	*spicata*	COMPOSITAE	Common
Artemisia	*jordanica*	COMPOSITAE	Endangered

Faunal Diversity

Results from the biodiversity assessment indicated the actual or potential presence of 19 species of mammals (3 carnivora, 8 bates, and 6 rodentia) and 22 species of reptiles (15 lizards and 7 snakes). Three of the recorded species have regional and/or national conservation status (Hyena, Asiatic jackal and cape hare) 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.

Table 6-19: Reptiles of Agricultural Area East of Wadi Rum. Global and Regional IUCN Status in [53], § Habitat Restricted, ‡ Nationally Threatened

Species	Common Name
Family Gekkonidae	
Bunospus tuberculatu	The Baluch Ground Gecko
Hemidactylus mindiae	Mount Sinai-Gecko
Ptyodactylus guttatus	Sinai Fan-fingered Gecko
Stenodactylus doriae	Short-fingered Gecko
Stenodactylus sthenodactylus	Elegant Thin-Toad Gecko
Family Chamaeleonidae	
Chamaeleo chamaeleon	Common Chameleon
Family Agamidae	
Stellagama stellio	Southern Starred Agama
Phrynocephelus nejdensis	Arabian Toadhead Agama
Pseudotrapelus sinaitus	Sinai Agama
Uromastyx aegyptia **(VU, NT)**	Egyptian Spiny–tailed Lizard
Family Lacertidae	
Acanthodactylus boskianus	Bosk's Fringe-toed Lizard
Acanthodactylus opheodurus	Arnold's Fringe-fingered Lizard
Mesalina brevirostris	Blanford's Short-nosed Lizard
Mesalina guttulata	Small-spotted Lizard
Family Varanidae	
Varanus griseus	Desert Monitor
Family Colubridae	
Platyceps elegantissimus	The Beautiful Whip Snake
Platyceps rhodorachis	Jan’s Whip Snake
Psammophis schokari	Forskål’s Sand Snake
Spalerosophis diadema	Clifford’s Snake
Telescopus dhara	The North- African Cat Snake
Family Viperidae	
Cerastes gasperettii	The Arabian Horned Viper
Echis coloratus	The Arabian Saw-Scaled Viper
Species richness	**22**
# Globally threatened	**1**

Table 6-20: Mammals of Agricultural Area East of Wadi Rum. Global and Regional IUCN Status in Parentheses [55], § Habitat Restricted, ‡ Nationally Threatened

Scientific Name	Common Name
Erinaceidae	
Paraechinus aethiopicus	Ethiopian Hedgehog
Hyaenidae	
Hyaena hyaena **(NT, EN)**	Striped Hyaena
Canidae	
Canis aureus	Asiatic Jackal
Vulpes vulpes	The Red Fox
Rhinolophidae	
Rhinolophus clivosus	Geoffroy's Horseshoe Bat
Rhinolophus hipposideros	Lesser Horseshoe Bat
Vespertilionidae	
Otonectris hemprichii	Hemprich Longeared Bat
Hypsugo ariel	Desert Pipistrelle
Barbastella leucomelas	Asian Barbastelle
Eptesicus bottae	Botta's Serotine Bat
Plecotus christii	African Long Ear Bat
Molossidae	
Tadarida teniotis	Free-tailed Bat
Diplodidae	
Jaculus jaculus	Three-toed Jerboa
Muridea	
Acomys dimidiatus	Eastern Spiny Mouse
Gerbillus nanus	Baluchistan Gerbil
Gerbillus cheesmani	Chessman's Gerbil
Gerbillus dasyurus	Wagner's Gerbil
Merionus crassus	Sundevall's Jird
Leporidae	
Lepus capensis **(LC, EN)**	Arabian Hare
Species richness	**19**
# Globally threatened	**1**
# Nationally threatened	**2**

In recent years, the agricultural area has expanded gradually. Unfortunately, little or no governmental control was put in place to regulate such activities, consequently, habitat degradation, fragmentation, and pesticide and chemicals usage are among the main threats affecting the natural habitats within this area. Figure 6-113 below shows litter and farm leftovers were a common seen in the northern portions of Wadi Rum.

Figure 6-113: Litter and Farm Leftovers were a Common Seen in the Northern Portions of Wadi Rum

Avifauna

Avifaunal community of this section is same as previous one of Rum but due to less accessibility to this section and less disturbance, habitats are more preserved hence supports larger populations of sudanain habitat associated species including: Sand Partridge, Chukar, Desert Owl, Hooded, Mourning and White-crowned Black Wheatears, Tristram's Grackle, Trumpeter Finch and Sinai Rosefinch.

Section A-4: from RGT3 to the cross point of the alignment with the desert highway between Jurf Al-Drawish and Al Hasa

Figure 6-114: Map Showing the Proposed Alignment of Section A-4

Figure 6-115: Image Showing the Proposed Location for the BPT

Habitat Type and Conditions

The eastern desert of Jordan is a highly diversified geomorphic area with different types of habitats that offer shelter and space for different assemblages of communities with different ecological requirements including rock-dwelling mammals, psammophiles and others preferring open land [57]. From basaltic fields and boulders (lava or harra desert), flat low land areas (marab), saline dunes (sabkhaht), sandy sheets, to wadi beds and flat deserts (gravel Hamada). The area is home to at least 38 species of mammals, 40 reptiles and amphibians, and many species of resident and migrant birds that pass through the area every year [58].

Figure 6-116: Biological Habitat within Section A-4

Vegetation Type and Floristic Diversity

The dominant species along this section are *Seidlitzia Rosmarinus, Anabasis articulata,* and *Achillea fragrantissima*. The vegetation cover is limited, as mentioned above, the vegetation cover is estimated to be around 10%. Other observed species are listed in Table 6-21.

Table 6-21: Observed Flora Species in Section A-3

Genus	Species	Family	Status
Filago sp		COMPOSITAE	Common
Anabasis	*Articulata*	CHENOPODIACEAE	Common
Cynodon	*Dactylon*	GRAMINEAE	Common
Fagonia	*Mollis*	ZYGOPHYLLACEAE	Common
Seidlitzia	*Rosmarinus*	CHENOPODIACEAE	Common
Plantago	*Ovate*	PLANTAGINACEAE	Common

Faunal Diversity

Direct and indirect studies in the site resulted in the confirmation of the presence of 14 species of mammal, including one lagomorph, 6 rodents, and 3 carnivore, and 9 amphibians and reptiles (1 frog, 4 lizards, and 4 snakes) through direct observations during the day transects.

One species of mammals (the striped hyena) is globally threatened while 3 species are threatened on the local scale.

Table 6-22: Mammalian Species Reported from the Eastern Desert Route Through Direct Observation and Indirect Observations

Species	Common Name	Arabic Name	IUCN Global Status	IUCN Local Status
Insectivora				
Paraechinus aethiopicus	Ethiopian hedgehog	قنفذ	LC	LC
Chiroptera				
Rhinopoma cystops	Mouse tailed bat	خفاش	LC	LC
Tadarida teniotis	Free tailed bat	خفاش	LC	LC
Otonycteris hemprichi	Long-eared bat	خفاش	LC	LC
Lagomorpha				
Lepus capensis	Arabian or Cape hare	الأرنب البري	LC	EN
Carnivora				
Hyaena hyaena	Striped hyena	الضبع	NT	EN
Canis Lupus	Wolf	ذئب	LC	EN
Vulpes vulpes	Red fox	الثعلب الأحمر	LC	LC
Rodentia				
Jaculus jaculus	Three toed jerboa	الجربوع	LC	LC
Meriones crassus	Sand Jird	جرذ الرمل	LC	LC
Meriones libycus	Libyan Jird	الجرذ الليبي	LC	LC
Gerbillus dasyurus	Wagner's Gerbil	جربوع واقنر	LC	LC

Species	Common Name	Arabic Name	IUCN Global Status	IUCN Local Status
Gerbillus henleyi	Pygmy Gerbil	الجربوع القزم	LC	LC
Gerbillus nanus	Baluchistan Gerbil	جربوع بالوخستان	LC	LC

Notes: IUCN status: LC Least Concern, NT Near Threatened, VU Vulnerable, E Endangered.

Table 6-23: Amphibians and reptiles reported from the eastern desert route through direct observation and indirect observations

Species	Common Name	Arabic Name	IUCN Global Status	IUCN Regional Status
Amphibians: Anura				
Bufotes viridis	the Green toad	ضفدع	LC	LC
Family Varanidae				
Varanus griseus	Desert Monitor	الورل	LC	LC
Family Agamidae				
Trapelus agnetae	Pale Agama	حرذون	LC	LC
Family Lacertidae				
Acanthodactylus boskianus	Bosk's Fringe-toed Lizard	سحلية	LC	LC
Mesalina brevirostris	Short-nosed Desert Racer	سحلية	LC	LC
Snakes				
Psammophis sckokari	Desert racer	حية	LC	LC
Lytorhynchus diadema	Awl headed snake	حية	LC	LC
Rhagerhis moilensis	False cobra	حية	LC	LC
Pseudocerastes fieldi	False horned viper	افعى مقرنة	LC	LC

Source: IUCN status: LC Least Concern, NT Near Threatened, VU Vulnerable, E Endangered.

This is the longest route along the designated area, thus particular routes should be used by vehicles inside the area to limit off roads and tracks as much as possible. Limiting off-road driving will minimize the impact of this activity on the vegetation cover. Larger mammals (such as the striped hyena) and reptiles (such as the spiny-tailed lizard) are threatened according to the IUCN red list, and are sensitive ti human disturbance.

The striped hyena has the widest distribution of large carnivores in Jordan (Qarqaz et al. 2004; Kempe et al. 2006). The presence of carrions from the livestock herds provides the main attractions for scavengers such as the steppe eagle, imperial eagle, and striped hyena (up to 72 km^2 for hyenas in the Middle East, Van Aarde et al 1988).

Avifauna

The habitat is a typical Saharo Arabian desert with low relief arid plateaus intersected by some hills and low altitudinal Rocky Mountains separated by gravel wadis. The area is scattered with sparse vegetation.

Important breeding birds include Cream-coloured Courser, Hoopoe Lark, Temminck's Lark, Desert Wheatear, Scrub Warbler, Long-legged Buzzars, and Brown-necked Raven. Accessible water resources in low catchment areas to the East of AL Jafr large mudflat attracts small numbers of wintering waterfowls.

The area 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. Soaring birds utilize columns of rising warm air—known as thermals— that mountain ranges and large wadis such the Rift Valley and Jordan Valley which functions as a land bridge or a "bottleneck" for the passage of those birds during their migration (Kirby 2010). Whereas waders and passerines pass through Jordan every year using the two largest Palearctic–African flyways Mediterranean/Black Sea Flyway and the East Asia/East Africa Flyway. These routes constitute the world's largest bird migration system with over two billion passerines and near-passerines migrating from their breeding grounds in Europe and central and western Asia to winter in tropical Africa (Hahn et al. 2009).

During their journey, these water birds and passerines chose routes encompassing highly-productive staging sites and rest stops with high vegetation cover and/or water reservoirs. Many soaring birds such as raptors, storks, and ibises migrate through the Rift Valley/Red Sea flyway during their migration between Europe and Africa. During their journey, raptors (including the Steppe Eagles and Steppe Buzzards) perform a key ecosystem service to the natural ecosystems such as the cleanup of carrion. Whilst most birds are negatively affected by considerable threats from factors like agriculture, energy, hunting, tourism and waste management along their migration.

The desalination route lies mostly across wadi beds and gravel Hamada deserts. These areas are composed of flat desert of clayey loam covered by gravel and interrupted by dry water courses that exhibit greater vegetation cover and flood during the rainy season.

6.3.5.2. Segment B (Middle Segment) which extends from the cross point of the alignment with the desert highway between Jurf Al-Drawish and Al Hasa to the beginning of Al Jiza Area (South of Amman)

Section B-1: from the cross point of the alignment with the desert highway between Jurf Al-Drawish and Al Hasa to Al Qatraneh

Figure 6-117: Map Showing the Proposed Alignment of Section B-1

Habitat Type and Conditions

The route between Jurf al daraweesh and Al Qatranah lies within the desert area of southeastern along the desert highway that connects Amman with southern Jordan until Aqaba. The area is mostly flat deserts (gravel Hamada) that is often interrupted by low lands (marab) and wadi beds.

Faunal Diversity

Due to the high disturbance from traffic and noise on the highway, the biodiversity is low and has no records of high conservation value. Direct and indirect studies in the site resulted in the confirmation of the presence of 10 species of mammals, including one lagomorph, 4 rodents, and one carnivore, and 10 reptiles (5 lizards and 5 snales) through direct observations during the day transects.

Table 6-24: Mammalian Species Reported from the Eastern Desert Route Through Direct Observation and Indirect Observations[2]

Species	Common Name	Arabic Name	IUCN Global Status	IUCN Local Status
Insectivora				
Paraechinus aethiopicus	Ethiopian hedgehog	قنفذ	LC	LC
Chiroptera				
Rhinopoma cystops	Mouse tailed bat	خفاش	LC	LC
Tadarida teniotis	Free tailed bat	خفاش	LC	LC
Otonycteris hemprichi	Long-eared bat	خفاش	LC	LC
Lagomorpha				
Lepus capensis	Arabian or Cape hare	الأرنب البري	LC	EN
Carnivora				
Vulpes vulpes	Red fox	الثعلب الأحمر	LC	LC
Rodentia				
Jaculus jaculus	Three toed jerboa	الجربوع	LC	LC
Meriones crassus	Sand Jird	جرذ الرمل	LC	LC
Gerbillus dasyurus	Wagner's Gerbil	جربوع واقنر	LC	LC
Gerbillus nanus	Baluchistan Gerbil	جربوع بالوخستان	LC	LC

Table 6-25: Amphibians and Reptiles Reported from the Eastern Desert Route Through Direct Observation and Indirect Observations[3]

Species	Common Name	Arabic Name	IUCN Global Status	IUCN Regional Status
Family Agamidae				
Trapelus agnetae	Pale Agama	حرذون	LC	LC
Stelloagama stellio	Starred Agama	حرذون	LC	LC
Family Lacertidae				
Acanthodactylus boskianus	Bosk’s Fringe-toed Lizard	سحلية	LC	LC
Mesalina brevirostris	Short-nosed Desert Racer	سحلية	LC	LC
Snakes				

[2] Note: IUCN status: LC Least Concern, NT Near Threatened, VU Vulnerable, E Endangered.
[3] Note: IUCN status: LC Least Concern, NT Near Threatened, VU Vulnerable, E Endangered

Species	Common Name	Arabic Name	IUCN Global Status	IUCN Regional Status
Psammophis sckokari	Desert racer	حية	LC	LC
Platyceps rogersi	Rogers Racer	حية	LC	LC
Rhagerhis moilensis	False cobra	حية	LC	LC
Eirenis rothi	Roth's Dwarf Snake	حية	LC	LC
Spalerosophis diadema	Diadem snake	حية	LC	LC
Family Viperidae				
Pseudocerastes fieldi	False horned viper	افعى مقرنة	LC	LC

This route has no particular impact on the biodiversity in the region, it is already sited along a heavily disturbed highway where the biodiversity elements are at their minimum.

Avifauna

A treeless Hamada habitat penetrated by several wadi systems some are large extending East-West, and the majority of this block is comprised by chert plains gently undulating platuea and vast stretches are comprised of sand covered by gravel. Despite being largely disturbed by grazing and stone mining activities, and deteriorated with poor vegetation cover, this area supports some lark species witnessed during the field visit indicating that these birds are resident breeders, including, Desert Lark, Bar-tailed Desert Lark, Hoopoe Lark, and Temminck's Lark, where the latter is the most dominant species in this particular region. Other expected breeders include Little Owl, Cream-coloured Courser, and Desert Wheatear.

Migrants include several passerine species that rest in the wadi vegetation; as well as many raptors passing over during migration.

Section B-2: from Al Qatraneh to Dhab'a area

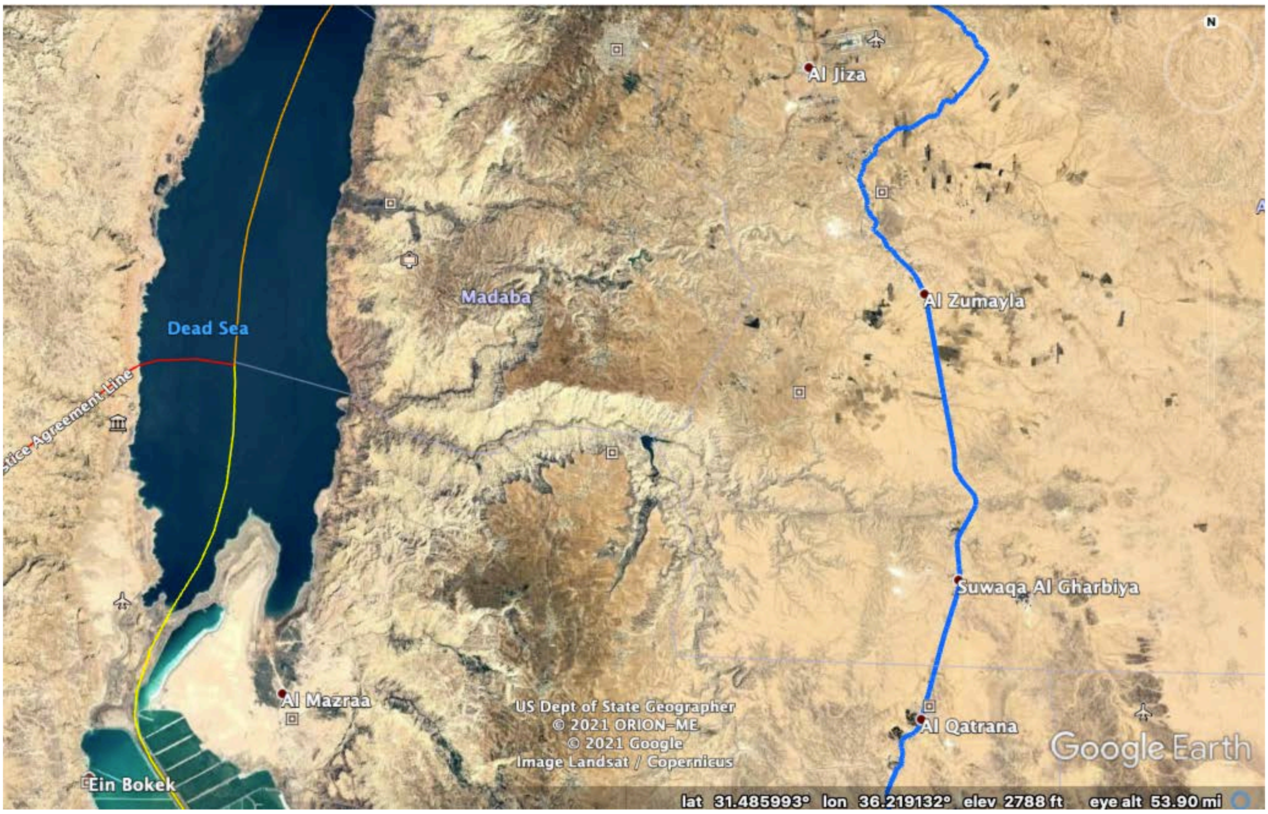


Figure 6-118: Map Showing the Proposed Alignment of Section B-2

Habitat Type and Conditions

The route between Al Qatraneh and Dhab'a lies within a semi desert area that represents the transition zone between the desert and the Mediterranean region of Jordan. However, the route lies along the desert highway that connects Amman with southern Jordan until Aqaba which enjoys heavy disturbance due to the busy traffic on the road. The area is mostly flat semi desert that is often interrupted by low lands (marab) and wadi beds.

Vegetation Type and Floristic Diversity

The dominant species along this section are *Anabasis syriaca* and *Noaea mucronata*. The vegetation cover is limited. Other observed species are listed in Table 6-26.

Table 6-26: Observed Flora Species in section B-2

Genus	Species	Family	Status
Anabasis	*syriaca*	*Chenopodiaceae*	Common
Noaea	*mucronata*	*Chenopodiaceae*	Common
Salsola	*sp*		
Centaurea	*aegyptiaca*	*Compositae*	*Common*
Achillea	*fragrantissima*	*Compositae*	*Common*
Ifloga	*spicata*	*Compositae*	Common
Onopordon sp		*Compositae*	Common
Hordum	*marainum*	*Gramineae*	Common

Figure 6-119: Image of the Habitat Within Daba' Grazing Reserve

Faunal Diversity

Due to the high disturbance from traffic and noise on the highway, the biodiversity is low and has no records of high conservation value. Direct and indirect studies in the site resulted in the confirmation of the presence of seven mammal species, including one lagomorph, 2 rodents, and 1 carnivore, and 13 species of amphibians and reptiles (1 frog, 7 lizards, 5 snakes) through direct observations during the day transects.

Table 6-27: Mammalian species reported from the eastern desert route through direct observation and indirect observations[4]

Species	Common Name	Arabic Name	IUCN Global Status	IUCN Regional Status
Insectivora				
Paraechinus aethiopicus	Ethiopian hedgehog	قنفذ	LC	LC
Chiroptera				
Tadarida teniotis	Free tailed bat	خفاش	LC	LC
Otonycteris hemprichi	Long-eared bat	خفاش	LC	LC
Lagomorpha				
Lepus capensis	Arabian or Cape hare	الأرنب البري	LC	EN
Carnivora				
Vulpes vulpes	Red fox	الثعلب الأحمر	LC	LC

[4] Note: IUCN status: LC Least Concern, NT Near Threatened, VU Vulnerable, E Endangered

Species	Common Name	Arabic Name	IUCN Global Status	IUCN Regional Status
Rodentia				
Meriones crassus	Sand Jird	جرذ الرمل	LC	LC
Gerbillus dasyurus	Wagner's Gerbil	جربوع واقنر	LC	LC

Table 6-28: Amphibians and Reptiles Reported from The Eastern Desert Route Through Direct Observation and Indirect Observations[5]

Species	Common Name	Arabic Name	IUCN Global Status	IUCN Regional Status
Amphibians: Anura				
Bufotes viridis	the Green toad	ضفدع	LC	LC
Gekkonidae				
Hemidactylus turcicus	House Gecko	أبو بريص	LC	LC
Family Agamidae				
Trapelus ruderatus	Syrian Agama	حرذون	LC	LC
Stelloagama stellio	Starred Agama	حرذون	LC	LC
Family Lacertidae				
Acanthodactylus tristrami	Tristram's Fringe-toed Lizard	سحلية	LC	LC
Ophisops elegans	Snake-eyed lizard	سحلية	LC	LC
Mesalina brevirostris	Short-nosed Desert Racer	سحلية	LC	LC
Eumeces schneiderii	Orange-tailed skink	سحلية	LC	LC
Snakes				
Psammophis sckokari	Desert racer	حية	LC	LC
Platyceps rogersi	Rogers Racer	حية	LC	LC
Eirenis rothi	Roth's Dwarf Snake	حية	LC	LC
Spalerosophis diadema	Diadem snake	حية	LC	LC
Family Viperidae				
Pseudocerastes fieldi	False horned viper	افعى مقرنة	LC	LC

This route has no particular impact on the biodiversity in the region, it is sited already along a heavily disturbed highway where the biodiversity elements are at their minimum.

The only important area along this route is the Dhab'a range land reserve, this area represents a refuge for the wildlife since it is fenced and isolated from the surrounding disturbance, we recommend that any construction or work near the reserve be done with minimal disturbance.

Avifauna

Birds within this section are mainly desert dwellers attached to this arid Saharo-Arabian biozone. Bird diversity in this particular area is low due to disturbance and grazing practices. Despite being largely disturbed and deteriorated, with very loose and poor vegetation cover, some lark species occur in the area indicating breeding, including Desert Lark, and Temminck's Lark, where the latter is the most dominant species in this particular region.

[5] Note: IUCN status: LC Least Concern, NT Near Threatened, VU Vulnerable, E Endangered

No other breeding birds are expected to this area, but some migrants mainly passerines are expected to use the site in both spring and autumn migration season. Migratory passerines probably include several species that use vegetation bushes in small wadis.

In summary, the avifaunal diversity is relatively low and largely dependent on the microhabitats within the block, ranging from flat Hamada to shrubbery flat low relief desert patches. The Wadi system varies to great extent depending on the height and vegetation cover, and most of the species observed during the field visit were observed at these wadis.

The preliminary ecological assessment concluded during the site visit, provides clear evidence that the site does not hold nor support any significant faunal communities. No threatened fauna species may occur within the site, due to the limited extent of vegetation and the high-level disturbance within and around the project site. Furthermore, the site and patchy vegetation cover within the site is subject to constant human disturbance.

6.3.5.3. Segment C (Northern Segment) which extends from Al Jiza to PS ADC and Abu A'landa Reservoir and to Al Muntazah reservoir

Section C-1: from Dhab'a to PS ADC

Figure 6-120: Map Showing the Proposed Alignment of Section C-1

Figure 6-121: The Proposed ADC Site – Thuheebah

Habitat Type and Conditions

The route between Dhab'a and the PS ADC site in Thuheebah lies within the transition zone between the desert and the Mediterranean region of Jordan. The route runs to the east around the Queen Alia Airport arbout 11 km east of the desert highway. The area is mostly semi desert that is often interrupted by lowlands (marab) and wadi beds, the area also has some small townships and villages several snmall-scale olive farms and vegetable farms.

Faunal Diversity

Due to the high disturbance from traffic and noise on the highway, the biodiversity is low and has no records of high conservation value. Direct and indirect studies in the site resulted in the confirmation of the presence of seven mammal species, including 3 rodents, and one carnivore, and 11 species of amphibians and reptiles (1 frog, 5 lizards and 5 snakes) through direct observations during the day transects.

Table 6-29: Mammalian Species Reported from The Eastern Desert Route Through Direct Observation and Indirect Observations[6]

Species	Common Name	Arabic Name	IUCN Global Status	IUCN local Status
Insectivora				
Hemiechinus auritus	Long-eared hedgehog	قنفذ	LC	LC
Chiroptera				
Tadarida teniotis	Free tailed bat	خفاش	LC	LC
Pipistrellus kuhli	Kuhl's pipistrelle	خفاش	LC	LC
Carnivora				
Vulpes vulpes	Red fox	الثعلب الأحمر	LC	LC
Rodentia				
Cricetulus migratoris	Gray hanster	الهامستر الرمادي	LC	LC
Gerbillus dasyurus	Wagner's Gerbil	جربوع واقنر	LC	LC

[6] Note: IUCN status: LC Least Concern, NT Near Threatened, VU Vulnerable, E Endangered

Species	Common Name	Arabic Name	IUCN Global Status	IUCN local Status
Spalacidae				
Nannospalax ehrenbergi	Palestine Mole rat	خلد / خلند	LC	LC

Table 6-30: Amphibians and Reptiles Reported from the Eastern Desert Route Through Direct Observation And Indirect observations[7]

Species	Common Name	Arabic Name	IUCN Global Status	IUCN Regional Status
Amphibians: Anura				
Bufotes viridis	the Green toad	ضفدع	LC	LC
Gekkonidae				
Hemidactylus turcicus	House Gecko	أبو بريص	LC	LC
Family Agamidae				
Trapelus ruderatus	Syrian Agama	حرذون	LC	LC
Stelloagama stellio	Starred Agama	حرذون	LC	LC
Family Lacertidae				
Ophisops elegans	Snake-eyed lizard	سحلية	LC	LC
Eumeces schneiderii	Orange-tailed skink	سحلية	LC	LC
Snakes				
Psammophis sckokari	Desert racer	حية	LC	LC
Platyceps rogersi	Rogers Racer	حية	LC	LC
Eirenis rothi	Roth's Dwarf Snake	حية	LC	LC
Spalerosophis diadema	Diadem snake	حية	LC	LC
Dolichophis jugularis	Large Whip Snake	حية حنيش	LC	LC

This route has no particular valuable biodiversity; it is already sited within a heavily disturbed area due to agricultural activities and grazing by livestock where the biodiversity elements are at their minimum.

Avifauna

Highly disturbed and urbanized section of the alignment characterized by poor habitat conditions. The deteriorated habitat in this part leaves little chance to any wild birds to inhabit the area, except for those dependent on human presence like house sparrow. Small areas, however, remain relatively far from human disturbance and may support occurrence of some species including crested lark and little owl.

[7] Note: IUCN status: LC Least Concern, NT Near Threatened, VU Vulnerable, E Endangered

Section C-2: from PS ADC to Abu Alanda Reservoir

Figure 6-122: Map Showing the Proposed Alignment of Section C-2

Habitat Type and Conditions

This is a heavily urbanised area and perhaps one of the densest in the area southeast of Amman. Agriculture and livestock represent a major source of income some of the local communities in the southern portion of the route. House gardens and irrigation systems and open pools provide foraging habitats for bats. As a result of different activities including agriculture, and housing development, the native vegetation has retracted significantly due to these activities. The negative implication of such human activity is very high. The area is already heavily disturbed with infrastructure services (road, water, and electricity). It hosts minimum biodiversity elements. The area is already disturbed from busy traffic and human settlements and has very little value for biodiversity.

Faunal Diversity

One amphibian (frog: *Bufotes viridis*), 5 lizards representing 5 families (Gekkonidae, Agamidae, Chamaeleonidae, Lacertidae and Scincidae), and 5 snakes including 2 families (Typhlopidae, Colubridae).

Table 6-31: Reptiles Recorded from the Vicinity of Southern Amman.[8]

Family Name	Species Name	Common Name	IUCN status
Bufonidae	*Bufotes viridis*	Green Toad	LC
Gekkonidae	*Hemidactylus turcicus*	Turkish Gecko	LC
Agamidae	*Laudakia stellio*	Starred Agama	LC
Chamaeleonidae	*Chamaeleo chamaeleon*	Chameleon	LC
Lacertidae	*Ophisops elegans*	Snake-Eyed Lizard	LC
Scincidae	*Mabuya vittata*	Bridled Skink	LC
Typhlopidae	*Typhlops vermicularis*	Worm Snake	LC
Colubridae	*Dolichophis jugularis*	Large Whip Snake	LC

[8] Note: IUCN status: LC Least Concern, NT Near Threatened, VU Vulnerable, E Endangered

Family Name	Species Name	Common Name	IUCN status
	Hermorrhois nummifer	Coin Snake	LC
	Platyceps rubriceps	Red- Headed Whip Snake	LC
	Eirenis rothi	Roth's Dwarf Snake	LC

The total number of mammalian species from southern amman and its vicinity is 9 species, with none having global IUCN status or regionally threatened. They are represented by 7 families in 4 groups. Bats and rodents are the most common mammals with a total of 4 and 2 species respectively.

Table 6-32: Mammals Recorded from the Vicinity of Southern Amman and their IUCN Global Status, Regional Status in Parentheses after Mallon and Budd (2011) [55][9]

Group	Family	Scientific Name	Common Name	IUCN Global status
Insectivores	Erinaceidae	Erinaceus concolor	European Hedgehog	LC
		Hemiechinus auritus	the Long-eared Hedgehog,	LC
Carnivores	Canidae	*Vulpes vulpes*	The Red Fox	LC
Bats	Rhinolophidae	*Rhinolophus hipposideros*	Lesser Horseshoe Bat	LC
	Vespertilionidae	*Pipistrellus pipistrellus*	Common pipistrelle	LC
		Pipistrellus kuhli	Kuhl's Pipistrelle	LC
	Molossidae	*Tadarida teniotis*	European Free-tailed Bat	LC
Rodents	Spalacidae	*Spalax ehrenbergi*	Palestine Mole rat	LC
	Muridae	*Meriones tristrami*	Tristram's jird	LC

Avifauna

Highly urbanized area with no suitable habitats for wildbirds. Exceptions are species associated to human settlements like house sparrow.

[9] Note: IUCN status: LC Least Concern, NT Near Threatened, VU Vulnerable, E Endangered

Section C-3: from PS ADC to Al Muntazah reservoir

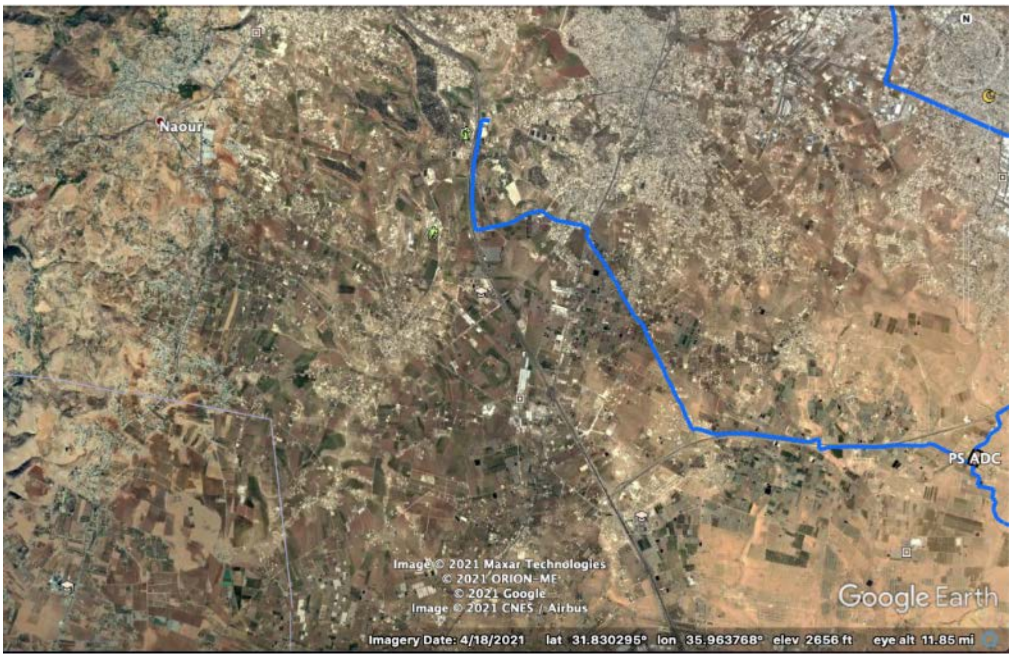


Figure 6-123: Map Showing The Proposed Alignment of Section C-3

Habitat Type and Conditions

The landscape in this area resembles an interwoven mosaic of farms, urban areas, and forest fragments. This area lies fully within the Mediterranean biogeographical region of Jordan. It contains farmlands (olives, various fruit trees, and crops). The soil is predominantly *Terra rosa*.

Within the western and southern portions of Amman, there are several man-made forested areas that were planted by the Ministry of Agriculture. Additionally, a large portion of the area has some form of agriculture, mostly olive and/or fruit farms and crops. The areas have been heavily degraded and altered by the agricultural activities, however, some species still survive using some microhabitats in the area (such as the stone walls, the hedges at the boundaries of the farms) or because of the supply of water from the irrigation of the farms.

Faunal Diversity

One amphibian (frog: *Bufotes viridis*), one tortoise (*Testudo graeca*), 5 lizards representing 5 families (Agamidae, Gekkonidae, Chamaeleonidae, Lacertidae and Scincidae), and 6 snakes including 3 families (Typhlopidae, Colubridae and Viperidae).

Table 6-33: Reptiles Recorded from the Vicinity of Southern Amman[10]

Family Name	Species Name	Common Name	IUCN status
Bufonidae	*Bufotes viridis*	Green Toad	LC
Testudinidae	*Testudo graeca*	Mediterranean Spurthighed Tortoise	VU
Gekkonidae	*Hemidactylus turcicus*	Turkish Gecko	LC
Agamidae	*Laudakia stellio*	Starred Agama	LC
Chamaeleonidae	*Chamaeleo chamaeleon*	Chameleon	LC
Lacertidae	*Ophisops elegans*	Snake-Eyed Lizard	LC
Scincidae	*Mabuya vittata*	Bridled Skink	LC

[10] IUCN status: DD: Data Deficient, LC Least Concern, NT Near Threatened, VU Vulnerable, EN: Endangered, CR: Critically Endangered.

Family Name	Species Name	Common Name	IUCN status
Typhlopidae	*Typhlops vermicularis*	Worm Snake	LC
Colubridae	*Dolichophis jugularis*	Large Whip Snake	LC
	Hermorrhois nummifer	Coin Snake	LC
	Platyceps rubriceps	Red- Headed Whip Snake	LC
	Eirenis rothi	Roth's Dwarf Snake	LC
Viperidae	*Daboia palaestinae*	Palestine Viper	LC

The total number of mammalian species from southeastern Amman and its vicinity is 11 species, with only one having global IUCN status. They are represented by 9 families in 4 groups. Bats and rodents are the most common mammals with a total of 4 and 3 species respectively.

Table 6-34: Mammals Recorded from the Vicinity of Southern Amman and their IUCN Global Status, Regional Status in Parentheses After Mallon and Budd (2011) [55].[11]

Group	Family	Scientific Name	Common Name	IUCN Global status
Insectivores	Erinaceidae	Erinaceus concolor	European Hedgehog	LC
		Hemiechinus auritus	the Long-eared Hedgehog,	LC
Carnivores	Canidae	*Vulpes vulpes*	The Red Fox	LC
	Mustilidae	*Vormela peregusna*	Marbled Polecat	VU
Bats	Rhinolophidae	*Rhinolophus hipposideros*	Lesser Horseshoe Bat	LC
	Vespertilionidae	*Pipistrellus pipistrellus*	Common pipistrelle	LC
		Pipistrellus kuhli	Kuhl's Pipistrelle	LC
	Molossidae	*Tadarida teniotis*	European Free-tailed Bat	LC
Rodents	Cricetidae	*Microtus guentheri*	The Levant Vole	LC
	Spalacidae	*Spalax ehrenbergi*	Palestine Mole rat	LC
	Muridae	*Meriones tristrami*	Tristram's jird	LC

Avifauna

Highly urbanized area with no suitable habitats for wildbirds. Exceptions are species associated to human settlements like house sparrow.

6.3.6. Identified Critical Habitats along the Proposed Alignment

Considering the limited quantitative information, the definition of critical habitats as per the EIB ES3 criteria was based on experts' judgement considering also the nature of the Project and the defined area of its influence (Table 6-35). The impacts assessment findings are elaborated in relevant sections of Chapter 7.3 of this ESIA study.

[11] Notes: IUCN status: DD: Data Deficient, LC Least Concern, NT Near Threatened, VU Vulnerable, EN: Endangered, CR: Critically Endangered.

Table 6-35: Critical Habitats Identified within the Project Area of Influence

Critical Habitat Criteria according to EIB ESS 3	Identified sections meeting respective critical habitat criteria
Criterion 1: habitat of significant importance to Critically Endangered, Endangered or Vulnerable species, as defined by the International Union for the Conservation of Nature (**IUCN) Red List of threatened species and in relevant national legislation**	**Section A-1: Intake/IPS to the RO Plant and to BPS4** is reported to host threatened species. More specifically the following is to be noted: 1) Wadi Al Yutum area is situated along the western border of Wadi Rum Protected Area with solid granite mountains at various altitudes. The remoteness of this area makes it an important refuge for large mammals such as the *Hyaena hyaena* (globally near threatened, declining global population, and endangered at local level in Jordan) and the ibex *Capra nubiana* (near threatened, declining global population). 2) The vulnerable Egyptian Spiny–tailed Lizard *Uromastyx aegyptia* which is reported to have decreasing population, and the near threatened *Platyceps Sinai* (unknown population trend). More specifically the flat gravelly areas east of the RO site contains a small population of the Egyptian Spiny–tailed Lizard. This species is of conservation status on both the local and the international level (listed as near threatened). **Section A-3: from RGT2 to RGT3** is reported to fall within Hizma IBA, and also to host threatened species such as: • The locally endangered *Artemisia jordanica* • The nationally near threatened and globally vulnerable (declining population) *Uromastyx aegyptia and Hyaena hyaena* • The nationally endangered and globally least concern *Lepus capensis*
Criterion 2: habitat important to the survival of endemic or restricted-range species, or unique assemblages of species	**The Aqaba Mountains IBA** from where the important Aqaba Agama *Pseudotrapelus aqabensis* was reported. This species has limited distribution along Aqaba Mountains in Jordan, and can be considered a species that requires more protection.
Criterion 3: habitat supporting globally significant migratory and/or congregatory species	The proposed **alignment section crossing Hizma and Aqaba IBA's**. IBA Criteria met by the Hizma IBA (Wadi Rum and Disi) are A3, B2, B3 (2000). While the IBA Criteria met by the Aqaba Mountains IBA are A4iv, B1iv, B2, B3 (2000). According to the IBA's database, **the Hizma IBA** "An unusually varied assemblage of desert and mountain birds. As well as species listed below, possible or known breeders include *Circaetus gallicus*, *Buteo rufinus*, *Aquila chrysaetos* (outside the Reserve), *Aquila verreauxii*, *Hieraaetus fasciatus*, *Falco pelegrinoides*, *Alectoris chukar*, *Bubo ascalaphus*, *Pycnonotus xanthopygos*, *Oenanthe lugens*, *O. leucopyga*, *Nectarinia osea*, *Corvus rhipidurus* and *Emberiza striolata*. Quite large numbers of migrating *Buteo buteo* have been seen irregularly (max. 100, April). Two key species, now apparently extinct, are the globally threatened *Chlamydotis undulata* (formerly a rare winter visitor) and the regionally threatened *Gypaetus barbatus* (formerly a rare resident)." [59] According to the IBAs database, **Aqaba IBA** is a "migratory bottleneck site also holding a breeding bird community representative of the Rift Valley. The enormous spring passage of raptors just across the border at Eilat only occasionally passes over Aqaba, as indicated by the relatively small maximum daily counts: *Buteo buteo* (105, April) and *Accipiter brevipes* (75, September). Generally, raptors cross the Rift Valley into Jordan further north up Wadi Araba (see site 013), but spring passage at

Critical Habitat Criteria according to EIB ESS 3	Identified sections meeting respective critical habitat criteria
	Aqaba undoubtedly exceeds 50,000 raptors per season. Raptor passage in autumn is relatively insignificant" [60] Refer to Figure 6-102
Criterion 4: highly threatened or unique ecosystems	The Aqaba Mountains IBA is reported by Birdlife to be under high pressure (threat) from recent economic developments in Aqaba, including ports development, industrial area, construction of the coastal road, tourism, hunting and overgrazing.
Criterion 5: areas associated with key evolutionary processes	None identified along the proposed alignment
Criterion 6: habitat of key scientific value	Little information is available about biodiversity within the Aqaba Mountains IBA due to the limited scientific research in this IBA. The identification of new to science species like Aqaba Agama, and the reported threatened species from the area indicate the need for more research. Though there is no reference in Jordan indicating habitat of key scientific value, hence, the Consultant believes this IBA qualifies under this criterion.

6.4. Socioeconomic Environment

This section presents the socioeconomic baseline condition in the project area. Along the conveyance route, the project crosses several governorates and districts in Jordan and Table 6-36 presents the areas relevant to the project components, while Figure 6-124 illustrates them geographically.

Table 6-36: Relevant Localities to the Project Components

No.	Governorate	District	Municipality	Locality	Project Component
1	Aqaba	Qasabat Aqaba	Aqaba City, Houd Al Disi, Rum	Aqaba, Dieseh, Rum, Salhiyeh, Twaiseh, and Al-Shakryeh	Water Desalination / Water Conveyance / Pumping Stations / Tanks
2	Maan	Qasabat Maan	Jafr	Jafr, Mudawara	Water Conveyance / Pumping Stations / Tanks
3	Tafileh	Hasa	Hasa	Hasa	Water Conveyance / Pumping Stations
4	Karak	Qatrana	Qatrana, Sultani	Qatrana, Sad Sultani, Wadi Abyad	Water Conveyance / Pumping Stations
5	Amman	Jeza	Jeza Al Jadida	Jeza, Qastal, Dabaa, Dobiaa, Saifieh, Qunaitera, Kteifeh, Lusane, Dheibeh Al Sharqiyyeh, Al Rjeib	Water Conveyance / Pumping Stations / Tanks
		Mouwaqer	Mouwaqer	Sewaqa, Damikhy, Rojem Al-Shami Al-Gharbi, Al-Dhaihybeh Al-Gharbieh, Al Kteifeh	
		Quwaismeh	Quwaismeh	Quwaismeh, Abu Alanda	
		Sahab	Sahab	Sahab	

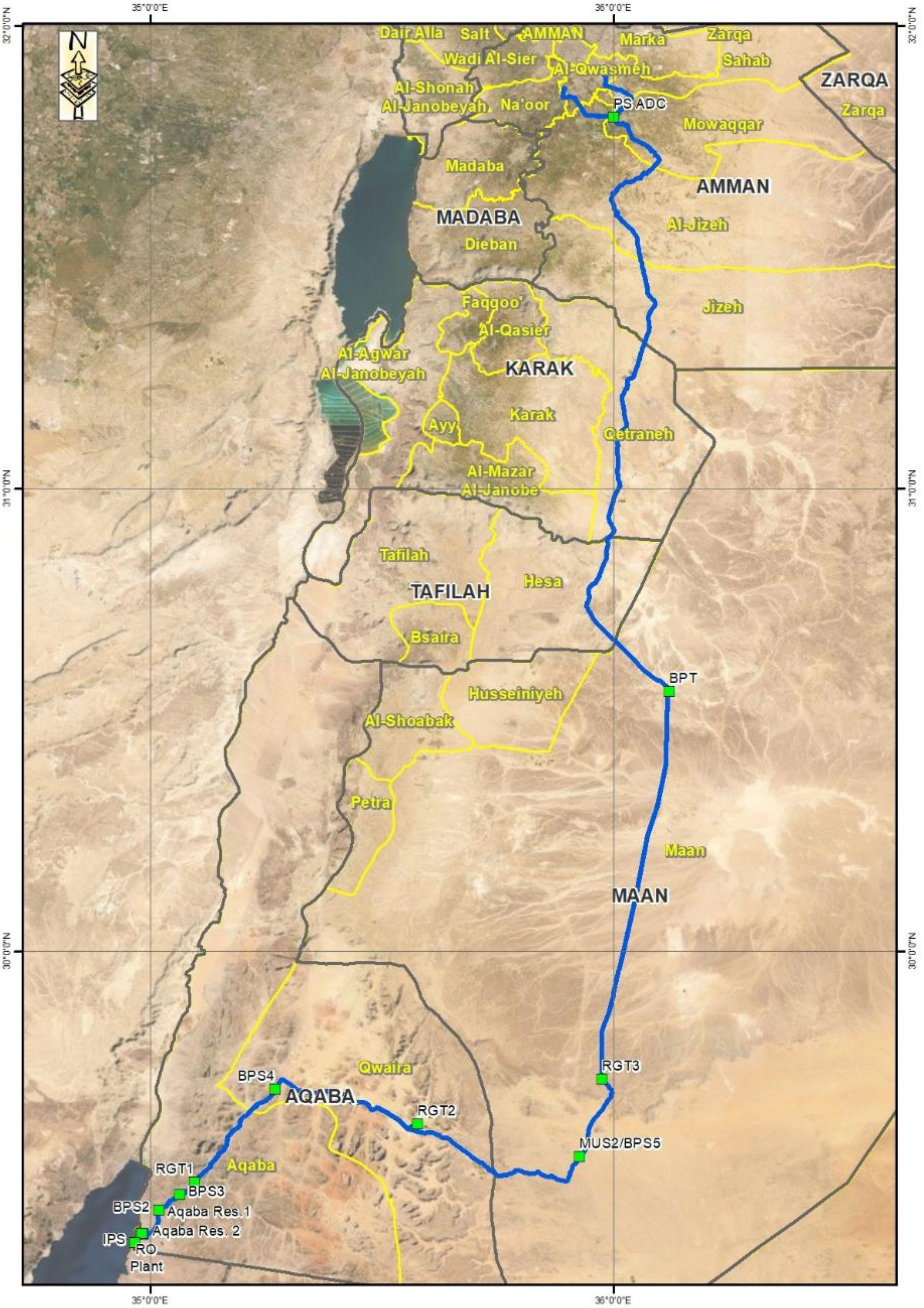


Figure 6-124: Governorates and Districts in within The Project Area

6.4.1. 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 between 15 – 64-year age and 3.7% are above 65. Table 6-37 below represents the number of households, total population and gender [61] as well as the population density [62] in each of the Governorates of Aqaba, Ma'an, Tafileh, Karak and Amman.

Table 6-37: Household, Population, Gender and Population Density in the Governorates of Aqaba, Ma'an Tafileh, Karak and Amman

Governorates	Households	Female	Male	Total Population	Population density per km^2
Aqaba	43,604	92,500	120,500	213,000	27.3
Ma'an	37,789	85,700	93,600	179,300	4.4
Tafileh	21,843	52,000	57,000	109,000	43.6
Karak	71,866	171,200	187,200	358,400	90.6
Amman	979,560	2,100,500	2,436,000	4,536,500	528.8

As of July 2021, the total number of refugees living in Jordan and originally coming from Syria, Iraq, Yemen, Sudan, Somalia and other countries is 756,729 refugees including 627,867 individuals living in urban areas (83%) and 128,862 (17%) living in camps. The highest number of refugees in Jordan is presented by the registered Refugees coming from Syrian with a total of 668,332 (88.3%) [63]. 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 [64].Jordan's urban population is about 91.4% of its total population. As Jordan continues to grow, the urban population is expected to continue growing too [65]. The project passes through 5 governorates including around 26 localities. The population estimates (Females and Males) in each locality are presented in Table 6-38 while Figure 6-125 depicts them on a map along with the project components.

Alquaismeh district is considered as the densest district with a population of 335,936. This is where PS ADC – Abu Alanda branch is connecting to the existing Abu Alanda reservoir, also passing through Sahab with a 191,800 population. Similarly, the second PS ADC – Al Muntazah branch passes through Khraibet Essooq, Jawa, Yadoode with around 210,731 population.

Table 6-38: Population of Localities Relevant to the Project [61]

Governorate	District	Sub-district	Municipality	Locality	Locality Population			
					Households	Total	Female	Male
Aqaba	Aqaba Qasabah	Aqaba	Iqleem Al Aqaba	Aqaba	35,245	167,986	71,504	96,482
	Quairah	Dieseh	Hud Aldisah	Dieseh	629	3,237	1,466	1,771
				Twaiseh	451	2,405	1,217	1,188
		Quairah	Quairah Aljadedah	Rum	389	2,245	1,040	1,205
				Salhiyeh	83	419	213	206
				Shakreyh	85	350	174	176
Ma'an	Ma'an Qasabah	Jafr	Jafr	Jafr	1,339	7,238	3,473	3,765
				Modawwarah	144	783	371	412
Tafileh	Hasa	Hasa	Hasa	Hasa	1,689	9,147	4,382	4,765
Karak	Qatrana	Qatrana	Qatrana	Qatrana	1,371	8,001	3,148	4,853
			El-Soltani	Sad Sultani	656	3,391	1,731	1,660
				Wadi Abyad	162	938	441	497
Amman	Jezeh	Jezeh	Jezeh	Jezeh	18,526	107,590	42,218	65,372
				Qastal		9,456	3,570	5,886
				Qunaitra		1,263	448	815
				Saifieh		603	254	349
			Amireah	Dabaa	286	1,767	820	947
		Um Rsas	Um Rsas	Damki	324	1,886	880	1,006
	Muwaqqar	Rojum Shami	Muwaqqar	Laseen	129	731	388	343
				Ktafeh	165	837	440	397
				Rojom Shami Gharbi	2,435	11,922	5,745	6,177
				Dhaibeh Gharbiyyeh	1,415	7,542	3552	3,990
				Ktafeh	165	837	440	397
		Muwaqqar		Dheibeh Al Sharqiyyeh	1,320	6,623	3,097	3,526
	Alquaismeh	Alquaismeh	Greater Amman	Alquaismeh, Aljwaydeh, Abu Alanda, Alrajeeb	67,973	335,936	154,132	181,804
				Khraibet Essooq, Jawa, Yadoode	41,376	210,731	97,541	113190
	Sahab	Sahab	Sahab	Sahab	36,475	191,800	79,170	112,630

Figure 6-125: Localities Along the Project Area

6.4.2. Economic Activities

Jordan's economy is among the smallest in the Middle East, with insufficient supplies of water, oil, and other natural resources. The World Bank estimated the Jordanian economy to have contracted by 1.6% in 2020. The economic shock of COVID-19 has exacerbated both existing structural weaknesses in the economy and unresolved social challenges, putting pressure on the country's fragile macroeconomic stance. 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. Female unemployment, which had been declining between 2017 and 2019, from 31.2% to 27%, rose sharply to 32.8% in Q4-2020. Moreover, youth unemployment (15–24 years) jumped significantly—from 40.6% in 2019 to an unprecedented high of 50% by the end of Q4-2020.

According to 2019 data, more than a quarter of employment is in public administration (Table 6-39). This includes a significant share of employees in the army, defence and the government sector. Other important sectors are wholesale and trade; education; manufacturing, and transportation.

Table 6-39: Employed Jordanians Age (15+ years) by Main Current Economic Activity, 2019 [66]

Economic Activity	Percent
Agriculture, Forestry & Fishing	1.7
Mining & Quarrying	0.6
Manufacturing	9.5
Electricity, Gas, Steam & Air Conditioning supply	0.9
Water Supply, Sewerage, Waste Management and Remediation Activities	0.4
Construction	4.9
Wholesale & Retail Trade, Repair of Motor Vehicles and Motorcycles	14.9
Transportation and Storage	6.8
Accommodation and Food Service Activities	3.2
Information and Communications	1.5
Financial and Insurance Activities	1.8
Real Estate Activities	0.3
Professional, Scientific and Technical Activities	3.0
Administrative and Support Service Activities	1.5
Public Administration and Defence, Compulsory Social Security	**27.1**
Education	12.9
Human Health and Social Work Activities	5.4
Arts, Entertainment and Recreation Activities	0.4
Other Service Activities	2.4
Activities of Households as Employers, Undifferentiated Goods and Services Producing Activities of Households for Own Use	0.1
Activities of Extraterritorial Organizations Bodies	0.6

The economic activities that characterize each of the Governorates where the project passes are identified as follows [62]:

Aqaba Governorate

Aqaba Governorate has the only sea port in Jordan and has a strategic location as it is bounded with Haqel town in the Kingdom of Saudi Arabia, Egypt, and Eilat. Since 2001, it has become a special economic zone suitable for investments and the Aqaba city became an important administrative center with industrial facilities, commercial free zones and the King Hussein Airport. Phosphate and some types of sea shells can be extracted from Aqaba. Moreover, it is famous for its diving sites and it shores on the Red Sea.

Ma'an Governorate

The first administrative centers were established in the city of Ma'an and the governorate is one of the oldest. The Governorate has a strategic location as it is close to Aqaba port and is crossed by the Saudi-Iraqi highway. Ma'an presents a diversity of terrains that include mountainous and desert regions and occupies 32% of the Kingdom's total area. The agricultural activities were undertaken through various investments in Shobak region, Mudawwarah, Ras Al-Naqab, and Al-Muhammadeyeh. The industrial sector in the governorate presents a low competitiveness and the existing Ma'an Industrial Park needs to receive industrial investment for its infrastructure. There are phosphate mines and some natural resources including building limestone, silica sand, phosphate and kaolin. The governorate hosts the Aqaba Railway Corporation where its offices are in Ma'an as well as the railways leading to Aqaba. Furthermore, an Economic Zone in Ma'an needs to be launched. As for the archeology and history of Ma'an, the main sites are mainly Petra City, Shobak Castle, and the palace of the founder of Jordan, King Abdullah I that are visited by the tourists.

Tafileh Governorate

Tafileh Governorate occupies the middle of the southern part of Jordan and is adjacent to the Desert Highway. Its climate is diversified including the Ghour, Semi-Ghour and mountainous regions and it is rich in water resources. Many agricultural lands are present in the governorate that is mainly renowed for its vine orchids and olive trees thousands of years. In addition, Tafileh is rich in raw materials (phosphate, raw materials for cement, and copper) and the mining sector is a main activity in the governorate where Al-Hassa County hosts phosphate mines and Al-Rashadeyeh in Bsairah County hosts a cement factory. The export of these materials is an activity of high importance for the governorate. Furthermore, touristic activities are mainly Dana Reservation, Efrah and Burbaitah Hot Springs.

Karak Governorate

Karak Governorate is mainly dependent on the agriculture and industrial sector and is characterized by its diverse terrains of desert, mountainous, semi-Ghour, and Ghour regions that present low prices in reference to the Capital Amman. Poultry farms in Karak cover 33% of Jordan's market consumption and several industrial estates and private sector companies are identified and an educated labor force is available. Moreover, in Karak some extraction activities of raw minerals occur such as potash, phosphate, bromine, cement raw materials, and gypsum. The tourism sector in the governorate is active as it hosts the lowest elevation point in the world (the Dead Sea), Al-Mujeb Dam as well as the warm Ghour region in winter and having Prophet's Companions Tombs.

Amman Governorate

Amman has a central geographical location among the Kingdom's governorates and is the commercial, administrative, economic and educational hub of Jordan. Due to its strategic position in Greater Syria and the Middle East, around 90% of economic investments are undertaken at the national level. It is home to 48% of the economic and commercial institutions nationally and has commercial businesses in the form of shopping and large commercial centers. Moreover, Amman has witnessed a speedy development of the construction sector. Amman is visited by many Arabs and tourists from Europe, North America, Japan, Australia due to its unique and modern architecture. The touristic activities cover various athletic and cultural centers, hotels (5 star-hotels), health and treatment centers.

Women's participation in the labour market is low despite high levels of education. Jordan has one of the world's lowest rates of female participation, comprising 19% of the workforce in 2019 [66]. Gender occupational segregation in the workforce is prevalent with women making up significant proportions of certain professions considered more socially acceptable, including education, health care, agriculture, welfare, or volunteer work. This has created gender gaps in the fields of technology, engineering, and business administration. Within the project area, Amman has the highest unemployment rate with around 42% total while Tafilah has the lowest rate with around 2% (Figure 6-126).

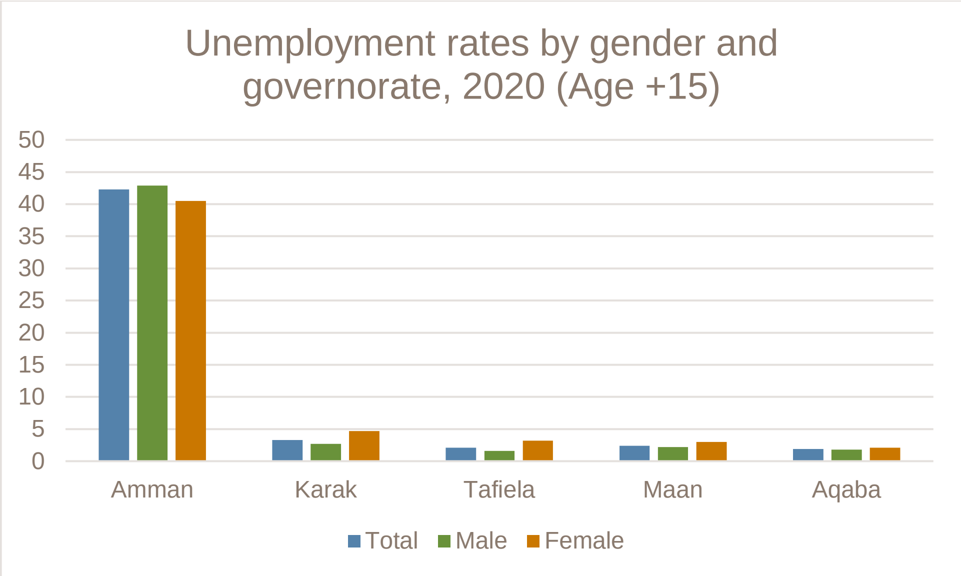


Figure 6-126: Unemployment Rates by Gender and Governorate, 2020 [67]

In 2018, the poverty rate in Jordan was 15.7% for Jordanians and 78% for Syrian refugees [68]. According to the last Poverty Analysis Report of 2012, the absolute poverty rate in Jordan was 14.4% and the poverty line was 813.7 JD per person annually (or 68 JD monthly). According to this report, Ma'an has the highest poverty rate in Jordan with 26.6% while Amman is the lowest with 11.45% (Figure 6-127).

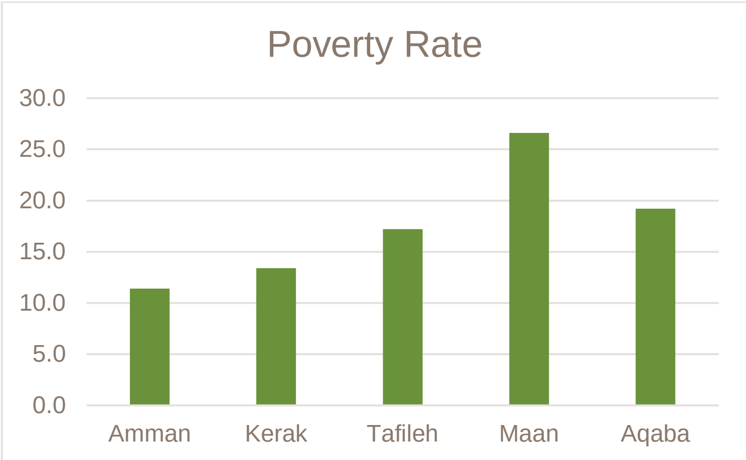


Figure 6-127: Poverty Rate in the Relevant Governorates [69]

6.4.3. Education Services

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 6-128). 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.

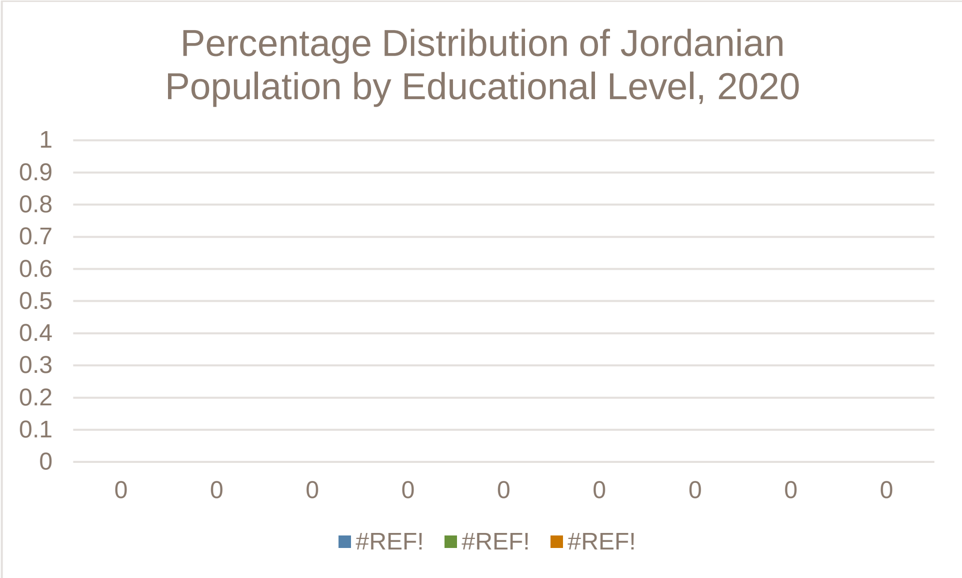


Figure 6-128: Percentage Distribution of Jordanian Population by Educational Level, 2020 [67]

In 2019, there were 838 schools in Amman, 309 in Karak, 192 in Ma'an, 121 in Tafileh and 77 in Aqaba [70]. The number of schools differs from one directorate to another in the relevant governorates. For example, in Amman Qasabah there is 431 school with 155,605 students (Table 6-40). In Mwaqqar, there are 66 school with 16,247 students. It is usually depending on the population density. Amman Governorate, which is the capital has the highest number of students with 794,981 students while the total country students are 2, 151,670.

Table 6-40: Number of Schools and Students in Relevant Directorates to the project [67]

Governorate	Directorate	Number of Schools	Number of Students		
			Total	Female	Male
Aqaba	Aqaba	151	50,378	24,877	25,501
Ma'an	Ma'an	61	12,945	6,379	6,566
	South Badia	86	15,620	7,895	7,725
Tafiela	Tafiela	104	21,787	10,779	11,008
Karak	Karak Qasabah	155	31,302	15,372	15,930
Amman	Amman Qasabah	431	155,605	79,180	76,425
	Sahab	93	33,298	16,233	17,065
	Al Qwesmeh	359	140,918	70,920	69,998
	Mwaqqar	66	16,247	8,313	7,934
	Jezah	106	18,467	9,600	8,867

Moreover, the Governorate of Amman hosts many universities such as the University of Jordan, Philadelphia University, Middle East University and many others as well as different colleges and specialized academic institutes. Ma'an Governorate comprises the King Hussein University and two community colleges that are in Ma'an and Shobak. In Tafileh, there is the Tafileh Technical University and in Karak, Mu'tah University [62].

6.4.4. 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 [67]. There were 72 hospitals and 179 healthcare centres are within the project area, divided as shown in Table 6-41.

Table 6-41: Number of Healthcare Centers and Hospitals in relevant governorates to the project [67]

Governorate	Number of Health's Centers	Number of Hospitals
Aqaba	13	4
Ma'an	22	2
Tafiela	17	1
Karak	39	5
Amman	88	60

6.4.5. Land Use

Actual land use of each component of the project varies from one to another and this can be confirmed due to the project size and spread from the south of Jordan to the middle where it passes near various land types and uses. This section discusses the actual land use of each component of the project and extends to describe each site of the project component.

6.4.5.1. IPS

The intake pumping station is an undeveloped land (Figure 6-129) located to the north of the phosphate jetty (Figure 6-130) and to the south of Aqaba thermal plant and Fajr Gas company. Currently, some areas of the land have been used as a stockpiling for a nearby construction project.

Figure 6-129: IPS Site

Figure 6-130: Phosphate Jetty

6.4.5.2. IPS to SWRO

The alignment from the intake pumping station to the desalination plant is clearly crowded by many industrial facilities. It is mostly a road that (Figure 2-22) passes in front of many industrial facilities such as phosphate company, potash company, Jordan Oil Terminal company, Aqaba Bulk Chemicals company, Aqaba Thermal Plant and Fajr Gas company. Right next to Jordan Oil Terminal company, the alignment will cross a valley (Figure 6-132) and another hill in order to be connected to the SWRO plant. Similarly, this route will also include the brine discharge pipeline from the desalination plant to the intake pumping station.

Figure 6-131: Main Road in the Industrial Zone Where the Conveyance Pipeline Passes from the IPS to the SWRO

Figure 6-132: A Valley Next to Jordan Oil Terminal Company

6.4.5.3. RO Plant and Aqaba Reservoir 2

The desalination plant site is extremely rugged and surrounded with main roads (Figure 6-133). However, it is barren land with clear water stream traces (Figure 6-134) and some burned out tires (Figure 6-135).

Figure 6-133: SWRO Site

Figure 6-134: Water Stream Traces in the Desalination Plant Site

Figure 6-135: Burned Tires at the Desalination Plant Site

6.4.5.4. RO to BPS 2 and Aqaba Reservoir 1

The conveyance pipeline mainly follows the right of way of the 'Ports Back Road' (Figure 6-136) for around 7 km to reach BPS 2 and Aqaba Reservoir 1. On its way, it passes opposite Aqaba University of Technology Figure 6-137.

Figure 6-136: RO to BPS 2

Figure 6-137: Aqaba University of Technology

6.4.5.5. BPS 2 and Aqaba Reservoir 1

The site of BPS 2 and Aqaba Reservoir 1 is also barren and has not been developed or used before. The site is almost flat and located opposite to Aqaba University of Technology and near to south Aqaba Investment Park on the Aqaba Back Road.

Figure 6-138: BPS 2 and Aqaba Reservoir 1 Site

6.4.5.6. BPS 2 to BPS 3

For around 6 km, the conveyance pipeline passes through the right of way of the 'Ports Back Road' from BPS 2 to BPS 3. Through that way it passes near to the 'Southern Arena for Trucks and Tanks' (Figure 6-139), the 'South Aqaba Investment Park on the Aqaba Back Road' (Figure 6-140), and the 'Vehicle Licensing Department/Technical Inspection Directorate'.

Figure 6-139: Southern Arena for Trucks and Tanks

Figure 6-140: South Aqaba Investment Park on the Aqaba Back Road

6.4.5.7. BPS 3

BPS 3 site has a stony hill feature (Figure 6-141) surrounded by extended undeveloped areas.

Figure 6-141: BPS 3 Site

6.4.5.8. BPS 3 to RGT 1

Around 5 km between BPS 3 and RGT 1, where the conveyance will pass through the right of way until it reaches the 'Aqaba Customs Yard 4' where RGT 1 is located to the east. The 'Aqaba Customs Yard 4' includes a customs area and some shops (Figure 6-142).

Figure 6-142: Aqaba Customs Yard 4

6.4.5.9. RGT 1

RGT 1 site (Figure 6-143) is a sandy barren land with a slight elevation difference between the access road level and the land itself.

Figure 6-143: RGT 1 Site

6.4.5.10. RGT 1 to BPS 4

There are around 30 km between RGT 1 and BPS 4. The distance includes mainly number of petrol stations, seasonal farms (Figure 6-145) and Wadi Al Yutum Customs (Figure 6-144). However, the conveyance pipeline will pass mainly through the desert highway (R15) right of way.

Figure 6-144: Wadi Al Yutum Customs

Figure 6-145: Seasonal Farms from RGT 1 to BPS 4

6.4.5.11. BPS 4

The site of BPS 4 is a flat arid undeveloped site as shown in Figure 6-146 below.

Figure 6-146: BPS 4

6.4.5.12. BPS 4 to RGT 2

The 35 km distance between BPS 4 and RGT 2 includes several localities such as Salhiyah, Shakriyah, Diseh and Twiseh in addition to number of tourists camps and shops (Figure 6-147 and Figure 6-148). The area within Wadi Rum also includes farms and agricultural areas (Figure 6-149) while the conveyance pipeline will go through the right of way of the existing road.

Figure 6-147: Shops in Diseh

Figure 6-148: Tourist Camp in Wadi Rum

Figure 6-149: Farms near RGT 2 Site

6.4.5.13. RTGT 2

RGT 2 site (Figure 6-150) is located on a mountain near the Rum Agriculture Company (Figure 6-151). The site is elevated and rocky.

Figure 6-150: RGT 2 Site

Figure 6-151: Rum Agriculture Company

6.4.5.14. RGT 2 to MUS2 / BPS5

Around 40 km is the pipeline distance between RGT 2 and booster pumping station 5. The land use within that segment can be divided into 2 main categories; agricultural areas within Wadi Rum well field area (Figure 6-152) where the conveyance pipeline passes through semi-off roads (agricultural service roads) (Figure 6-153)) near existing farms and undeveloped virgin areas in the vicinity of Mudawara site 2 (Figure 6-154).

Figure 6-152: Agricultural Area within Wadi Rum Well Field

Figure 6-153: Agriculture Service Roads

Figure 6-154: Undeveloped Virgin Areas in the Vicinity of Mudawara Site 2

6.4.5.15. MUS2 / BPS5

BPS 5 site (Figure 6-155) is adjacent to Mudawwara site 2 (Figure 6-156). The land is flat and barren.

Figure 6-155: BPS 5 Site and MUS2

Figure 6-156: MUS2

6.4.5.16. MUS2 / BPS5 to RGT 3

Starting from BPS 5 to reach Dab'a and Dubai'a (South of Amman), the conveyance pipeline will follow Disi pipeline route (Figure 6-157 and Figure 6-158). The approximately 18 km segment of the conveyance pipeline between BPS 5 and RGT 3 will be mainly through the right of way of the existing Disi pipeline service road. The route also includes number of existing facilities for Disi pipeline (Figure 6-159).

Figure 6-157: Disi Pipeline Manhole

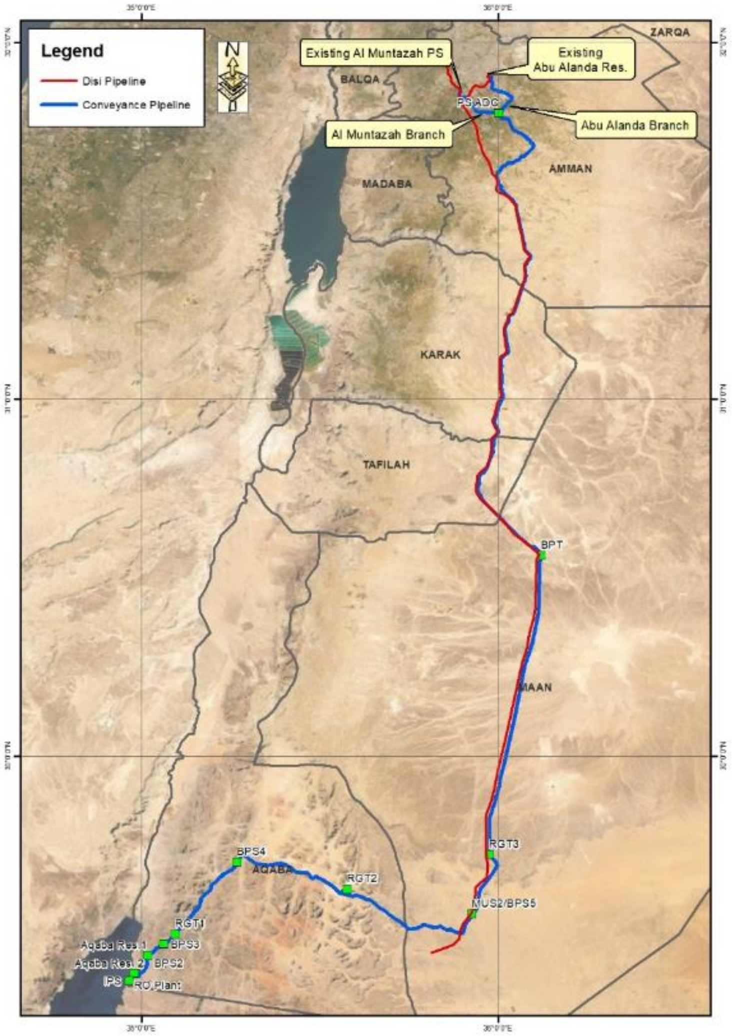


Figure 6-158: Conveyance Pipeline and Disi Pipeline

Figure 6-159: Existing Facility for Disi Pipeline

6.4.5.17. RGT 3

RGT 3 site (Figure 6-160) is located in front of an existing facility for Disi pipeline (Figure 6-161). The site is semi-flat and sandy. The land is undeveloped and barren.

Figure 6-160: RGT 3 Site

Figure 6-161: Existing Facility for Disi Pipeline

6.4.5.18. RGT 3 to BPT

Around 95 km span between RGT 3 and the BPT. Throughout this distance, the conveyance alignment follows the Disi pipeline (Figure 6-162) through its service road right of way and passes through a number of primary and secondary existing roads (Figure 6-163). The stretch also includes agricultural areas northeast of King Faisal Air Base in Al Jafer (Figure 6-164).

Figure 6-162: Some Disi Manholes

Figure 6-163: Existing Road Along the Route Between RGT 3 and BPT

Figure 6-164: Farms near to King Faisal Air Base (Al Jafer)

6.4.5.19. BPT

The BPT site (Figure 6-165) is in front of existing Disi pipeline facility (Figure 6-166). The site is flat and sandy with some desert shrubs. The surrounding area is undeveloped and barren.

Figure 6-165: BPT Site

Figure 6-166: Existing Disi facility

6.4.5.20. BPT to PS ADC

Approximately 140 km exist between BPT to ADC pumping station. The first 25 km of the conveyance pipeline from BPT towards PS ADC is mainly within the Disi pipeline service road right of way. The land use in the vicinity of that segment is mainly undeveloped with some scattered pastoral desert areas (Figure 6-167). Afterward the conveyance pipeline passes through the desert highway (R15) right of way, south to Al Hasa district (Figure 6-168).

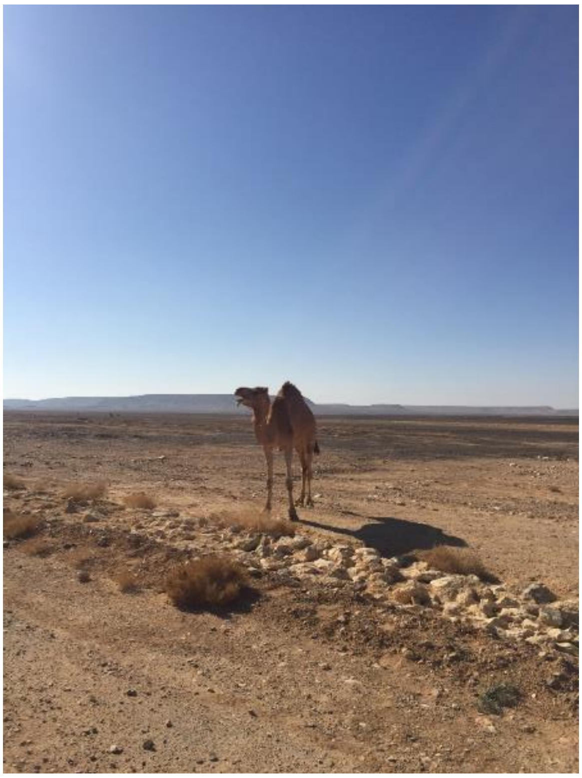


Figure 6-167: Observed Camels

Figure 6-168: Al Hasa District

From Al Hasa district towards PS ADC, the conveyance pipeline passes through number of localities and developed areas such as Wadi Abyad, Al Sultani, Al Qatrana, Al Zumayla, Damkhi, Swaqa, Zmaileh, Zabayer Al Wtairi, Araynba Al Sharqiyah, Araynba Al Gharbiya, Al Saifyeh, Al Qunaitra, Al Kutaifa, Al Tneib, Thuheiba Al Gharbia and Thuheiba Al Sharqiyah, Dab'a and Dbai'a. These localities include number of shops, petrol stations, governmental complexes, and houses (Figure 6-169, Figure 6-170 and Figure 6-171) in addition to some scattered farms (Figure 6-172). The conveyance pipeline will be mostly laid in the right of way of existing roads. However, it will also pass-through some privately owned lands (Figure 6-173) to the south and east of Queen Alia International Airport area.

Figure 6-169: Observed Shops

Figure 6-170: Observed Trucks

Figure 6-171: Observed Petrol Station

Figure 6-172: Observed Farms

Figure 6-173: Some Private Lands Ownership to the South of QAIA

6.4.5.21. PS ADC

PS ADC (Figure 6-174) is close to number of farms and there are a few houses on the western side of the site. However, there are no adjacent farms around the site. The site is flat and currently undeveloped.

Figure 6-174: PS ADC

6.4.5.22. Abu Alanda Branch

Around 15 km length branch pipeline (Figure 6-175) will be connecting PS ADC with existing Abu Alanda Reservoir (Figure 6-176) in Abu Alanda, the branch will pass through the right of way of existing roads surrounded by heavily crowded area especially in Sahab and Abu Alanda. The area has a mixed land use which consists of residential, commercial, and industrial use (Figure 6-177, Figure 6-178, Figure 6-179 and Figure 6-180).

Figure 6-175: Abu Alanda Branch

Figure 6-176:Existing Abu Alanda Reservoir

Figure 6-177: Observed Shops Between PS ADC and Abu Alanda Existing Reservoir

Figure 6-178: Residential Area in the Vicinity of Abu Alanda Existing Reservoir

Figure 6-179: Observed Street Vendor in the Vicinity of Abu Alanda Existing Reservoir

Figure 6-180: Industrial Area Between PS ADC and Existing Abu Alanda Reservoir

6.4.5.23. Al Muntazah Branch

Around 16 km pipeline branch will connect PS ADC and Al Muntazah Existing Reservoir (Figure 6-181). This segment consists of mostly agricultural areas and some residential such as Khrebet Al Souq (Figure 6-182). The pipeline will follow the existing roads within the right of way and are adjacent to some farms (Figure 6-183).

Figure 6-181: Existing Al Muntazah Reservoir

Figure 6-182: Al Muntazah Branch

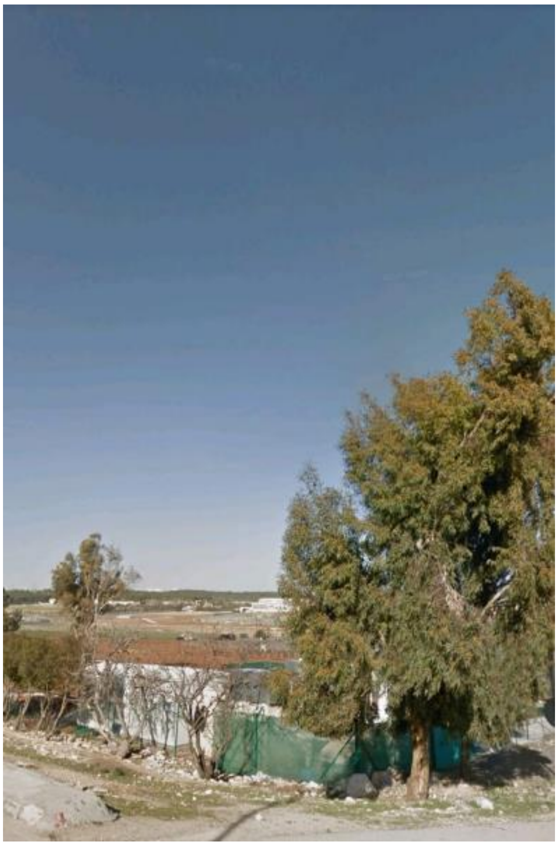


Figure 6-183: Agricultural Area in the Vicinity of Al Muntazah Existing Reservoir

6.4.6. Noise

Noise levels were measured at two locations along the conveyance pipeline representing the northern and southern areas of the Project. Table 6-42 presents a summary of the monitoring results, which are found in detail in **Annex 10.** The results 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.

Table 6-42: Summary of Noise Level Monitoring

Site, Coordinates of monitoring (Lat, Long)	Parameter, Unit	Result									Instruction for Reduction and Prevention of Noise for 2003	Test Method
		Daily Min. reading			Daily Max. reading			Daily average				
		Day 1	Day 2	Day 3	Day 1	Day 2	Day 3	Day 1	Day 2	Day 3		
Site 1 (Coordinates: 29°32'33.3"N 35°43'09.8"E)	Noise (dBA) Daytime	32.1	32.1	31.3	73.2	66.9	71.3	43.3	40.3	41.9	65 dBA	ANSI S1.13
	Noise (dBA) Nighttime	31.6	31.4	32.6	71.4	70.1	68.1	40.2	38.0	38.6	55 dBA	
Site 2 (Coordinates: 31°52'19.0"N 36°00'09.0"E)	Noise (dBA) Daytime	37.7	36.8	37.4	77.8	79.5	78.6	55.0	55.1	52.6	65 dBA	ANSI S1.13
	Noise (dBA) Nighttime	37.9	37.6	36.8	79.7	77.6	75.6	48.0	46.3	44.4	55 dBA	

6.4.7. 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 fact, water is delivered ones per week on average in big cities while some areas receive water every other or two weeks. This intermittent supply regime generates risk on the water quality due to intrusion of pollutant to the supply network and long storage time.

In 2014, the available renewable freshwater resources in Jordan were 533MCM, depending on annual rainfall. This amount was less than 60 m^3 per person. Annually, the country requires about 1,400 MCM (2014) but has, on average, only 848 MCM of freshwater supply available for various uses. Of the total requirement, 381 MCM freshwater is allocated to agriculture and pastoral uses, 429 MCM for municipal supply and around 37 MCM for industrial activities.

Since the Disi-Amman Conveyor became operational in the Summer of 2013, the continuity of supply in Amman has increased. However, the Jordanian population in the Northern Governorates have not benefitted fully due to increase in demand resulting from the influx of refugee after onset of the war in Syria. As for the south, Aqaba has continuous water supply from the Disi aquifer. As a matter of fact, groundwater contributes to around 61% of the total water supply; however, out of the 12 major groundwater basins, six are over-extracted, four are at capacity and two are underexploited. The National Water Strategy emphasizes desalination and wastewater reuse to meet shortfalls in freshwater availability and to bridge the remaining gap between demand and supply through increased use of non-conventional water [71].

Regarding illegal water resource uses, in 2013, the MWI started a campaign aiming to stop all illegal water uses including closing unlicensed groundwater wells. The first step was amending the legislations by increasing penalties, the second enforcing the amended legislation. Figure 6-184 presents the location and distribution of public wells in different governorates within the project area.

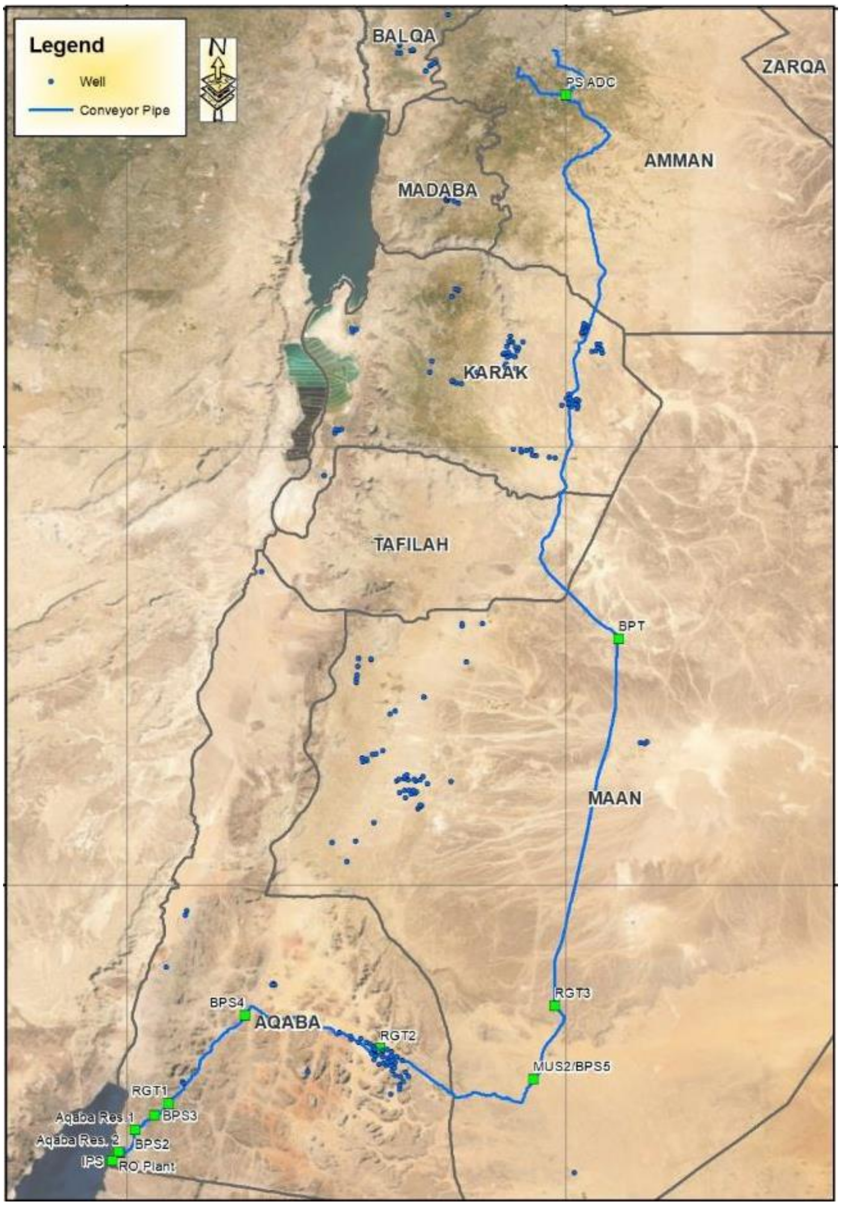


Figure 6-184: Location of Public Wells within the Project Area

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. This percentage is expected to increase to 80% by 2030. 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. It is estimated that by 2025, the volume of treated wastewater will be 240 MCM. The 33 central wastewater treatment plants are expected to treat this capacity by 2025; however, many of the existing plants will need urgent rehabilitation and extension work. Figure 6-185 shows the existing wastewater treatment plants (WWTP) within the project area [71].

Figure 6-185: Location of WWTP within the Project Area

Table 6-43 presents a general description of each WWTP located within the project area.

Table 6-43: Characteristics of WWTP within the Project Area [72]

WWTP	Year of Construction	Treatment Method	Capacity (m^3/day)	Effluent (m^3/day)	Disposal Standards
Aqaba	2000	Activated Sludge	28,000	10,876	Irrigation
Ma'an	2013	Activated Sludge/BNR	5,772	2,536	Irrigation
Wadi Musa	2000	Activated Sludge	2,400	2,863	Irrigation
Shoubak	2010	Stabilization Ponds	350	130	Irrigation
Mansourah	2010	Stabilization Ponds	50	Evaporation ponds	-

WWTP	Year of Construction	Treatment Method	Capacity (m^3/day)	Effluent (m^3/day)	Disposal Standards
Tafila	1988	Trickling Filters	1,600	1,977	Wadis
Mu’ta	2013	Activated Sludge	7,000	1,914	Irrigation
Allujun		Waste stabilization ponds			
Al Karak	1988	Activated Sludge	1,400	1,330	Irrigation
Al Jizah	2008	Activated Sludge	4,000	761	Irrigation
Madaba	2005	Activated Sludge/BNR	7,600	6,844	Irrigation
Wadi Es Saier	1996	Aerated Lagoons	4,000	5,821	Wadis
Fuheis	1995	Activated Sludge	2,400	2,997	Wadis
Alsalt	1994	Activated Sludge	7,500	9,444	Wadis
Abu Nuseir	1986	Activated Sludge	4,000	3,663	Wadis
Baqa’a	2002	Trickling Filters	14,900	13,154	Wadis
Tal Al Mantah	2005	Activated Sludge and Trickling Filters	400	475	Wadis
As Samra	2015	Activated Sludge	364,000	-	Wadis

6.4.8. Traffic and Transportation

The project involves several hotspot areas, highways, and roads that will be affected 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, including the intake pumping station, is located on an undeveloped land approximately 18 km South of Aqaba City, within the Aqaba industrial zone by the Red Sea, and adjacent to the newly constructed industrial port. The area of the intake system is surrounded by several facilities and infrastructure, including a thermal plant discharge pathway, gas line of the “Jordanian Egyptian Fajr Company”, permanent gas storage ship, water intake system of the Phosphate company, Phosphate discharge outfall, and phosphate berth.

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. Figure 6-57 shows an aerial photo indicating the hotspot areas and main roads.

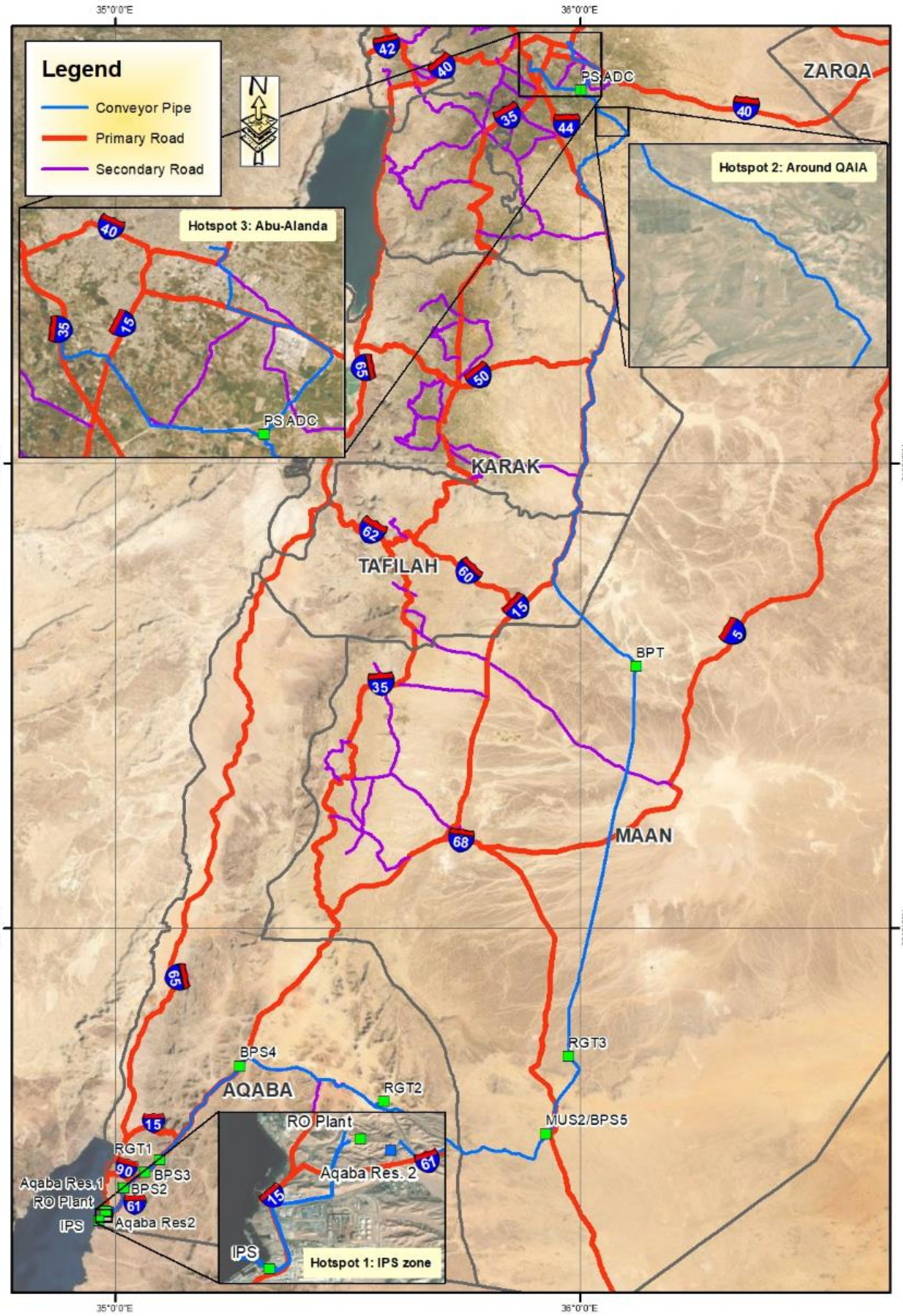


Figure 6-186: Primary and Secondary Roads within the Project Area

As for the conveyance pipeline that will connect the two hotspots, it will pass through several roads and key highways as such:

- The Desert Highway (R15)

The desert highway, which is known as "Al-Sahrawi" is an important route for Jordan, being the main highway leading to Aqaba's port and connecting Jordan to Saudi Arabia. It begins in Aqaba running northeast towards Ma'an, going through the desert to the east of the main settlements in the southern region of Jordan. It then merges into Highway 35 (King's Highway) going to Amman.

Figure 6-187: Sections of the Desert Highway (Source: Mid Contracting)

The highway has been a black spot in traffic safety records. It has witnessed many traffic accidents and fatalities in recent years due to road fatigue and cracks, violation of speeding rules, and bad road lighting, especially at night. As such, the Government of Jordan signed the Desert Highway Road Tenders in 2018 to rehabilitate the highway in terms of removing all asphalt layers and building a new highway with three lanes on each side, with a third lane designated for heavy vehicles. The work also included creating sidewalks and traffic islands in addition to adding road signage and ensuring adherence to traffic laws. Figure 6-187 shows the Desert Highway. the "Ports Back Road" and existing primary and secondary roads

The conveyance pipeline will pass through several existing roads surrounded by localities, agricultural areas, and farms. Some of the roads are four lane divided roads with two lanes running in each direction. Others are two lane undivided roads and single lane roads. Figure 6-188 shows some of the existing roads within the project area.

Figure 6-188: Existing Roads within The Project Area

The increase in population has increased the passenger traffic whereby the level of motorization in Jordan amplified at a compound annual growth rate of 5.2% between 2012 and 2016, with passenger cars accounting for 75% of the total. Meanwhile, Jordan's road infrastructure has not kept pace with population growth. The country's towns and cities have dense road networks and face severe road congestion, while cities are connected through highways. In fact, there are 7,891 km of roads in Jordan out of which 7,203 km were paved roads in 2016. Jordan's road network is split between trunk roads (1,644 km linking Jordan to other countries, and connecting the capital and the governorates); primary roads (1,049 km linking the main cities), secondary national roads (1,850 km linking the main settlements), and tertiary roads (2,815 km of formerly rural or village roads). 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. However, traffic volumes remain low at these borders [73]. Figure 6-186 represents the primary and secondary roads linking different governorates within the project area.

In addition, 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 (Figure 6-189). The Industrial Port handles bulk, chemicals, fertiliser, LPG, livestock, potash, salt, sulphur and timber.

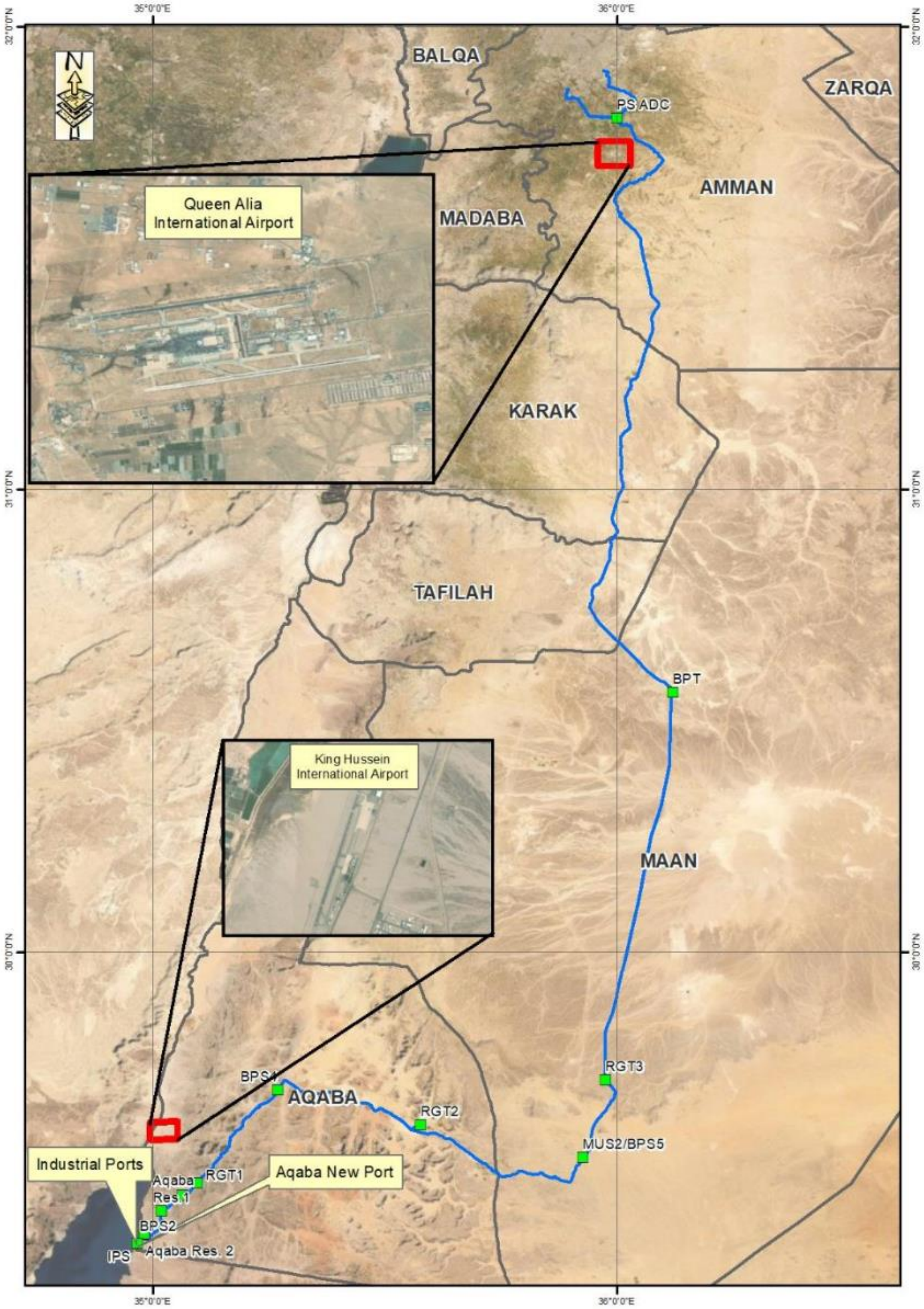


Figure 6-189: Location of Airports and Ports within the Project Area

6.4.9. 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. Most of the generated waste ends up in landfills. In fact, Jordan annually disposes around 2.1 million tons of municipal solid waste in its landfills. Future projections show that waste volume will increase by 3-5% annually, and, as the country continues to urbanize, municipal waste generation will continue to grow from the current per capital rate. 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. The waste composition differs across the country, but in municipalities it is mostly 51% organic, 15% plastics, and 14% paper.

Landfilled waste is an important component of Jordan's GHG emissions profile, contributing 10% of GHG emissions, a figure that is expected to grow as the population grows. Most of the solid waste generated in the country is disposed of in one of its 21 landfills, seven of which are closed landfills and only meets international best practice, which is Al Ghabawi landfill. 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 [74]. Figure 6-190 represents the location of landfills in different governorates in relation to the project area.

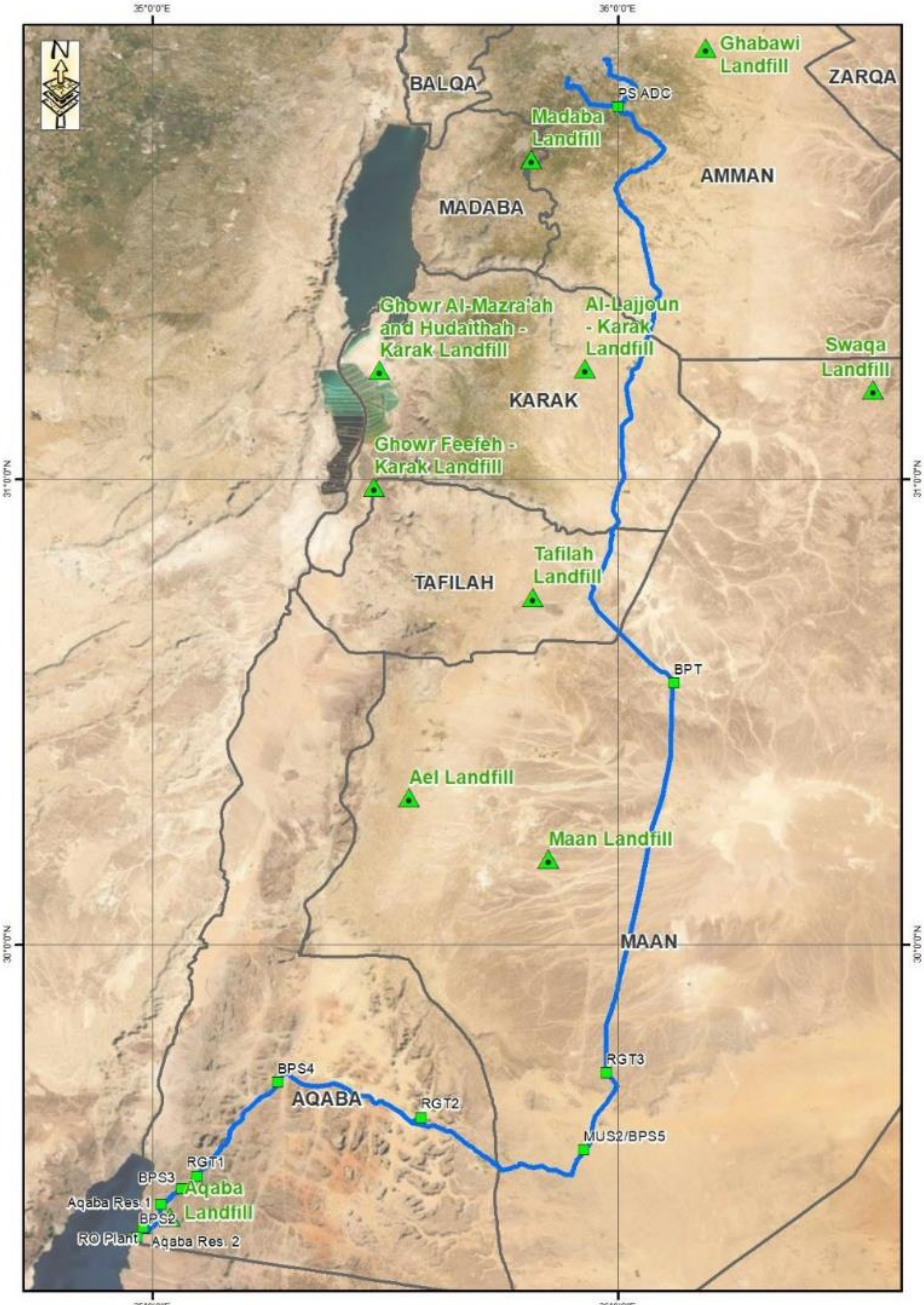


Figure 6-190: Location of Landfills within Project Area

6.4.10. Cultural Resources

6.4.10.1. Previous Archaeological and Cultural Heritage Research in Project Area:

Parts of the project area have been surveyed archaeologically and some nearby sites of the proposed pipeline route have been excavated, particularly Aqaba and Amman, as well as other sites in Wadi Al-Yutum area. The Cave of Sleepers in Amman has also been subjected to intensive excavations, as have other caves in the surrounding area of Abu Alanda, close to the proposed AAWDC project.

Nevertheless, archaeological research in the Aqaba, Maan, east Madaba and Amman has been constrained by three factors:

- Fieldwork has inevitably been carried out completely independently of the major sites, and there is no overall understanding or even map of all known sites in both Wadi Al-Yutum and astern Maan.
- With certain exceptions, the project area in Aqaba has in general has been regarded as a barrier and as a hinterland of sites in the east, but its role as a route - not only north-south but especially east-west - is so far poorly understood.
- Much of the survey work in eastern areas of Maan and Madaba is unpublished, and even lists of sites and their coordinates are difficult to access.

Little is known about the archaeology of Wadi Al-Yutum toward Wadi Rum Area as the Department of Antiquities has historically paid little attention making access difficult to conduct fieldworks.

The assessment of previous field investigations, surveys and excavations, as well as the available information and literature revealed that there is not one archaeological site that is fully protected and conserved in eastern Aqaba and Maan close to the proposed pipeline, either by foreign missions or by the Department of Antiquities. Most of the sites severely suffered from looting during the past years.

Initial and later field work and investigations of South Jordan already suggest large parts of the southern Jordan are immensely rich in archaeological remains and most of those identified are certainly pre-Islamic and probably several thousand years old. Detailed interpretation of one ‘window’ in the middle of Aqaba (Ayla Complex) forms the basis for illustrating the richness of the heritage and importance of trade routes.

The AAWDC project passes through Wadi Rum, which has been inhabited by many human cultures since prehistoric times, with many cultures–including the Nabataeans–leaving their mark in the form of petroglyphs, inscriptions, and temple. In June 2011, the area of Wadi Rum in Southern Jordan was added to the UNESCO World Heritage List as a mixed natural and cultural site. The outstanding landforms of Wadi Rum have played an essential role in fostering human settlement in the area and enhancing the development of sophisticated intellectual activity. Spanning at least 12,000 years, one of the world's richest collections of rock art and epigraphy is housed at the site. The growing pressure from visitors, and especially from off-road vehicles, is damaging the fragile desert ecology.

6.4.10.2. Gaps in Information and Pressures on Archaeological Sites

Analysis of the available data from different projects revealed some gaps identified during the past years. For example, the area extending from Amman to Aqaba played a vital role during the past as a major caravan corridor for incense trade and pilgrims routes. However, limited attention has been paid to the archaeological and cultural resources of the eastern areas of these areas, leaving most of the potential resources under-studied or inadequately excavated by scientists, subject to massive destruction either by ignorance, development and/or natural factors. Thus, considerable portions of Aqaba, Maan, Madaba, Kerak, Tafeileh and Amman heritage have been lost, and those that have been protected are often under threat by the impact of natural, physical and social conditions.

Table 6-44: Preliminary Information on Three Religious Archaeological Sites Identified

Site Name	Location	Historic Information
Qatraneh Haj Fort	Located close to main highway	Al-Qatraneh Castle is one of the famous castles on the right side of the main highway toward Aqaba City. Some scholars reported limited information regarding the earliest known historical occupation on the site.

Site Name	Location	Historic Information
		The existing remains consist of square fort two stories high. The gate opens towards the south direction, while the large pool is located to the east of the castle and very close to the modern highway
Hasa Haj Fort	Located at a distance of 4 KM to the west of paved road .	The fort measures 23.30 x 22.40 m; square-plan building it is like a *khan*. The main facade, to the north, had a pointed-arch entrance giving access to a 4-metre corridor at the end of which a rectangular door with a lintel opened onto the courtyard. The outside walls were topped on both sides with machicolations resting on consoles: this meant hot oil or burning liquids could be poured on undesirable visitors. In the centre of the courtyard a small square building reached by a staircase covered a well. Around the courtyard, large openings with pointed arches and smaller, rectangular ones with chamfered corbels opened onto rooms with semi-circular or groined vaults. At each end of the south side a straight staircase leads to the upper level, where a passageway with arrow slits was used by the guards. The fort also included a small mosque with a pointed vault and a *mihrab* niche. In addition to the rainwater well, a pond very close to the fort provided water. Also to be noted are a small, three-arched bridge and a Roman-type stone-paved road. The building style is reminiscent of that of the Roman forts in the region and reflects the climatic conditions of this desert site. The same layout is to be found in the Roman palace of Halabat, then in buildings by the Ummayads (Qasr al-Kharana), the Ayyubids (the forts of Azrak [1236] and Ajlun), the Mamelukes (the fort of Qa'it Bay in Alexandria [1477]) and lastly the Ottomans, with the Egyptian castles dotted along the pilgrim roads. The same is true of the distinctive system of double-sided machicolations, already known to the Romans.
Cave of Seven Sleepers	Located near Amman Ring Road close to Sahab, Abu Alanda Reservoir .	The story of the Seven Sleepers occurs both in Islam (as sura 18 of the Koran) and in Christianity ('The Seven Sleepers of Ephesue' in Jocobus de Voragine's 13th century collection of apocrypha known as 'The Golden Legend). In each case the story concerns a group of young men escaping from persecution by local pagan ruler who fall asleep in a cave. Through divine intervention they sleep safely for a hundred years or more and wake up after the area has been converted to the appropriate religion. Different kinds of caves were dug in the natural limestone rocky area. Graves were dug inside these caves to burry the dead. Some of these burial caves were robbed. Remains of pottery shreds and bone fragments are still visible in front of some of these caves and date back to the Byzantine period; the 5th -6th century AD. Some of these graves were found to be silty and affected by the erosion during winter season

6.4.10.3. Identified Historic Periods

The findings of the research within the project area show clear representation of all periods and many types of sites, ranging from flint and shard scatters, stone circles and enclosures to towers and agricultural installations, and many cemeteries. The referenced periods are listed in Table 6-45.

Table 6-45: Summary of Historic Periods Used in the Classification of Archaeological Resources of AAWDC Project

Historic Group	Historic Period (Sub-groups)	Dating
Prehistory Archaeological Sites (BC)	**Paleolithic**	40,000-8000BC
	Neolithic Age	8000-4200BC
	Chalcolithic Age	4200-3200BC
	Bronze Age	3200-1200BC
	Iron Age	1200-539BC
	Helenistic Age	539-200BC
Pre-Islam Historic Sites (AD)	**Roman Age**	200BC-333AD
	Byzantine Age-Classical	333-636AD
Islamic Historic Sites	**Early Islamic Period**	636-650AD
	Umayyad Period	650-750AD
	Abbasside Period	750-950AD
	Fatimid Period	950-1171
	Ayubi-Mamluk Period	1171-1516
	Ottoman Period	1516-1918
Modern Islamic Heritage Sites	**Modern Period**	1918AD – nowadays
Museums	**All historic periods (collection of heritage objects)**	Not applicable

An analysis of the sites' time sequence and representation of archaeological periods shows that there is a significant shortage of information about the presence of archaeological sites belonging to the periods after the Lower Paleolithic age until the Neolithic Age, and after the Roman-Byzantine period during Islamic eras. Several reasons contribute to this situation; however the core problem is noted to be the insufficiency of research and field investigation of such resources as shown in Table 6-46.

Table 6-46: Summary of Archaeological Periods Represented by Identified Sites Through Literature Study Near AAWDC Pipeline Route

Period	Date	Major Revealed Sites Belonging to Period	Representation Assessment
Palaeolithic	40,000-8000 BC	East Maan,Jafer	Represented
Neolithic Age	8000-4200 BC	Wadi Hasa	Represented
Chalcolithic Age	4200-3200 BC	Not Represented	Gap
Bronze Age	3200-1200 BC	Not Represented	Gap
Iron Age	1200-539 BC	Not Represented	Gap
Helenistic Age	539-200 BC	Not Represented	Gap
Roman Age	200BC-333 AD	Al-Mezfer Tower &Cave of seven sleepers	Represented
Byzantine Age-Classical	333-636 AD	Al-Raqeem Mausoleum	Represented
Early Islamic Period	636-650AD	Al-Mushata Palace	Represented

Period	Date	Major Revealed Sites Belonging to Period	Representation Assessment
Umayyad Period	650-750AD	Khirbet er-Raqeem	Represented
Abbasside Period	750-950AD	Not Represented	Represented
Fatimid Period	950-1171AD	Ayla –Aqaba	Represented
Ayubi-Mamluk Period	1171-1516AD	Not represented	Represented
Ottoman Period	1516-1918AD	The Qatraneh Haj Fort	Represented
Modern Period	1918AD-Nowdays	The Traditional Village and Houses in Al Jafer	Represented

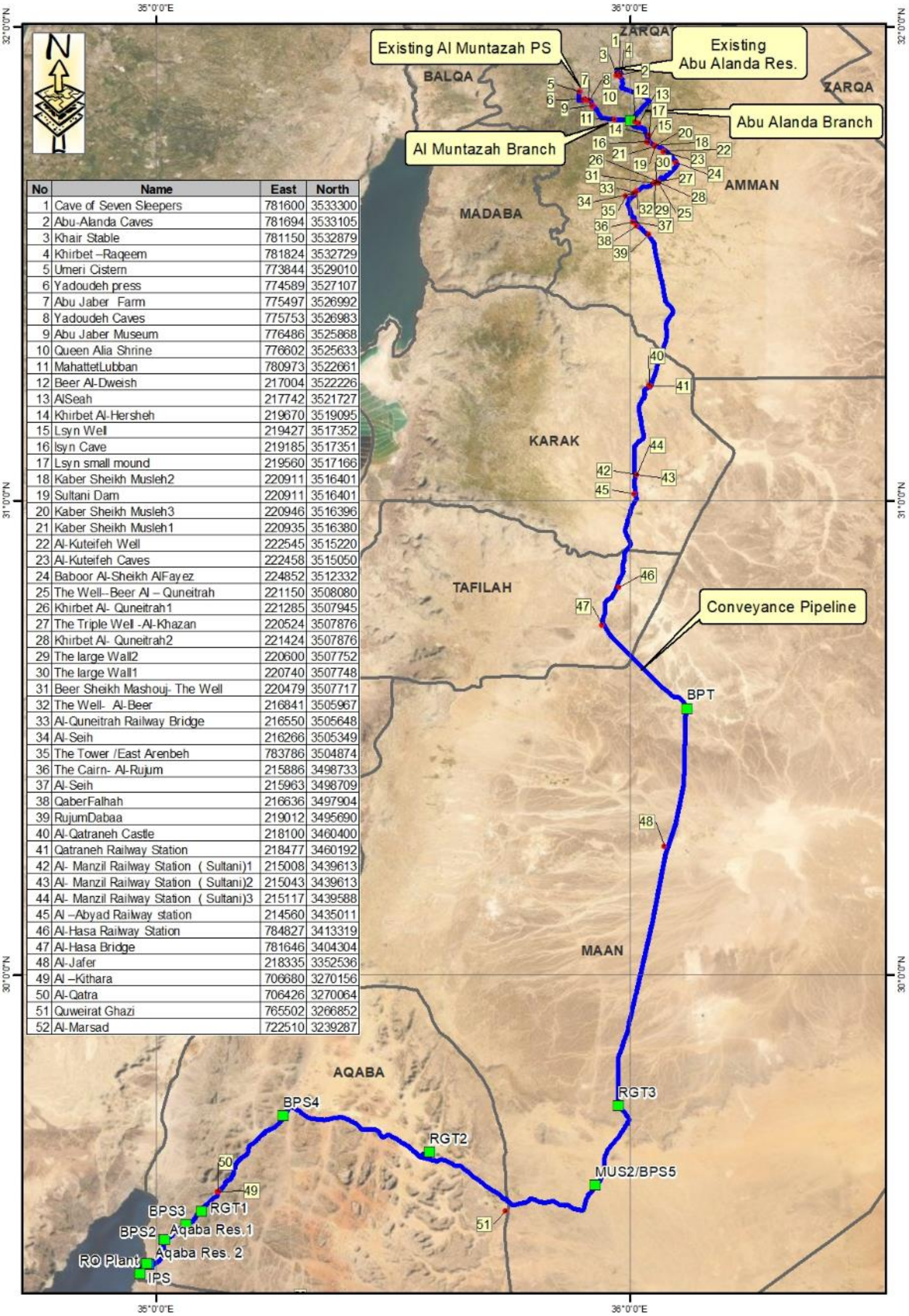
6.4.10.4. Identified Archaeological Sites Related to the Project

A total of 46 sites were identified 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. The ESIA team had access, with cooperation of the local community, to areas along the proposed conveyance route, many of which which had been surveyed systematically in previous times. Given the semi desert and difficult landscape, it is interesting to note that there are a considerable number of sites, albeit small ones.

The areas can be divided as follows:

- Ten sites within District of Amman borders from Abu-Alanda Reservoir to Lubban,
- Twenty-four sites within Madaba District covering the area between Lubban to Qatraneh.
- Five sites in Kerak from Qatraneh to Al-Abyad
- Two sites within Tafeileh District from Al-Abyad to the end of Al-Hasa,
- One site within Maan District from Al Jafer to Wadi Rum
- Four sites were found within Aqaba District borders, from Wadi Rum to Red Sea.

The locations of archaeological sites within Amman, Madaba, Kerak, Tafeileh, and Aqaba are shown in Figure 6-93 and Table 6-34. Details on each site can be found in **Annex 15.**



No	Name	East	North
1	Cave of Seven Sleepers	781600	3533300
2	Abu-Alanda Caves	781694	3533105
3	Khair Stable	781150	3532879
4	Khirbet –Raqeem	781824	3532729
5	Umeri Cistern	773844	3529010
6	Yadoudeh press	774589	3527107
7	Abu Jaber Farm	775497	3526992
8	Yadoudeh Caves	775753	3526983
9	Abu Jaber Museum	776486	3525868
10	Queen Alia Shrine	776602	3525633
11	MahattetLubban	780973	3522661
12	Beer Al-Dweish	217004	3522226
13	AlSeah	217742	3521727
14	Khirbet Al-Hersheh	219670	3519095
15	Lsyn Well	219427	3517352
16	lsyn Cave	219185	3517351
17	Lsyn small mound	219560	3517166
18	Kaber Sheikh Musleh2	220911	3516401
19	Sultani Dam	220911	3516401
20	Kaber Sheikh Musleh3	220946	3516396
21	Kaber Sheikh Musleh1	220935	3516380
22	Al-Kuteifeh Well	222545	3515220
23	Al-Kuteifeh Caves	222458	3515050
24	Baboor Al-Sheikh AlFayez	224852	3512332
25	The Well--Beer Al – Quneitrah	221150	3508080
26	Khirbet Al- Quneitrah1	221285	3507945
27	The Triple Well -Al-Khazan	220524	3507876
28	Khirbet Al- Quneitrah2	221424	3507876
29	The large Wall2	220600	3507752
30	The large Wall1	220740	3507748
31	Beer Sheikh Mashouj- The Well	220479	3507717
32	The Well- Al-Beer	216841	3505967
33	Al-Quneitrah Railway Bridge	216550	3505648
34	Al-Seih	216266	3505349
35	The Tower /East Arenbeh	783786	3504874
36	The Cairn- Al-Rujum	215886	3498733
37	Al-Seih	215963	3498709
38	QaberFalhah	216636	3497904
39	RujumDabaa	219012	3495690
40	Al-Qatraneh Castle	218100	3460400
41	Qatraneh Railway Station	218477	3460192
42	Al- Manzil Railway Station (Sultani)1	215008	3439613
43	Al- Manzil Railway Station (Sultani)2	215043	3439613
44	Al- Manzil Railway Station (Sultani)3	215117	3439588
45	Al –Abyad Railway station	214560	3435011
46	Al-Hasa Railway Station	784827	3413319
47	Al-Hasa Bridge	781646	3404304
48	Al-Jafer	218335	3352536
49	Al –Kithara	706680	3270156
50	Al-Qatra	706426	3270064
51	Quweirat Ghazi	765502	3266852
52	Al-Marsad	722510	3239287

Figure 6-191: Archaeological Sites in the Project Area

Table 6-47: Identified Archaeological Sites Along the Project

No.	Site Name	Coordinates U.T.M E	Coordinates U.T.M N	Site Owner	Related Party
1	Cave of Seven Sleepers	E 360781600	N 35333	MAIA+DAJ	MAIA+DAJ
2	Khirbet –Raqeem	E 360781824	N 3532729	Private	MOTA
3	Khair Stable	E 36073115	N 3532879	Private	MOTA
4	Abu-Alanda Caves	E 360731694	N 3533105	Private	MOTA
5	Umeri Cistern	E 360773844	N 3529010	Private	MOTA
6	Yadoudeh press	E 360774589	N 3527107	Private	MOTA
7	Abu Jaber Farm	E 360775497	N 3526992	Private	MOTA
8	Yadoudeh Caves	E 360775753	N 3526983	Private	MOTA
9	Abu Jaber Museum	E 36 0776486	N 3525868	Private	MOTA
10	Queen Alia Shrine	E 360776602	N 3525633	JHRC	Royal Court RC
11	Mahattet Lubban	E 360780973	N 3522661	JHRC	JHRC
12	Beer Al-Dweish	E 370217004	N 3522226	Private	MOTA
13	AlSeah	E 370217742	N 3521727	Private	MOTA
14	Lsyn Well	E 370219427	N 3517352	Private	MOTA
15	Lsyn small mound	E 370219560	N 3517166	Private	MOTA
16	lsyn Cave	E 370219185	N 3517351	Private	MOTA
17	Khirbet Al-Hersheh	E 370219670	N 3519095	Private+Daj	DAJ

No.	Site Name	Coordinates U.T.M E	Coordinates U.T.M N	Site Owner	Related Party
18	Kaber Sheikh Musleh	E 370220935 370220911 370220946	N 3516380 3516401 3516396	MAIA	MAIA
19	Baboor Al-Sheikh AlFayez	E 37 02248521	N 3512332	MAIA	MOTA
20	Al-Kuteifeh Well	E 370222545	N 3515220	Private	MOTA
21	The Well--Beer Al – Quneitrah	E 370221150	N 3508080	Private	MOTA
22	Al-Kuteifeh Caves	E 370222458	N 3515050	Private	MOTA
23	Khirbet Al-Quneitrah	E 370221285 370221424	N 3507945 3507876	Private+Daj	DAJ
24	The large Wall	E 37 0220740 37 0220600	N 3507748 3507752	Private	MOTA
25	The Triple Well- Al-Khazan	E 370220524	N 3507876	Private	MOTA
26	Beer Sheikh Mashouj- The Well	E 370220479	N 3507717	Private	MOTA
27	The Well - Al-Beer	E 370216841	N 3505967	Private	MOTA
28	Al-Quneitrah Railway Bridge	E 370216550	N 3505648	JHRC	JHRC
29	Al-Seih	E 370216266	N 3505349	Private	MOTA
30	The Tower /East Arenbeh	E 360783786	N 3504874	DAJ	DAJ
31	Qaber Falhah	E 370216636	N 34979904	MAIA	MAIA
32	Al-Seih	E 370215963	N 3498709	Private	MOTA
33	The Cairn- Al-Rujum	E 370215886	N 3498733	Private	MOTA

No.	Site Name	Coordinates		Site Owner	Related Party
		U.T.M E	U.T.M N		
34	Rujum Dabaa	E 370219012	N 3495690	Private	MOTA
35	Al-Qatraneh Castle	E 3702181	N 34604	DAJ	JHRC
36	Qatraneh Railway Station	E 370218477	W 3460192	JHRC	JHRC
37	Al- Manzil Railway Station (Sultani)	E 37215008 370215043 370215117	N 3439613 3439613 3439588	JHRC	JHRC
38	Sultani Dam	E 370220911	N 3516401	Private	MWI
39	Al –Abyad Railway station	E 370214560	N 3435011	JHRC	JHRC
40	Al-Hasa Railway Station	E 360784827	N 3413319	JHRC	JHRC
41	Al-Hasa Bridge	E 360731646	N 3404304	JHRC	JHRC
42	Al-Jafer	E 37 0218335	N 3352536	DAJ	DAJ
43	Quweirat Ghazi	E 360765502	N 3266852	DAJ	DAJ
44	Al-Marsad	E 360722510	N 3239287	DAJ	DAJ
45	Al –Kithara	E 360706680	N 3270156	DAJ	DAJ
46	Al-Qatra	E 360706426	N 3270064	DAJ	MOTA
Total	MOTA:26 sites	DAJ: 8 sites	JHRC:10sites	MAIA:3Sites	MWI:1,site

Figure 6-94 presents the distribution of the sites according to relevant governorates.

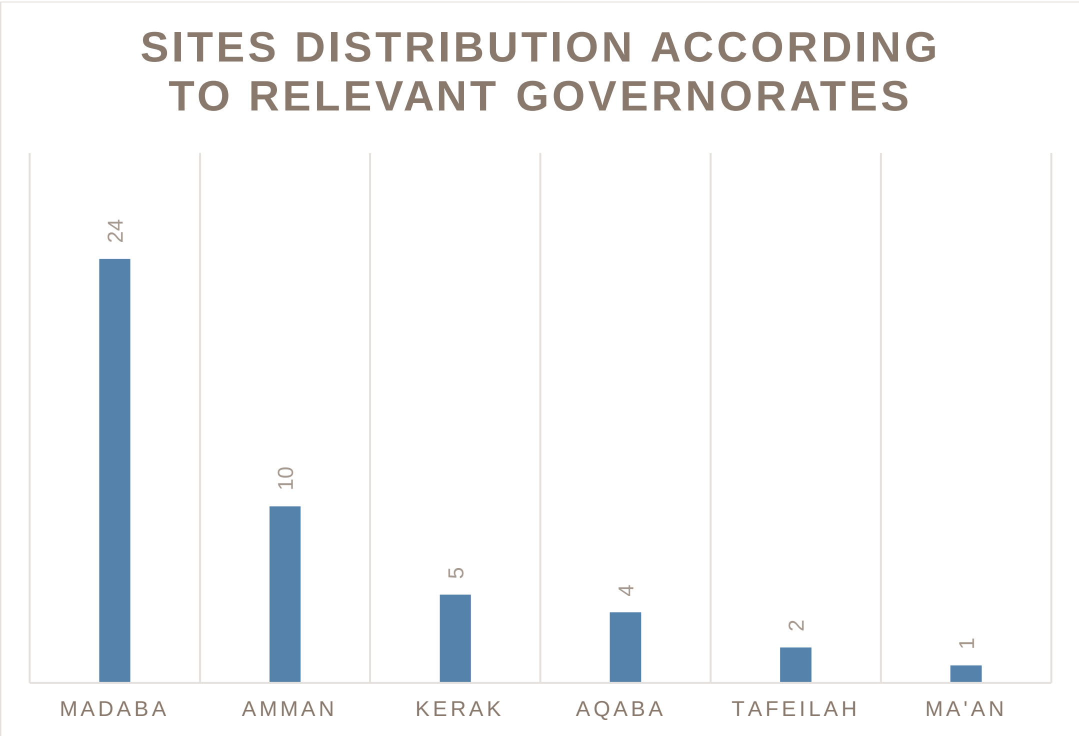


Figure 6-192: Site Distribution According To Relevant Governorates

7. Stakeholder Engagement

The following section presents the stakeholder engagement conducted during preparation of the ESIA.

7.1. Scoping Session

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 by the design team (CDM Smith), after which technical questions were answered. This was followed by a break, then a presentation of all environmental and social issues associated with the project, the methodology of the ESIA and next steps. The floor was then opened for feedback and discussion. At the end of the session, all participants (in-person and online) were requested to fill out a questionnaire on environmental and social concerns (which 32 persons completed). This section presents the main issues that were raised during the session and how this report, and the ESIA, aim to address them. All details pertaining to this session can be found in **Annex 16** including the presentation, letters of invitations, list of participants, agenda, detailed proceedings, questionnaire and results, and photographic documentation.

7.1.1. Discussions

Issues raised by stakeholders during the technical discussion and were noted by the Design Team are as follows:

- Location of the intake near several industries makes it vulnerable to pollution events such as oil spills;
- Take into consideration existing infrastructure such as the gas pipeline to Amman while designing the conveyance pipeline;
- Take into consideration planned developments in Aqaba when designing the conveyance pipeline from the inlet to the RO plant such as the planned miscellaneous liquids terminal;
- Consider use of the Disi pipeline instead of running parallel to it;
- Consider the use of alternative power options such as renewable and nuclear;

A major issue raised by the participants was lack of detailed information presented on the project locations and components. This point was taken into consideration for the disclosure session.

During the discussion on environmental and social issues and the ESIA study methodology, the following issues were raised and noted by the ESIA Team:

- 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;
- 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.

7.1.2. Results of the Questionnaires

During the scoping session a questionnaire was distributed among the participants at the end of the session in an effort to give all the attendees the chance to rate the project in terms of specific impacts during both the construction and operation phase. The questionnaire included 31 questions related to different construction and operation impacts. The first part of the questionnaire (questions 1 to 11) was designed to collect data on the impacts associated with the construction of the desalination plant whereas the second part (questions 12 to 20) consists of questions related to the impacts associated with the construction of the conveyance pipeline. The third part (questions 21-31) considered impacts associated with operation of the AAWDC project. The questionnaire was prepared in both Arabic and English languages. The questionnaire sections and results are described below.

7.1.2.1. Environmental and Social Impacts and Issues

7.1.2.1.1. Impacts associated with Construction of the Desalination Plant

In line with the discussions during the scoping session, around 47% of the respondents considered that the impact on marine habitat from excavation works to be of high significance, with the same percentage considered the impact of medium significance. This was also the case regarding the impact on Gulf of Aqaba water quality from accidental oil/chemical spills or leakages as the percentages of respondents rating this impact as high and medium significance was 41% for each (a total of 82%). As for the alteration of trophic conditions of Gulf of Aqaba, respondents were equally divided between low, medium and high significance. Half of the respondents find that impact on surface water quality and flow during construction is of moderate significance. Almost half the respondents (47%) considered that construction impacts on the groundwater table are of low significance. As for impact of construction activities on the cultural heritage sites, the majority of respondents (59%) indicated that it is considered of medium significance. This was also the case regarding the issues of land acquisition and alternation of existing land uses, whereby over half of the respondents rated them as having medium significance. Almost half (47%) of the respondents found that health and safety risks were of low significance. About 44% of the respondents consider that alteration in ship mobility patterns during construction is of medium significance. The same percentage also considers that the disruption to industries in the desalination components system area is of medium significance while 41 found it to be of low significance (Table 7-1).

Table 7-1: Summary of Questionnaire Responses for Construction of Desalination Component

Impact	Percentage		
	High	Medium	Low
Marine habitat destruction from excavation works	46.875	46.875	6.25
Alteration of trophic conditions of Gulf of Aqaba	31.25	34.375	34.375
Degradation of Gulf of Aqaba water quality from accidental oil/chemical spills or leakages	40.625	40.625	18.75
Water quality and hydrology of wadi flood pathways	18.75	50	31.25
Changes in groundwater table	12.5	40.625	46.875
Damage to of cultural heritage sites	3.125	59.375	37.5
Alteration of existing land uses	15.625	56.25	28.125
Permanent land acquisition	9.375	53.125	37.5
Worker and public health and safety risks	15.625	37.5	46.875
Alteration in ship mobility patterns	21.875	43.75	34.375
Disruption to industries in the desalination components system area	15.625	43.75	40.625

7.1.2.1.2. Impacts associated with Construction of the Conveyance Pipeline

In this part of the questionnaire, the majority of the respondents (56%) indicated that construction of the conveyance pipeline impact on the wadis and surface and ground water is of medium significance. The same was true of disturbance from the generated dust and noise, in addition to 28% who believe this impact is of high significance. As for terrestrial habitat loss or alteration, 44% and 38% of the respondents indicated that this impact is of medium and low significance, respectively. Over half respondents (53%) thought that the disruption/destruction to existing infrastructure during construction of the conveyance pipeline is of low significance, while over a third (34%) found it to be of medium significance. Regarding impact on traffic movement, half of the respondents (50%) indicated that it is of medium significance. As with the construction of the desalination components, half of the respondents thought that health and safety during construction was of low significance while 41% though it was of medium significance. None of the respondents indicated significant concerns related to the disruption or loss of cultural heritage within the area of the conveyance pipeline, while the majority of the respondents (69%) rated this impact as medium significance. Just under half of the respondents stated that the impacts associated with land acquisition and disruption to businesses along the route is of moderate significance (Table 7-2).

Table 7-2: Summary of Questionnaire Responses for Construction of the Water Conveyance Component

Impact	Percentage		
	High	Medium	Low
Wadis, surface and ground water contamination	9.375	56.25	34.375
Disturbance from generated dust and noise	28.125	56.25	15.625
Terrestrial habitat loss or alteration	18.75	43.75	37.5
Disruption/destruction to existing infrastructure	12.5	34.375	53.125
Disruption of traffic movement	15.625	50	34.375
Worker and public health and safety risks	9.375	40.625	50
Disruption/loss of cultural heritage	0	68.75	31.25
Permanent land acquisition	18.75	46.875	34.375
Disruption to businesses along the route	18.75	43.75	37.5

7.1.2.1.3. Impacts associated with Operation of the Project

Disruption of soil from backwash sludge during operation was considered by 44% of the respondents to be of moderate significance compared to over half of the respondents (59%) who considered that the change in water circulation by open intakes when large volumes of water are extracted is of moderate significance. As for impact on ambient seawater salinity and alteration of seawater quality (enrichment of nutrients, organic matter, pollutants, or trace metals), 44% of the respondents indicated these issues are considered highly significant impacts. By far, most respondents were concerned about the disruption of such projects on the marine flora and fauna mainly from the open intakes and discharge of filters' backwash and brine whereby 63% of the respondents rated this impact as a highly significant impact and 31% rated it of moderate significance. About 44% rated impact on marine and terrestrial habitats from generated noise during operation to be of moderate significance with 38% rating it as high. As for worker health and safety risks during operation, 44% found this impact to be of moderate significance while the same percentage rated it as low. Habitat fragmentation during maintenance activities was rated as medium significance by over half the respondents (53%). In addition, 41% of the respondents considered that disturbance from the generated noise to nearby communities from operation of the project is of moderate significance

Despite these concerns, 81% of the respondents considered that the proposed project will have a high positive impact on the national water security (Table 7-3).

Table 7-3: Summary of Questionnaire Responses for Operation of the Project

Impact	Percentage		
	High	Medium	Low
Disruption of soil properties from backwash sludge	28.125	43.75	28.125
Disruption of seafloor and sediments characteristics (salinity) from brine discharge and filters' backwash	37.5	53.125	9.375
Change in water circulation by open intakes when water is extracted	25	59.375	15.625
Increase in ambient seawater salinity	43.75	40.625	15.625
Alteration of seawater quality (enrichment of nutrients, organic matter, pollutants, or trace metals)	43.75	40.625	15.625
Disruption of marine flora and fauna from open intakes and discharge of filters' backwash and brine	62.5	31.25	6.25

Impact	Percentage		
	High	Medium	Low
Marine and terrestrial habitat loss from generated noise	37.5	43.75	18.75
Worker health and safety risks	12.5	43.75	43.75
Disturbance from generated dust and noise	25	40.625	34.375
Habitat fragmentation and disturbance during maintenance activities	15.625	53.125	31.25
Positive impact of the project on national water security	81.25	15.625	3.125

7.1.2.2. Other Concerns and Suggestions

The questionnaire also presented an opportunity for the respondents to add other issues of concern they may have in narrative format. They were also given the opportunity to propose suggestions in terms of mitigation measures, project component design and location, actions that might enhance the public participation process, or any other suggestion that in their point view might enhance the ESIA and the project. The following provides a summary of the main concerns that were raised by the participants along with the proposed suggestions and the ESIA Consultant's response or plan to address them.

Design Phase:

- Reconsider the current intake and outlet location to somewhere north of the LPG terminal to avoid any impact on the current projects or future opportunities in the area
- Concerns regarding lines after Wadi-crossing through Aqaba Bulk Chemicals Company expansion lot. Suggestions to change the current proposed line after Wadi crossing as the current route will go through Aqaba Bulk Chemicals Company expansion lot. Design Team will investigate and address
- Suggestion to use the same pipeline of the DISI project rather that constructing a new water conveyance pipeline to Amman
- Take into account the presence of Arab gas pipelines extending south from the southern coast and heading north, and thus the possibility of intersections with the proposed pipelines route, as well as the possibility of interfering with pumping stations and the RO plant
- Concerns regarding the presence of congestion in the pipelines inside the streets within the Southern Industrial Zone (after adding the pipelines for the project) along the proposed route

Construction Phase:

- Concerns regarding the location of the intake pipeline as the proposed site entails numerous interferences with existing pipelines
- Suggestions for close and direct communications with companies in the project areas
- Concerns regarding the effect of the project on the navigation traffic
- Effect of the pipeline crossing through the Wadi and the main coastal road
- Effect of the intake pipeline on the cooling line of the industrial complex
- Impact of construction works on the neighbouring industrial sites
- Contingency plans in place to contain accidental chemical spill events
- Concerns regarding timing of construction activities and their concurrence with the migrations of birds
- Concerns regarding the proximity of the conveyance pipeline to the nature reserves
- Conduct traffic and transport impact assessment
- Concerns regarding the impact of construction activities on the archaeological and touristic sites as well as the visitors of these sites. Suggestions to conduct an archaeological survey within the project areas in order to determine the archaeological and touristic sites
- Suggestions to study the impact of constructions inside the sea on the navigation movement and the existing gas pipeline
- Suggestions to reconsider the water abstraction / intake site
- Studying the corridor services along the entire route of the project to identify pipelines for other projects such as the Fajr gas line and the line for the Kirkuk oil project in the future, so that they are all within the buffer space corridor.

- Suggestions to establish a greenbelt surrounding the project within the setbacks to maintain the project in addition to isolating it visually and to decrease the generated noise within the surrounding area.
- Concerns regarding impacts on the community next to the conveyance pipeline
- Suggestion regarding the location of the outlet to be located in a region other than the current one, for example, in the Electricity District, due to the possibility of pollution

Operation Phase:

- Concerns regarding the location of the intake pipeline as it is in close proximity to an industrial zone (Phosphate Company and power station jetties) and the associated risks such facilities pose on the used seawater quality if accidental chemical spill events occur (contamination from oil or phosphate products)
- Impact of noise generated from the pumping stations
- Concerns of affecting marine waters in the Gulf, especially with the declaration of a 7 km marine reserve in Aqaba
- Disruption of marine ecosystem due to the discharge of the brine having a high salinity content
- Impact on the marine environment if the backwash water is mixed with the brine and then discharged to the sea
- Recommendations for in-depth studies to assess the effect of the project on the marine organisms
- Suggestions to coordinate with local experts and researchers in the field of marine environment in the College of Basic and Marine Sciences regarding the marine part of the project and study the environmental impact on the environment in general and the marine environment in particular
- Suggestions to dilute the brine using fresh seawater line prior to mixing it with the sea water
- Conduct 3D modelling of Brine water
- Inquiry regarding the energy sources for the desalination process and the energy required for the entire project as well as the ability to secure it
- Suggestions for a security plan to protect the pipelines from being stolen
- Suggestions to present all operation workers and organizations/departments, including the Occupational Safety and Health Department along with their role

Others:

- Suggestions to present all project components and their location as well as the pipelines connecting the neighbouring areas, and their impact on the existing pipelines and the industrial complex operations
- Consider decommissioning of the Project
- Suggestions to present the specifications of the desalinated drinking water
- Suggestions to present the marine environment protection regulations or instructions
- Suggestions to add a chapter on disclosure session to the EIA, as there is a difference between the stages of the EIA between the Ministry of Environment and ASEZA
- Suggestions to re-conduct such consultation sessions whereby each component is explained in more detail
- Suggestions to conduct more meetings/consultations
- Suggestions to provide translation in future workshops and to provide the participants with the presented material along with some key information about the project
- Inquiry about the estimated cost of such a project

7.2. Meetings with Local Authorities and Communities

Table 7-4 presents all the meeting conducted during the stakeholder engagement activities in the field, during which 32 meetings were conducted during the months of June and July 2021.

It is worth mention that a stakeholder engagement plan (SEP) has been developed and can be found in **Annex 9.**

Table 7-4: Record of Stakeholder Engagement during Field Visits

No.	Stakeholder / PAP Category	Stakeholder / PAP	Key Concerns – Construction Phase	Key Concerns – Operation Phase	Remarks / Suggestions / Notes
1	Governmental Departments / Local Municipality	**Al Jeezeh Al Jadeedah Municipality** - Eng. Shaker Al Stoul, Executive Director (Tel. 0798166385) - Eng. Ahmad Abed Rabbo, Head of Building Construction (Tel. 0788261357)	- Preserving the Hijazi Railway and its ancient bridges - Expecting job opportunities - Making sure the line is protected so future municipal works do not affect it - Land acquisition could be beneficial for owners	- Need to benefit the local communities from the water conveyance pipeline through providing additional quantities of water - Employment opportunities (positive) - Additional water availability for households will reflect positively on women	- Lack of water resources within the area. Additional water is brought in at a cost - No significant impact considering that the line passes through mostly open, uninhabited areas
2	Governmental Departments / Local Municipality	**Al Ameriyyah Al Jadeedah Municipality** - Eng. Shaher Al Stoul, Executive Director (Tel. 0795113196) - Attorney Tareq Abdallah Msallam, Municipality Legal Advisor (Tel. 0796337206)	- Accessibility to properties and local roads - Landscape disfigurement - Removal of waste and construction debris - Property fragmentation - Land use changes - Like Disi Project, legal cases related to resettlement are expected - Reduction in property frontage - Interference with existing utilities - Need to maintain good coordination with the municipality to minimize negative impacts and maximize benefits - Impacts on Dab'a rangeland, Dab'a and Khan Al Zbeeb historical sites	- Need to benefit the local communities with water from the conveyance pipeline through providing additional quantities of water to the municipality - Employment opportunities (positive) - Additional water availability for households will reflect positively on women	During Disi Project, there were legal cases by local people filed against the project regarding resettlement. This is also expected here.
3	Governmental Departments / Local Municipality	**Sahab Municipality** - Dr. Abdul Hadi Tahrawi, Executive Director (Tel. 0798337780) - Eng. Mohammad Ali Assaf, Head of Investment Promotion Unit (Tel. 0796906735)	- Reinstatement of streets and roads - Interruption of businesses and local facilities - Removal of waste and construction debris - Ensuring quality of reinstated sections to prevent later settlement - Need to avoid working during the winter months (wet season) because of the poor drainage in the municipal streets especially Seteen Road - Interference with public utilizes especially electricity and water lines - Employment opportunities (positive)	- Positive impacts on the municipality from additional water quantities available - Positive impacts on the poor because they cannot afford buying water from private wells - Employment opportunities (positive) - Cost-saving on reinstating streets by the Municipality following works conducted by WAJ to rehabilitate the local water network	The Seteen Road where the conveyance pipeline will pass along divides Sahab into two major parts and is a critical transport route for the city. The Road is under the jurisdiction the Ministry of Public Works and Housing. This road serves around 80,000 vehicles per day.

No.	Stakeholder / PAP Category	Stakeholder / PAP	Key Concerns – Construction Phase	Key Concerns – Operation Phase	Remarks / Suggestions / Notes
4	Governmental Departments / Local Municipality	**Qatraneh Municipality** Ali Mohammad Bani Attieh, Executive Director (Tel. 079708011)	- The pipeline will affect major roads and cause disruption of traffic on both the Desert Highway and the service road where about 90% of the commercial facilities are located. - Municipal services especially waste collection will be affected. - Shallow groundwater will affect excavation activities and prolong the construction period. - Vibrations from heavy equipment will affect nearby buildings. - Dust will cause nuisance and affect the commercial sector. - Employment opportunities for the local community (positive) - Improved business for the shops in Qatraneh if the contractor uses local resources (positive)	- Poor reinstatement after completion of construction will increase the cost on the Municipality during yearly maintenance.	- Qatraneh covers the municipality of Sad Sultani (Abyad) - The executive director proposed changing the pipeline alignment by moving it to the opposite side of the Desert Highway since it is mostly vacant land. Another option would be to circle around the town of Qatraneh. - He has concerns that the service road will not be able to accommodate another water conveyance pipeline.
5	Private Business / Commercial Complex	**Sameeh Mohammad Abu Tarboush** Abu Tarboush Supermarket, Bakery and other commercial store in Qatraneh (Tel. 0796047907)	- Access to shops by customers and suppliers using the Desert Highway or the Service Road will be affected and this will significantly damage the business. - Dust and noise will affect the shops and their products. - Movement of construction vehicles and workers will affect the daily operations. - The impact will be higher if the duration of construction is too long. - Vibrations from heavy construction equipment may affect the structural elements of the shops.	- Any maintenance activities during the operation of the line have to be coordinated with the business owners.	This interviewee claimed to have received compensation during Disi Project but it was less than expected.
6	NGO/Community Leader	**جمعية أبناء المحطة الخيرية** Abdul Rahman Mohammad Abu Tarboush, Chairman of the **Members of Mahatta Charitable Society in**	- Construction will affect the local shops and stores which will reduce the income and increase unemployment. - Nuisance from dust and noise for the local community and businesses.	- Need to offer employment opportunities for the local community in maintenance and operation	They hope that the project will use local workers unlike the Disi Project

No.	Stakeholder / PAP Category	Stakeholder / PAP	Key Concerns – Construction Phase	Key Concerns – Operation Phase	Remarks / Suggestions / Notes
		Qatraneh (Tel. 0795582134)	- Employment opportunities for the local community (positive)		
7	Governmental Departments / Local Municipality	**Muwaqar District Municipality** Sleiman Abeidan Al Jbour, Executive Director (Tel. 0777426342)	- Dust and noise will affect the local communities especially that the conveyance pipeline passes close to houses and shops in Kteifeh, Lusane, Dheibah Al Sharqiyah and Dheiheibah Al Gharbiyyeh - Interruption of access to houses, farms and shops - Public safety concerns from construction activities where the line passes close to residences - Interference with municipal activities and services - A project will begin soon by the Municipality to install street LED lights which may be affected by construction activities of the project - Need to increase the awareness of the local communities about the project to generate acceptance and avoid conflicts	- Need to offer employment opportunities for the local community in maintenance and operation - Leaks caused by damage to the line will affect local residences, shops and farms	Deputy Mayor Mohammad Awwad Al Shakhanbeh attended part of the interview
8	Governmental Departments / Local Municipality	**Hasa Municipality** Naser Mohammad Sleiman Al Hajaya, Executive Director (Tel. 0799027923)	- Movement of the local residents between the two main neighborhoods of Hasa will be interrupted. The Eastern neighborhood contains most of the government departments, shops schools and banks. - Construction of the pipeline could affect the natural surface runoff patterns thus causing obstruction and impoundment in wadis and streams - Construction activities and movement of high construction. equipment may affect highway bridges - Increased risk of accidents along the highway due to construction activities and lack of proper warning signs.	- Need to offer employment opportunities for the local community in maintenance and operation activities	The executive director proposed changing the pipeline alignment by moving it to the opposite side of the Desert Highway
9	Local Community / Livestock Farmer	**Livestock Farmer in Hasa**	- Noise from construction will affect the livestock.	- Construction waste and debris remaining after completion of construction.	Suggested changing the pipeline alignment by moving it to the

No.	Stakeholder / PAP Category	Stakeholder / PAP	Key Concerns – Construction Phase	Key Concerns – Operation Phase	Remarks / Suggestions / Notes
		Ali Awad Al Hajaya, (Tel. 0797215999)	- Preventing access to local shops will affect his activities of selling products and buying supplies. - Movement of livestock herds may be affected by construction. - Dust generation causes health issues. - Interruption of road access affects his business. - Obstruction of water flow in the main wadi crossing Hasa.		opposite side of the Desert Highway
10	Private Business / Bank	**Islamic Bank** - Hasa Branch, Hasa Ahmad Mohammad Al Shabatat – Office Manager, (Tel. 0799626049)	- Customer and employee access to the bank and parking could be affected – for both vehicles and pedestrians - Customer safety issues due to excavation and construction. - Dust generated from construction will add to an already dusty environment. - Noise and nuisance to employees and customers	- Improper reinstatement can cause negative changes in the discharge of street water runoff.	The interviewee emphasized the importance of the following: - Warning and precautionary signs - Providing pedestrian crossings over trenches and excavations - Securing temporary parking areas for employees and customers
11	Governmental Departments / Public Security (Police and Gendarmerie)	**Public Security Department – Southern Gendarmerie Force - Hasa** Major Moa'th Mohammad Zuqaili (Tel. 06-5100360 – Ext. 2530)	- There is a critical need to maintain vehicular access to and from the Southern Gendarmerie Headquarters during construction for both security and operational purposes. - Dust generation. - Damage to existing utility lines in the area affecting power and communications make it important to coordinate with the concerned authorities. - Security issues related to the presence of foreign labor around the Southern Gendarmerie facility.	- Reinstatement and removal of all construction waste and debris after construction is complete	
12	Private Business / Investment Park	**South Aqaba Investment Park** – (Part of National Real Estate Company NREC), Aqaba	- Obstructing the two main entrances – one used for the investors' trucks and the other for the staff and employees. - Need for more security to be provided for the Park in the presence of construction crews.	- Maintenance operations need to be coordinated with the Park management to avoid any disruption of work. - Reinstatement of roads in front of the Park need to be done properly.	- A solution proposed by the general manager was switching between the two existing gates when construction of the pipeline is taking place. Another is opening a new gate.

No.	Stakeholder / PAP Category	Stakeholder / PAP	Key Concerns – Construction Phase	Key Concerns – Operation Phase	Remarks / Suggestions / Notes
		Murad Abu Rous, General Manager (Tel. 0797141516)	- Risk of damaging utility lines as the factories and facilities inside the Park use power and water lines 24/7. - Dust and noise generation. - Disruption in delivery of raw materials and exporting finished products. - Vibration from heavy equipment can cause damage to building.		- Making more water quantities available will attract new investment especially those relying on water in their industry.
13	Governmental Departments / ASEZA	**Aqaba Special Economic Zone (ASEZA)** Eng. Taghreed Ma'aytah, Head of Environmental Section at ASEZA, Aqaba (Tel. 0797121623) *(Gender: Female)*	- General impacts on the marine environment. - Impacts on the infrastructure. - Impacts on villages and farms. - Damage to existing utility lines especially in industrial zones (electricity, gas, water, communications). - Impacts on port operations and handling of goods. - Impacts on road safety. - Dust generation. - Waste disposal. - Noise from operating the large pumps at the intake station. - Blocking access to industrial and commercial facilities - Employment opportunities (positive)	- Leaks and accidents pose risks to ASEZA operations - Employment opportunities (positive)	- Emphasized the need for a full risk analysis to be done covering the entire life cycle of the project. - The need to investigate the risks on the marine environment from returning saline water to the sea.
14	Governmental Enterprise / Power Generation	**Aqaba Thermal Power Station (CEGCO), Southern Industrial Zone, Aqaba** Eng. Zuhair Abu Zaid, General Manager (Tel. 0797411162)	- Damage to existing lines feeding and serving the power station including the main fuel line. There are more than 10 separate lines that could intersect with the AAWDC pipeline alignment. - Blocking the main entrance to the power station.	- Leaks and accidents pose risks to CEGCO operations which make important to protect the line - Cooling water for the power station may become less effective as salinity is expected to increase due to returning the brine back to the sea.	Suggested re-alignment of the pipeline to the north to run adjacent to the Fertilizers Company's boundary line following the existing gas line.
15	Private Business / Major Industry	**Arab Potash Company (APC), Aqaba** – Eng. Khaled Mahmoud Abu Al	- Blocking the main and only road used by APC trucks to carry potash - Construction equipment interfering with APC movement of potash across the industrial port	- Maintenance operations can damage utility lines - Leaks and accidents pose risks to APC Aqaba operations	- Suggested to plan road closure in advance and to be implemented in a manner that keeps traffic flowing.

No.	Stakeholder / PAP Category	Stakeholder / PAP	Key Concerns – Construction Phase	Key Concerns – Operation Phase	Remarks / Suggestions / Notes
		Samen, Executive Director (Tel. 0777111164) Eng. Mohammad Abdulatif Ma'aytah, Director of Technical Department and Operations (Tel. 0775482410)	- Direct impacts on the industrial port		- Need to implement road safety measures through precautionary, warning and directional signs
16	Private Business / Major Industry	**Jordan Phosphate Mines Company Industrial Complex, Aqaba** Eng. Abdul Azziz Marakzeh, General Manager (Tel. 0790140342) Eng. Rifad Al Rafay'ah, Head of the Safety Department (Tel. 0797118339)	- Obstructing access of the main gates used by employees and visitors. - Preventing access of raw materials to the Complex which is brought in daily. - Damaging utility lines feeding the Complex with power, water and other services can be affected. - Risk of damage to the cooling water lines used by the Industrial Complex	- Leaks and accidents could interfere with road traffic thus affecting the Industrial Complex operations - Maintenance could affect the cooling water lines used by the Industrial Complex	Suggested the following: 1) Providing alternative routes for the entrance and egress to the Industrial Complex during construction. 2) Cutting short the construction period especially in front of the main access points.
17	CBO/Community Leader	جمعية سيدات قرى حوض الديسة، قرية الديسة Qutnah Mohammad Al Hweitat, Chairman of the **Disi Ladies Society** (Tel. 0772495908) *(Gender: Female)*	- Noise and nuisance affecting the Society's beneficiaries - Dust affects the Society's tools and machines used in its workshops like sewing machines. It will also affect products and exhibited items (medicinal plants project) - Interference with access to the Society's offices and its adjacent projects will affect the beneficiaries including women and children - Presence of foreign workers will affect movement of village women participating or benefiting from the Society's training and projects	- Presence of foreign staff for maintenance and operation of the AAWDC line will affect privacy and movement of village women - This CBO is active in catering and food preparation and can offer the project contractor their services which will benefit both parties	- The CBO's chairman suggested coordinating the construction activities with the local events of the CBO to avoid nuisance and negative impacts. - This CBO received support from the Disi project for its activities. - They commended the Disi Project for providing work opportunities for the local community. - Providing pedestrian and vehicular crossings will be important for the local people

No.	Stakeholder / PAP Category	Stakeholder / PAP	Key Concerns – Construction Phase	Key Concerns – Operation Phase	Remarks / Suggestions / Notes
					- Provide alternative back access road for the Society during construction - Accelerating the construction phase will avoid many adverse impacts
18	Private Business / Tourist Camp	**Zawaideh Tourist Camp,** Mahmoud Abdallah Al Zawaideh, Camp Owner and Manager (Tel. 0779479113)	- Blocking access to the tourist camp for tourists and employees will affect its business - Noise and dust generation will affect the quality of the tourist experience	- Any waste left after construction is completed will affect the landscape and cause visual intrusion	The camp owner strongly recommended providing work opportunities for the local people during construction due to the high unemployment rate. He suggested postponing the works affecting access to the camp until the end of the project. Coordinate the construction activities with the camp to avoid busy days at the camp.
19	CBO/Community Leader	**جمعية قرى حوض الديسة السياحية، قرية الديسة** Awad Ayed Al Zawaideh, Chairman of the **Disi Basin Tourist Society** (Tel. 0772796360)	- Interfering with access to the Society offices and projects and tourist and visitor mobility - Impacts on the vehicle parking area used by the Society for bringing in and offloading tourists. The AWWDC pipeline passes in front of this parking area.	- Need to offer employment opportunities for the local community in maintenance and operation activities	The Society suggested providing a temporary parking area for tourist buses during construction. Avoid the two peak tourist seasons (Sep-Dec & Mar-Jun). They emphasized the need to provide job opportunities. There may be alternative access routes and bus offloading areas to the Society but they need further examination.
20	Private Business / Tourist Complex	**Rock Adventure Village &Echo Jordan Tourist Company,** Islam Saleh Abdel Rahman Qatawneh, Owner & General Manager (Tel. 0795625892) *(Gender: Female)*	- Blocking access to the tourist complex for tourists and employees will affect business - Noise and dust generation will affect daily operations - Damage to utility lines serving the tourist complex - Dust will affect the plantations around the tourist complex	- Improper reinstatement will cause long-term effects on the road and infrastructure and will require additional maintenance to be done by the tourist complex - Need to offer employment opportunities for the local community in maintenance and operation activities	PAP suggestions: - Paying compensations for construction impacts affecting the business. - Offering catering services to the project's workforce. - Need to propose traffic solutions when the road is closed for construction.

No.	Stakeholder / PAP Category	Stakeholder / PAP	Key Concerns – Construction Phase	Key Concerns – Operation Phase	Remarks / Suggestions / Notes
			- Foreign labor will be rejected by the local communities if not associated with local labor	- Residual construction waste will affect the visual quality at the tourist complex	- Closure due to construction should be timed with the low season.
21	Governmental Departments / Local Municipality	**Al Quweirah Al Jadeedeh Municipality** - Eng. Malek Hasan Reyati, Executive Director (Tel. 0787608990) - Eng. Sleiman Mohmmad Al Mara'yeh, Head of the Local Development Unit (Tel. 0788880997)	- The four access points to the two villages of Salehiyyah and Um Al Basateen will be affected thus affecting municipal services works in addition to the movement of local inhabitants - Noise and dust will increase and will affect the local communities and increase the burden on the municipal services. - Foreign labor will not be accepted by the local communities if the project is not using local resources for work and services during project construction	- Need to benefit the local communities with employment opportunities and use the services of the local communities in project maintenance and operation. - Improper clean-up of waste from construction and reinstatement will place a burden on the Municipality	This Executive Director attended the Scoping Session on March 1, 2021. The Municipality provides direct water supplies to Um Al Basateen village as it is not connected to the water network thus any interruption of this service will be vital.
22	Private Business / Petrol Station	**Hasa Petrol Station (JO Petrol), Hasa,** Hatem Abdul Rahman Tarawneh, General Manager (Tel. 0799523007) N30 47' 43" E35 59' 34"	- Impeding access to the station during construction will stop/reduce the number of vehicles being served by the station - The digital fuel pumps are sensitive to dust which will be generated from construction activities - Risk of permanent loss of regular customers who have long-term contracts with the station for fueling their vehicles - Public safety risk for users of the station	- Need to clean up the area after completion of construction. - Improper reinstatement of road and pavement will have impacts on the vehicles and the overall service of the station.	This PAP made the following suggestions: - It is critical to complete the construction along the station's frontage as fast as possible. - Phase the construction of the pipeline along the frontage in coordination with the management and such that service is not seriously affected. - Set up alternative access as needed. - Need to post warning and signs and make safety precautions.
23	Private Business / Rest House	**Pillars of Jerusalem Rest House, Hasa,** Hasan Ibrahim Ababneh , Co-owner & General Manager (Tel. 0797022793) N30 47' 45"	- Blocking access to the Rest House for tourists and employees will affect the business especially tourist groups arriving specifically to this location in big buses - Dust generation will negatively affect the souvenirs and food items thus the daily operations of the Rest House	- Improper reinstatement will cause long-term effects on the road and infrastructure and will require additional maintenance to be done by the Rest House	PAP suggestions: - The contractor needs to promptly remove the waste generated from construction activities and not allow to accumulate

No.	Stakeholder / PAP Category	Stakeholder / PAP	Key Concerns – Construction Phase	Key Concerns – Operation Phase	Remarks / Suggestions / Notes
		E35 57' 37"	- Noise will also affect the comfort of tourists using the Rest House	- Residual construction waste left around the area will affect the big buses coming into the Rest House	- Offering catering services to the project's workforce. - Need to propose an access if closure is to take place during construction. - Closure due to construction should be quick and timed with the low season.
24	NGO/Community Leader	جمعية العقبة للتطوير والتمكين المجتمعي Fayzah Khalawi Al Khateeb, Chairman of the **Aqaba Development and Empowerment Society, Aqaba** (Al Mahdoud Al Gharby) (Tel. 0795191963) *(Gender: Female)*	- Delay, cancel or postpone the implementation of the Society's activities and functions in the areas affected by the pipeline construction.	- Since part of the scope of the Society is water conservation, the Project will serve as a good example of water projects (positive impact)	The NGO's chairman suggested the following: - Provide alternative access routes for the participants in the Society's activities where construction is causing closures. - Providing alternative meeting halls to avoid construction areas.
25	CBO/Community Leader	جمعية الشاكرية والصالحية السياحية Yousef Hussein Al Sweilhiyeen, Chairman of the **Shakeriyyeh and Salihiyyeh Tourist Society**, Salihiyyeh Qweira, Aqaba (Tel. 0796077214)	- Need to provide employment opportunities for the local people. - Obstructing access to the villages from construction activities. - Phasing of the construction along the Salihiyyeh village frontage which extends about 1km along the pipeline route.	- Need to benefit the local communities by offering them employment opportunities and using the services of the local businesses (water tankers, loaders, transportation vehicles, etc.) during project operation and maintenance.	- The CBO's chairman suggested considering re-routing the pipeline so that it is adjacent to the Disi-Aqaba pipeline which runs about 150m away from the main road. - He mentioned that these communities benefited from the Disi Pipeline Project and look forward to a similar experience with the AAWDC Project. - The NGO's chairman suggested raising awareness of the local communities about the project in advance of project commencing.
26	Private Business / Tourist Facilities	إسطبلات خيول رم / مشروع من المزرعة إلى المائدة	- Potential damage to three main utility lines serving this facility.	- Need to benefit the local businesses from	PAP suggestions:

No.	Stakeholder / PAP Category	Stakeholder / PAP	Key Concerns – Construction Phase	Key Concerns – Operation Phase	Remarks / Suggestions / Notes
	(horse stables, catering and food, traditional kitchen)	Khitam Khalil Al Hasanat, Busines Owner and Manager, **Rum Horse Stables & Farm-to-Table Project,** Salihiyyeh Qweira, Aqaba (Tel. 0772443963) *(Gender: Female)*	- Dust and construction waste could negatively affect the food products and food preparation process. - Obstructing access to the facility for visitors and employees from construction activities. - Positive impact from generating business for this tourist facility (food catering)	employment opportunities and using their services.	- Phasing of construction activities in a manner to reduce impacts on the tourist season, mainly from September to May. - It is important not to remove / obstruct directional signs posted on the main road during construction as they are important to guide tourists to this business facility. - Reducing the construction duration is crucial for this and similar businesses in the area.
27	Governmental Departments / Local Municipality	**Disi Municipality** Sidki Khalil Al Rfou', Chairman of Disi District & Municipality, Disi, Aqaba (Tel. 0772123442)	- The local residents will not accept the presence of foreign unskilled workers if the project is not employing local residents and using local resources (from local shops) during project construction - Dust and construction waste will affect the residents of Disi. - Road closure caused by construction activities will affect local residents and businesses and will affect municipal services	- Need to remove all residual construction waste and provide proper reinstatement of roads affected otherwise it will be a burden on the Municipality to perform frequent maintenance - Need to benefit the local residents and business during operation and maintenance by offering them employment as and using the services of the local businesses	The stakeholder suggested planning construction in a manner that does not close the two sides of the road during construction but shifting traffic to one side at a time.
28	Private Business / Tourist Camp	**Sun City Tourist Camp,** Abdul Azziz Salem Al Zawaideh, Camp Owner and Manager (Tel. 0772227047)	- Noise and dust generation may affect the quality of the tourist experience at the camp especially that the background dust is already high - Road closure will block access to the tourist camp for tourists and employees which will affect its business	- Construction waste remaining after completion of construction will affect the visual quality - Need to offer local residents jobs in operation and maintenance considering the high unemployment rate	The camp owner suggested: - Providing work opportunities for the local people during construction due to the high unemployment rate. - Plan the construction activities to avoid the busy season at the camp.

No.	Stakeholder / PAP Category	Stakeholder / PAP	Key Concerns – Construction Phase	Key Concerns – Operation Phase	Remarks / Suggestions / Notes
					- Consider alternative and emergency access routes for the camp. - Need to shorten the construction period as much as possible. - Avoid working at night to prevent nuisance for the tourists. - Provide clear directional and warning signs at work locations and detours.
29	Governmental Departments / Local Municipality	**Um Al Rassas Al Jadeedah Municipality** Eng. Mais Salman Al Ka'abneh, Executive Director, Madaba Governorate (Tel. 0798585047) *(Gender: Female)*	- Closure of the main road will affect the municipal services such as waste collection and maintenance of street lights and roads - Emergency municipality services may be affected during construction of the pipeline such as cleaning culverts during winter storms. - Damage to power and water utility lines feeding Damkhi. - Interruption of mobility for residents using the main road or who need access to the Desert highway. - Need to fairly compensate owners of land if acquired by the project	- Improper reinstatement of roads will cause the Municipality to perform frequent maintenance - Need to offer employment opportunities for the local community in maintenance and operation - Water leaks from damaged line will affect the main and secondary roads.	The Executive Director of the Municipality suggested performing a detailed examination of the location of the utility lines feeding Damkhi in order to avoid any damage during construction. Also, to consider setting up alternative access roads to facilitate the movement of municipal service vehicles and residents of the area.
30	CBO / Community Leader	جمعية الكتيفة الخيرية Ekhleif Erhayyan Ajjaj Al Hardan, Chairman of the Kteifeh Charitable Society, Al Kteifeh, Muwaqqar District (Tel. 0772264880)	- Obstructing access to the village mosque, health center and the local municipal council building. Also access to the only boys school in the village may be blocked by construction. - Some residences and commercial shops will be affected by loss of access including the CBO's building. - Damage to utility lines from construction (water, electricity and communication lines) - Risk to the public if construction takes place at night since the main street is not lit.	- Improper reinstatement of the main road will cause the roads to settle and become unusable. - Need to offer employment opportunities for the local community in maintenance and operation	The CBO chairman suggested: - Considering providing revolving loans to the CBO to help the local community. - Avoid working at night to prevent accidents as the road in unlit. - Provide clear directional and warning signs at work locations and detours. - Provide alternative access roads to vital community facilities.

No.	Stakeholder / PAP Category	Stakeholder / PAP	Key Concerns – Construction Phase	Key Concerns – Operation Phase	Remarks / Suggestions / Notes
			- It is critical to keep the surface water drainage culverts open during construction and not block water flow by construction waste since these culverts are under road to the village.		
31	Governmental Departments / GAM	**Greater Amman Municipality (GAM)** Eng. Suha Abdul Wahab Al Shishani, Head of Section for Environmental Monitoring of Projects at GAM, Amman (Tel. 0799054175) *(Gender: Female)* *(attended the Scoping Session on March 1, 2021)*	- Preventing access to residences, community facilities and shops. - Damage to service and utility lines including water, wastewater, electricity and communications - Dust and noise affecting residential and commercial areas especially restaurants located along the main roads - Excavations in some areas where the soil is unstable may cause damage to houses and garden walls - Interference with road traffic during construction - Construction could disrupt school activities	- Improper reinstatement of roads will cause GAM to perform frequent and costly maintenance - Construction waste remaining after completion of construction - Leaks and accidents pose risks to ASEZA operations - Employment opportunities (positive)	- Emphasized the need to adhere to the standard specifications for reinstating road s and road pavement - Consider using noise barriers where construction is close to residential areas - Provide warning and directional signs and limit vehicular speed near construction sites and use flag men - Provide lighting for construction sites at night - Inform the residents and businesses of work schedules ahead of time - Ensure there is a clear and easy grievance mechanism in place and - Need to coordinate between GAM and the BOT Contractor - Need to ensure the BOT Contractor applies the chance finds procedure
32	CBO / Community Leader	**جمعية العهد والإتفاق الخيرية / الإتحاد النوعي لجمعيات لواء الموقر** Farhan Qasem Al Methan, Chairman of Ahed and Itifiaq Charitable Society, Muwaqqar District (Tel. 0798281320)	- Dust will affect community health of the local residents especially those with respiratory problems. Also dust will affect he local crops and livestock - Obstructing access to the village residences, a few commercial shops and the village's only school - Risk to the community from construction activities on the narrow streets of the area	- Construction waste remaining after completion of construction will cause dust generation - Improper reinstatement of the roads will cause damage to the vehicles of the villagers	The CBO chairman suggested: - Considering supporting local CBOs to help the local community. - Use the local CBOs to spread awareness about the project.

No.	Stakeholder / PAP Category	Stakeholder / PAP	Key Concerns – Construction Phase	Key Concerns – Operation Phase	Remarks / Suggestions / Notes
			- Need to provide job opportunities to the local youth during construction and use local businesses and construction machinery	- Need to offer employment opportunities for the local community in maintenance and operation	- Provide clear directional and warning signs at work locations and any detours. - Inform the local residents and businesses of the construction work schedules before commencing activities. - Monitor the health condition of residents who are sensitive to dust due to existing respiratory problems. - Limit the duration of the construction period as much as possible.

7.3. Disclosure Sessions

7.3.1. Virtual Disclosure Session

On February 22, 2022, the ESIA Team, in coordination with ASEZA, MoE and MWI, held a virtual Disclosure Session using MS-Teams to present the results of the AAWDC's ESIA study to stakeholders and obtain their feedback. Over 85 invitations were sent to various ministries, agencies and institutions to attend this session. In total, 139 persons participated. During the session, a technical description of the project was presented by the design team (CDM Smith). This was followed by a presentation of the environmental baseline conditions of the Project's Area of Influence, impacts and mitigations for four main environmental components as follows: physical environment, terrestrial environment, socio-economic environment (in addition to cultural heritage) and marine environment. The main components of the Project ESMP during both construction and operation were also presented. The floor was then opened for questions and discussion. At the end of the session, all participants were requested to fill out a questionnaire on environmental and social concerns (which 14 participants completed).

This section presents the main issues that were raised during the discussion and the results of the questionare. All details pertaining to this session can be found in **Annex 17** including the presentation, letters of invitations, list of participants, agenda, detailed proceedings, questionnaire and results

7.3.1.1. Discussions

The main issues raised by the attendees during the session and their responses are as follows:

- How can the impacts faced by Al-Disi project be avoided in this Project and can the project area especially Wadi-Rum handle another project as AAWDC after Al-Disi Project? **Response:** Disi project biodiversity impacts were significant because a lot of work was done at the wellfield location, including drilling of wells. The construction for this project will mainly affect the vegetation and habitats along the corridor and if the contractor applies the mitigation measures in the ESMP, these impacts will be reduced to acceptable levels.
- Will the project reduce or increase GHG emissions? **Response:** The project will lead to an increase in GHG but the extent of the increase is dependent on whether renewable energy is adopted by the BOT Developer.
- Training the MWI operators by the BOT contractor before the contract ends. **Response:** The ESIA states that a capacity building program is needed to ensure that MWI are properly trained on various aspects related to the project. In addition, it is a requirement in the BOT contract to train MWI operators before the end of concession period and handover of facilities to MWI.
- The ESIA Approval to the Project components within Al-Aqaba Governorate is from ASEZA only. **Response:** This will be clarified in the ESIA Report.
- There was no detailed traffic study, risk assessment, and emergency plan in the ESIA Study. **Response:** AAWDC is a BOT project, so the ESIA was done for a preliminary design and the BOT Contractor is the one who is responsible to do the detailed design. As this project is still at the preliminary design stage, there is not enough data to conduct a full traffic study and other detailed assessments mentioned. All these have been included in the ESMP to be executed as the responsibility of the BOT Developer.
- A disclosure session needs to be held face to face to discuss the issue of the brine water. Response: In-person meeting was held (refer to Section 7.3.2).
- The ESIA study should be available online. **Response:** The non-technical summary has already been provided and the full ESIA will be made available online in both Arabic and English languages once finalized.
- The intake and outtake locations are sensitive and not considered suitable. Better locations should be investigated. **Response:** ASEZA stated that a committee including representatives from Aqaba Water and MWI selected this location after considering several other ones and due to various factors. Please refer to Chapter 4 of the ESIA (site alternatives).
- People are stealing water from Al-Disi Conveyor and this should be studied for AAWDC project. **Response:** A Security Plan is required to be prepared and implemented by the BOT Developer to address the issue of theft.
- In the Executive Summary, it was mentioned that the Electricity provider is EDCO and it will provide the desalination Plant with 200 MVA, while EDCO network cannot handle 200 MVA. So, the company should

be changed from EDCO to NEPCO. **Response:** The discussion on the electricity capacity and source is ongoing and decisions have not been finalized.

- Solids will be upwards of 7000 kg/d. Volume will be higher, based on water content. Where will this be disposed of? **Response:** Dewatered sludge from the onsite STS (of dry solids content > 20%) will be disposed or offsite to a dedicated landfill in coordination with the regulators.
- Does the ESIA includes the options of supplying the project with energy and evaluate each option? **Response:** The study estimated the GHG emissions for each option.
- Is there any potential effect of oil spillage from berthing ships or tankers that may go with water into Intake pipes/cages all the way to IPS, I refer to heavy spills (sinkers that is suspended in water and not on the surface)? **Response:** The intake towers would be located at a water depth of 12-15 m, with windows more than 5m below sea surface level; hence floating oils would not be entrained. Oils with entrained solids causing bulk density greater than seawater would tend to sink. The very steep sea bathymetry would result in these migrating to deeper waters away from the intake. SWRO plants are equipped with hydrocarbon detection systems at intake pump stations to alert and protect the plant should such hydrocarbons enter the intake. Such provisions have been included in the ESMP. Provision for floating barriers for the protection of the intake system has also been included in the ESMP. There are many SWRO intake facilities located at power plants where tankers load oil fuel at jetties nearby.
- Do you foresee any challenges in land acquisition? Is there any involuntary resettlement involved? **Response:** No physical/involuntary resettlement is anticipated for the project. We only anticipate land acquisition, mostly barren or agricultural land. A Land Acquisition Policy Framework has been prepared for this purpose.

7.3.1.2. Results of the Questionnaire

At the end of the session a questionnaire form was sent to the participants via MS Teams chat, to give all the attendees the chance to rate the project in terms of specific impacts during both the construction and operation phase. The questionnaire was the same as the questionnaire distributed among the participants at the scoping session, it included 31 questions related to different construction and operation impacts. The first part of the questionnaire (questions 1 to 11) was designed to collect data on the impacts associated with the construction of the desalination plant whereas the second part (questions 12 to 20) consists of questions related to the impacts associated with the construction of the conveyance pipeline. The third part (questions 21-31) considered impacts associated with operation of the AAWDC project. The questionnaire was prepared in both Arabic and English languages.

Table 7-5 shows the results for the first part of the questionnaire, which is the impacts associated with the construction of the desalination plant, around 54% of the respondents considered that the impact on marine habitat from excavation works to be a low significance. Also, the case regarding the impact on Gulf of Aqaba water quality from accidental oil/chemical spills or leakages, half of respondents considered this impact as low significance and it was the highest percentage. As for the alteration of trophic conditions of Gulf of Aqaba, it is the same as the previous impacts, where around 54% of the respondents considere it as a low significance. 54% of the respondents find that impact on Water quality and hydrology of wadi flood pathways is of low significance. Non of the respondents considered that construction impacts on the groundwater table are of high significance, while the majority (85%) considere it as a low significance. As for impact of construction activities on the cultural heritage sites, the majority of respondents (69%) indicated that it is considered of medium significance. This was also the case regarding the issues of alternation of existing land uses. Almost half (46%) of the respondents found that permanent land acquisition was of low significance. More than the half of the respondents (54%) consider that health and safety risks on workers and public during construction is a low significance. 46% also considers that the Alteration in ship mobility patterns is of low significance, however 62% found disruption to industries in the desalination components system area it to be of low significance.

Table 7-5:Results of First Disclossure Session's Questionnaire Responses for Construction of Desalination Component

Impact	Percentage		
	High	Medium	Low
Marine habitat destruction from excavation works	23.08	23.08	53.85
Alteration of trophic conditions of Gulf of Aqaba	16.67	33.33	50

Impact	Percentage		
	High	Medium	Low
Degradation of Gulf of Aqaba water quality from accidental oil/chemical spills or leakages	7.69	38.46	53.85
Water quality and hydrology of wadi flood pathways	7.69	38.46	53.85
Changes in groundwater table	0	15.38	84.62
Damage to of cultural heritage sites	7.69	69.23	23.08
Alteration of existing land uses	23.08	61.54	15.38
Permanent land acquisition	15.38	38.46	46.15
Worker and public health and safety risks	15.38	30.77	53.85
Alteration in ship mobility patterns	23.08	30.77	46.15
Disruption to industries in the desalination components system area	7.69	30.77	61.54

Table 7-6 illustrates the results of the questionnaire second part, which is related to the impacts associated with the construction of the conveyance pipeline. Almost half the respondents (46%) indicated that construction of the conveyance pipeline impact on the wadis, surface and ground water is of low significance. The same percentage was for disturbance from the generated dust and noise but the renspondents considered the imact as of medium significance. As for terrestrial habitat loss or alteration, 46% and 38% of the respondents indicated that this impact is of low and medium significance, respectively. However, the case regarding the impact on Disruption/destruction to existing infrastructure as the percentages of respondents rating this impact as low and medium significance was 38% for each (a total of 76%). while over half (54%) found Disruption/destruction to existing infrastructure to be of medium significance. As with the construction of the desalination components. the majority of the respondents (78%) thought that health and safety during construction was of low significance while only 7% though it was of high significance. Quarter of the respondents concedered the concerns related to the disruption or loss of cultural heritage within the area of the conveyance pipeline as of high significance, where most of the respondents (67%) rated this impact as medium significance. Just over half of the respondents (54%) stated that the impacts associated with land acquisition and disruption to businesses along the route is of moderate significance (Table 7-2).

Table 7-6: Results of First Disclossure Session's Questionnaire Responses for Construction of the Water Conveyance Component

Impact	Percentage		
	High	Medium	Low
Wadis, surface and ground water contamination	38.46	15.38	46.15
Disturbance from generated dust and noise	15.38	46.15	38.46
Terrestrial habitat loss or alteration	15.38	38.46	46.15
Disruption/destruction to existing infrastructure	23.08	38.46	38.46
Disruption of traffic movement	7.69	53.85	38.46
Worker and public health and safety risks	7.69	15.38	76.92
Disruption/loss of cultural heritage	25	66.67	8.33
Permanent land acquisition	8.33	25	66.67
Disruption to businesses along the route	15.38	53.85	30.77

According to the results of the third part of the questionnaire as shown in Table 7-7, the disruption of soil from backwash sludge during operation was considered by 38% of the respondents to be of high significance, while the rest (31% each) consider it as of medium and low significance. The same percentage for the high, medium and low of significance for disruption of seafloor and sediments characteristics (salinity) from brine discharge and filters' backwash impact. whereby 38 of the respondents who considered that the change in water circulation by open intakes when large volumes of water are extracted and impact on ambient seawater salinity is of low significance. As for impact on alteration of seawater quality (enrichment of nutrients, organic matter, pollutants, or trace metals), most of the respondents (62%) indicated these issues are considered medium significant impacts. By far, almost half of respondents (46%) rated the disruption of such projects on the marine flora and fauna mainly from the open intakes and discharge of filters' backwash and brine as od medium significance. About 46% rated impact on marine and terrestrial habitats from generated noise during operation, Worker health and safety risks and disturbance from generated dust and noise impacts to be of low significance with 38% rating it as moderate. Habitat fragmentation during maintenance activities was rated as high significance by half the respondents.

However, 64% of the respondents considered that the proposed project will have a high positive impact on the national water security

Table 7-7:Results of First Disclosure Session's Questionnaire Responses for Operation of the Project.

Impact	Percentage		
	High	Medium	Low
Disruption of soil properties from backwash sludge	38.46	30.77	30.77
Disruption of seafloor and sediments characteristics (salinity) from brine discharge and filters' backwash	33.33	33.33	33.33
Change in water circulation by open intakes when water is extracted	30.77	30.77	38.46
Increase in ambient seawater salinity	30.77	30.77	38.46
Alteration of seawater quality (enrichment of nutrients, organic matter, pollutants, or trace metals)	23.08	61.54	15.38
Disruption of marine flora and fauna from open intakes and discharge of filters' backwash and brine	23.08	46.15	30.77
Marine and terrestrial habitat loss from generated noise	15.38	38.46	46.15
Worker health and safety risks	15.38	38.46	46.15
Disturbance from generated dust and noise	15.38	38.46	46.15
Habitat fragmentation and disturbance during maintenance activities	16.67	33.33	50
Positive impact of the project on national water security	64.29	35.71	0

The questionnaire presented an opportunity for the respondents to raise other issues of concern which included:

- Impact on the sensitive environment of the Gulf of Aqaba
- Focus on the operational phase; especially, there might be a high pollution risk if the brine wasn't treated.
- Georisks (earthquakes, tectonic movements, land stability, flooding, etc.):
- Detailed geological study of the desalination plant site is required
- It is critical to receive the full ESIA document and not just the summary.

7.3.2. Hybrid Disclosure Session

On March 16, 2022, the ESIA Team, in coordination with ASEZA and MWI, held a second disclosure session at the Hyatt Regency Aqaba Ayla Hotel and online (in hybrid format) to present issues related to the Project impact on the marine environment to stakeholders and obtain their feedback. Around 30 agencies and institutions were invited to this session such that 44 persons attended. During the session, the Project was presented, as were all findings related to the marine environment were explained by the ESIA Team. The floor was then opened for feedback, discussion and questions. Interpretation in English and Arabic languages was made available throughout. At the end of the session, all participants (in-person and online) were requested to fill out a questionnaire on environmental and social concerns (which 27 persons completed).

This section presents the main issues that were raised during the session and how this report, and the ESIA, aim to address them. All details pertaining to this session can be found in **Annex 18** including the presentation, letters of invitations, list of participants, agenda, questionnaire and results, and photographic documentation.

7.3.2.1. Discussions

Additional issues raised by the attendees during the second session and their responses are as follows:

- Do the intake towers generate currents that may affect the ships? **Response:** The intake towers are designed to have large openings to reduce the velocity of the incoming water. Hence, we do not anticipate inshore or offshore currents.
- There is a need for Security Plan for the project facilities. **Response:** ASEZA will contact the Royal Jordanian Navy, ADC and Jordan Maritime commission to see if there is a need for a Security Plan. In any case, the ESMP requires the BOT Contractor to prepare and implement a Worksite Security Strategy and Plan that limits access to all project facilities.
- In case of fire near the intake towers there should be a plan to protect the intake towers. **Response:** Intake towers are submerged structures at water depths of 12 to 15m. Any fire incidents due to combustible hydrocarbons leaks will occur at the surface and are highly unlikely to affect the towers at those depths. The mitigation measure that is mentioned in the ESMP and the emergency plan in the ESIA will protect the intake towers from fire and prevent leaks to enter abstracted water.
- Is there a chance to reuse the brine water instead of discharging it? **Response:** The project is a BOT project for water supply and not commercial exploitation of brine. Alternative options for brine exploitation have been assessed by MWI but not promoted for this project. However, the BOT Developer may decide to change the design, and choose another method instead of discharging the brine water.
- The currents in the gulf of Aqaba causes upwelling, which is the main source of nutrients in the eastern part of the gulf. Will the intake towers and brine water discharging (due to the upwelling, it will increase water salinity) have a critical effect on the northern area of the project? **Response:** Aqaba Gulf is not affected by the upwelling so the brine will not reach the surface.
- The expert used simulation to find the mixing zone regulation for the RO Plant in Aqaba. However, why does the expert select the Mixing Zone Regulation for the RO plant in Aqaba according to the Saudi project in the Red Sea not according to the Saudi project in the Gulf? **Response:** There is no set mixing zone regulation in Jordanian legislation. Following detailed review of mixing zone regulations in other countries operating large scale desalination facilities, inclusive of Saudi Arabia, the ESIA selected the Saudi (Red Sea) set mixing zone regulation of 2% salinity increase above ambient seawater salinity at 100m from the diffusers throughout the water column. Currently, this is the most stringent mixing zone rule globally, hence was selected as the most protective for the Gulf of Aqaba. The near field modelling did not set the regulation for the mixing zone; it showed that the set salinity standard is achieved within 100m from the diffusers.
- It is not mentioned whether governorates other than Amman will benefit from the Project and received desalinated water. **Response:** All governorates through which the conveyance will pass will receive a share from the treated water. The infrastructure needed for this will be undertaken by MWI, not the BOT Contractor in parallel to project construction
- What is the source of the wastewater that will be sent to the wastewater treatment plant? **Response:** The wastewater source is from the plant workers (15 worker / day) and is considered domestic.
- Where will the treated wastewater and sludge be discharged? **Response:** There are several options for discharge, including potential reuse in line with the Jordanian standards. Sludge is required to be handled in accordance with JS 1145.
- The Project committee should provide ASEZA with a list of alternative locations or use the current locations and keep a corridor at the seafront for future projects. **Response:** A redesign was done and sent to the ADC whereby a 15m corridor was kept for future projects.

7.3.2.2. Results of the Questionnaire

During the second disclosure session a questionnaire was distributed among the participants at the end of the session in an effort to give all the attendees the chance to rate the desalination component in terms of specific impacts during both the construction and operation phase. it included 23 questions related to different construction and operation impacts. The first part of the questionnaire (questions 1 to 11) was designed to collect data on the impacts associated with the construction of the desalination plant whereas the second part (questions 12 to 19) consists of questions related to the impacts associated with operation of the Desalination Component. The questionnaire was prepared in both Arabic and English languages.

Table 7-8 shows the results for the first part of the questionnaire, which is the impacts associated with the construction of the desalination plant, around 56% of the respondents considered that the impact on marine habitat from excavation works to be a moderate significance and no one considere it as a low significance. Also, the case regarding the impact on Gulf of Aqaba water quality from accidental oil/chemical spills or leakages, 44% of respondents considered this impact as moderate significance and it was the highest percentage. As for the alteration of trophic conditions of Gulf of Aqaba, around the half (48%) of the respondents considere it as a moderate significance. 44% of the respondents find that impact on Water quality and hydrology of wadi flood pathways is of low significance and the same percentage of the respondents thought that this impact will have a moderate significance. More than the half of respondents (56%) considered that construction impacts on the groundwater table are of low significance. As for impact of construction activities on the cultural heritage sites, the majority of respondents (74%) indicated that it is considered of low significance. regarding the issues of alternation of existing land uses. Almost 42% of the respondents found that permanent land acquisition was of low significance and the same percentage found it as a medium significance. More than the half of the respondents (59%) consider that health and safety risks on workers and public during construction is a moderate significance. Around the half (52%) of the respondents considers that the Alteration in ship mobility patterns is of low significance, however 48% found disruption to industries in the desalination components system area it to be of medium significance.

Table 7-8:Results of Second Disclossure Session's Questionnaire Responses for Construction of Desalination Component

Impact	Percentage		
	High	Medium	Low
Marine habitat destruction from excavation works	44.44	55.56	0
Alteration of trophic conditions of Gulf of Aqaba	22.22	48.15	29.63
Degradation of Gulf of Aqaba water quality from accidental oil/chemical spills or leakages	14.81	44.44	40.74
Water quality and hydrology of wadi flood pathways	11.11	44.44	44.44
Changes in groundwater table	14.81	29.63	55.56
Damage to of cultural heritage sites	1.11	14.81	74.04
Alteration of existing land uses	15.38	42.31	42.31
Permanent land acquisition	14.81	44.44	40.74
Worker and public health and safety risks	18.52	59.26	22.22
Alteration in ship mobility patterns	11.11	37.04	51.85
Disruption to industries in the desalination components system area	7.41	48.15	44.44

According to the results of the second part of the questionnaire as shown inTable 7-9, the disruption of soil from backwash sludge during operation was considered by 44% of the respondents to be of moderate significance, while 29% consider it as of high significance. Almost half (48%) of respondents find the significance for disruption of seafloor and sediments characteristics (salinity) from brine discharge and filters' backwash impact as a moderate significance. whereby 38 of the respondents who considered that the change in water circulation by open intakes when large volumes of water are extracted and impact on ambient seawater salinity is of high significance. As for impact on alteration of seawater quality (enrichment of nutrients, organic matter, pollutants, or trace metals), around half of the respondents (46%) indicated these issues are considered medium significant impacts. By far, almost half of respondents (53%) rated the disruption of such projects on the marine flora and fauna mainly from the open intakes and discharge of filters' backwash and brine as of low significance. Exactly half of the respondents rated impact on marine and terrestrial habitats from generated noise during operation, to be of high significance. However, 46% rated Worker health and safety risks impact as a moderate significance.

However, 60% of the respondents considered that the proposed project will have a high positive impact on the national water security

Table 7-9:Results of Second Disclosure Session's Questionnaire Responses for Operation of the Project.

Impact	Percentage		
	High	Medium	Low
Disruption of soil properties from backwash sludge	29.63	44.44	25.92
Disruption of seafloor and sediments characteristics (salinity) from brine discharge and filters' backwash	40	48	12
Change in water circulation by open intakes when water is extracted	38.46	30.77	30.77
Increase in ambient seawater salinity	38.46	34.61	26.9
Alteration of seawater quality (enrichment of nutrients, organic matter, pollutants, or trace metals)	34.61	46.15	19.23
Disruption of marine flora and fauna from open intakes and discharge of filters' backwash and brine	53.85	34.62	11.54
Marine and terrestrial habitat loss from generated noise	50	34.62	15.38
Worker health and safety risks	23.08	46.15	30.77
Positive impact of the project on national water security	60	40	0

Issues raised by the paricipants who filled out the questionnaire included:

- In the presentation it was mentioned that chlorine will not be use for disinfisction, but in NTS page 13 it is mentioned that chlorine gas is one of the disinfection methods.
- Protect the desalination components from weather conditions and sea storms.
- There should be mitigation measeres for any leakage happened near the intake towers either from the gas pipeline or other source.
- The project area is an important area in terms of the economic importance of the Kingdom, and this impose great security challenges, most of the ports for exporting potash, phosphate and chemical industrial complexes near the project area.
- Contingencies should be in place should a leak occurr from one of the industrial areas near the intake towers.
- Change in the food chain should be studied.
- Nothing about the wastewater and sludge generated from WWTP is mentioned in the NTS.

7.4. Addressing Stakeholder Feedback

All the 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 ESMP appended as **Annex 19** 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 2** 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 9** 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 8** of the ESIA study provides the Land Acquisition and Resettlement Policy Framework for the 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).

8. Impact Assessment and Mitigation

This chapter describes the identified potential environmental and social impacts that may result from construction and operation of the proposed project on the physical, biological and socioeconomic environment along with discussing mitigation measures for those impacts.

8.1. During Construction

8.1.1. Physical Environment

8.1.1.1. Geology and Soil

8.1.1.1.1. Water Desalination Component (Onshore Facilities) and Conveyance Pipeline

Impacts

The project will be implemented at several locations having different soil characteristics. Therefore, soil quality and morphology might be disturbed by construction activities depending on its condition. Potential impacts include 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. This issue is significant where the project components will be installed along the wadis (two wadis at the SWRO desalination plant site and other wadis along the conveyance pipeline), which have natural bush vegetation and scattered orchards.

Excess excavated material or unsuitable excavated material for fill may have impacts on soil quality and morphology if disposed improperly. In addition, soil could become polluted as a result accidental oil or chemical spills from the equipment used during the construction activities especially in areas near Gulf of Aqaba and near wadis along the conveyance pipeline.

In addition, soil could be polluted as a result of improper disposal solid waste and wastewater generated during construction activities.

Although the Gulf of Aqaba and the wadis near the SWRO and along the conveyance route are considered sensitive receptors and the impact of construction activities on the soil quality is moderate, this impact is restricted to the construction period as machinery and equipment will be removed after the completion of construction works and its effect if local (within a 5 km radius of Project site). As such this impact is considered to have a low significance.

Mitigation

Soil disturbance and contamination risk will be reduced by applying the following measures found in the Project ESMP:

- Schedule construction activities to reduce the amount and duration of soil exposed to erosion by wind, rain, runoff and vehicle movement.
- Preserve existing vegetation to the extent possible and ensure revegetation when possible.
- Ensure stabilization of disturbed slopes.
- Immediately remediate any localized erosion during excavation and drilling activities.
- Abide by a Pollution Prevention Management Plan.
- Abide by waste management measures including those related to spoils and excavation materials.
- Abide by general and specific waste management measures including those related to hazardous, non-hazardous and domestic waste.
- Abide by general and specific management provisions for effluent generation
- Abide by erosion and sediment transport procedures including:
    - Earthworks shall be planned and the management of space shall be optimised to ensure that all cleared surfaces and areas exposed to soil erosion are minimised as practically feasible.
    - The appropriate locations and the type of erosion control measures required shall be determined in the Contractor's Construction Methods Plan.

- o Unless otherwise specified in Project specifications, erosion matting shall be installed to provide an immediate protection for slopes against erosion, prevent the washing-out of seeds and enhance the micro-climatic conditions in the soil for plant growth. Erosion matting is used to provide temporary protection of the soil surface until sufficient natural vegetation cover has been established.
- Abide by specific management provisions regarding erosion and sediment transport including those related borrow pits and quarries, and specific activities such as earthworks and backfilling and stockpiling of backfill materials.
- All Project Areas and landscapes disturbed by the works shall be rehabilitated to their original condition where possible upon completion of construction and prior to commissioning.
- Document changes in condition of all Project Areas from the start of works until the completion of works and commissioning.

Taking into account the proposed mitigation and management measures during construction, the residual impact will be limited to accidental cases such as spillage of wastewater and/or oil/chemicals. This residual impact is unlikely to occur, and if it does, measures will be in place to contain it and limit its spread thus reducing its significance to negligible.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Medium	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Short-term	Short-term
Extent	Local	Local
Scale	**Low**	**Low**
Significance	**Low**	**Negligible**

8.1.1.1.2. Water Desalination Component (Onshore and Offshore Facilities)

Impacts

The construction impacts on seabed morphology/geology may be subdivided in the following categories:

- Disruption of sediment layering and structure
- Surface sealing (if structures placed on the seabed)

Different construction methods may be used for the installation the intake towers and intake and outfall pipelines. A basic distinction is between open trench techniques, involving submarine excavators or jet streams for embedding the structures in the seafloor, or trenchless techniques. Alternatively, the intake and outfall structures can be placed above ground and moored to the seafloor. The construction impact, though temporary and confined to the location of the works, may be significant. The severity of the impact is a function of the level of disturbance to the environment and of its natural sensitivity, which in turn is dependent on the specific nature of the habitat and on the specific communities. Pursuant to the Preliminary Design Report for the Intake and Outfall Systems dated September 2021, the AAWDC Project involves the construction of four (4) intake towers connected to four (4) intake pipelines heading to the intake pumping station (IPS) for the required seawater abstraction Considering the Project design capacity of 300 MCM/year, he intake towers will be very large structures of anticipated dimensions 13 m long x 5.5 m wide (*Preliminary Design for the Intake and Outfall Systems dated September 2021 refers*). The lower sill of intake tower windows will be raised above the seabed to reduce the entrainment of the fine sand/silt material from the seabed. This sand/silt material has to be removed by the pre-treatment process. There is not a uniform approach to the selection of this separation height on large desalination facilities. Examples have been observed between 1.5 m and 5 m. From an environmental point of view, in order to minimise entrainment of sessile organisms reside the seabed, it is required that a minimum height of 3 m between the seabed and the lower sill window be selected but this will be confirmed in detailed design.

Construction activities comprising excavations/dredging, trenching, cut and fill, compaction and levelling activities, installation of the intake towers, laying of intake and outfall pipelines, are expected to cause a displacement or disturbance of sediments and sediment layering and/or cause unavoidable sealing of seabed. These are assumed to be potential adverse impacts cause by a direct interaction of project activities with the surrounding marine environment. Considering the baseline conditions at the marine area where the intake and outfall structures will be constructed, the magnitude of these impacts at a first glance is evaluated as high because they have the potential to cause major alteration of natural properties, functions, processes, and the likelihood of occurrence is also evaluated as highly probable. Therefore, the intensity of disruption of sediments layering and structure and seabed sealing as a result of construction activities relative to offshore project structures is evaluated high. However, considering the wave and tides patterns in the target marine area, the extent of disruption of sediments is considered to be local, i.e., expected to be noticeable within an area of less than 3 km from the source, and its duration is expected to occur only along the duration of construction. Therefore, the temporal and geographical scale of said impact is considered to be low. On this basis, the overall significance of this impact is considered to be moderate. Seabed sealing cannot be avoided due to the very nature of the Project (i.e., installation of required structures and pipelines), but the occupied area shall be kept confined to the necessary sizes to be confirmed in detailed design.

Mitigation

A set of specific mitigation measures is required to avoid, minimise, and/or offset these impacts. The target of these measures is to decrease the potential impacts to a low intensity level and to reduce their geographical and temporal scale to be more confined, i.e., limited to the construction site and just for the duration of construction activities. Following the application of mitigation measures, the significance of the residual impact on seabed morphology/geology will be of acceptable low levels.

Keeping in mind that the human factor is very important and that all teams (i.e., BOT Developer, Project Promoter, Regulators, IFIs) involved in Project construction will practice all the necessary care and take all the necessary precautions, the following mitigation measures are considered necessary for increased environmental protection:

- Optimise the water abstraction depth considering suitable distances from the seabed and from the sea surface and keeping the length of submerged intake pipelines as minimum as possible. An effective seawater abstraction depth assessed in this ESIA study is around 12 m.
- Laying of 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), thus minimising the disturbance of the seabed.
- Minimise the footprint of excavation/dredging activities by considering placing the intake and outfall pipelines into the same trench up to a certain depth and thus minimising seabed disturbance.
- Appropriate planning and keeping the duration of construction activities according to schedule.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Medium	Low
Likelihood	Medium	Low

Parameter	Assessed Impact	Residual Impact
Intensity	**Medium**	**Low**
Duration	Short-term	Short-term
Extent	Local	Site
Scale	**Low**	**Low**
Significance	**Low**	**Negligible**

8.1.1.2. Water Resources (Surface Water and Groundwater)

8.1.1.2.1. Water Desalination Component (Onshore Facilities/SWRO) and Water Conveyance Component

Impacts

Contamination of seawater, surface and groundwater may occur as a result of seepage of domestic or construction wastewater, accidental oil and chemical spillages, and diversion of contaminated rainwater runoff from the construction site. Since the proposed SWRO is in close proximity to Gulf of Aqaba and two wadis, the improper management of the generated wastewater along with the improper handling and storage of chemicals will likely contribute to surface water and sea water pollution with suspended particles, hydrocarbon or chemical substances and organic loads. Groundwater and surface water (presence of several groundwater bodies and wadis) along the conveyance pipeline are also at risk of contamination from similar incidents. Potential groundwater contamination might occur especially at vulnerable groundwater sources along the conveyance pipeline including groundwater along Wadi Wala (Heedan wellfield - Madaba Governorate) and groundwater in the vicinity of Mujib Dam (Karak Governorate). In addition, improper management of the generated solid waste might deteriorate nearby surface and ground water quality. However, best practice measures are sufficient to minimize this impact.

Moreover, the temporary dislocation of the existing drainage patterns, especially along the project alignment where several groundwater bodies and wadis are present is predictable during this phase as cut and fill operations take place. If proper care is not exercised to provide sufficient cross drainage, construction activities may lead to the following impacts:

- Formation of ponds associated with localized potential threats to the human health and potential damage to surrounding soils and vegetation.
- Localized rising of water tables associated with increased threat of pollution and the presence of localized surface water.
- Flooding with consequent damage to the nearby establishments.

Impact on water resources quality and drainage system will therefore be limited to the construction phase and will only occur under during exceptional conditions or as a result of accidental spillage. As such, this impact is considered of low significance.

Mitigation

Minimizing this impact will require the BOT Developer to implement best practice measures such as general management provisions for the generation of effluents:

- No effluent generated during construction shall be discharged into water courses or bodies including the marine environment or to ground surface or infiltrated into subsoils, without prior treatment and without monitoring quality of the treatment's performance.
- Effluent discharge and flow rates into natural water bodies shall be managed to control erosion and sediment load.
- All sources of effluents and outlets to the natural environment shall be characterised (flow, expected quality, discharge frequency) and reported in the Construction ESMP.
- An Effluent Quality Monitoring Report shall be submitted on a monthly basis during construction.

- For wastewater run-off appropriate measures shall be taken to ensure that discharges of any process wastewater, sanitary wastewater, wastewater from utility operations or storm water to surface water or seawater will not result in excess contaminant concentrations.
- For rainwater run-off the following measures shall be implemented
    - All platforms where generators, hydrocarbon storage tanks and refuelling stations are installed shall have impervious and chemical resistant surfaces and are drained separately and equipped with an oil removal treatment. For concrete batching plants, run-off shall be drained to a settling basin, where the pH will be buffered.
    - Workers and subcontractors shall be prohibited from bathing or washing vehicles/equipment and clothing in water courses or in the marine environment.
- In addition to the above general measures, the Project ESMP provides more specific provisions for the management of the generated effluents during construction.
- Abide by the provisions for mitigation/management measures as set out in the Project ESMP appended to this ESIA study.

Adopting these measures will reduce the likelihood of such accidents and contain and limit their spread should they occur.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Medium	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Short-term	Short-term
Extent	Local	Local
Scale	**Low**	**Low**
Significance	**Low**	**Negligible**

8.1.1.2.2. Water Desalination Component (Onshore and Offshore Facilities)

Impacts

Construction activities comprising excavations/dredging, trenching, cut and fill, compaction and levelling activities, installation of the intake towers, laying of intake and outfall pipelines, are expected to cause resuspension of sediments that may increase turbidity, pollutant or nutrient levels or decrease oxygen levels. These are assumed to be potential adverse impacts cause by a direct interaction of project activities with the surrounding marine environment. Considering the baseline conditions at the marine area where the intake and outfall structures will be constructed, the magnitude of these impacts at a first glance is evaluated as high because they have the potential to cause major alteration of natural properties, functions, processes, and the likelihood of occurrence is also evaluated as highly probable. Therefore, the intensity of sediments resuspension as a result of construction activities relative to offshore project structures is evaluated high. However, considering the wave and tide patterns in the target marine area, the extent of sediments resuspension is considered to be local, i.e., expected to be noticeable within an area of less than 3 km from the source, and its duration is expected to occur only along the duration of construction. Therefore, the temporal and geographical scale of said impact is considered to be low. On this basis, the overall significance of this impact is considered to be moderate.

Mitigation

A set of specific mitigation measures is required to avoid, minimise, and/or offset these impacts. The target of the proposed mitigation measures is to avoid and/or minimise the potential impacts to a low intensity level and to reduce their geographical and temporal scale to be more confined, i.e., limited to the construction site and just for the duration of construction activities. Following the application of mitigation measures, the significance of the residual impact on seawater quality will be of acceptable low levels.

To this effect, the following mitigation measures are considered necessary for increased environmental protection:

- Optimise the water abstraction depth considering suitable distances from the seabed and from the sea surface and keeping the length of submerged intake pipelines as minimum as possible. An effective seawater abstraction depth assessed in this ESIA study is around 12 m.
- Use of turbidity screens (silt curtains) to enclose the perimeter of construction works in order to keep the impacted area footprint as minimal as possible and avoid the dispersion of suspended solids generated during the excavation/dredging 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 shall be screened and contained in a barge for transportation and disposal on-shore at dedicated sites. Marine disposal of such material shall be avoided.
- Develop and abide by a Pollution Prevention and a Hazardous and Non-Hazardous Waste Management Plan as part of the Construction ESMP.
- Design and implement an extensive marine monitoring program as part of Project requirements to assess environmental conditions before, during, and after the completion of the construction works so that the ‘new’ baseline conditions before operation commences are determined. More specifically, for the establishment of baseline conditions before and after construction commencement, the monitoring program to comprise:
    - Bathymetry survey
    - Seawater column vertical profiling through conductivity (salinity) – temperature – depth (CTD) at proposed diffuser location and 100m from the diffusers and at an ambient control location.
    - Marine species survey through underwater video recording and species identification / mapping repeated once per season during project design and construction and then repeated once after construction completion to establish the “new” baseline conditions in the near field path of the brine plume.
    - Seawater quality sampling survey with focus on salinity, temperature, and nutrients (NH_3 and phosphates near sources where pollution is suspected).
    - Continuous monitoring of turbidity, temperature, pH, DO, and conductivity/salinity during design and construction phases, by setting up a monitoring buoy at the proposed location for the intake towers.
    - Detailed analyses for benthic fauna abundance and distribution and sediments control at selected locations relative to construction works and at ambient control locations.
- Abide by the provisions for mitigation/management measures as set out in the Project ESMP appended to this ESIA study.

Adopting these measures will reduce the likelihood of such accidents and contain and limit their spread should they occur.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse

Parameter	Assessed Impact	Residual Impact
Type	Direct	Direct
Magnitude	High	Medium
Likelihood	High	Medium
Intensity	**High**	**Medium**
Duration	Short-term	Short-term
Extent	Local	Local
Scale	**Low**	**Low**
Significance	**Moderate**	**Low**

8.1.1.3. Energy Resources

Impacts

Energy consumption during the construction phase will mostly be from the power generator(s) installed at the construction sites offices for energy supply and construction vehicles including for supply of construction material. Fuel and oils are needed for the generators and for operation and maintenance of machinery engines and vehicles on and off site. If generators and engines are left running without being used in any activity, overconsumption and depletion of fuel is expected. The known duration and extent of the use of energy resources render this impact of medium scale. Thus, the impact is considered to be of moderate significance.

Mitigation

Several measures can be implemented by the Contractor to reduce energy consumption at the site. These measures include:

- 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

This impact will be reduced when all the mitigation measures presented in the ESMP are implemented. The residual impact will be reduced to Low.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Low	Low
Likelihood	High	Medium
Intensity	**Medium**	**Low**
Duration	Short-term	Short-term
Extent	Regional	Local
Scale	**Medium**	**Low**
Significance	**Moderate**	**Low**

8.1.1.4. Air Quality

Impacts

The machinery and vehicles used during the construction phase will produce exhaust emissions and gases that can temporarily affect local air quality. Exhaust gas emissions will also result from the power generators that will be utilized during the construction phase. In general, these exhaust gases contain particulate matter, Benzene, Toluene, Xylenes, Ozone, Nitrogen Oxides, and Sulphur Oxides, Carbon Dioxide and Carbon Monoxide. In addition, Volatile Organic Compounds may be released during storage of fuel and other chemicals.

Excavation activities, site preparation, trenching, and other earthwork activities along with the movement and transportation of heavy machinery on the site, generate particulate emissions such as dust that can affect local air quality. Dust emissions could disturb nearby receptors along the conveyance pipeline such as residential areas. The level of dust emissions is highly dependent on the wind conditions during the construction phase.

Residents in localities along the conveyance pipeline route, most prominently:

- Section from **BPS 4 to RGT 2** including several localities such as Salhiyah, Shakriyah, Diseh and Twiseh
- Section **BPT to PS ADC,** from Al Hasa district towards PS ADC, including Wadi Abyad, Al Sultani, Al Qatrana, Al Zumayla, Damkhi, Swaqa, Zmaileh, Zabayer Al Wtairi, Araynba Al Sharqiyah, Araynba Al Gharbiya, Al Saifyeh, Al Qunaitra, Al Kutaifa, Al Tneib, Thuheiba Al Gharbia and Thuheiba Al Sharqiyah, Dab'a and Dbai'a. This section comprises a number of shops, petrol stations, governmental complexes, and houses
- **PS ADC:** close to a number of houses.
- **Abu Alanda Branch:** will pass through roads surrounded by heavily crowded area especially in Sahab and Abu Alanda. The area has a mixed land use which consists of residential, commercial, and industrial use.
- **Al Muntazah Branch:** This segment consists of some residential areas such as Khrebet Al Souq

These localities are considered sensitive receptors as exposure to dust, air emissions can negatively affect their occupants' health and wellbeing. This impact is also applicable to construction workers. Although the intensity of this impact is classified as medium, the effect of this impact restricted to construction and will most probably occur within a local geographical scale. Therefore, this impact is considered to be of low significance.

In addition, construction of the AAWDC Project will emit an estimated total of 172,167 GHG (refer to GHG Emissions Report in **Annex 20**).

Mitigation

Best practice mitigation measures have been included in the Project ESMP, including:

- Equipment shall be used and construction and transport methods shall be adopted so that generated atmospheric emissions are not in excess of national and international emission standards (EIB/USAID).
- Water shall be applied to the area creating the dust and along with other dust control measures such as using windbreaks, netting screens or semi-permeable fences.
- Control vehicle speeds to reduce traffic-induced dust dispersion and resuspension by setting and enforcing speed limits. This shall include posting speed limit signs in sensitive areas.
- Ensure trucks hauling sand, dirt or other loose materials are covered (sheeting trucks).
- Suspend topsoil stripping and replace it during strong winds.
- Use a dust collection system for bulk materials unloading.
- Wet suppression (as needed, depending on the soil type) in the dry season, where unpaved roads and/or the working strip is located <200 m from settlements taking appropriate abatement measures

- Considering the water scarcity facing Jordan, water dampening of roads with freshwater for dust dispersion prevention is not considered a sustainable option. However, treated domestic wastewater is understood to be used for side-road irrigation purposes in Jordan and this option may be used for dust control in certain areas of works especially where construction activities are executed within urban settings.
- Paving roads is considered expensive, but may need to be considered in some Project locations in close proximity or within residential areas to reduce emissions of dust during construction activities. The alternative use of binding agents shall be adequately assessed and justified in terms of effectiveness and potential contamination of soils and groundwater due to leaching. More specifically, heavily used areas (e.g., any batching plant), long term construction sites, and access roads to workers' camps shall be paved and swept regularly through vacuum sweepers.
- Record the maintenance records for the fleet of vehicles, machinery, and equipment.
- Maintain the fleet of vehicles or equipment emitting combustion gases at the intervals and according to the methods specified by the manufacturer.
- The Construction ESMP shall describe the road sections designated for the application of dust suppression agents and the methods and frequencies programmed.
- Visual inspections of atmospheric emissions shall be conducted where applicable, especially dust and emissions from vehicles and machinery.
- When storage, transport and handling of bulk materials is made in the open air and exposed to the wind, the necessary dust abatement measures shall be implemented as set out in the Construction ESMP.
- Abide by the provisions for mitigation/management measures as set out in the Project ESMP appended to this ESIA study.

After implementing these measures, residual impacts on air quality may result from unexpected malfunctions in the used equipment and generators. This impact will therefore become less likely, have a lower intensity and geographic reach and thus the residual impact will be of negligible significance.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Medium	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Short-term	Short-term
Extent	Local	Local
Scale	**Low**	**Low**
Significance	**Low**	**Negligible**

8.1.2. Biological Environment

8.1.2.1. Water Desalination Component (Offshore Facilities)

Impacts

Similar to the case of the physical environment impact receptors of the biological environment are:

- Marine Ecology: Marine ecosystem non-living components, namely seawater and non living bottom substrate.
- Marine Ecology: Marine ecosystem living components, namely flora and fauna.

The following potential impacts are envisaged on the biological environment:

- Habitat destruction by excavation works

- Increased turbidity leading to reduced light penetration and increased sedimentation rates (blanketing)
- Remobilization of nutrients or pollutants from sediments
- Contamination by spills or leakages
- Constructed structures may act as artificial reefs (attachment of macro algae, sessile hard bottom species or attraction of reef dwellers) and may attract species, e.g. due to increased food supply
- Behavioural responses and temporary habitat loss due to sediment plumes, noise, and vibrations, etc.
- Disruption of haul out sites of marine mammals or nesting sites of turtles in the landing area
- Exposure to residual chemicals that may be present in the discarded wastewater during commissioning

It is noted that the selected site for the AAWDC is an industrial site hosting a modified habitat. One of the potential impacts "*Constructed structures may act as artificial reefs: attachment of macro algae, sessile hard bottom species or attraction of reef dwellers and may attract species, e.g. due to increased food supply*" is considered moderately positive. Another envisaged potential impact "*Disruption of haul out sites of marine mammals or nesting sites of turtles in the landing area*" although negative, is considered weak because the proposed Project Site is not known as a marine mammal dwelling or turtles nesting site. Live corals that might be encountered during construction and which will be excavated for the installation of the intake and outfall systems need to be transplanted. The intensity of disruption to marine life as a result of construction activities relative to offshore project structures is evaluated as moderate to high. However, considering the wave and tides patterns in the target area, the extent of this impact is considered to be local, i.e., expected to be noticeable within an area of less than 3 km from the source, and its duration is expected to occur only along the duration of construction. Therefore, the temporal and geographical scale of this impact is considered to be low. On this basis, the overall significance of the potential impacts is considered to be moderate with the exception of "Potential impacts from increased turbidity leading to reduced light penetration and increased sedimentation rates (blanketing)" whose significance is considered high.

Mitigation

The target of the proposed mitigation measures is to avoid or minimise the potential impacts to a low intensity level and to reduce their geographical and temporal scale to be more confined, i.e., limited to the construction site and just for the duration of construction activities. Following the application of mitigation measures, the significance of the residual impact on the biological environment will be of acceptable low levels.

Keeping in mind that the human factor is very important and that all teams (i.e., BOT Developer, Project Promoter, Regulators, IFIs) involved in construction will practice all the necessary care and take all the necessary precautions, the following mitigation measures are considered necessary for increased environmental protection:

- Design outfall with high velocity diffusers that achieve very rapid dilution of the brine in very short distances so that brine discharged during commissioning is quickly dissipated into the marine environment to ambient levels.
- Optimise the water abstraction depth considering suitable distances from the seabed and from the sea surface and keeping the length of submerged intake pipelines as minimum as possible. An effective seawater abstraction depth assessed in this ESIA study is around 12 m.
- Appropriate planning and keeping the duration of construction activities according to schedule.
- Develop and implement a Pollution Prevention and Management Plan and a Waste Management Plan as part of the Construction ESMP. Carefully collect and transplant any corals that might be encountered during the construction works before any construction works commence. This is a larger area than the actual excavation and levelling area needed for the intake and outfall constructions and pipeline laying. The actual coral removal area needs to be specified in the detailed design and Construction Methods Plan based on the actual construction area and the extra area needed for machinery manoeuvring and temporary works during construction.
- Laying of 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), thus minimising the disturbance of the seabed.
- Use of turbidity screens (silt curtains) to enclose the perimeter of construction works in order to keep the impacted area footprint as minimal as possible and avoid the dispersion of suspended solids generated during the excavation/dredging 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 shall be screened and contained in a barge for transportation and disposal on-shore on dedicated sites. Marine disposal of such material shall be avoided.
- Minimise the footprint of excavation/dredging activities by considering placing the intake and outfall pipelines into the same trench up to a certain depth and thus minimising seabed disturbance.
- Design and implement an extensive marine monitoring program as part of Project requirements to assess environmental conditions before, during, and after the completion of the construction works so that the 'new' baseline conditions before operation commences are determined.
- Abide by the provisions for mitigation/management measures set out in the Project ESMP appended to this ESIA study.

Coral Transplantation for the Construction and Operation Phases

Coral transplantation is a mitigation measure that needs to be coordinated with the regulator (ASEZA). The protocol involves determining the exact number of corals to be transplanted and the destination area in which the corals will be relocated. Coral transplantation is an acceptable mitigation measure according to the Jordanian standards. It has been practiced in previous projects and the local know how and practical experience to do it do exist.

What is presented below, is a rough estimation of the corals that might be subject to transplantation based on the expected area to be affected according to the marine works preliminary design and to the indicative diving video survey. Figure 8-1 shows a schematic diagram of the area that might be impacted by the construction and operation of the marine works (intake and outfall systems). The approximate affected area is about 6,000 m^2. The area is mainly rocky and rich of coral reefs. But these corals are dispersed and differ significantly in live cover within the affected area. Taking a conservative estimate of 10% coral cover over the entire area gives an estimated coral transplantation area of about 600 m^2. Corals that exist between the shoreline and the depth contour of -30 m shall be considered for transplantation.

Figure 8-1: Estimated Coral Transplantation Area

In addition, artificial reef development shall be promoted around the marine infrastructure, such as along the pipeline route, around the intake structures.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	High	Medium
Likelihood	Medium	Low
Intensity	**High**	**Low**
Duration	Short-term	Short-term
Extent	Local	Local
Scale	**Low**	**Low**
Significance	**Moderate**	**Negligible**

8.1.2.2. Water Desalination Component (Onshore Facilities)

Impacts

Construction works of the onshore facilities of the water desalination component at the IPS location is expected to be limited to the construction zone/corridor within the selected land plot. This includes land clearance, cut-and-fill operations, pilling of cut materials and construction materials, temporary storage of construction waste on site, construction and finishing works of the IPS facility, installation works of the IPS, installation of the pipelines and other auxiliary equipment's, etc.

The above activities are associated with (1) total habitat loss and clearance of the vegetation cover within the construction site and materials temporary storage locations, (2) habitat loss within the routes for vehicles and machineries movement and parking, (3) generation of elevated noise levels which can reach up to 110 dB at source (i.e., within one meter from the machinery), (4) emissions to air from the vehicles and machineries, (5) oil spills from machineries on site lubrication and petrol supply, contamination due to leaks/spills of construction chemicals (e.g. paints, lubricant oils, etc.), and (6) possible attraction of species (especially birds) due to increased food supply.

Based on available information the proposed onshore facilities (IPS, SWRO Plant) are within an urban environment (port and industrial activities), and thus is already degraded and of very low value as a terrestrial habitat. However, behavioural disturbance to avifauna during migratory and breeding seasons is possible and require regular monitoring, though the two sites (i.e., the IPS and SWRO Plant) are not reported as feeding, roosting or breeding site for birds.

Equally important, it is anticipated that the proposed construction activities of the onshore prominent features and facilities will not preclude linkages and movement corridors. Hence, monitoring of such impacts should be arranged as per of the below presented monitoring measures.

The magnitude of such impacts is theoretically high if the affected terrestrial biological environment is of particular value. Hence, noting the ecological character of the IPS and the SWRO plant proposed locations, being degraded and currently of low terrestrial biodiversity value, therefore the probability is assessed to be low. Accordingly, the overall intensity of the above listed impacts is assessed to be moderate, and it is likely to extend, mostly due to possible mismanagement or non-compliance with best practices, beyond a 100-meter radius.

Regarding the duration of impacts, it is understood that the proposed facilities will be permanent, and therefore, the impacts will be permanent within the construction footprint (i.e., constructed facilities and above ground installations). Hence, the duration will be short term for the rest of the construction zone, and these sites will be rehabilitated after completion of the construction activities. Accordingly, the overall impact significance before the application of any mitigation measures is assessed to be high, and will be confined to the site.

Mitigation

Nevertheless, through the following mitigation measures, it is expected that the intensity of the above listed impacts will be confined and prevented to extend beyond the construction footprint, and its geographical and temporal scale will be low. Therefore, the significance of the residual impact on terrestrial biodiversity is expected to be avoided or at least minimized to acceptable low levels.

The proposed mitigation measures include:

Avoidance measures. During the construction phase, the BOT Developer shall apply maximum care not to conduct unnecessary damage to the local landscape and natural resources beyond the determined construction footprint (i.e., the planned facilities and above ground installations). Where clearing is required for permanent works, for approved construction activities and for excavation operations, local geomorphology, natural drainage systems and natural vegetation must be conserved and protected from the resulting damage. Changing the morphology, the local drainage systems and clearing of flora shall be prohibited outside the proposed Project construction zones and corridor. Furthermore, dumping solid waste in the wadi crossings shall be prohibited. Other related avoidance measures include:

- Ensure selection for the Project offices and camp locations that avoid biodiversity sensitive areas or sites that might require substantial modification of the natural landscape and morphology.
- Avoid unnecessary excavation and off-road driving and utilize existing roads instead of making new ones whenever possible.
- Avoid accumulation of excavation materials and other solid wastes especially during rainy season in wadis and runoffs and minimize them through synchronizing excavation and filling processes.
- Avoid changing topography within large wadis and runoff areas.
- Avoid and strictly prohibit wildlife persecution, hunting, and all forms of animal and plant collection and active taking.
- Provide project staff with adequate training on species identification, ecology and the need to conserve nature.

Reduction measures are also proposed to control and confine the anticipated impacts on the natural landscape, geomorphology and natural resources. This particularly relates to minimizing land levelling and destruction of existing habitat by identifying early machinery movement routes and excavated material accumulation areas.

As for **rehabilitation measures**, and after work completion, all work areas shall be rehabilitated, smoothed and graded in a manner to confirm the natural appearance of the surrounding landscape. The restoration option is upon incidence of impact and mainly directed to:

- Restore as possible changing surface morphology to maintain natural water flow and to avoid soil erosion.
- Restore the beach to its natural or near natural condition.
- All work stations and worker camps shall be rehabilitated to their original condition.
- Ensure use of local natural vegetation and avoid the introduction of exotic and/or invasive species in the landscaping of the site.
- Apply appropriate wastewater collection and management measures.
- Apply appropriate solid waste collection and management measures.
- Avoid working night shifts to the extent possible to control noise at night.

In summary, the BOT Developer shall abide by all provisions for mitigation/management measures as set out in the Project ESMP appended to this ESIA study.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	High	Medium

Parameter	Assessed Impact	Residual Impact
Likelihood	Low	Low
Intensity	**Medium**	**Low**
Duration	Long-term	Long-term
Extent	Local	Site
Scale	**High**	**Moderate**
Significance	**High**	**Low**

8.1.2.3. Water Conveyance Components

Construction works of the Water Conveyance Component will be undertaken along the entire route from the proposed IPS location, heading to the north until it reaches the Abu Alanda Reservoir and Al Muntazah reservoir. These works are expected to be limited to the construction zone/corridor along the selected route and is assumed to have a construction corridor not exceeding 100 m. The construction activities will include land preparation, levelling and clearance, cut-and-fill operations, pilling of cut materials and construction materials, temporary storage of construction waste on site, construction and finishing works of the above ground installations (AGIs), installation of the pipelines and other auxiliary equipment's, etc. Logically, the above activities are associated with the following impact categories:

I. Impact on local morphology and surface hydrology. This impact category is likely to include:
    a. Habitat loss and fragmentation
    b. Impact to natural water flow in the intermittent wadis and streams
II. Pollution impact on biodiversity
III. Disturbance of natural fauna from noise, vibration and lighting
IV. Hunting and active taking of wildlife

The following provides description of the assessment of the identified possible impacts by the water conveyance component.

Impact on local morphology and surface hydrology

During the conveyance construction, existing vegetation is expected to be cleared in a strip of 20 to 50 m along the proposed route, while the construction corridor is expected to extend to about 100 m or less to accommodate the movement and operation of the construction machineries and workers along the route, and also expected to extend to up to few hundred square meters in the locations of the pump stations, above ground installations, and the construction camps.

Land works within the construction strip are anticipated to cause temporary, on some occasions prolonged, changes in local geo-morphological settings. These land works include cut, fill, accumulated piles of construction materials and waste, construction camps and storage areas, and many others.

Once construction of the conveyance is completed, permanent facilities and AGIs will be visible along the whole route. These installations and facilities are permanent features of the conveyance component, and will include several water dikes, ditches and culverts as needed to avoid obstructing natural stormwater / wadis intermittent floods from continuing its natural flow during the rainy season.

The clearance of vegetation and the above-mentioned land works are expected to disturb the surface hydrology. The expected disturbance will be manifested in accelerated soil erosion especially at the depleted areas and changing the flow of surface runoff. Additionally, moving vehicles and equipment needed for construction will accentuate the abrupt of the surface hydrology.

Removal of sand fixatives in the areas of sand dunes and weathered (windblown sand) areas is expected to cause significant impacts on other vegetation within the affected area and will indirectly affect the downstream areas. Such an impact will also affect other life forms including faunal and avifaunal species.

Habitat loss and fragmentation: Construction activities will result in permanent removal of vegetation and deleterious changes in the biological habitats within the construction zone, more specifically within the proposed plots for the pumping stations and above ground installations (AGIs). Temporary removal of habitat and vegetation covers is expected within the construction corridor, where machineries will use spaces for movement and parking, and where worker camps and temporary service facilities will be established.

The magnitude of this impact is anticipated to be severe within sensitive habitats located within the route. Segment A and the main wadis in Segment B are considered the most affected receptors. Species like carnivores and other endangered species will be affected.

Since a service road already exists to serve the operation and maintenance of the Disi-Amman Conveyance, and noting that most of the route between the IPS and RGT2 is served by an existing network of asphalted roads, it is therefore expected that the Disi-Amman Conveyance service road will be rehabilitated and used by the AAWDC project, the existing road networks will be used without additional works, and a service road is expected to be constructed between RGT2 and MUS2/BPS5. The establishment of service roads, maintenance of existing service roads, installation of the conveyance pipeline and AGIs, establishment of permanent facilities and accumulation of materials and waste stockpiles are not anticipated to cause habitat fragmentation to the level where it causes serious access limitation to the feeding grounds by faunal species, in particular carnivores which require vast feeding grounds.

The construction, through land preparation, construction of access roads, cut and fill operations, materials storage, and waste piles, may cause removal of vegetation cover within the construction corridor (assuming 100 m in width, along the entire route). Such removal of vegetation will be temporary throughout the route, except at the locations of the pumping stations and AGIs' where the impact will be in the form of permanent habitat loss. More specifically:

- Accumulation of excavated material and litter will result in removal of native vegetation (temporary, until completion and restoration).
- Alteration of surface morphology and drainage paths (important areas providing vegetation cover within the desert plains, in areas such as Hasa and Al-Abyad) which will result in temporary loss of habitat at the construction sites, and temporary degradation of habitat downstream the construction areas.
- Ground clearance resulting in the removal of native vegetation and tree stands (Acacia and Tamarix in Abu Tarfa, Disi and the mountains of Aqaba), which is assumed to be not necessary for the Project and can be avoided.
- Removal of Acacia trees (representative assemblages) and other ground vegetation from within Segment A. Such action is assumed not to be necessary for the Project and can be avoided. Hence, in case it is not avoided, then the removal of trees will affect breeding bird's dependent solely on these trees (Arabian Warbler) and affecting migratory passerines using these trees while migration within the section between the proposed desalination plant and Al Rashdiyah. And it causes disturbance and affect breeding birds and other important species like the Verraux's Eagle (former breeder) and the globally threatened Lesser Kestrel (rare) in the section between Al Rashdiyah and Baten Al Ghoul. Removal of vegetation cover from the alignment between RGT3 near Baten Al Ghoul and Al Rashdiyah might, but not nessessrly, include removal of Acacia trees (A. tortilis and A. gerrardii) and Tamarix aphylla and other ground vegetation mainly sand fixatives and sandy communities and represented by leading species of Arthrocnemum machrostachyum, Savignya parviflora, Hamada salicornica, Holoxylon persicum and gymnocarpus decandrum. The removal of rare plants species such as calligonum cumosum and Artemisia monosperma, and endemic species like Fagonia Arabica is possible.
- Removal of Tamarix stands and other key vegetation in Wadi Hasa and Abyad. The site is very unique in terms of species richness and species representation in this segment and possibly in the whole desert of Jordan. The plant community is largely dependent on the water flow from the nearby industry.
- Construction activities and removal of rocks along the alignment within the flat relief desert corridors will affect negatively breeding bird communities of Wheatears in this particular area. Cut activities at the areas nearby the basement of the Rocky Mountains will affect breeding habitats of breeding birds (Sinai Rosefinch, white crowned black wheatears and Trumpeter Finch).

- If construction requires blasting or removal of large stone masses into the wadi, this require taking measure not to affect the viable populations of the Dabb, *Uromastyx aegyptia* (nearly threatened under the IUCN RED List) and the rare Gekko, *Tropiocolotes nattereri*. Other small mammals such as *Gerbillus gerbilles* and *Sekeetamys calurus* could be affected during the construction stage.
- The removal of vegetation, change in local morphology, pollution and noise are expected to affect the biome restricted breeding species in this area include: Sand Partridge, White-crowned Black Wheatear, Mourning Wheatear, Little Owl, Kestrel, Scrub Warbler, Long-legged Buzzard, Hooded Wheatear, and Desert Wheatear. Majority of these breeders are localized in Baten El Ghoul area.

Upon completion of the construction activities, habitat alteration or loss of habitat for native species can be caused in the following cases:

- If the construction sites and natural water flow are not effectively restored to its natural or near natural condition, then the above impacts will turn into permanent impacts. This particularly concerns:
    - The wadi systems, drainage paths and biological habitat within the desert plains, in areas such as Hasa and Al-Abyad.
    - The Acacia and Tamarix in Abu Tarfa, Disi and the mountains of Aqaba.
- Upon completion, prominent features (i.e., AGI's and abandoned piles of construction waste and materials) could preclude linkages and movement corridors
    - Alteration of surface morphology and drainage paths (important areas providing vegetation cover within the desert plains, in areas such as Hasa and Al-Abyad) which will result in temporary loss of habitat at the construction sites (or permanent if not restored after completion of the construction activities), and temporary degradation of habitat downstream the construction areas (also can be permeant if natural water flow is not restored).
    - Habitat fragmentation from the creation of construction access roads (permanent), cut and fill operations (temporary), accumulation of construction waste in the wadis and streams (can be temporary or permanent), and other construction activities.
    - **Impact to wadis:** The wadis along the planned conveyance planned conveyance system are fragile ecosystems. The biotic components of these wadis are dependent on the running floodwater after rainfall events. Therefore, disturbance of the natural flow of floodwater and surface runoff are expected to cause drastic effects on the flora and fauna in these wadis. The potential impacts include:**Loss of biodiversity.** The wadi beds (marabs) and wadis (run-on hamada) are the most important habitats for harboring the vegetation in the Badia. The disturbance of these two habitats which are scattered throughout the Badia will result in drastic dragapacks on the flora. Reducing surface runoff and floodwater will favor dry tolerant plant species. The change in the structure and composition of flora in fragile ecosystems is usually irreversible. On the other hand, the coverage and biomass of vegetation will be reduced as a result of reducing the floodwater received. Consequently, the composition and population of fauna occupying or benefiting from these wadis will be reduced. The magnitude of loss in biodiversity depends on the timing, frequency and scale (number of hectares subjected to disturbance because of land work activities) of disturbance.

    - **Disruption of the natural flow of the floods in the wadis.** Any construction in the wadis, however small, will affect the direction flow of the floods. This may lead to increasing or decreasing the spreading of the flood water; in both cases the soils will be vulnerable to erosion. Obstructing water movement in wadis which will affect the flood cycles within the area and the downstream communities. This will cause significant impact on reptilians (e.g., the threatened *Uromastyx aegyptia* and the small mammal *Gerbillus gerbillus*) in the section between the desalination plant and Al Rashdiyah. It will also directly affect several reptiles in the section between Al Rashdiyah and Baten Al Ghoul (Uromastyx aegyptia, Phrynocephelus arabicus) as well as other sand dwelling species (Scincus scincus), and will also affect large mammals, especially carnivores, such as the Hyena may be severely impacted during construction.

    - **Soil erosion.** The majority of soils in the wadis are transported from the upper areas. The presence of vegetation and soil capping are the main factors that reduce soil erosion by water and wind. Reducing the vegetation cover and/or disturbing the soil surface because of vehicle movement will accelerate soil erosion.

- **Restriction of flocks' mobility.** The proposed route will cross many large and small wadis, in many parts of the country, which represent the main grazing resources for sheep and goat flocks raised under extensive production. Besides the negative impact on the socioeconomics of the pastoral communities, the route will have an indirect impact on the biodiversity by restricting the mobility of flocks. Confinement of flocks' mobility means overstocking which will result in destructive grazing, and if persisted, the degradation of the grazing ecosystem will be permanent.

- **Disruption of farming in the wadis.** The pastoralists, especially the transhumance, used to cultivate sizable areas of the wadis with barley as a forage source for feeding their flocks of sheep and goats. The areas designated for barley production within the wadis are cultivated annually because of the high probability of receiving floods. Therefore, interventions disturbing the natural flow of floods in the wadis will have a negative impact on barley cultivation which is considered as an important source of fodder for feeding the livestock.

- **The facilities and AGIs' needed for operating the conveyance route could have an impact on the environment more than the route itself.** The pump stations, storehouses/warehouses, wastes (water and chemicals) of the facilities and buildings could pollute the watershed or the whole basin. The organic and inorganic pollutants may be harmful for the grazing animals and wildlife. Therefore, it is important to furnish the information pertaining to the AGI's and other facilities that are needed for operating the conveyance system.

The magnitude of such impacts is assessed to be high, especially at the sections where the affected terrestrial biological environment is of particular value, including those discussed below for mitigation measures. The probability is assessed to be high before the implementation of adequate mitigation measures. Accordingly, the overall intensity of the above listed impacts is assessed to be high and it is likely to extend, mostly due to possible mismanagement or non-compliance with best practices, beyond 100 meters radius (local extent).

Regarding the duration of impacts, it is understood that the proposed facilities will be permanent, and therefore, the impacts will be permanent within the construction footprint (i.e., constructed facilities and AGIs'). Hence, the duration will be short term for the rest of the construction site, and these sites will be rehabilitated after the completion of the construction activities. Accordingly, the overall impact significance before the application of any mitigation measures is assessed to be high, and will be confined to the site.

Mitigation

In addition to the measures described in the previous section (for the Onshore Desalination Component), through the following mitigation measures, it is expected that the intensity of the above listed impacts will be confined and prevented from extending beyond the construction footprint. Therefore, the significance of the residual impact terrestrial biodiversity is expected to be avoided or at least minimized to acceptable low levels. The proposed mitigation measures include:

Avoidance measures. During the construction phase, the BOT Developer shall apply maximum care not to cause unnecessary damage to the local landscape and natural resources beyond the determined construction footprint (i.e., the route of the pipeline, the planned facilities and above ground installations). Only, where the clearing is required for permanent works, for approved construction activities and for excavation operations, local geomorphology, natural drainage systems and natural vegetation must be conserved and protected from the damage that might result from the construction activities. Changing the morphology, the local drainage systems, in addition to flora demolition shall be prohibited outside the proposed project construction zones and corridor. Furthermore, dumping solid waste in the wadi beds shall be prohibited. Other related avoidance measures include:

- Reduce as possible removal of vegetation. As a general rule, it is recommended to avoid unnecessary removal of native vegetation and wood collection by workers within the designated corridor and prohibit it beyond the corridor. It is important that unique vegetation assemblages be preserved: mainly sand dunes and granite scups and alluvial fans that harbor Acacia woods in the southern segments where they occur, and as well the Tamrix wood; this is to be communicated to project team to enable them to identify such habitats during the construction period.
- Avoid sand dunes areas, areas with tree stands (Acacia and Tamarix) in segments where they occur, artificially forested areas and grazing reserves areas as possible.

- Avoid changing topography within large wadis and runoffs.

Conservation of Agricultural and Pastoral Resources. The following components shall be monitored on a regular basis:

- Safe passageways dedicated for the use of Herders. Availability of safe passageways can eliminate any inconvenience arising from restrictions on mobility for farms along the route.
- Removal from the construction corridor and/or cutting of Acacia, Tamrix and other natural trees or parts of trees for wood collection.
- Removal of trees within farms along the route and from forested areas.
- Number of direct or indirect killing of pastoral animals by the project activities, workers or machinery.

Protection of Terrestrial Biodiversity. The BOT Developer shall also avoid the removal of the Acacia, Tamrix and other native tree community and translocation of those unavoidable ones (if applicable) in coordination with related authorities including the Ministry of Agriculture, the Royal Society for the Conservation of Nature, the Ministry of Environment and Aqaba Special Economic Zone Authority.

In summary, the BOT Developer shall abide by all provisions for mitigation/management measures as set out in the Project ESMP appended to this ESIA study.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	High	Moderate
Likelihood	High	Low
Intensity	**High**	**Low**
Duration	Long-term (at AGIs)	Long-term (at AGIs)
Extent	Local	Site
Scale	**High**	**Moderate**
Significance	**High**	**Low**

<u>Pollution</u>

Pollution sources during the construction phase include, but are not necessarily limited to, leaks from construction machineries, stock and materials storage, wastewater generated by the work force, wastewater generated from the routine and emergency maintenance and serving of construction machineries, and other fluid materials used during the construction phase.

Leakages of fluid waste and accumulation of solid waste will cause water and soil pollution. Consequently, this will affect the flora and fauna.

During the construction and operation phases emissions and air pollutants are expected to be generated by the construction machineries. The major direct pollutants present in emissions are:

- Carbon monoxide (CO): a product of incomplete burning of fuel.
- Hydrocarbons (HC): incomplete burning or evaporated fuel or solvents, produced by mobile sources.
- Nitrogen oxides (NOx): products of high-compression internal combustion engines.
- Sulphur oxides (SOx): product of the burning of sulphur- rich fossil fuel, particularly coal with minor emissions from motor vehicles.
- Particulates: mostly carbon particles much like soot.
- Lead: the result of burning leaded gasoline.

The occurrence of pollution and its magnitude depends on the management performance, commitment to and implementation of effective mitigation measures as well as the quality of the equipment used. The magnitude of this impact has also much to do with the site of occurrence, for instance if close to flood area during the flood season.

Another possible source of pollution is the accumulation and improper management of waste from work force and camps. These stressors are likely to cause contamination to the biological habitat at the construction sites and would consequently cause deleterious impact on wildlife (habitat, flora and fauna).

The magnitude of such impacts is anticipated to be moderate to high, and controllable. The probability of occurrence is directly related to contractor management performance and compliance with the best practices and the set mitigation measures. It is assessed herewith following a conservative approach as high potential. Accordingly, the overall intensity of the above listed impacts is assessed to be high and it is likely to extend, mostly due to possible mismanagement or non-compliance with best practices, beyond 100 meters radius (local extent).

Regarding the duration of impacts, it is assessed to be short term, and these sites will be rehabilitated after the completion of the construction activities. Accordingly, the overall impact significance before the application of any mitigation measures is assessed to be low, and will be confined to the site.

Mitigation

Through the following mitigation measures, it is expected that the intensity of the above listed impacts will be confined and prevented from extending beyond the construction footprint. Therefore, the significance of the residual impact terrestrial biodiversity is expected to be avoided or at least minimized to acceptable low levels.

The mitigation measures discussed in above section to mitigate identified possible impacts to the local morphology and landscape also applies for pollution impacts, most importantly those designed to apply:

- Appropriate wastewater collection and management measures.
- Appropriate solid waste collection and management measures.

In summary, the BOT Developer shall abide by all provisions for mitigation/management measures as set out in the Project ESMP appended to this ESIA study.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	High	Moderate
Likelihood	High	Low
Intensity	**High**	**Low**
Duration	Short-term	Short-term
Extent	Local	Site
Scale	**Low**	**Low**
Significance	**Moderate**	**Low**

Disturbance – noise, vibration and lighting

Ambient noise is the total noise composed of all natural and human-made sources considered as part of the acoustical environment of the general area. It is expected that the construction of the conveyance system will generate noise, vibration and lighting.

Noise, especially during the breeding season of animals and birds, will cause disturbance to breeding species. In some cases, it might force abandoning nests or offspring. The sections most affected by this impact are expected to be A-2, A-3 and A-4.

Blasting and vibration caused by the movement of heavy machinery are also expected. Blasting can cause direct killing of live forms. Both blasting and vibration will frighten birds and animals in the area, thus they will escape to other areas. The magnitude of this impact can be more serious during the breeding seasons.

Lighting is also expected when construction activities proceed during night shifts. Lighting might force nocturnal species to escape, however it is expected to attract night migrant birds during the migration periods.

The magnitude of such impacts is anticipated to be high, and controllable. Blasting can be avoided, as well as night shifts which will introduce lightning impacts. The probability of occurrence is directly related to contractor management performance and compliance with the best practices and the set mitigation measures. It is assessed herewith following conservative approach as high potential. Accordingly, the overall intensity of the above listed impacts is assessed to be high.

Regarding the duration of impacts, it is assessed to be short term. With regard to extent, it is likely to extend, mostly due to possible mismanagement or non-compliance with best practices, beyond 100 meters radius and less than 5 kms radius (local extent) beyond which the impacts are negligible. Accordingly, the overall impact significance before the application of any mitigation measures is assessed to be low, and will be confined to the site.

Mitigation

The significance of the residual impact on terrestrial biodiversity is expected to be avoided for blasting and lighting impacts, and minimized to acceptable moderate or low levels for the noise impacts. The mitigation measures include:

- Avoid night shifts to the extent possible and avoid unnecessary lights at the construction camps.
- Avoid blasting.
- Use construction machinery with lowest possible noise generation, at least at the specified biodiversity sensitive habitats in Sections A-2, A-3 and A-4.

In summary, the BOT Developer shall abide by all provisions for mitigation/management measures as set out in the Project ESMP appended to this ESIA study.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	High	Moderate
Likelihood	High	Low
Intensity	**High**	**Low**
Duration	Short-term	Short-term
Extent	Local	Site
Scale	**Low**	**Low**
Significance	**Moderate**	**Low**

Hunting and active taking of wildlife pressure

Legal and illegal collection of woods and hunting of birds and animals can be noted in many areas in Jordan. Legal hunting is being practiced by licensed hunters in pre-defined hunting seasons and with well-established bag limits in many locations west of the existing Hijaz Railway; nevertheless, hunting is not legal east of Hijaz

Railway. Illegal hunting occurs east of the Hijaz Railway, or west of the railway out of the permitted seasons. Exceeding bag limits is also illegal.

Hunting is not allowed in any sort in protected areas in the country. Most if not all protected areas in the country, were known to be very popular sites for hunting before being declared as protected areas. Hunting in Wadi Rum Protected Area is still a threat. The area has been popular for hunting Ibex and resident birds. The only migratory bird species that was and is still targeted in the area is Common Crane (*Grus grus*). Being the largest protected area in the country, Wadi Rum Protected Area is running a patrol plan in order to control hunting in the area.

As for falcons, several species are targeted for different reasons. Saker Falcon is the species that is facing the highest pressure from trapping. Being a migrant species, trappers expect it to pass in Jordan in the period from the 15th of September until end of November. The highest targeted falcon species in the desert is the Lanner Falcon which is a rare resident species in Jordan. A wild bird could be sold for up to JOD70,000. Kestrels and Hobby are also subject to active taking and during trapping season, trappers go out in small groups on trips searching for falcons.

However, law enforcement and monitoring of hunting and active taking of animals is conducted year-round by the Royal Rangers (Administration for Environment Protection), by the rangers of Wadi Rum Protected Area (ASEZA employees) and by the rangers of the Royal Society for the Conservation of Nature. Caught violations to the hunting law and related regulations are subject to legal actions as governed by related hunting legislation.

Presence of venomous snakes (*Cerastes gasperetti, Pseudocerastes fieldi, Echis coloratus, and Daboia palaestinae*) and scorpions *(Lwiurus quinquestriaus* and *Buthus occitanus*) may cause stings and bite accidents among workers during construction phases. The workers are expected to indiscriminately kill any observed snake or scorpion at sight to avoid possible stings and health risks. This is most anticipated at the construction camps.

It is anticipated to have incidents of active taking of live animals and birds and also shooting of wildlife, in particular near water bodies and in vegetated habitats, which will be a violation of the hunting regulations. It is also anticipated that collection of wood and cutting Acacia and Tamarix trees for wood will take place by the construction workers.

This impact is expected to occur during the construction and operation phases. Also, it will persist after the reclamation phase since access roads, if any, will provide comfortable access to the breeding and feeding grounds of huntable species.

The magnitude of this impact is totally dependent on the BOT Developer's compliance with the best practices and ESIA mitigation measures, and the enforcement of strict mitigation measure like strict prohibition of off-road driving, strict prohibition of shooting and active taking of animals and birds, active enforcement of relevant hunting regulations in addition to other measures. The assessment of the magnitude following conservative approaches assumes the magnitude to be high, and the probability to be moderate. The duration is assumed to be short term and the extent to be local.

In addition to the above, the following actions shall be strictly adhered to in order to mitigate the project anticipated impacts on the biological environment:

- Avoid and strictly prohibit wildlife 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 non-compliance by the staff.
- Avoid introduction of pets.

In summary, the BOT Developer shall abide by allprovisions for mitigation/management measures as set out in the Project ESMP appended to this ESIA study.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	High	Low
Likelihood	Moderate	Low
Intensity	**High**	**Low**
Duration	Short-term	Short-term
Extent	Local	Local
Scale	**Low**	**Low**
Significance	**Moderate**	**Low**

8.1.3. Socio-economic Environment

8.1.3.1. Economic Activities

Impacts

Construction of the Project components is considered an economic opportunity for the selected contractor and their subcontractors. Local businesses may also benefit from construction activities through selling raw materials, equipment, machinery and goods. In addition, the project will create jobs for the local community with varying skill requirements. The presence of workers within the communities could increase local business opportunities. This impact is, however, temporary and jobs will be discontinued as soon as construction works are complete.

On the other hand, economic displacement is expected to be another potential key impact during the construction phase especially where the water conveyance pipeline passes in close proximity to commercial districts. Interruption of access to businesses (shops, petrol stations, etc.) will have social and socio-economic impacts due to reduced income during the construction period. Furthermore, impacts on farms and rangeland will reflect economically on farmers and livestock breeders. Loss of value of property is also a potential impact.

Based on the site investigation and meetings with potentially affected persons and enterprises, direct impacts on businesses are expected to occur mostly in Aqaba City, Disi, Wadi Rum area, Hasa, Qatraneh, Jezah, and Sahab. Furthermore, Economic impacts on tourist camps and rest houses are expected to occur in Wadi Rum area and Disi.

Due to the excavation works and pipe laying within the above areas, surrounding businesses and visitors using common roads may be disrupted, inconveniencing residents, shop owners and guests as a result of emitted dust, noise and difficulty to access certain areas. This impact will be temporary mostly for the duration of the excavation and pipe laying works that will likely be completed in a few days on each stretch of the road, its magnitude is considered moderate. Moreover, although socio-economic activities and local businesses owners within these areas are considered sensitive receptors this impact is considered to have a medium intensity and is restricted to the construction phase only. The impact significance on local business during construction has therefore been assessed as low.

It is important to note that the area between the IPS and SWRO where the conveyance of seawater and brine will pass requiring a 40-m right-of-way is a busy industrial area with the existing internal road in continuous use by the other occupants. An impact on the activities of these occupants is thus expected. However, as the details of this route have been left up to the BOT Developer to define in his detailed design, the ESIA team was not able to assess any potential environmental or social impacts on this issue.

Mitigation

Measures have been included in the Project ESMP such as installing temporary structures from excavation sites (mainly roads) to local businesses and informing the residents and shops' owners about construction activities and the planned schedule of works along with proper communication and coordination with affected owners will reduce the magnitude and intensity of this impact and its significance will thus become negligible.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Medium	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Short-term	Short-term
Extent	Local	Local
Scale	**Low**	**Low**
Significance	**Low**	**Negligible**

8.1.3.2. Land Use and Development Plans

Impacts

The installation of the proposed water conveyance component including regulating tanks, pumping stations and pipelines will take place on several areas having different land use classifications such as empty virgin lands, rocky lands or agricultural lands that may experience a change in land use. Some of these components will be installed along public roads and others will be placed on government or private owned lands. These lands might be used for agricultural or grazing activities which are considered as a source of income for the landowners. As such, land acquisition will economically affect the landowners where the components are proposed.

In fact, the Project will affect both government and private land which may be subject to acquisition, parcelling, fragmentation, etc. Furthermore, residential or commercial structures existing on those plots may also be affected. Since the AAWDC Project promoter is the Government of Jordan, acquiring government land will follow well-established procedures. Acquiring private land will involve lengthier and more detailed processes compared to government land or land owned by Jordan's Treasury.

The project is expected to affect 128 plots of land (refer to **Annex 8** (Land Aquisistion and Resettlement Planning Framework (LARPF) for details). These will be subject either to land allocation from ASEZA (7 cases), land acquisition (21 cases) or Right-of-Way (3 cases). The following are the ownership status of the affected plots (Table 8-1). However, the list needs to be updated by in line with the detailed design once completed.

Table 8-1: Affected Plots and Ownership Status

Affected plot owner	Number of plots affected
ASEZA	3
Private owners	87
Government of Jordan	29
ADC	3
ARCJO	1
Hijaz Rail	3
WAJ	2
Total	**128**

Consultations with stakeholders and PAPs revealed that, generally, owners of vacant land plots are not so much concerned about the potential acquisition of entire plots as they are about acquisition resulting in parcelling or fragmentation of land which often renders the rest of the plot area unusable or unfit for its designated land use (residential, commercial). During the consultation, most of the PAPs interviewed expressed their opinion that the GoJ pays fair and equitable compensation for acquired land.

As mentioned previously, land acquisition will economically affect the landowners where the project's component sites are proposed. Due to its moderate magnitude and high probability of happening along with its long-term effect, this impact is considered to have a high significance.

Mitigation

However, if proper mitigation measures for project affected persons were implemented, the impact intensity can be reduced to low, thus minimizing its significance. Mitigation measures to be implemented include:

- The use of publicly owned land over privately owned land shall be encouraged by the Project Promoter and considered by the BOT Developer/Contractor in his detailed design
- Fair compensation to affected persons (in case of private owned lands) shall be ensured through the Resettlement Action Plans pursuant to Jordanian laws and EIB/USAID E&S standards in line with the LARPF found in **Annex 8** of this report.
- Coordination with the Department of Lands and Survey shall be made so that all AAWDC Project related land use will be with the permission of the landowner and/or land user and compensation is provided at full replacement cost or as agreed through an open market transaction.
- Monitoring procedures shall be put in place ensuring that negotiations occurred and the agreed compensation to private landowners will be provided in a timely manner for the purpose of securing that their living standard and income opportunities remain at their pre-Project levels.
- A grievance mechanism shall be put in place that receive complaints on land acquisition matters.
- The BOT Developer will be responsible to cover any occupancy indemnities for the extraction or use of construction materials, and the cost of acquiring the necessary land to stockpile excess backfill material.
- The BOT Developer will be responsible to cover any damage suffered by the owners or users of the land as a result of a serious misconduct by his construction personnel.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Indirect
Magnitude	Medium	Low
Likelihood	High	Low
Intensity	**High**	**Low**
Duration	Long-term	Long-term
Extent	Site	Site
Scale	**Medium**	**Medium**
Significance	**High**	**Low**

8.1.3.3. Noise

Impacts

Sources of noise pollution during construction include excavators, generators, concrete mixers and other construction machinery and vehicles. These equipment and machinery are used for the installation of the conveyance pipeline. Increased noise levels during construction can be a source of nuisance to local residents, especially where the proposed pipeline passes in populated villages. Moreover, increased noise levels could potentially cause hearing impairment and other health problems to the construction workers. Noise levels are highly dependent on the extent and duration of the construction activities and are specific to the construction phase.

Due to high variability, estimation of noise generated from construction activities is difficult. The noise generated during the construction phase depends on specific activities and equipment. Some activities could be continuously generating noise, whereas others are momentary. Table 8-2 shows the typical noise levels from various equipment used for construction activities, some of which will be deployed during the construction phase of the Project.

Table 8-2: Typical Noise Emissions from Construction Equipment [75]

Equipment	Capacity/type	SPL at 20-30 m (dB)
Concrete pump on truck	120 m^3/hr, 40 m boom	70
Concrete truck mixer	10 m^3	70
Mobile compressor		70
Crawler cranes		70
Excavator with bucket		75
Diesel Generator set	2500 kvA, 11kv	75
Water sprinkler truck	20 m^3	75
Tipper truck	16 m^3	75
Single drum compactor	10 t	80
JCB	3X	80
Bulldozer 80 dB	CAT D9	80
Rebar yard	shear line normal / multiline	85
Welding machine	Semi-auto COMMERCY	85
Bending machine	Robot smart future	85

In addition, the installation of the conveyance pipeline along the districts in the project area requires the transportation of materials and equipment carried by trucks and large vehicles thus potentially leading to traffic congestion which is considered a source of noise pollution. Noise levels are highly dependent on the extent and duration of the excavation works and certain noisy activities. It is possible that for short durations, ambient noise standards may be exceeded. The main receptors are residents along the conveyance pipeline and construction workers, both of whom are considered sensitive receptors as exposure high noise levels may lead to hearing loss or general lack of wellbeing (EU-OSHA, ND; Fernández et al., 2009). However, noise is temporary and after completion of the construction works, noise levels will turn back to baseline conditions. Therefore, impact significance from noise is assessed to be low.

Mitigation

A number of measures have been included in the Project ESMP for adoption by the BOT Developer to reduce noise impacts. These measures include:

- A Noise and Vibration Management Plan supplemented with a Noise/Vibration Monitoring Program shall be provided as part of the Construction ESMP.
- Equipment should be used and construction and transport methods shall be adopted in order not to generate noise levels in excess of values set out in national or international standards.
- High noise generating works (e.g., pile driving, blasting, rock clearing, drilling, percussion drilling) to be planned in line with national regulations and respect maximum ambient noise-levels and night time rest hours at the nearest receptor areas.
- Stationary equipment (such as power generators and compressors) shall be located as far as possible from nearby receptors.
- Equipment known to emit noise strongly in one direction, whenever possible, shall be orientated so that the noise is directed away from any sensitive receptors.

- Plan construction activities so that activities which may generate significant noise are planned with regard to local occupants and sensitive receptors.
- 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.
- Develop Noise Monitoring Program comprising those Project Areas close to which noise impacts were predicted in the ESIA study as a result of construction equipment and activities and implemented during construction.
- Develop and implement a Traffic and Transport Management Plan (TTMP) as part of the Construction ESMP. TTMP shall take into account he relevant noise standards and the receptors in the area.

In addition to these general measures, the Project ESMP provides more specific provisions for the management of the generated noise and vibration such as:

- Unless specified otherwise in the contract and/or national legislation, heavy vehicles may not be used at night.
- Standard noise abatement equipment shall be fitted to equipment, used, and maintained in accordance with manufacturers' instructions.
- All machines in intermittent use shall be shut down in the intervening periods between work or throttled down to a minimum.
- Temporary noise barriers shall be used to reduce noise levels where appropriate and practicable.
- Where reasonably practicable, fixed items of construction plant shall be electrically powered in preference to diesel or petrol driven.
- Selection of inherently quiet plant where appropriate; installing silencers for fans, and placing hoarding around site perimeters to screen noise.
- Where practicable, pre-fabrication shall be undertaken at sites not situated in close vicinity to sensitive areas.
- All compressors and generators should be "sound reduced" models and fitted with properly lined and sealed acoustic covers which shall be kept closed whenever the machines are in use, and all pneumatic percussive tools should be fitted with mufflers or silencers of the type recommended by the manufacturers.
- All ancillary plant such as generators and pumps shall be positioned so as to cause minimum noise disturbance, and, if necessary, acoustic enclosures should be provided.
- Any Tunnel Boring Machine (TBM) support sites, especially if operating on a 24 hour basis shall be located in sufficient distances away from residential areas.
- Normal working hours in or close to residential areas shall be respected, and in general, night time working shall be kept to a minimum.
- As far as practicable, any demolition activities shall be carried out using equipment that breaks concrete in bending in preference to percussive methods.
- All pile driving shall be carried out by plant equipped with a noise reducing system or by silent driving systems. Percussive piling shall only be used where no other suitable system is available.
- The use of any vehicles, either on or off road generating excessive, exhaust or noise emissions shall be avoided. In any built-up areas, noise mufflers shall be installed and maintained in good condition on all motorized equipment.

As a result, residual impacts will be reduced to low intensity. Thus, the significance of the residual impact will become negligible.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Medium	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**

Parameter	Assessed Impact	Residual Impact
Duration	Short-term	Short-term
Extent	Local	Local
Scale	**Low**	**Low**
Significance	**Low**	**Negligible**

8.1.3.4. Infrastructure

8.1.3.4.1. Water Desalination Component (Offshore Facilities)

Impact

Construction and laying of the seawater intake and brine discharge pipeline may include excavation, trenching, cut and fill, compaction and levelling activities. Those activities can damage or negatively affect the operation of existing offshore utilities such as the gas pipeline and the gas storage ship located to the north of the IPS coastline, and/or the phosphate export jetty facilities located to the southwest. The damage, if occur, would have site consequences and implications. The impact considered to be high intensity due to the crowded site of the IPS coastline and the limited area available for the proposed offshore facilities. The impact is therefore of moderate significance.

Mitigation

During construction, the BOT Developer needs to plan and coordinate with relevant authorities and a safety exclusion zone shall be set since the detailed design for the protection of the submerged gas pipeline located at the north of the IPS location and pursuant to the guidelines/provisions of the competent national authorities. A similar exclusion zone shall be also considered in the detailed design for the phosphate loading/unloading jetty located at the south of the IPS location.

If the above plans and measures are implemented, the significance of the residual impact will be reduced to Negligible.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	High	Medium
Likelihood	High	Low
Intensity	**High**	**Low**
Duration	Short-term	Short-term
Extent	Site	Site
Scale	**Low**	**Low**
Significance	**Moderate**	**Negligible**

8.1.3.4.2. Water Desalination Component (Onshore Facilities) and Water Conveyance Component

Impact

Different types of waste are expected to be generated during the construction of the water conveyance pipeline and other project components. This waste will include the following types:

Construction waste and debris: This includes any excavated earth, building rubble, unused construction material, etc. generated during site preparation and restoration of worksites. This excludes excavated material which is assumed to be reused for backfilling and site restoration. Construction waste will likely cause visual impacts and may block roads, intersections and water courses. This waste needs to be disposed of by the BOT Developer at designated disposal sites allocated by the respective municipalities.

Domestic (municipal) waste: This includes waste generated from offices and administration buildings associated with the worksites in addition to the workers' camps. It includes mainly organic waste, paper, packaging, plastics, etc. This waste needs to be transported to designated municipal waste disposal sites by the BOT Developer.

Special wastes: (hazardous, oil, grease, used vehicle and equipment parts, etc.). These wastes will be generated during construction and need special handling and treatment. These will include the oily wastes associated with vehicle maintenance and equipment repair; unused or waste chemicals, lubricants, paints and solvents; and any other wastes that are unsuitable for disposal in municipal type landfills. These wastes shall be segregated for collection and disposal by waste contractors and disposed of at designated sites approved for such wastes.

Domestic (municipal) wastewater: This includes domestic wastewater generated at workers' camps and work sites. It is expected that the BOT Developer will provide package sewage treatment plants or septic tanks to collect wastewater at all locations. If septic tanks are used and, at the end of construction, removal of the septic tanks shall be undertaken by the BOT Developer directly or through licensed waste handlers to be disposed of appropriately.

During construction, the use of public utilities such as water supply and waste disposal facilities and wastewater treatment plants is expected to result in negative impacts for local communities and the municipal providers.

In addition, as the proposed alignment of the conveyance pipeline crosses residential areas, temporary disruption or disturbance to local road networks and services provided within the vicinity of the sites such as the electricity network, water supply network and telecommunication services might occur as a result of the excavation works and pipe laying in towns, villages and districts. PAPs have expressed their concern during stakeholder consultations that the project may interrupt vital services to their residences, businesses and vital community centers as they have experienced in similar past projects. This concern was also expressed by almost all municipalities interviewed, citing previous experience with similar infrastructure projects in areas under their jurisdiction.

Damage to utilities will have negative social and socio-economic consequences and will likely interfere with critical community services such as hospitals and fire-fighting (civil defence) stations.

The impact has therefore been assessed to be of medium intensity as proper investigation of existing and planned underground pipes and cables will be undertaken by the contractor to ensure that services are not disrupted and thus minimizing its occurrence. The impact is therefore of low significance.

Mitigation

During construction, main contractors need to implement the following in order to avoid any damage to the existing infrastructure:

- Develop a detailed Construction Methods Plan comprising, but not limited to the location of proposed borrow areas or areas to be excavated, the proposed backfill material stockpile locations or zones designated for the rubble from any demolition works, Project related maintenance facilities, storage areas, batch plants, and any side casting during the construction of linear infrastructure (roads, pipelines, transport routes).
- The BOT Developer will be responsible for any damages to people and property caused by the execution of the works or the procedures used for execution (e.g., Project vehicles demolishing local fences or houses, driving accidentally over crops, or causing any other material grievances) and associated compensation thereof.
- Include in the Construction ESMP procedures to manage, rectify, and record any incidents related to utilities damages or community disturbances
- Should Project construction activities require blasting, the integrity of existing housing or public service buildings situated within a radius of 500 meters around the Project Areas where blasting will occur shall be examined by a bailiff and his statement report shall be included in the Construction ESMP.

- Plan and coordinate with other contractors and the municipality to avoid disruption to utilities and underground infrastructure.
- The detailed design shall take due consideration any crossings with existing utilities so that utilities are maintained in good operating condition by temporary/ permanent diversions or by supporting in position. This shall be included in the Project's work procedures including detailed method statements from contractors prior to site activities taking place.
- A safety exclusion zone shall be set since detailed design for the protection of the submerged gas pipeline located at the north of the IPS location and pursuant to the guidelines/provisions of the competent national authorities. A similar exclusion zone shall be also considered in the detailed design for the phosphate loading/unloading jetty located at the south of the IPS location.
- Damage to infrastructure must be considered within the emergency preparedness and response plan to describe measures to be taken if unforeseen disruptions occur such as damage to water pipes or electricity lines.

In addition, the BOT Developer shall abide by all management provisions for domestic effluent generation as set out in the Project ESMP including:

- Adequate sanitation facilities shall be provided for the workforce. Domestic wastewater should either be discharged to the sewage network (if any), or to septic tanks or to the on-site domestic Wastewater Treatment System. The condition of the septic tanks shall be checked regularly and accumulated sludge must be pumped out and disposed to an appropriate regulated facility off-site as per the national regulations. If wastewater treatment is selected, proper operation of the facility shall be ensured and effluent quality monitored regularly in line with national standards. Sludge generated from the process shall be treated onsite and transported to an approved waste disposal facility.
- Discharge of untreated wastewater or sludge to the sea, streams or wadi beds shall be prohibited.

The BOT Developer shall also implement the following measures in order to manage the generated solid waste.

- Develop and abide by general waste management measures including:
  - All waste produced on the Project Areas shall be identified, collected, and properly treated or transported pursuant to the national waste management regulations and EIB / USAID E&S standards.
  - Minimize waste generation.
  - Any waste reuse, recycle and recovery activities shall be carried out in a manner that is safe for the public health and the environment.
  - A Waste Management Plan shall be developed as part of the Construction ESMP.
  - All personnel shall be trained in proper waste management procedures as appropriate to their level of responsibility and duties.
  - The amount of waste produced shall be minimized by efficient ordering of materials, and careful stock control.
  - Waste generated shall be properly contained to prevent uncontrolled release into the environment, and segregated into different waste types to ensure the maximum potential for reuse and recycling.
  - All waste that cannot be reused or recycled shall be treated or disposed of in the most technically feasible and environmentally sound manner and pursuant to national legal provisions and EIB / USAID E&S standards.
  - A waste register shall be established since the mobilisation of the construction works and maintained throughout construction duration.
  - Waste shall be categorised according to the following definitions: Non-hazardous solid waste, hazardous solid waste and hazardous liquid waste.
- Abide by waste management measures including those related to spoils and excavation materials.
- Abide by general and specific waste management measures including those related to hazardous, non-hazardous and domestic waste.

The development of these plans and procedures must be carried out in conjunction with the relevant municipal agencies, Governorates, and local police. A detailed investigation of existing and planned underground pipes and cables shall be undertaken prior to construction commencing. This will be done through proper cooperation with utilities companies and telecommunications companies.

If the above plans and measures are implemented, the significance of the residual impact will be reduced to negligible.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Medium	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Short-term	Short-term
Extent	Local	Site
Scale	**Low**	**Low**
Significance	**Low**	**Negligible**

8.1.3.5. Traffic and Transportation

8.1.3.5.1. Water Desalination Component (Offshore Facilities)

Impact

Construction activities of the seawater intake and brine discharge facilities and pipelines will likely impact marine traffic in the vicinity of the IPS coastline site. There will be restrictions around the intake and the outfall during construction, especially for diving cases which may slightly limit the movement of fishing boats and pleasure craft. However, fishing in the area is extremely limited (prohibited), and the area is not an important one for glass boat excursions or ships movement. On the other hand, traffic restrictions would limit the phosphate ship movement, if the BOT Contractor designed intake or outfall intersect with the phosphate ship site of service. Furthermore, there is a risk of shipping accidents during construction activities due to accidental stranding. The impact considered to be medium intensity due to the low shipping movement in the area while the impact will only affect the site area. The impact is therefore of low significance.

Mitigation

Construction activities will require the contractor to coordinate with the relevant authorities in Aqaba especially for traffic movement restricted cases. Flags and light signals shall be set up as agreed with the navigational authorities to alert maritime traffic. Construction activities and marine traffic restrictions shall be limited as possible to avoid any adverse impacts on ships mobility and imports/exports operations. The BOT Contractor shall also implement a traffic management plan which also includes marine traffic management plans and restricted zones, if any. Strict adherence to international standard best practice measures related to navigation and safety shall be ensured.

If the above plans and measures are implemented, the significance of the residual impact will be reduced to negligible.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	High	Medium
Likelihood	Low	Low
Intensity	**Medium**	**Low**

Parameter	Assessed Impact	Residual Impact
Duration	Short-term	Short-term
Extent	Site	Site
Scale	**Low**	**Low**
Significance	**Low**	**Negligible**

8.1.3.5.2. Water Desalination Component (Onshore Facilities) and Water Conveyance Component

Impact

The installation of the conveyance pipeline along the districts in the project area requires the transportation of materials and equipment carried by trucks and large vehicles thus potentially leading to traffic congestion. In addition, the closure of certain streets for pipe laying will also increase traffic volume temporarily thus resulting in traffic delays. Furthermore, there is a risk of materials falling from vehicles during the transportation potentially causing accidents and leading to traffic congestion.

This was also a shared concern expressed by almost all project-affected persons who were interviewed throughout the stakeholders' consultation process. PAPs emphasized the need to maintain access to their villages, homes, businesses, shops, farms, essential community centers and public service facilities during the construction phase. Local municipal governments reported increased public complaints in connection with similar projects in the past (e.g., Disi Water Conveyance Project) arising from limiting or preventing access, combined with an extended period to complete construction.

The impact during construction can be divided into the following three categories:

- **Medium to severe impact on traffic circulation in the two hotspots:** Construction works in the congested hotspots will have a significant impact on traffic circulation. Lane closures or complete road closures will require vehicles to take alternative routes during the construction period, further exacerbating congestion levels and increasing delays and areas that already experience such challenges. Furthermore, road closures will have an impact on access to residences, commercial properties, and other facilities located within the construction zone. This can be especially problematic for residents, customers, and visitors of those facilities.
- **Medium impact along the conveyance line outside the hotspots:** A similar, but less severe, impact will take place along the conveyance line. The impact is less severe than that within the hotspots because (1) areas outside the hotspots are less congested and (2) there is generally more road space in these areas, such that complete road closures can be avoided in favour of partial closures, in which alternatives can be found in other lanes or adjacent service roads.
- **Minimal impact from construction vehicles on surrounding roads:** Heavy vehicles transporting material to the construction zone will have some impact on traffic on adjacent roads. This impact is expected to be minimal, though, given the small number of construction vehicles relative to the overall traffic volumes on these roads.

Mitigation

As required in the Project ESMP, the BOT Developer shall develop and abide by aTTMP based on a Traffic Impact Assessment at the identified hotspot areas. The plan shall include the following:

- The characteristics of the fleet of vehicles and site machinery shall be defined in the TTMP, which will target to prevent construction site vehicle incidents and accidents through effective management of transport operations throughout the construction duration.
- The TTMP shall define itineraries to be used on a map for each route between the different Project Areas and for each phase of the construction works.
- The TTMP shall describe the expected traffic created by the construction fleet of vehicles (frequency of trips between Project Areas, working hours, convoys, etc.).
- The number and positions of flagmen shall be described in the Traffic Management Plan.

- The Contractor's ESMP shall comprise a consultation and notification process to give any local residents and businesses advance warning of potential delays on the road network as a result of increased traffic and any abnormal loads associated with construction activities in any Project Areas.

In addition to the above specific traffic management measures were also included in the ESMP such as:

- Administrative authorities shall be informed for the areas crossed by the construction vehicles, and for the itinerary and characteristics (frequency of passing, size and weight of trucks, materials carried) of the BOT Developer's fleet of vehicles.
- In the case of public roads and/or bridges are used, a bailiff shall be mandated to develop a sworn report regarding the state of the road/bridge prior to its use by the construction vehicles.
- Only selected routes to the Project worksites shall be used during construction activities,
- The BOT Developer will be held responsible for any damage caused to the roads and bridges due to the transportation of excessive loads, and will be required to repair such damage to the approval of the competent national authorities.
- Construction area warning signs must always be visible when work is being performed, and removed or covered promptly when the work is completed.
- The trailers and skips used to carry materials, which could be dispersed (sand, crushed material, aggregates, selected materials), shall be covered with a tarpaulin for the entire itinerary between two Project Areas.
- All abnormal loads will be suitably marked to warn other road users.
- The access roads to Project worksites and camps shall not be made wider than that required for efficiency and safety reasons
- To confine traffic as much as possible, the use of one two-way access roads is preferable to two separate one way roads.
- To confine vehicles to the approved paths as per the TTMP, access roads shall be clearly delineated.
- Truck trips on the highway during peak traffic flows should be avoided.
- Specific routes for construction traffic shall be agreed with competent national authorities especially for Project worksite areas within residential / urban settings
- Construction personnel shall be provided with organised bus commuting from and to Project worksites as a measure to prevent additional traffic by individual vehicular travelling.

The residual impact will thus be limited to any unusual incident such as car accidents, which are unlikely to occur under normal circumstances. As such, the significance of the residual impact will be reduced to low.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	High	Medium (in hotspots)
Likelihood	High	Medium
Intensity	**High**	**Medium**
Duration	Short-term	Short-term
Extent	Local	Local
Scale	**Low**	**Low**
Significance	**Moderate**	**Low**

8.1.3.6. Public Health and Safety

Impacts

During the construction phase, the local community may be exposed to several health and safety risks due to the excavation works and the presence of heavy machineries onsite, especially near residential areas where the installation of the conveyance pipeline, regulating tanks and pump stations are proposed. Construction activities generates high levels of dust and noise causing nuisance and health problems to the residents that are in close proximity to the construction sites. Moreover, as a major part of the pipeline will be installed along existing roads, activities associated with the installation might lead to road closure or narrowing the original width of the road, thus increasing traffic volumes in the concerned towns. Increased traffic volumes can result in traffic accidents and injuries to the local community that use these roads. In addition, although the IPS coastline site is restricted for fishing and not attractive for tourists, fishermen and offshore workers may still be exposed to several health and safety risks due to the construction of offshore works. Furthermore, there may be an increased risk of phosphate or other vessel accidents during the construction.

Although, the receptor, which includes the local community and workers in the area, are considered sensitive, the intensity of this impact is considered medium due its notable alteration and medium chances of occurring. Therefore, this impact is considered to have a low significance.

Mitigation

Community health and safety risks are addressed in the Project ESMP and require the BOT Developer to develop and implement a Community Health and Safety Plan, Traffic Management Plan, as well as an Emergency Preparedness Plan (EPRP). These plans include areas of active work sites to be barricaded or fenced off to prevent public access and avoid injuries to the local communities. In addition, posting warning and directional signs and safety instructions on roads and at active work sites will alleviate the risk to public and avoid accidents due to construction works.

Measures to be implemented to safeguard local community members and the public should include the following:

- Fence the construction area from all sides to prevent access to the site.
- Prohibit unattended/unauthorized public access.
- Install proper fence marked by red warning lights at night around excavations, material dumps or other obstructions at the construction sites (especially along the proposed roads where the conveyance pipeline will be installed).
- Install warning signs for drilling and construction at the external part of the site and at a distance of 100 meters.
- Equip Project drivers with telephones for contacting the emergency services to enact the EPRP if necessary in case of emergency.
- Keep Project stakeholders informed of the Project (in particular its schedule) and monitor stakeholder engagement.
- Manage the grievance mechanism through which community members can make complaints about Project activities.
- Address potential increase demands on local health facilities from in-Project migration arising from the construction workforce and support to health facilities located in the Project area (e.g. in terms of infrastructure, equipment, staff or financial/running costs).
- Conduct influx management forums throughout the construction phase with the local communities to identify their experiences and concerns of impacts.
- Information dissemination and education programmes regarding safety awareness around construction sites and traffic as well as sanitation and hygiene, particularly in schools in the area of the Project.
- The community health and safety plan should cross reference with other relevant management plans such as the TTMP and EPRP. Local health care and emergency services shall be consulted in the development of the plan.

To prevent and/or to reduce traffic related accidents, the following actions shall be taken:

- Pedestrians and vehicles to be kept apart (e.g., through providing separate entrances, walkways, signals).
- Vehicle movements to be minimized to the absolutely needed for construction activities.
- Drivers to be adequately trained and have the appropriate permits for driving vehicles.
- Turning circles for turning vehicles to be installed.
- The night movements of heavy vehicles shall be prevented between 22:00 and 06:00 hrs.

- Actions shall be taken for the control and check of speed limits for all construction vehicles and machinery to appropriate levels complying to the lowest limits as set out in national regulations or the following limits:
    - 20 km/h within the Project Areas.
    - 30 km/h in villages or hamlets, in towns, from 100m before the first house.
    - 80 km/h on unpaved roads outside of towns, villages, hamlets, and camps.
- It will be strictly prohibited to transport people, equipment, or products other than those required for the Project works and the management of Project Areas, on board any of the construction vehicles

The EPRP needs to be discussed and disclosed to service providers and local affected communities prior to construction. The EPRP will identify:

- Accidents and emergency situations and the communities and individuals that may potentially be impacted.
- Response procedures, provision of equipment and resources, designation of responsibilities, communication systems and channels and periodic response training.

The Project will need to implement EPRP training and drills at all the construction sites. In addition, the Project will also need to liaise with the district and municipal departments in charge for emergency response for the project, in order to ensure they have trained for project-specific emergency procedures.

The Project will also include a grievance mechanism (GRM) to ensure that resident complaints are documented and responded to. Upon implementation of these measures, the residual impacts can be reduced in terms of their magnitude and likelihood, rendering it of negligible significance.

In addition, The BOT Developer shall ensure close coordination with relevant authorities in Aqaba and to implement an exclusion zone in place surrounding the footprint of construction activities at sea. The routing of the pipelines should be marked with buoys so that any obstruction to marine navigation and traffic is avoided. Also, strict adherence to international standard best practice measures relative to navigation and safety shall be ensured. This is meant to include management of vessels movement via AIS.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Medium	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Short-term	Short-term
Extent	Site	Site
Scale	**Low**	**Low**
Significance	**Low**	**Negligible**

8.1.3.7. Occupational Health and Safety

Impact

Throughout the construction phase there will be important health and safety risks for the project workers. Accidents and injuries to workers may be caused from several construction activities including site preparation, excavation works, work at heights, lifting operations, operating heavy equipment, transporting material and equipment. These activities might lead to transportation accidents, falls, electric shock, mishandling of machinery and other construction related accidents. For example, the high noise generated from the machinery could damage the hearing of the workers and dust generation from the different construction activities, movements and transportation may cause respiratory problems for workers on site if appropriate personal protection equipment is not being used. Moreover, injuries to workers might occur during excavation works as this activity might require workers to enter confined spaces, as well as the risk of drowning while working on construction of the offshore facilities. In addition, natural environmental challenges such as extreme cold conditions, heat stroke or snake bites might cause health problems to onsite workers.

There are also risks of injuries to workers from accidents with vehicles driving near construction sites, especially within residential areas where space is likely to be limited. Without effective barriers and safety signs in place, there are risks of vehicles driving into construction areas such as into excavated trenches thus causing injuries to workers from car accidents. Furthermore, there is a risk of spreading of communicable and infectious diseases (such as Influenza and Covid-19) between workers on site or at worker camps. Due to the health implications associated with this impact and to the sensitivity of the receptor, who are the construction workers, this impact is considered to have a high magnitude. However, this impact has a medium chance of occurring during construction. In addition, knowing that this impact is only restricted to the construction phase, as such its significance is considered to be moderate.

Mitigation

Occupational health and safety risks are addressed in the Project ESMP and require the BOT Developer to develop and implement a Health and Safety Plan. This includes a risk assessment to identify work hazards onsite and determine corresponding protection measures such as installing warning signs around hazardous areas, providing workers with PPEs (include hard hat, safety shoes, reflective vets, gloves in addition to other PPEs depending on the risks involved in specific tasks performed by the workforce), in addition to approved buoyancy equipment (e.g. life jackets, vests, floating lines, ring buoys) when workers are over, or adjacent to, water where there is a drowning hazard. The use of PPE must be made mandatory in the employment contract and the contractor should provide first aid kits on site, identify the nearest medical emergency facility for each component of the Project and segment of the conveyance line, ensure that all equipment are maintained in a safe operating condition and train workers on health and safety procedures. The Project ESMP includes specific health and safety control measures for different hazards such as for excavation/trenching, confined spaces, working at heights, scaffolds, hot works, materials handling, traffic and driving hazards, tractor operations, noise hazards, respiratory hazards, electrical hazards, hazardous chemicals and waste.

It is also important to keep record of health and safety incidents on site and health and safety incidents must be reported immediately. In addition, the Project human resources policies and procedures will be in accordance with national laws and the ILO Core Labour Standards to which Jordan is a signatory.

Residual impact might occur only in accidental cases such as minor injuries from unexpected or unidentified hazards within the construction site. However, measures will be in place to reduce the impact immediately. Thus, the residual impact will have a negligible significance.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	High	Medium
Likelihood	Medium	Low
Intensity	**High**	**Low**
Duration	Short-term	Short-term
Extent	Site	Site
Scale	**Low**	**Low**
Significance	**Moderate**	**Negligible**

8.1.3.8. Labour Influx and General Labour Conditions

Social tensions may arise, if a significant portion of job opportunities are offered to foreign workers recruited for the Project, as Jordanian workers may perceive that such job opportunities could have been filled by them. Social tensions between national and foreign workers may also arise if they are not equally compensated as per the scale of market price rates. Moreover, labour influx may also lead to social interactions between workers and the surrounding communities leading to culturally insensitive behaviours and incidents such as gender-based violence, sexual abuse and exploitation and sexual harassment incidents.

It is worth noting that PAPs expressed their concern that the potential presence of a foreign workforce in or near their local communities will have a negative impact on privacy and on the mobility of women. This is mostly expected to be an issue in rural and remote areas which constitute most of the project area. On the other hand, some of the interviewed business owners in Hasa, Qatraneh, Disi and Wadi Rum see the presence of foreign workers as an opportunity to improve their business

Potential recruitment of minors in hazardous tasks may occur during the construction phase, in addition to gender discrimination during the recruitment process. Although the intensity of this impact is medium, its scale is low. The impact has therefore been assessed as low significance.

Avoiding social tension, culturally insensitive behaviour by workers, gender discrimination and recruitment of minors during construction will be ensured by the contractor adhering to the measures laid out in the Project ESMP, including:

- Implement and abide by Labour Conditions specified in the Project ESMP.
- Draft a Code of Conduct for workers and ensure that workers sign and understand the Code of Conduct.
- Develop and implement a Grievance Redress Mechanism and respond to culturally insensitive behaviors and incidents as a matter of priority.
- Coordinate and implement public awareness campaigns for workers regarding dealing with the local population to minimize friction caused by contacts between the construction workforce and communities.

After implementing these measures, residual impacts will be limited to certain incidents that will be handled swiftly. As such the significance of the residual impact will be negligible.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Medium	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Short-term	Short-term
Extent	Local	Site
Scale	**Low**	**Low**
Significance	**Low**	**Negligible**

8.1.3.9. Cultural Resources

Impacts

None of the listed archaeological sites within this zone are located near areas where project excavation or construction activities will occur. As such, no adverse impacts on such cultural heritage and archaeological sites and resources are expected to occur during the installation of both the desalination components and the conveyance pipeline. However, due to the presence of archaeological sites within the area, unknown artifacts may be uncovered during the excavation activities.

In addition, construction activities considered to be a source of vibration and dust resulting from the drilling operations vehicles movements that may affect nearby sites.

On the other hand, the conveyance pipeline will cross Al Hijaz Railway, which considered as cultural site, at the following six points.

- 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
- Madaba/Lubban-Near Railway station

Mitigation

Mitigation measures for the impacts on archaeology and cultural heritage during construction include the following:

- Ensure all chance finds of cultural heritage (e.g. graves, old ceramic, old building fragments) are reported immediately to DoA, excavation stopped, and contractor awaits instructions from DoA.
- Ensure coordination between the Contractor and DoA.
- Prepare and abide by a Pollution Prevention Management Plan.
- Leave a 15-m buffer zone around each site.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Moderate	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Short-term	Short-term
Extent	Site	Site
Scale	**Low**	**Low**
Significance	**Low**	**Negligible**

8.2. During Operation

8.2.1. Physical Environment

8.2.1.1. Soil and Geology

Impact

During operation, accidental spills from fuel, oil and other chemicals used for the maintenance and operation of the conveyance pipe or the PSs may occur due to irregular maintenance and inadequate monitoring of storage tanks. Thus, accidental chemical spills and leakages could negatively affect the soil quality. In addition, improper disposal of domestic and office waste as well as improper discharge of domestic wastewater of operators at the various facilities including the IPS, SWRO and PSs will also lead to soil pollution. However, best practice measures are sufficient to minimize this impact. Moreover, if the BOT Developer will provide for a domestic WWTP within the SWRO site, unexpected untreated wastewater leakages may lead to pollution of soil in the area.

Mitigation

The following mitigation measures shall be implemented in order to prevent the adverse effects on the soil quality during operation and/or maintenance:

- Provisions for drainage in all Project sites shall be included in the Operation ESMP. These will include measures to ensure that any surface water run-off is contained and managed appropriately pursuant to the Project permits and national legal requirements.
- A regular cleaning and maintenance programme for drainage systems, sumps and oil interceptors shall be implemented at all Project sites and reported as part of the Operation ESMP.
- Any contamination of the surrounding environment shall be prevented.
- Vehicle/machinery and equipment operations, maintenance and refuelling shall be carried out to avoid spillage of fuels and lubricants and ground contamination. An “oil interceptor” shall be provided for wash-down and refuelling areas. Fuel storage shall be located in proper bunded areas.
- All spills and collected petroleum products shall be disposed of in accordance with standard environmental procedures/guidelines or as directed by the competent national regulatory authorities.
- Oil, chemicals, and other contaminants stored on the Project sites for operational purposes shall be properly stored, isolated and bunded, with secondary containment of adequate volume where appropriate
- Connect the generated domestic wastewater from PSs operators and guards to the sewage network and prohibit its discharge into the environment.
- Abide by spill prevention and management measures as required in the Project ESMP.
- All waste produced on the Project sites shall be identified, collected, and properly treated or transported pursuant to the national waste management regulations and EIB/USAID E&S standards.
- The generation of waste shall be minimised whereas any waste reuse, recycle and recovery activities shall be carried out in a manner that is safe for the public health and the environment.
- A Waste Management Plan shall be developed as part of the Operation ESMP, which shall set out a concept to manage non-hazardous and hazardous waste in line with the national law and regulations and EIB/USAID E&S standards and adapted to the level of hazards for public health or the natural environment.
- The Operation Waste Management Plan shall be disseminated to all Project sites.
- Personnel at an appropriate level of seniority shall be nominated to be responsible for good site practices and arrangements for collection and effective disposal of all waste generated by the Project sites. The BOT Developer shall nominate one or more staff with responsibility for implementing the waste management procedures detailed in the Operation Waste Management Plan.
- All personnel shall be trained in proper waste management procedures as appropriate to their level of responsibility and duties.
- Overall, the amount of waste produced shall be minimized.
- Waste generated shall be properly contained to prevent uncontrolled release into the environment, and segregated into different waste types to ensure the maximum potential for reuse and recycling.
- All waste that cannot be reused or recycled shall be treated or disposed of in the most technically feasible and environmentally sound manner and pursuant to national legal provisions and EIB/USAID E&S standards.
- A waste register shall be established since the commencement of Project operation.
- Waste shall be categorised as non-hazardous waste, hazardous solid waste and hazardous liquid waste.
- The Operation Waste Management Plan should comprise dedicated procedures for working with handling and disposal of the identified waste categories as required in the Project ESMP.
- General waste shall be transported directly to the nearest local and approved landfill for final disposal.
- Prohibit the disposal of solid waste in open areas under any conditions as well as onsite burning.

- Implement office and domestic waste reduction and recycling techniques during operation.
- If the BOT Developer will provide for a domestic WWTP within the SWRO site, then the effluent has to comply with the national standards for the reclaimed domestic wastewater and according to the targeted use.

Regular maintenance of the domestic WWTP to avoid any leakage and shutdown affecting the treatment performance and treated effluent quality.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Moderate	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Short-term	Short-term
Extent	Site	Site
Scale	**Low**	**Low**
Significance	**Low**	**Negligible**

8.2.1.2. Coastal and Marine Environment

The operation activities of the water desalination component may affect the physical coastal and marine environment through the following attributes:

- Brine Discharge – Salinity
- Brine Discharge – Residual Chemicals
- Filters' Backwash
- RO Membranes CIP Cleaning
- Seawater intake

The impact receptors are:

- Soil and Geology: Seafloor and Sediments
- Seawater Quality and Hydrology

The following potential impacts on the coastal and marine physical environment have been identified as follows:

- 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
- 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)

In order to handle these impacts, the two main technical components during operation are considered. These are the seawater intake and the reject brine discharge. There are several design practices accepted universally for both elements based on specific project conditions. Below is a summary of design criteria deemed most appropriate for the AAWDC Project.

For seawater abstraction the present ESIA study suggests the use of either Velocity Cap Tower Intake or Passive Screening Intake.

The velocity cap intake tower Intake solution is the most widely used and globally proven for SWRO seawater abstraction. The operation of this solution for the AAWDC Project is considered to be pre-feasible provided the following conditions are achieved:

- The intake tower is located in the seawater depth not less than 12 m.
- The intake window lower sill is at least 3 m above the seabed to minimise sand and silt entrainment.
- The top of the intake tower window should be at least 5 m below the seawater surface (MSWL) to minimise the potential of the entrainment of surface pollution, particularly oils.
- A horizontal velocity cap design type of intake should be selected if an intake tower is used.
- The through screen velocity should not exceed 0.15 m/s with all intake towers in service, 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 use of passive screens is also considered to be pre-feasible and shall be allowed to be offered by BOT Developers because it offers the potential to eliminate shore screening and also possibly direct intake pump coupling to the intake pipes, which could give a developer flexibility of footprint within the intake pump station. However, the seawater current velocity in the area is low and the developer should satisfy themselves with the passive screen suppliers that the currents are sufficient with the steep bathymetry of the intake location selected by the Developer to remove the screenings released by air blast cleaning systems.

The positive environmental impacts of passive screens could counter the negative impacts. The main positive benefits are: (i) reduced entrainment of small fish and swimming fauna and (ii) no use of landfill disposal for screened material. The main negative environmental impacts are: (i) high copper alloy screen is needed for fouling control, which will corrode over time into the sea and (ii) additional excavation disturbing the benthic community is needed for 9-14 air blast system 200 mm HDPE pipes required for fouling control.

If passive screens are to be provided, the following conditions shall be achieved:

- Intake screen through velocity not exceeding 0.15 m/s, with all screens in service and ultimate SWRO production capacity of the 300 MCM/y.
- The passive screen shall be located where the seabed depth is not less than 15 m.
- The screen bottom should be at least 3 m above the seabed to minimise sand and silt entrainment.
- The top of the intake screen should be at least 5 m below the seawater surface (MSWL) to minimise the potential entrainment of surface pollution particularly oils.
- An air blast cleaning system shall be provided, capable of cleaning each screen individually

Irrespective of either a velocity cap intake tower or a passive screen intake is selected, it is essential to also consider an effective macrofouling control strategy for the intake system. Due to concerns relative to THMs formation when chlorination is used as macrofouling control and the fact that THMs cannot be removed during dechlorination with SBS, as residual free chlorine can, the selected cleaning strategy for the intake pipelines both submerged and on-shore from the IPS to the SWRO plant shall avoid chlorination unless there is no other feasible technical solution (i.e., divers manual cleaning and/or mechanical pigging). Should chlorination be essential, then THMs concentration of the brine effluent shall be monitored continuously and both a zero chlorine concentration and no THMs concentration increase above ambient THMs concentration shall be achieved for brine discharge.

For brine discharge with effective protection of the natural ecosystem of the Gulf of Aqaba, it is essential that the discharge is designed to achieve very high dilution in the near field mixing zone. The present ESIA study follows a precautionary approach with regard to brine proposal, which requires:

- Design of the diffusers shall ensure that dilution of the brine salinity be maximised to achieve the concentration of brine plume closer to ambient sea concentration in very short distance from the diffusers.
- The brine shall as far as practically possible only comprise the concentrated dissolved salts that originate from the local sea. It shall be free of disinfectants, disinfection by-products if possible, and organic membrane cleaning substances.
- Discharge of the pre-treatment solids, coagulant precipitated solids, and post treatment waste solids shall be minimised using an on-site solids treatment plant with high solids capture in order to minimise the overall brine turbidity and iron discharge.

The most globally known protective mixing zone and ambient conditions standards are applied in the Red Sea by Saudi Arabia. The present ESIA study recommends that the Saudi mixing zone standards are adopted for the AAWDC Project. This requires:

- The size of mixing zone size shall be 100 m from the diffusers throughout the water column
- The ambient standard to be achieved for salinity shall be less than or equal to 2% salinity increase above ambient seawater salinity at the end of the mixing zone.

Brine dispersion modelling that has been carried out for the AAWDC Project demonstrated that a well-designed outfall diffuser system can achieve brine dispersion to a salinity of 1.3-2% above the ambient at 100 m from the diffusers. It is anticipated that a dispersion of less than 2% should provide protection for the local flora and fauna outside of the mixing zone. A long term Whole Effluent Toxicity testing shall be carried out by the BOT Contractor during plant construction and early plant operation to confirm the dilution needed to have no observable impact on the flora and fauna outside of the 100 m mixing zone.

The following end of pipe standards shall be achieved by the AAWDC Project:

Dissolved oxygen shall be ≥ 3.5 mg/l

Turbidity shall be ≤ 5 NTU (90% ile) plus ambient intake seawater turbidity; and

< 10 NTU (100% ile) plus ambient intake seawater turbidity

Total Iron shall be ≤ 0.3 mg/l on average, ≤ 0.5 mg/l maximum

Residual Chlorine shall be = 0

No increase in THMs concentration above the limit concentration, where the limit concentration for THMs will be the ambient measured THMs multiplied by the plant concentration factor (at overall recovery).

pH ≥ 7 and ≤ 9

Other requirements regarding the brine discharge ensuring environmental protection include:

- RO membrane CIP waste which has used organic cleaning chemicals or biocides, or chelating agents shall not be discharged to the brine for ultimate outfall disposal.
- Other RO or MF/UF Membrane CIP waste that have used only inorganic chemicals and can be allowed ultimate entry to the brine outfall. These CIP wastes must be first neutralised to pH 7-9 before being sent to the solids treatment plant and subsequently to the brine for ultimate outfall disposal.
- No organic or halogen disinfectants shall be discharged to the brine.
- The use of chlorine for intake pipeline barnacle fouling protection shall be avoided by the Project if it is technically and long term operationally possible without affecting the intake pipeline hydraulic capacity.
- Antiscalants shall only be used if they are demonstrated as essential for plant operation by the use of pilot testing and subsequent RO membrane autopsy during construction or by presenting such testing from another recent project or recent published research. Antiscalants if used shall be nitrogen-free,

readily biodegradable in the marine environment and dosed at a minimum effective quantity established by pilot testing.

- On-site solids treatment shall be provided with the following features:
  - o shall receive the backwash effluents from for media filtration solids and/or UF/MF, post treatment limestone filter backwash (post treatment backwash can be sent to a buffering tank but the high solids content from the bottom of tha tank shall be send to solids treatment) or lime saturator effluents after neutralisation and spent non-organic neutralised RO membrane cleaning waste. This system shall include sludge thickening and dewatering.
  - o solids treatment system thickening and dewatering shall remove ≥ 90% of the solids entering.
  - o solids to be thickened and dewatered to achieve sludge cake of dry solids ≥ 20%.
  - o supernatant liquors from the sludge thickener and/or dewatering centrifuges shall be allowed to discharge to the brine for outfall disposal if the supernatant has turbidity of ≤ 30 NTU.
- The outfall diffusers shall be located in water depth that allows a gap of 5 m between the maximum height of brine plume rise above the diffusers and seawater surface.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Moderate	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Short-term	Short-term
Extent	Site	Site
Scale	**Low**	**Low**
Significance	**Low**	**Negligible**

8.2.1.3. Water Resources (Surface Water and Groundwater)

Impact

Implementation of the AAWDC project will have a positive impact by reducing the water supply deficit in the context of severe water scarcity that Jordan is facing by providing a safe and reliable freshwater to Amman and other areas along the pipeline route, relieving pressure on groundwater resources that are being pumped unsustainably.

On the other hand, water resources including wadis and groundwater sources along the conveyance pipeline and its associated facilities such as PSs (especially at vulnerable groundwater sources including groundwater along Wadi Wala (Heedan wellfield - Madaba Governorate) and groundwater in the vicinity of Mujib Dam (Karak Governorate) might become polluted from accidental spills during maintenance activities or from the improper disposal of domestic wastewater and solid waste generated from the offices. However, best practice measures are sufficient to minimize this impact. As for the SWRO site, if the BOT Developer will provide for a domestic WWTP within the SWRO site, unexpected untreated wastewater leakages may lead to pollution of soil in the area.

Mitigation

As described in the Project ESMP, the following mitigation measures shall be implemented in order to prevent the adverse effects on the water resources quality:

- Provisions for drainage in all Project sites shall be included in the Operation ESMP. These shall include measures to ensure that any surface water run-off is contained and managed appropriately pursuant to the Project permits and national legal requirements.

- A regular cleaning and maintenance programme for drainage systems, sumps and oil interceptors shall be implemented at all Project sites and reported as part of the Operation ESMP.
- Any contamination of the surrounding environment shall be prevented.
- Vehicle/machinery and equipment operations, maintenance and refuelling shall be carried out to avoid spillage of fuels and lubricants and ground contamination. An “oil interceptor” shall be provided for wash-down and refuelling areas. Fuel storage shall be located in proper bunded areas.
- All spills and collected petroleum products shall be disposed of in accordance with standard environmental procedures/guidelines or as directed by the competent national regulatory authorities.
- Oil, chemicals, and other contaminants stored on the Project sites for operational purposes shall be properly stored, isolated and bunded, with secondary containment of adequate volume where appropriate.
- Connect the generated domestic wastewater from PSs operators and guards to the sewage network and prohibit its discharge into the environment.
- Abide by spill prevention and management measures as required in the Project ESMP.
- All waste produced on the Project sites shall be identified, collected, and properly treated or transported pursuant to the national waste management regulations and EIB/USAID E&S standards.
- The generation of waste shall be minimised whereas any waste reuse, recycle and recovery activities shall be carried out in a manner that is safe for the public health and the environment.
- A Waste Management Plan shall be developed as part of the Operation ESMP, which shall set out a concept to manage non-hazardous and hazardous waste in line with the national law and regulations and EIB/USAID E&S standards and adapted to the level of hazards for public health or the natural environment.
- The Operation Waste Management Plan shall be disseminated to all Project sites.
- Personnel at an appropriate level of seniority shall be nominated to be responsible for good site practices and arrangements for collection and effective disposal of all waste generated by the Project sites. The BOT Developer shall nominate one or more staff with responsibility for implementing the waste management procedures detailed in the Operation Waste Management Plan.
- All personnel shall be trained in proper waste management procedures as appropriate to their level of responsibility and duties.
- Overall, the amount of waste produced shall be minimized.
- Waste generated shall be properly contained to prevent uncontrolled release into the environment and segregated into different waste types to ensure the maximum potential for reuse and recycling.
- All waste that cannot be reused or recycled shall be treated or disposed of in the most technically feasible and environmentally sound manner and pursuant to national legal provisions and EIB/USAID E&S standards.
- A waste register shall be established since the commencement of Project operation.
- Waste shall be categorised as non-hazardous waste, hazardous solid waste and hazardous liquid waste.
- The Operation Waste Management Plan shall comprise dedicated procedures for working with handling and disposal of the identified waste categories as required in the Project ESMP.
- General waste should be transported directly to the nearest local and approved landfill for final disposal
- Prohibit the disposal of solid waste in open areas under any conditions as well as onsite burning.
- Implement office and domestic waste reduction and recycling techniques during operation.
- If the BOT Developer provides a domestic WWTP within the SWRO site then the effluent has to comply with the Jordanian Standard number 893/2021 for the reclaimed domestic wastewater and according to the targeted use.

Regular maintenance of the domestic WWTP to avoid any leakage and shutdown affecting the treatment performance and treated effluent quality.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct

Parameter	Assessed Impact	Residual Impact
Magnitude	Moderate	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Short-term	Short-term
Extent	Site	Site
Scale	**Low**	**Low**
Significance	**Low**	**Negligible**

8.2.1.4. Energy Resources

Impact

The AAWDC Project will require a significant amount of energy/power for the operation of the SWRO and PSs as well as for maintenance activities. The power demand required for the operation of all project components is presented in Section 2.2.3. As such, the Project will contribute to the depletion of non-renewable energy resources such as fuels used for power generation and increase the fiscal burden on the country as fuel is imported. As such, the magnitude of this impact is considered to be medium and its scale is high. Therefore, the significance is assessed as high.

Mitigation

- Regular maintenance of stand-by generators and pumps.
- The Operation ESMP shall comprise procedures ensuring energy efficiency in all Project related operations and at all Project sites.
- Assess the feasibility of installing renewable energy facilities to compensate for power needed to operate the Project.

Taking into account the proposed mitigation and management measures during operation, the residual impact intensity will be reduced to low thus reducing its significance to moderate.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Medium	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Long-term	Long-term
Extent	Regional	Regional
Scale	**High**	**High**
Significance	**High**	**Moderate**

8.2.1.5. Air Quality

Impact

Operation of the project will be a source of GHG emissions due to the significant power demand required for the operation of the SWRO and the PSs along the conveyance pipeline route. Assuming the Project will use power from the national grid, annual GHG emissions for the AAWDC operation has been estimated at 1,244,430 tCO_2 (refer to GHG Emissions Report in **Annex 20**). Transport methods relative to the Projects operations are also considered sources of GHG emissions. As such this release into the environment will add to Jordan's contribution to global GHG mainly due to the size of the SWRO and the PSs. Therefore, the significance of this impact was found to be high. Foul odor from the domestic WWTP (if established) might be generated if proper maintenance is not carried out. Gases responsible for these odors include hydrogen sulfide (H2S) and ammonia (NH3). This foul odor might disturb workers, and surrounding areas.

Mitigation

- Transport methods relative to Project operations shall be adopted so that generated atmospheric emissions are not in excess of the threshold emission values set out in national regulations or international recognised standards including those of the EIB/USAID.
- Regular maintenance of stand-by generators and pumps.
- The Operation ESMP shall comprise procedures ensuring energy efficiency in all Project related operations and at all Project sites.
- Assess the feasibility of installing renewable energy facilities to compensate for power needed to operate the Project.
- Regular maintenance of odour control units at the domestic WWTP.
- Regular disposal of sludge in accordance with the competent authority.

Taking into account the proposed mitigation and management measures during operation, the residual impact intensity will be reduced to low, thus reducing its significance to moderate.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Medium	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Long-term	Long-term
Extent	Regional	Regional
Scale	**High**	**High**
Significance	**High**	**Moderate**

8.2.2. Biological Environment

8.2.2.1. Marine Biodiversity

The following potential impacts on the coastal and marine biological environment were identified, namely:

- Entrainment of macro flora spores, invertebrate larvae, fish eggs and early stages through open intakes
- Impingement of nektonic species through seawater intake
- 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

- Potential loss of habitat or loss of feeding and nesting grounds due to increased noise levels

The following sections discuss these impacts and the respective mitigation measures for their control.

Seawater abstraction conditions optimization is fundamental for controlling potential impacts on the coastal and marine biological environment. Optimization of seawater abstraction conditions involves the technical considerations of the intake system discussed above and the location of the intake system with respect to biological productivity. Recommending the optimum conditions location of the seawater intake constituted a serious challenge in the present ESIA study, especially because a previous intake optimization study of the Red Sea Dead Sea (RSDS) Project suggested an intake at a water depth of – 144 m, which is technically impossible in terms of operating a desalination plant with the up to date known technology. However, subsequent modelling and field studies proved that the - 144 m (or -120 m also assessed) depth water intake is not the only solution to minimise entrainment of macro flora spores, invertebrate larvae, fish eggs and early stages and particularly coral gametes. The present ESIA analysis of the optimum seawater intake depth to minimise entrainment of Planktonic and small Nektonic organisms and yet provide practical operational conditions for desalination with minimal environmental impact on the coastal and marine biological environment are as follows:

- Locating the seawater abstraction at a seabed depth of 12 – 20 m provides a pre-feasible solution for the AAWDCP SWRO Desalination Plant seawater supply that respects the physical and environmental conditions at the Project location. The key benefits of the recommended depth are:
    - 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 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.
- Locating the seawater abstraction at the seabed depth of -144 m was considered for the RSDS project to reduce plankton entrainment. This depth is 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 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 AAWDCP is expected to have no significant impact neither on larvae entrainment nor 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. Also 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 all its deterring cost and smooth running if built and with all its technical difficulties to construct and to operate, would result in significantly less larvae entrainment than a shallow intake (10 - 25 m).

- o Coral larvae entrainment in a shallow intake of less than 20 m depth can be much easier mitigated through design than a deeper one sited at more than 120 m depth.
- o 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, and 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.
- o 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.
- o 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.
- o The location of the intake at -144 m will 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.
- o 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.

Brine discharge is the other main factor leading to potential impacts on the coastal and marine biological environment. Positioning and dilution of the brine discharged are key parameters in determining the brine discharge impact significance both due to its higher salinity and to residues of added chemicals that it may contain. In order to provide the best possible evident based recommendation concerning brine discharge, the present ESIA study investigated the Project's site thoroughly by bottom video survey and modelled the near field and far field brine dilution.

During the pre-scoping phase, positioning targeted a location at 50 m seabed depth where the seabed topography identified by the video survey could be considered appropriate as it provides a relatively gently sloping area covered with rubble and very poor live cover. This was found beyond a steeply sloping area between seabed depths 35 – 50 m that contained interspersed in poor conditions corals. Figure 8-2 illustrates the seabed nature at the surveyed brine discharge site.

Figure 8-2: Seabed Conditions at the Suggested 50m Deep Brine Discharge Site

The Brihne Model was used to assess the brine dispersion impact of the diffusers at the set Plant capacity of 300 MCM/y drinking water.

The diffuser configuration for the Brihne model was established by using the Roberts Abessi equations. To ensure validity of the Roberts equations, the Froude number has to be greater or equal to 20 to ensure the equations were valid.

Two scenarios were examined:

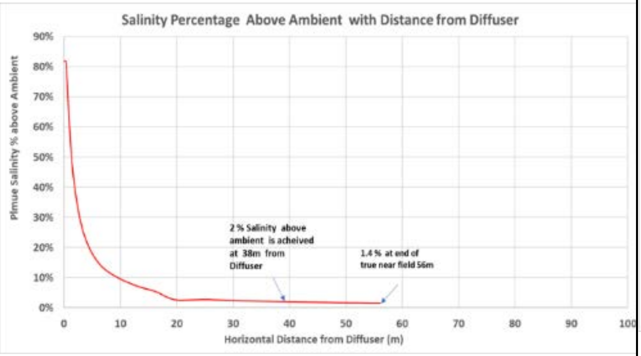
- Scenario 1 - Desalination Plant Recovery 45%
- Scenario 2 - Desalination Plant Recovery 42%

The results of the model confirmed that the set rule for the Mixing Zone of 2% above Ambient @ 100m from diffusers is achievable.

<table>
<tr><th>Scenario 1 - Desalination Plant Recovery 45%</th><th>Desalination Plant Recovery 42%</th></tr>
<tr><td>

A mixing zone requirement of achieving no more than 2% salinity above the ambient at 100m from the diffusers can be comfortably achieved at this location in the near field. The 2% above ambient salinity is shown to be achieved at the distance of 38 m from the diffusers (see Figure A). The model indicates that the end of the near field, 56 m from the diffusers, the brine plume salinity concentration would be just 1.4% above the ambient. These would all be excellent results for protecting the flora and fauna from elevated salinity.

Figure A: Salinity Percentage Above Ambient with Distance from Diffuser at 45% Plant Recovery



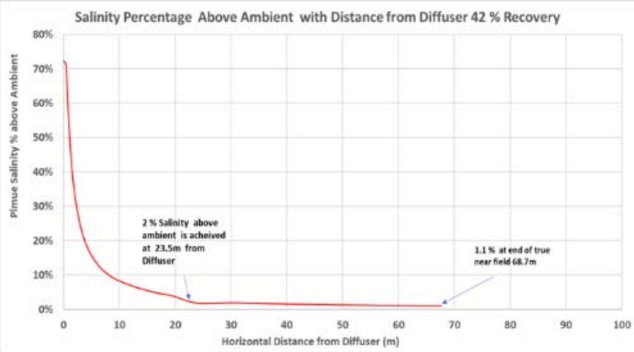
The maximum plume height reached above the seabed is 20.15 m by using the Brihne model (Figure B), which is higher than that calculated using the Roberts/Abessi equation (2.25 x Froude x Do + 3.5) = 17.7 m. Allowing a margin of, 5m on Roberts/ Abessi max plume height value gives a water depth of approx. 23 m, which should be sufficient to ensure the brine plume does not reach sea surface.

Figure B: Plume Height with Distance from the Diffusers at 45% Plant Recovery

</td><td>

A mixing zone requirement of achieving nor more than 2% salinity above the ambient at 100m from the diffusers can be comfortably achieved this location in the near field. The 2% above ambient salinity is shown to be achieved at the distance of 23.5 m from the diffusers (see Figure A'). The model indicates that the end of the near field, 69 m from the diffusers, the brine plume salinity concentration would be just 1.3% above the ambient. These would all be excellent results for protecting the flora and fauna from elevated salinity.

Figure A': Salinity Percentage Above Ambient with Distance from Diffuser at 42% Plant Recovery



The maximum plume height reached above the sea bed is 23.45 m using the Brihne model (Figure B'), which is higher than that calculated using the Roberts/Abessi equation (2.25 x Froude x Do + 3.5) = 20.7 m. Allowing a margin of 5 m on Roberts/ Abessi max plume height value gives a water depth of approx. 25.5 m which should be sufficient to ensure the brine plume does not reach sea surface.

Figure B': Plume Height with Distance from the Diffusers at 42% Plant Recovery

</td></tr>
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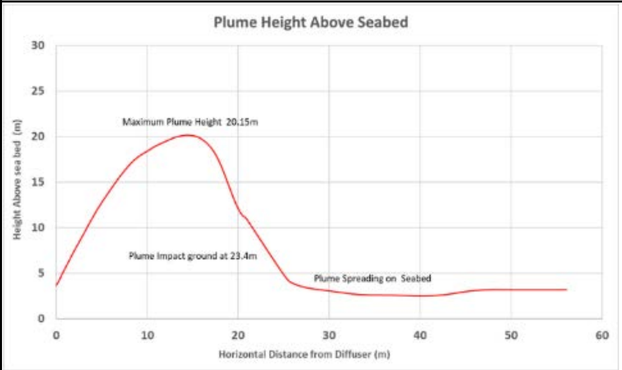	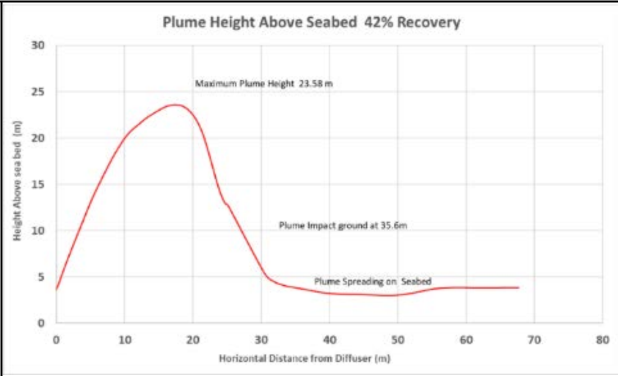
The Brihne model indicated that the end of the near field will be at a distance of approx. 56 m from the diffusers. By this distance, the plume has hit the sea bed spread out as a layer and lost its forward momentum impacted by the diffusers. The brine plume spread layer thickness is established from the Brihne model as approx. 3.18 m. The top of brine plume spread layer has concentration of just 25% of the maximum concentration in the spread layer. Until the end of the nearfield is reached, brine plume dispersion has been caused by turbulent entrainment resulting from by the high velocity jet diffusers. After the end of near field distance of 56 m the brine plume will flow as density current along the sea bed flowing the seabed bathymetry into deeper water. The brine plume will very gradually become more diluted to the local low ambient currents and by concentration diffusion. The path of brine plume and the further concentration reduction with distance will be established with the far field modelling.	The Brihne model indicated that the end of the near field will be at a distance of approx. 69 m from the diffusers. By this distance, the plume has hit the sea bed spread out as a layer and lost its forward momentum impacted by the diffusers. The brine plume spread layer thickness is established from the Brihne model as approx. 3.8 m. The top of brine plume spread layer has concentration of just 25% of the maximum concentration in the spread layer. Until the end of the nearfield is reached brine plume dispersion has been caused by turbulent entrainment resulting from by the high velocity jet diffusers. After the end of near field distance of 69 m the brine plume will flow as density current along the sea bed flowing the seabed bathymetry into deeper water. the brine plume will very gradually become more diluted to the local low ambient currents and by concentration diffusion. The path of brine plume and the further concentration reduction with distance will be established with the far field modelling.

The near field model assessed the following configuration for the outfall system as comprised in the Intake & Outfall Systems Preliminary Design Report dated September 2021 as illustrated in Figure 8-3. The diffusers in this design are not constructed on a relatively flat bottom of approximately fixed depth parallel to the coastline, but rather installed with an angle to the coastline following the natural seawards slope starting at a depth of about 25 m and ending at a depth of about 55 m. In order to minimise impacts to the seabed and to simplify construction activity, the routing design is based upon arrangement of the intake and outfall pipelines such that they are laid on predominantly common alignments and such that they are laid with predominantly common invert levels between the shore crossing and the location of the intake towers. The intake and outfall pipelines will be laid and buried in a common trench and protected with rock in the nearshore shallow reef areas extending offshore to the location of the intake towers. In the shallow area between the shore crossing and the -4.5 m MSL seabed contour the pipelines need to be buried in a trench and protected with rock. After the intake towers at approximately -12.5 m MSL, the outfall pipelines will turn approximately 35^0 toward the south to run down the seabed slope with an alignment as far as reasonably practicable perpendicular to the seabed contours with the outfall pipeline in the deep area offshore from the intake tower locations being laid directly onto the seabed.

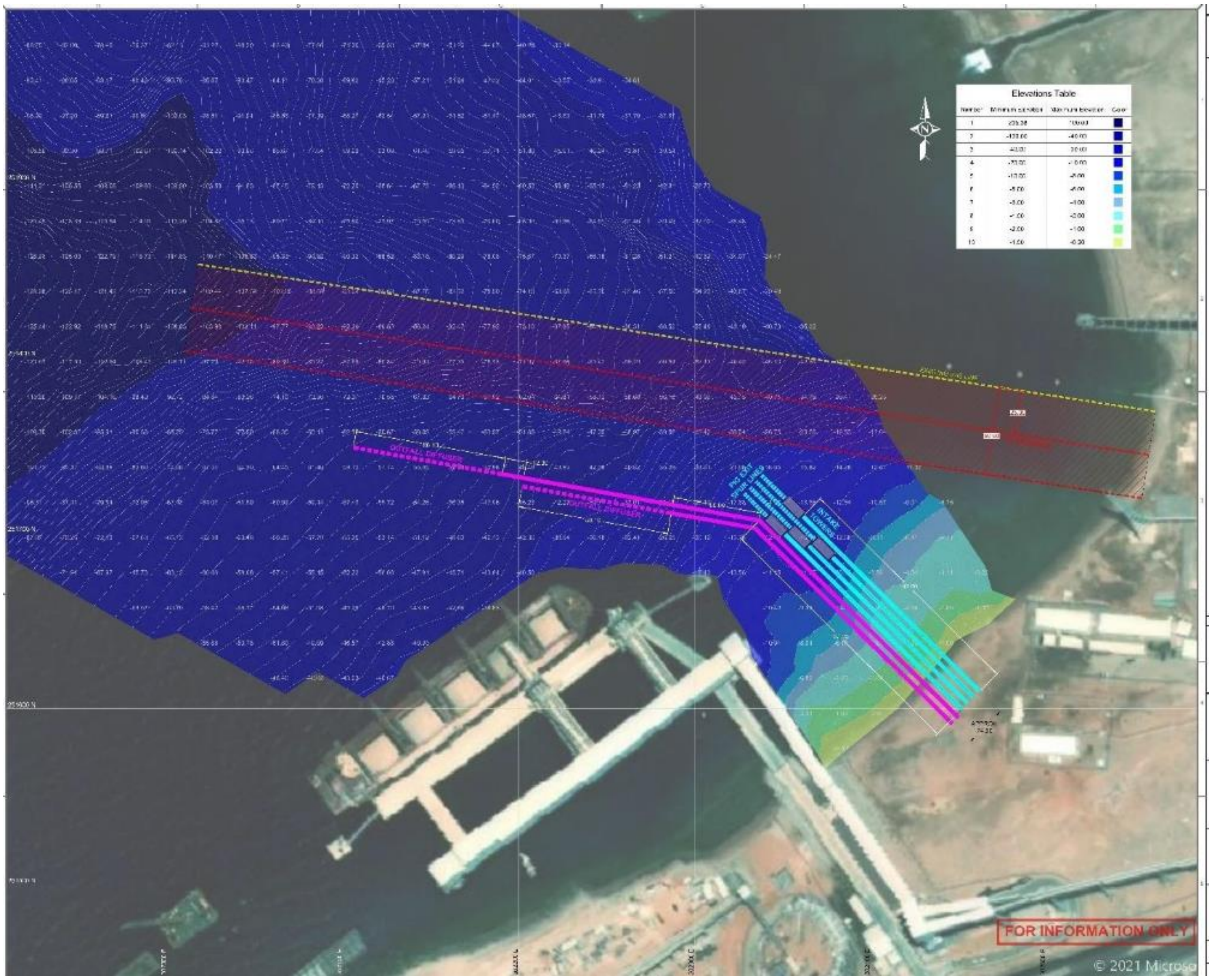

Figure 8-3: Layout of the Outfall Diffusers and Intake System

Far field modelling was also carried out as part of this ESIA study by using the Mohid model (details can be found in **Annex 2**). The specific objective of the modelling study was to determine the hydrodynamics and saline dispersion (brine path) from the outfalls and estimate the possible brine recirculation potential through the intake's pipelines and assess the concentration above the ambient at different distances reaching out to 3 km from the diffusers.

The expected brine plume dispersion at 45% Plant Recovery is illustrated in Figure 8-4. The brine plume starting at ≤ 2% above ambient seawater salinity will slowly become more diluted over several kilometres by underwater currents, while brine rolls downslope under gravity and concentration diffusion. The brine plume will travel as density current, following the bathymetry under gravity to deeper waters. Table 8-3 presents the concentration of brine plume at different distances from the diffusers. It can be observed from the table that the brine salinity concentration continues to be diluted in the far field. At distances of approx. 1.5 km from the diffuser, it would be difficult to observe the brine plume because the salinity concentration is less than 0.1 PSU above the ambient which is the sensitivity of many CTD instruments used to monitor brine plumes.

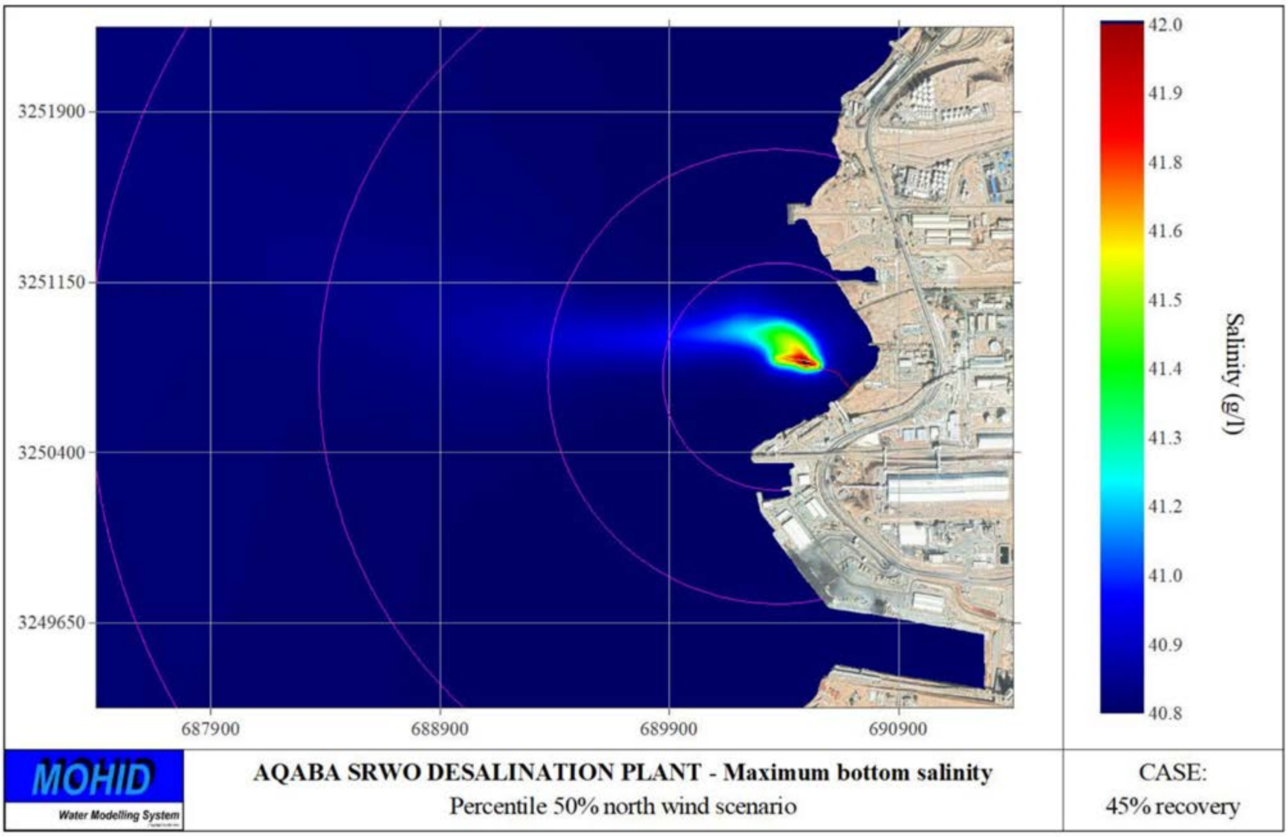

Figure 8-4: Far Field Brine Dispersion 45% recovery (ambient Salinity taken as 40.8 PSU)

Table 8-3: Far Field Brine Salinity Concentration at Various Scenarios (ambient Salinity 40.8 PSU)

Scenario	Maximum Salinity (PSU) from the Diffusers			
	500m	1000m	2000m	3000m
Mean Wind North	41.02	40.94	40.85	40.84
90th Percentile Wind North	41.02	40.93	40.85	40.84
90th Percentile Wind South	41.02	40.93	40.85	40.84

Regarding brine recirculation, because the brine plume is slightly denser than the seawater in the far field region, it will travel downslope as a density current to deeper waters, and therefore, very little brine plume can recirculate to the intake towers provided that those intake towers are located at shallower depths than the outfall diffusers. Figure 8-5 shows the Mohid far field model results for the impact of salinity on the intake towers. The ambient salinity is taken as 40.8 PSU, the salinity elevation due to the brine is less than 0.012 PSU, therefore the salinity increase caused by the recirculation brine to the intake can be considered as negligible.

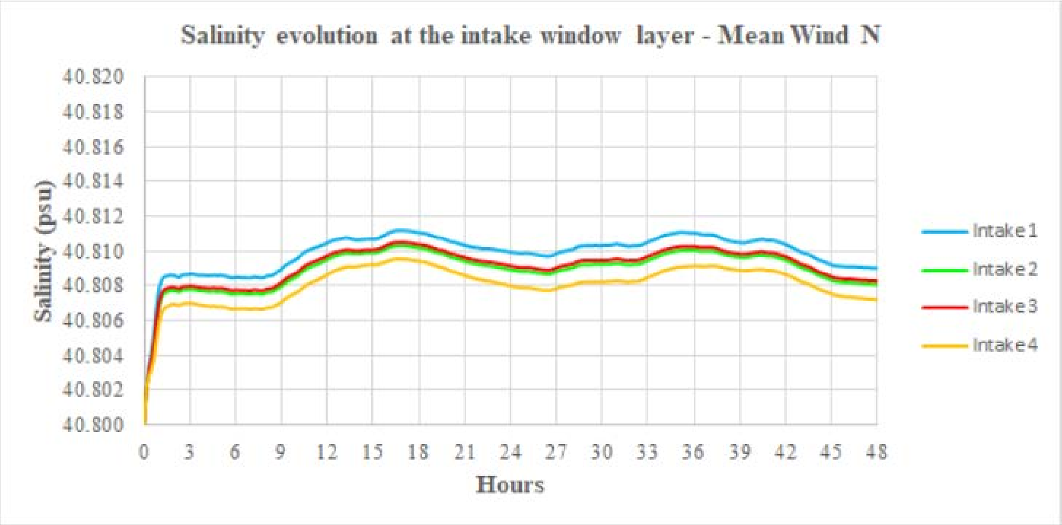

Figure 8-5: Brine Plume Salinity Concentration Recirculation to the Intake Towers

The main conclusions of the far field modeling study were as follows:

- The study offered a complete dispersion and recirculation model to design seawater intake and reject brine discharge of the AAWDC Project in Aqaba, Jordan.
- Two scenarios of Plant Recovery were assessed: 42% and 45%.
- The diffuser was designed using the BrIHne model and guarantees that the increase in salinity with respect to the seawater at the point of impact of the jet on the seabed complies with the Required Environmental Standards (i.e., the set mixing zone rule of 2% salinity increase above ambient at 100 m from the diffusers).
- Having designed the diffuser and the discharge plume in the near field, the MOHID model was used to calculate the dispersion and recirculation of the discharges for 3 hydrodynamic conditions: mean winds from the north, strong winds (90th percentile) from the north and from the south.
- As a main conclusion, diffusers discharge brine at a depth far enough from the intake towers to avoid brine recirculation. The excess salinity values obtained at the intake positions are very low, hence, it can be assured that recirculation to the intake towers will not be noticeable.
- In addition, the results at different distances from the diffusers suggested that the mixture of brine with seawater occurs in a short distance with a very reduced impact.

WET Testing at the Brine Outfall Area

The impact of the brine discharge on living organisms just outside the mixing zone shall be verified by long term WET testing to be designed and implemented by the BOT Developer during construction and then after the first year of operation with real plant brine effluent. The WET tests shall confirm the required dilution that will have no observable impact on the flora and fauna outside of the 100 m mixing zone. The following principles shall be observed by the BOT Developer:

- Selected species for testing shall be representative of the discharge area at the end of the near field mixing zone as established by baseline monitoring.
- Selected species shall be representative of trophic levels (e.g., 3 to 4 trophic levels to be covered), to cover early life cycle stages (e.g., fertilisation and larval growth), and be known for their sensitivity (e.g., corals, crustaceans, echinoderms, etc.).
- Tests shall be conducted to establish both acute and chronic toxicity tolerance of examined species.
- Tests shall ensure covering annual temporal changes.
- Tests shall establish the Species Protection Trigger Value (SPTV), which represents the safe brine dilution ratio that protects a certain percentage of species (Species Protection Level) from adverse impacts. Although the AAWDC Project discharge area is a modified ecosystem due to human interventions (pursuant to EIB and IFC classification), a recommended SPL for the AAWDC Project is 99% (i.e., 99% of species will be protected, ANZECC Guidance) under the precautionary approach for increased protection of the Gulf of Aqaba.

- There are no legal requirements and standardised protocols in Jordan for the execution of WET tests. A competent and accredited national laboratory shall be contracted to develop and execute a suitable execution approach.
- It is understood that no explicit approvals are required by ASEZA or MoEnv for the execution of WET tests.

The following mitigation measures are considered necessary to be considered in the BOT Developer's detailed design for optimum prefeasibility and environmental protection from operational impacts relative to the AAWDC Project seawater intake and brine discharge systems.

Seawater Intake Recommendations

- Manholes for diver access with BA sets shall be located in appropriate distances along the length of the pipes.
- The through screen velocity shall be less than or equal to 0.15 m/s with all intake towers in operation and clean screens to minimise entrainment of marine life.
- To prevent potential brine recirculation, the intake towers to be located at seabed depths at least 5 m higher that the nearest outfall diffuser seabed depth and at an appropriate straight line distance validated by far field modelling.
- The lower sill of the intake tower windows shall be at minimum 3 m above seabed to prevent ingress of sediments and sessile organisms from the seabed.
- The upper sill of the intake tower windows shall be at minimum 5 m below seawater surface to prevent any floating oil pollution from entering the intake system and subsequently the SWRO desalination plant.
- The towers' screen mesh shall be provided with aperture of nominal size less than or equal to 75 mm. The material of the mesh shall be non-metallic. The mesh panels shall be easily removable and with non-metallic fixings.
- Intake towers shall have access hatches of non-metallic material for divers' entry as required for cleaning and inspection purposes.
- The intake pipes shall be suitable for pigging using a steel mandrel type pig with polypropylene rings and not just foam pigs.
- The intake pipes shall be fully buried in a trench in the surf zone, considered up to a seabed depth of 5 m. The depth of the cover over the top of the pipe in the surf zone trench shall be at least 1 m.
- Outside of surf zone, the intake HDPE pipes shall be installed in trench, and backfilled to at least half way up pipe, or higher if that is needed to ensure pipes stability.
- Steel used for nuts and bolts of the pipe flanges and concrete ballast locking mechanisms shall have pitting resistance equivalent number (PREN) of at least 40.
- The intake structure shall be designed for high intensity seismic events (e.g., nearby 1995 Egypt Nuweiba earthquake was > 7.2 magnitude).
- The ESIA study assessed a seabed depth of equal to or more than 12 m to be technically and environmentally feasible for the construction of the intake towers. The proposed area corresponding to that depth has been investigated through underwater video recording which indicated a relatively flat seabed, surrounding areas are almost empty of corals, shore distance to that depth is reduced hence would result in less excavation and subsequently less seabed degradation/destruction, and is good enough in terms of water quality (i.e., leaves an adequate submergence window for the towers). However, deeper seawater depths might be used but taking into consideration that intake towers or passive screens need to be cleaned regularly by divers, which restricts the location of the intake towers/passive screens to seabed depths of less than 30 m and preferably less than 20 m to allow safe diver prolonged cleaning time (i.e., without decompression stops).
- Should a pigging system be used for the cleaning of the intake pipes from macrofouling, the pigging system shall not discharge the pig and resulting debris into the intake tower. Instead, pigs shall discharge using a tower bypass spur and the discharge of the pig shall be located where the seabed depth is at least 5m deeper than the location of the intake tower to avoid accumulation of shell material inside the tower.
- The intake towers shall be designed for high intensity seismic events.
- Marker buoys shall be installed above each intake tower.

- A separate wireless monitoring buoy shall be located above each intake tower measuring the actual seawater salinity (in practical salinity scale PSS-78 from conductivity), temperature, turbidity, and chlorophyll A). The data shall be monitored online.
- Should passive screens be used for seawater abstraction instead of intake towers, they shall meet the following requirements:
  - Aperture size shall be ≤ 5mm.
  - Through screen velocity shall be less than or equal to 0.15 m/s at the ultimate capacity of 300 MCM/y.
  - Copper nickel alloys shall be used for mesh material, which inhibits marine biofouling.
  - Ability to air blast each passive screen automatically and individually shall be provided.
  - Means to isolate passive screens from intake pipes when an intake pipe is being pigged shall be provided.
  - Passive screens shall be located where the seabed depth is at least 15m so that the screenings can disperse away downslope.
  - The bottom of the screen must be at least 3 m above the seabed.
  - The upper part of the screen must be at least 5 m below the seawater surface.
- The intake pipes shall be preferably constructed from solid wall HDPE, to provide greater resilience for earthquakes and be suitable for mechanical pigging.
- The intake pipes shall be suitable for pigging using a steel mandrel type pig with polypropylene rings and not just foam pigs.
- Provision shall be made for manholes for diver access with breathing apparatus (BA) sets to be located at intervals of no more than 50 m.
- The intake pipes shall be fully buried in a trench in the surf zone, considered up to a seabed depth of 5 m. The depth of the cover over the top of the pipe in the surf zone trench shall be at least 1 m.
- Outside of surf zone, the intake HDPE pipes shall be installed in trench, and backfilled to at least half way up pipe, or higher if that is needed to ensure pipes stability.
- Steel used for nuts and bolts of the pipe flanges and concrete ballast locking mechanisms should have pitting resistance equivalent number (PREN) of at least 40.
- The ESIA study concluded that the use of chlorination for intake system macrofouling control shall be avoided unless it is proven that there is no other technical solution to this effect (i.e., manual diver cleaning or mechanical pigging). However, should chlorination be used, the chlorination dosing pipelines shall be double contained and equipped with a leak detection system. Further, a means to prevent scaling of the chlorination dosing lines would be needed if hypochlorite is used.
- An exclusion zone for vessels and fishing boats shall be defined over the whole routing of the intake pipelines and intake towers in coordination with the Project Promoter and the competent national authorities.
- Seawater, soil, and groundwater pollution during operation shall be prevented through the placement of appropriate secondary containments to all fuel/oil and other hazardous chemicals containing tanks.
- Notwithstanding the above, the BOT Developer's detailed design shall be allowed to select (a) specific locations for the intake and outfall pipes; (b) intake tower sizes, (c) pipe sizes, (d) diffuser number and sizes and respective works provided the Project constraints in Section 2.9.2.1 of the Project ESMP are accounted for and all requirements in Section 2.9.2.2 of the Project ESMP are achieved.

Brine Discharge Recommendations

- The diffusers design must achieve dispersion of the brine salinity to ≤ 2% above the ambient seawater salinity concentration at 100 m from the diffusers, in stagnant seawater conditions.
- Multiport diffusers shall be used.
- The diffusers design shall have a Froude number, F, equal to or more than 20.
- The discharge angle of the diffuser port to the horizontal shall be 60 degrees.
- The diffusers' direction shall be orientated so that the brine plumes do not return to the diffusers. The diffusers can be back-to-back provided this is restriction is respected.
- The design of the diffusers shall ensure that the variation in flowrate due to diffusers laid at different depths shall not exceed 10% between the diffusers at the design flow to maximise brine dispersion.

- To prevent interference between the brine plumes of each diffuser, the minimum separation distance between the diffusers or (back-to-back diffusers pair) centrelines shall be in minimum 2 x do x F, where do is the diffuser port diameter (m), F is the Froude Number.
- The diffusers shall be located at a seawater depth so that ensures a gap of equal to or more than 5 m between the maximum height of brine plume rise above the diffusers and the seawater surface is achieved. The maximum brine plume height above the diffusers being calculated as 2.25 x F x do, where do is the diffuser port diameter (m), F is the Froude Number.
- The diffusers must be located in seawater depth that is at least 5 m deeper than that at the closest intake tower location.

Operational Monitoring

- Seawater column vertical profiling through CTD loggers at the same locations as baseline monitoring. Surveys shall map the brine plume after the diffusers and its concentration profile for the different stages of the sea stratification. Surveys shall be repeated every 4 months in the first 3 years and annually henceforth. If the plant production is increased, the mapping for the different seasons shall be repeated.
- Marine species survey through underwater video recording and species identification / mapping along outfall, brine plume and to selected reference locations with similar characteristics to the brine discharge site. These surveys shall be repeated annually. The video recording of marine flora and fauna to include (a) the nearfield path of the brine plume to 100 m from the diffusers, (b) the area around the intake towers, and (c) the pipeline paths of the intake and outfalls.
- Long term in-situ measurement and monitoring programs with particular attention to understanding of seasonal / annual larvae concentrations at the intake head locations.
- Continuous measurements of flow, pH, temperature, conductivity, turbidity, and residual chlorine at the total combined flow before brine discharge.
- Annual condition assessment of outfall integrity by divers/ROVs with video cameras.

Brine dispersion and discharge compliance monitoring

- Use the Roberts and Abessi's semi empirical equations and brine discharge measurements (i.e., flow, conductivity, temperature) to demonstrate dilution compliance at the brine impact point (i.e., where the brine plume hits the seabed) and at the boundary of the near field mixing zone.
- 24-hour flow proportional composite sampler on the brine outfall (at the outlet of brine reservoir of the SWRO Desalination Plant). Daily onsite laboratory sampling for COD, Total Nitrogen, Total Phosphorus, Turbidity, Total Iron. Monthly laboratory tests on Total Suspended Solids.
- Dedicated flow, turbidity, and pH, total iron, temperature, and salinity (PSS-78) monitoring at the brine outfall reservoir. Total iron can be measured by using a grab sample instead of online monitoring provided that a flow proportional composite sampler is used.
- Continuous residual chlorine monitoring at the brine outfall reservoir.
- Daily Composite THM monitoring at brine reservoir only if chlorine for Intake fouling control is used. Continuous flow, turbidity, and pH monitoring of the solids processing thickening supernatant.
- Continuous flow, turbidity, and pH monitoring of the solids processing dewatering supernatant.
- RO CIP neutralisation tank pH monitor.

Annual reporting to the regulatory authority (ASEZA) with records on:

- Daily production, continuous (15mins intervals) intake flow record, seawater feed temperature, turbidity, pH and Salinity (Practical salinity scale), Number of RO membrane CIPs used, chemical and volumes used for CIPS, chemicals and volumes used for the coagulants, antiscalant. RO CIP Neutralisation record.
- Solids processing and sludge dewatering liquors: Continuous Flow record, pH, Turbidity.
- Outfall flow data: Continuous flow record, pH, turbidity, conductivity, salinity (PSS-78), temperature, total iron.
- Daily brine outfall sample laboratory analysis composite samples: Total COD, Turbidity, Total Iron, Total Phosphorus, Total Nitrogen.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Medium	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Long-term	Long-term
Extent	Site	Site
Scale	**Medium**	**Medium**
Significance	**Moderate**	**Low**

8.2.2.2. Terrestrial Biodiversity

8.2.2.2.1. Water Desalination Component (Onshore Facilities)

Potential loss of habitat or loss of feeding and nesting grounds due to increased noise levels

It is anticipated that noise levels will be high at the project intake pumps, SWRO high pressure pumps, energy recovery systems. Such stressors will cause disturbance to wildlife, especially during the breeding season at the sensitive biological habitat. Hence, the assessment of such impact's notes, based on available information, that the proposed desalination component offshore and onshore facilities are within urban environment (port and industrial activities), and it is already degraded and of very low value as a terrestrial habitat.

Even more, best design practices can introduce and integrate noise abatement which will help containing and limiting noise dispersion beyond the AGI site. Accordingly, the magnitude of such stressors and impacts is assessed to be high before the application of relevant noise abatement and mitigation measures as described in the Project ESMP. The probability is high, the duration is long term, and the extent is local.

Residual impacts are anticipated to be low magnitude, moderate probability, long-term and site specific.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	High	Low
Likelihood	High	Moderate
Intensity	**High**	**Low**
Duration	Long-term	Long-term
Extent	Local	Site
Scale	**High**	**Moderate**
Significance	**High**	**Low**

Potential exposure to hazardous substances due to accidental spillage or leakage

The storage and handling of chemicals at these facilities shall comply with best international practices and with applicable national regulations. Hence, accidents, mismanagement or improper handling and management of chemicals storage and handling might happen. If accidental spillage or leakage happens then wildlife in the local area can possibly be exposed to hazardous substances, and as such will be either killed or affected. Accumulation of such substances in the higher trophic species depends on the magnitude and frequency of such incidents.

Noting that the IPS location is planned at an urban site of low value to terrestrial biodiversity, therefore, the magnitude of anticipated impacts caused by accidental spillage and leaks is assessed to be moderate. Hence, the magnitude of such impacts at the location of the RO plant, following conservative approaches, is assessed to be high as such leaks might result in large quantities of chemicals released to the local environment. The probability of occurrence is assessed as moderate, and the impacts before mitigation can be for long term if not properly mitigated.

Measures to prevent and control the occurrence of such chemicals pillage or leak are set out in the Pollution Prevention Management Plan described in the Project ESMP. In addition to those measures, and upon occurrence of such leaks/spillage, the impacted sites should be rehabilitated to its original condition, and monitoring of post leakage impacts on wildlife should be arranged.

After efficient implementation of the above discussed mitigation measures, the residual impacts are anticipated to be low magnitude, moderate probability, short-term and site specific.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	High	Low
Likelihood	Moderate	Moderate
Intensity	**High**	**Low**
Duration	Long-term	Short-term
Extent	Local	Site
Scale	**High**	**Low**
Significance	**High**	**Low**

8.2.2.2.2. Water Conveyance Components

Habitat fragmentation, disturbance and active taking of wildlife

As discussed in the above sections, the need to construct new access roads is limited, and is discussed under the construction impacts. No additional habitat fragmentation or disturbance is anticipated to occur as a result of project operations other than those discussed in the construction phase, except for increased accessibility to remote areas, and from improper accumulation of litter and solid waste.

The increased access to remote areas is expected in the Hizma basin (Rum and Disi areas), and it is not expected to be in large number of people (i.e., will be limited to the operation staff and the locals who are already in the area, and occasionally other visitors), or to be of much higher frequency. Hence, it can be associated with tree cutting, wood collection, collection of endemic or threatened flowering and edible plants, hunting of birds and animals and increased persecution and disturbance due to increased human presence.

The assessment of the magnitude of such impacts notes the consultant previous experience in the study area and the observations of similar impacts from the Disi-to-Amman conveyance pipeline. The magnitude of such impacts during the operation phase is assessed to be moderate, high probability, mostly of local extent and long term.

The mitigation measures discussed in Section 8.1.2.3 shall also be applied during the operation phase, and are deemed efficient and effective to prevent and control the subject impacts.

After efficient implementation of the discussed mitigation measures, the residual impacts are anticipated to be low magnitude, moderate probability, long-term and site specific.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Moderate	Low
Likelihood	High	Moderate
Intensity	**High**	**Low**
Duration	Long-term	Long-term
Extent	Local	Site
Scale	**High**	**Moderate**
Significance	**High**	**Low**

Potential contamination by spills or leakages

Similar to the impacts discussed in Section 8.2.2.2.1 for the SWRO and the IPS, there is a possibility for the project to cause contamination by spills or leaks of chemicals and lubricants during the operation phase, in addition to limited contamination events due to improper handling and management of chemicals at the AGI's and from the operation vehicles. Another source of contamination impacts is the accumulation and improper management of waste from the operational workforce.

Upon occurrence of accidents or mismanagement, these stressors are likely to cause contamination to of the biological habitat at the construction sites and would consequently cause deleterious impact on wildlife (habitat, flora and fauna).

If such impacts happen at wadis and other intermittent water courses, near Acacia or Tamrix woods or at any other similar sensitive habitats and species, then the impact can be high significance. Hence, the assessment assumes that the operation of almost all above ground installations along the conveyance is not expected to store or use large quantities of chemicals and possible contaminants. Therefore, the magnitude of such impacts at the location of the above ground installations, following conservative approaches, is assessed to be moderate as such leaks might result in moderate quantities of chemicals released to the local environment. The probability of occurrence is assessed as moderate, and the impacts before mitigation can be for long term if not properly mitigated.

If these impacts are not efficiently mitigated then the duration of the impacts will be long term, and the extent can become local as such contamination might disperse.

Measures to prevent and control the occurrence of such chemicals pillage or leak are set outin the Pollution Prevention Management Plan described in the Project ESMP. In addition to those measures, and upon occurrence of such leaks/spillage, the management of the impacted sites should be rehabilitated to its original condition, and monitoring of post leakage impacts on wildlife should be arranged.

After efficient implementation of the above discussed mitigation measures, the residual impacts are anticipated to be low magnitude, moderate probability, short-term and site specific.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Moderate	Low
Likelihood	Moderate	Moderate
Intensity	**Moderate**	**Low**
Duration	Long-term	Short-term
Extent	Local	Site
Scale	**High**	**Low**
Significance	**High**	**Low**

8.2.3. Socio-economic Environment

8.2.3.1. Economic Activities

Jordan suffers from a high unemployment rate especially among its young population. Jobs are scarce and the impact of COVID-19 during the past 18 months has exacerbated the financial strain on Jordan's economy. During the public consultation process, local communities in the areas of the Project expressed their interest in benefiting economically from the project during the operation phase, mainly through offering them employment opportunities when the project is operational.

It is expected that during the operation phase, the project would require a limited number of skilled and semi-skilled workers for its operational and maintenance activities. An indirect positive social impact from the project would be that individuals employed during the operational phase will benefit from personal development opportunities. Therefore, the impact on the economic activities is considered to be positive.

However, it is important to give priority to employing qualified persons from the local communities as this would improve their living standards and enhance the project's economic benefits for the country. In addition, training programs can be undertaken by the BOT Developer to qualify those who need additional skills and training to fill positions required for the operation and maintenance of the Project. It is also important that the BOT Developerimplement and abide by the Labour Conditions set out in the Project ESMP, draft a Code of Conduct for employees, ensure that employees sign and understand the Code of Conduct and develop and implement a Grievance Redress Mechanism and respond to culturally insensitive behaviors and incidents as a matter of priority.

Moreover, and to the extent possible, materials and supplies required for the operation and maintenance of the project components shall be purchased by the BOT Developer from local suppliers and businesses where the project components exist.

8.2.3.2. Noise

Impact

During operation, noise is expected to arise mainly from operation of PSs at the SWRO and along the conveyance pipeline. Since some of the PSs are located near residential areas (BPS 4, BPT, and PS ADC) the noise generated will disturb the local community. The generated noise might also disturb workers at the SWRO plant and at the PSs. Due to the sensitivity of the receptors which are the residents along the conveyance pipeline as well as the operation workers, the intensity of this impact is considered medium. In addition, since this impact has a long-term duration, its significance was assessed as moderate.

Mitigation

A number of measures have been included in the Project ESMP for adoption by the BOT Developer to reduce noise impacts. These measures include:

- A Noise and Vibration Management Plan supplemented with a Noise/Vibration Monitoring Program should be provided as part of the Operation ESMP.
- Project plant and equipment shall be used and maintained pursuant to the manufacturer's specifications adopted in order not to generate noise levels in excess of values set out in national regulations or international recognised standards including those of the EIB/USAID.
- Transport methods relative to Project operations shall be adopted in order not to generate noise levels in excess of values set out in national regulations or international recognised standards including those of the EIB/USAID.
- Noise complaints (a dedicated point of contact will be made available to members of the public) shall be investigated and recorded as part of the Operator's ESMP.
- The Noise Monitoring Program to be developed in operation shall comprise the following elements:
    - Identification of noise/vibration sources and downstream sensitive receptors.
    - Description of legal requirements relative to noise/vibration measuring parameters, measuring locations, frequency of monitoring (intermittent or continuous).
    - Description of arrangements for noise/vibration mitigation during operation in relation to identified noise sources and sensitive receptors.
    - Reporting lines relative to noise/vibration monitoring results.
    - Communication/disclosure lines relative to noise/vibration monitoring results.

As a result, the residual impacts will be reduced to low intensity. Thus, the significance of the residual impact will be low.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Medium	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Long-term	Long-term
Extent	Site	Site
Scale	**Medium**	**Medium**
Significance	**Moderate**	**Low**

8.2.3.3. Traffic and Transportation

Planned and unplanned maintenance or improvement activities during the operation phase may limit or prevent physical access to villages, homes, businesses, shops, farms, essential community centers and public service facilities as these activities are associated with the transportation of materials and equipment carried by trucks and large vehicles thus potentially leading to traffic congestion. This impact may be amplified if activities occur over an extended period of time or are performed on an emergency basis especially if they are associated with replacement of major equipment or machinery.

Impact of traffic will be largely limited to the period whereby work is being undertaken on a specific section of the road. This impact is considered to have a medium intensity and is restricted to a specific maintenance period only. As such, this impact is considered to have a low significance.

Mitigation

The BOT Developer shall implement the following in order to minimize the impact on traffic roads within the maintenance area.

- Regular maintenance activities need to be carefully planned and persons/communities who may be affected should be informed in advance.
- Proper warning signs and shall be installed on the road where maintenance activities are undertaken to warn the passing cars and ensure the traffic is not blocked.
- If blocking a road is necessary, an alternative route shall be clearly marked.
- Ensure that any material transported by trucks is well covered along transportation

The residual impact will thus be limited to any unusual incident such as car accidents, which are unlikely to occur under normal circumstances. As such, the significance of the residual impact will be reduced to negligible.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	Medium	Low
Likelihood	Medium	Low
Intensity	**Medium**	**Low**
Duration	Short-term	Short-term
Extent	Site	Site
Scale	**Low**	**Low**
Significance	**Low-**	**Negligible**

8.2.3.4. Public Health and Safety

In line with the aim of the Project, increased safe and reliable freshwater will be supplied to Amman and other areas along the pipeline route. This will in turn improve the overall health of the local community within the entire project area as well as their quality of life. The impact of the Project on public health during the operation phase is therefore positive.

Most of the operation phase activities will take place in the private domain such as the desalination plant in Aqaba, regulating tanks, booster pump stations, and the water conveyance pipeline along the right-of-way of the project route. As such, it is expected that operational activities including the use of equipment and machinery will have limited impacts on public health and safety.

Nonetheless, the BOT Developer shall barricade and fence off active work sites to prevent unauthorized entry and public access in order to avoid injuries to the local communities. Posting warning and directional signs and safety instructions at active work sites and on roads will alleviate the risk to the public and avoid traffic accidents caused by ongoing maintenance activities.

8.2.3.5. Occupational Health and Safety

Impact

During the operation phase, worker exposure to risks of accidents, injuries and health impacts associated with the operation and maintenance of the offshore components, IPS, SWRO plant and the PSs might occur. This includes activities such as working in confined spaces or exposure to chemicals and drowning (for the offshore facilities). Furthermore, there is a risk of spreading of communicable and infectious diseases (such as Influenza and Covid-19) between workers in offices. Due to the health implications associated with this impact and to the sensitivity of the receptor, who are the employees at the SWRO plant or at the PSs, this impact is considered to have a high magnitude. However, this impact has a medium chances of occurring during operation. As such its significance is considered to be moderate.

Mitigation

An Operation Health and Safety Management Plan (OHSMP) shall be developed and implemented by the BOT Developeras part of the Operation ESMP. This includes a risk assessment to identify work hazards onsite and determine corresponding protection measures such as installing warning signs around hazardous areas, providing workers with PPEs (include hard hat, safety shoes, reflective vets, gloves in addition to other PPEs depending on the risks involved in specific tasks performed by the workforce), in addition to approved buoyancy equipment (e.g. life jackets, vests, floating lines, ring buoys) when workers are over, or adjacent to, water where there is a drowning hazard. The OHSMP shall identify and specify several issues as required in the ESMP to ensure the safety of his workers as well as public safety. In general, the following should be implemented as part of the OHSMP:

- The BOT Developer shall assign Health and Safety Officers to be responsible for the implementation and oversight of the Operation HSMP.
- All accidents, dangerous occurrences and investigations shall be documented in a structured system
- Any incident shall be investigated, recorded, and systematic follow-up of relevant findings and recommendations shall be reported.
- A monthly H&S progress report shall be developed. This report shall contain the following data, as related to the Project operations at all Project sites
- The BOT Developer shall ensure efficient and effective H&S communication and consultation with all personnel involved in the Project operations at all Project sites. This includes but is not limited to toolbox meetings prior to the start of any Project operations, H&S meetings at Project sites on a regular basis with all parties involved.
- The BOT Developer shall ensure that supervision, directly in charge of operation activities, fully brief and discuss with operations personnel at H&S Tool Box Talks at the start of operations and prior to commencing any new activities.
- The BOT Developer shall evaluate the security strategy and arrangements required for all Project sites including transport. This evaluation shall be performed by qualified security experts and shall be submitted as part of the Operation ESMP.
- All Project facilities and equipment shall be inspected, tested, and maintained by the BOT Developerpursuant to the manufacturer's specifications.
- PPE such as hard hats, ear protection, safety glasses, and work boots must be provided by the BOT Developer and used by operation personnel at all Project sites.
- The BOT Developer must train his personnel who must use PPE
- The provision of mandatory PPE signs in various areas at the Project sites are an important visual reminder of the BOT Developer H&S policies and procedures.
- Appropriate PPE shall be made available to all operations staff involved in operations with inherent respiratory hazards and especially working in confined spaces (e.g., when cleaning the intake pipelines and IPS to SWRO plant seawater pipelines from macrofouling).
- In addition to standard PPE as noted above, use approved buoyancy equipment (e.g. life jackets, vests, floating lines, ring buoys) when workers are over, or adjacent to, water where there is a drowning hazard.
- Regular inspection of ventilation systems shall be undertaken to all Project sites related enclosed storage areas for chemicals/waste as well as confined spaces
- The BOT Developer shall ensure and maintain proper in-house storage and handling of hazardous chemicals/waste to reduce or eliminate risks associated with their handling.
- Chemicals shall be properly labelled and stored according to information specified on the Material Safety Data Sheet (MSDS).
- Emergency equipment must be provided by the BOT Developerwhen storing or handling chemicals. This equipment shall include, but not limited to, first aid supplies, emergency phone numbers, eyewash and shower facilities, fire extinguishers, spill clean-up supplies and PPE, all of which shall be readily available on-site at any Project site.
- Basic training and written materials for applied hazardous chemicals in Project operation activities shall be available to operation staff.
- All operation staff handling or using cylinders of compressed gases (e.g., chlorine gas) shall have basic training in the use of gas cylinders, emergency shutoffs, proper equipment design, leak-testing procedures, and the use of appropriate respiratory protection in the event of a release of a compressed gas.

- When in storage, compressed gas cylinders must be restrained using straps, chains, or other suitable stand to prevent them from falling. Also, full cylinders must be segregated from empty cylinders and need to be legibly marked with the chemical or trade name of the gas.
- The BOT Developer shall ensure that storage areas be well ventilated to prevent accumulation of explosive concentrations of gas. No ignition sources shall be permitted in these areas.
- The BOT Developer shall undertake proper hazardous and non-hazardous waste management.
- Adequate training shall be provided to all employees working on Project sites who may be exposed to harmful substances and situations
- An Emergency Preparedness and Response Plan shall be developed as part of the Operation ESMP. The Operation EPRP shall comprise detailed procedures covering the emergency situations as stated in the ESMP

Residual impact might occur only in accidental cases such as minor injuries from unexpected or unidentified hazards within the operation site. However, measures will be in place to reduce the impact immediately. Thus, the residual impact will have a negligible significance.

Summary of Impact Assessment

Parameter	Assessed Impact	Residual Impact
Nature	Adverse	Adverse
Type	Direct	Direct
Magnitude	High	Medium
Likelihood	Medium	Low
Intensity	**High**	**Low**
Duration	Short-term	Short-term
Extent	Site	Site
Scale	**Low**	**Low**
Significance	**Moderate**	**Negligible**

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

8.3.1. Marine Ecology Impact on the AAWDC Site

Brine discharge impact on the ecology of the AAWDC area can be best understood in the framework of the specific features of brine discharge site, which is an industrial site with steeply sloping rocky bottom (Baseline Conditions refer), general features and potential wider impact of the Gulf of Aqaba, advancements in desalination technology leading to cleaner less environmentally stressing brine and foreseen mitigation to keep the brine as most clean and harmless to the marine environment as possible **(Project ESMP – Annex 19 – Section 2.9.2).**

Having all these factors considered, the ecological impact of the brine discharge 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 AAWDC site has already witnessed several constructions which resulted in some impacts on the coral reef, which could be clearly seen in the diving video survey.

Near field modelling 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 that the actual end of the near field region was at 56 m from the diffusers where the brine plume salinity concentration was just 1.4% above the ambient seawater salinity. These results ensure the protection of local the flora and fauna from elevated salinity.

Whereas far field modelling predicted the brine salinity further dispersion up to 3 km from the diffusers. More specifically, the brine plume started at ≤ 2% above ambient salinity and slowly become 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. It was observed that the brine salinity concentration continues to be diluted in the far field region. At distances of approx. 1.5 km from the diffusers it would be difficult to observe the brine plume because the concentration is less than 0.1 PSU above the ambient, which is, typically, the sensitivity of many CTD instruments used to monitor brine plumes.

8.3.2. Marine Ecology Impact on the Gulf of Aqaba and Aqaba Marine Reserve

Jordan's all maritime resources extend on a short stretch coastline of 27 km on the north-eastern side of the Gulf of Aqaba, Red Sea. This is the backbone of the Aqaba Special Economic Zone, which has been established in the year 2000 to serve as a global hub for investors and tourists alike. It forms a strategic outlet for regional and international markets, maximizing business opportunities in all sectors and providing an advanced standard of living. The Zone is governed by the Aqaba Special Economic Zone Authority, which is an independent institution that deals with the development and management of the Aqaba Special Economic Zone and provides integrated services to investors and registered enterprises and is responsible for the sustainable management of the Zone. Since its beginning ASEZA has been keen on environmental protection in fulfilment of its law "32/2000" and regulation of environmental protection "21/2001".

In spite of the tight space available, coastal investment is managed with care and about 25% of the Jordanian coastline has been under special management for coral reefs conservation since late 1970s. In 1999 this stretch has been declared as Aqaba Marine Park (AMP). Recently on December 8th, 2020 the same territory of the AMP has been registered in the Jordanian Protected Areas network as Aqaba Marine Reserve (AMR). Boundaries of the Reserve follow the original boundaries of the AMP. It extends over 7 km length from the Passenger Terminal in the north to the Royal Diving Club in the south. The terrestrial boundary lies 50 m east of the Mean High Water Mark and the marine boundary lies 350 m west of the Mean High Water or a bottom depth of 70 m, whichever is longer. The southern boundary of AMR is about 3km straight line 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 100m from diffusers in all directions. The mixing zone will expand at a water depth between 25 m and 70 m. This means that seawater salinity of about 40.84 PSU is expected to be generated about 3 km away from the AMR and at a depth reaching the outer depth boundary of the Reserve. Horizontal currents are weak and form eddies along the central access of the Gulf of Aqaba. According to the Coastal Environment National Monitoring Program Current speed and direction measured continuously at 10 minutes interval in coastal waters down to 40m in front of the MSS, which is a part of AMR, reveal percent frequency of current speed below 10 cms^{-1} over an annual cycle for most years in the range 70%-90%. The dominant current direction during all seasons, about 40%-75% of the current records, is between 180°-240° (south-southwest). With brine being denser than the surrounding seawater it will have a much more 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 strongly unlikely that any elevated salinity will be detected within the boundaries of the Aqaba Marine Reserve.

8.3.3. Assessment of 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 comfortably be 1.5 - 2% above ambient. For an ambient salinity of 40.8 PSU (highest recorded summer surface layer), the brine concentration above ambient would be 0.612 – 0.816 PSU. This salinity differential would continue to diminish as the brine flows as density current along the seabed to deeper waters (far field modeling results refer).

Whole effluent toxicity testing on local flora and fauna is proposed for this Project during plant construction to establish the no impact concentrations/ dilutions for the brine discharge. To provide some flora and fauna impact context to the dispersion numbers that would be achieved the following information is presented below.

The brine outfall dispersion design of Spanish desalination plants is influenced by the need to protect the seagrass Posidonia Oceanica. The WET studies on seagrasses in the Mediterranean showed the seagrass

Posidonia was locally most sensitive to brine salinity the threshold of salinity tolerance of this seagrass species is very low, only 1–2 PSU higher than the mean ambient salinity [76]. Such a salinity increase tolerance indicates that the AAWDC project dispersion for brine would be protective of seagrasses at the end of the near field 100 m from the diffusers and beyond.

Van der Merwe studied the tolerance of one coral species, Fungia Granulosa to the brine concentrations resulting from different distances to actual brine discharge from the 40,000 m^3 SWRO desalination located at Kaust in the Red Sea near Jeddah [77]. The outfall of this facility is a low velocity tower which has not been designed for rapid dispersion of the brine. These studies showed that the coral species under study was tolerant of salinity up to 50 PSU, which is approx. 10 PSU higher than the local Red Sea Ambient salinity.

The Egyptian Taba desalination plant is located 15.5 km across the Gulf of Aqaba and has capacity of 5,000 m^3/d, the brine discharges to the shoreline using an open pipe next to rock jetty. The antiscalant used by the plant is Osmotech 1141, which is nitrogen free blend of carboxylic acids with phosphonic acids.

A CTD and video survey of the outfall area was conducted in June 2016. The maximum salinity increase of brine plume measured near the rock jetty was approx. 1.7 PSU (AAWDC will achieve 0.6-0.8 PSU above ambient at 100 m). There was abundant seagrass present on the sandy seabed and the manmade jetty rocks were becoming colonised by corals.

Figure 8-6: Taba SWRO Shore Brine Outfall Next to Rock Jetty

Figure 8-7: Seagrass in Brine Path Visible Unaffected by Brine at Taba SWRO Plant

Figure 8-8: Seagrass in Brine Path Visible Unaffected by Brine at Taba SWRO Plant

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% of availability and 42% 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 x $10^9 m^2$ this implies evaporation from the Gulf of about 16,000,000 $m^3.day^{-1}$. The surface seawater becomes more saline as seawater travels to the north of the gulf of Aqaba, the surface salinity at the north of the Gulf of Aqaba ranges between 40.6 - 40.8 PSU depending on the time of year [76]

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 at the straights of Tiran. Lower salinity seawater (approx. 40.2 PSU [78] - 40. 5 PSU [79]) enters the Gulf of Aqaba at the straights 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 straights of Bab el Mandeb where Lower salinity Indian ocean seawater replenishes the Red Sea. The surface salinity of the Indian ocean side of the Straits of the Bab el Mendab is approx. 36 PSU [80] .

Bitcon and Gildor provided [81] used an oceanic general circulation model to investigate the general circulation in the Gulf of Aqaba and the exchange flux with the Red Sea. Some points of note from the Bitcon and Gildor work are:

- During the restratification season (April‐August), the exchange flux with the northern Red Sea is maximal and is driven by density differences between the basins. The observed warming of the surface layer is mainly due to advection of warm water from the northern Red Sea, with a smaller contribution from surface heating.
- During the mixing season (September‐March), the exchange flux and the advection of heat are minimal and atmospheric fluxes drive convection rather than the exchange flow.
- The major dynamic patterns observed in the gulf such as the exchange flow with the northern Red Sea, the circulation driven by density differences, and stratification are mainly affected by temperature changes, while changes in salinity are minor players.
- The seasonal variability in the exchange flow is large and ranges from 0.04 Sv during early spring to 0.005 Sv during early winter.

The existing Jordan power station at Aqaba Industrial port discharges 80,000 m^3/d of spent cooling seawater with a temperature of 3 ^{0}C 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 of the 0.5 - 1 ^{0}C above the ambient. Because the Aqaba Gulf circulation and stratification are mainly affected by temperature changes, it not anticipated that the AWDCC brine will significantly impact salinity levels, stratification, or the circulation currents of the Gulf. However, this subject needs more long-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 free of the nutrient nitrogen to avoid accumulation of these nutrients into the Gulf of Aqaba when degradation of the antiscalant occurs.

Small quantities of iron particulate ($Fe(OH)_3$) and soluble iron will discharge with the brine (less than 0.3 mg/l total iron on average), this will be approx. 128 tonnes per year of iron. This brine concentration will be diluted by at least a factor of 41 by the outfall diffuser design resulting in an iron concentration of less than 0.0074 mg/l of iron at 100 m from the diffusers. It is not anticipated that this iron will settle quickly on leaving the near field mixing zone because it has already passed through a solids process facility at the SWRO 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.

9. Environmental and Social Management Plan

The Project ESMP has been developed as a stand-alone document appended to the Project ESIA study at the request of the EIB and pursuant to the ToR related to '*Preliminary Risks Assessment and ESIA for the Aqaba-Amman Water Desalination and Conveyance (AAWDC) Project*'. It has been appended to this report as **Annex 19.**

The Project ESMP complements and forms an integral part of the Environmental and Social Impact Assessment as presented in this Project ESIA study 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.

The purpose of the Project ESMP is 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.

More specifically, the Project ESMP has integrated all necessary mitigation measures for the prevention and minimisation of the Project related adverse environmental and social impacts, as detailed in Chapter 8 of the Project ESIA study relative to Impacts Assessment and Mitigation, and further strived to supplement said mitigation measures with best practice E&S and H&S aspects management in an effort to effectively cover any potential adverse impacts that cannot be fully assessed at the present state of AAWDC Project preliminary design and in fulfilment of national laws and regulations and EIB/USAID E&S principles and standards. Also, it has been structured to include the required monitoring plans/programs to be undertaken by the BOT Developer during the construction and operation phases of the AAWDC Project so that the predictions of the Project ESIA study are validated and that the effectiveness of applied mitigation measures is appropriately monitored.

The Project ESMP (as well as the Project ESIA study) shall be appended to the BOT Tender Documents since both said documents set out the Project E&S impacts and risks and proposed abatement thereof that the BOT Developer shall duly consider in his detailed design and associated Construction and Operation ESMPs.

The Project ESIA study and the ESMP for the AAWDC Project shall be submitted to the competent Jordanian Regulators (i.e., MoEnv and ASEZA) for their respective approvals.

In addition, a Climate Risk Vulnerability Assessment was conducted to ensure that climate adaptation measures are incorporated into the Project. The mitigation measures are included in the Project ESMP and the Climate Risk Vulnerability Assessment can be found in **Annex 21** of this report.

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11. Annexes

Annex 1 – Correspondence with MoEnv and ASEZA

Annex 2 – Summary of Task 1.3 Brine discharge Risk Assessment Report and Modelling

Annex 3 – IPS Site Layout and the Marine Works

Annex 4 – IPS to SWRO Conveyance Profile (Sea Water)

Annex 5 – SWRO to IPS Conveyance Profile (Brine)

Annex 6 – Process Flow Diagrams

Annex 7 – General Layout of the RO Desalination Plant

Annex 8 – Task 1.13 LARPF

Annex 9 – Task 1.11 SEP

Annex 10 – Noise Level

Annex 11 – Marine Video Surveys

Annex 12 – ROV

Annex 13 – Trihalomethanes and Residual Chlorine Analysis

Annex 14 – Seawater Characteristics Investigations

Annex 15 – Details of Archaeological Sites

Annex 16 – Scoping Session Details

Annex 17 – First Disclosure Session Details

Annex 18 – Second Disclosure Session Details

Annex 19 – Task 1.12 ESMP

Annex 20 – Task 1.8 GHG

Annex 21 – Task 1.7 Climate Risk Vulnerability Assessment