Taweelah 200 MIGD IWP Seawater Reverse Osmosis Plant

Abu Dhabi, UAE

Environmental & Social Impact Assessment (ESIA)

Volume 2-Main Text, Tables & Figures

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
AAQ	Ambient Air Quality
AAQMS	Ambient Air Quality Monitoring Station
ADM	Abu Dhabi Municipality
ADWEA	Abu Dhabi Water and Electricity Authority
ADWEC	Abu Dhabi Water and Electricity Company
CESMP	Construction Environmental Management Plan
Ch2O	Formaldehyde
CICPA	Critical Infrastructure and Coastal Protection Authority
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CWM	Centre of Waste Management
DAF	Dissolved Air Filtration
dBA	Decibels
DMA	Department of Municipal Affairs
EAD	Environment Agency Abu Dhabi
EGA	Emirates Global Aluminium
EHS	Environmental health and safety
EIA	Environmental Impact Assessment
ESIA	Environmental & Social Impact Assessment
EWEC	Emirates Water and Electricity Company
F-	Fluoride and its Compounds Including HF & SiF4
FeCl3	Iron trichloride
GHG	Greenhouse Gas
GIS	Global Information System
HF	Hydrogen Fluoride
IDB	Industrial Development Bureau
IWP	Independent Water Project
KIZAD	Khalifa Industrial Zone Area
kWh	kilowatt hour
MARPOL	Marine Pollution
MED	Multi Effect Distillation
MEMAC	Marine Emergency Mutual Aid Centre
mg/L	miligrams per litre
MIGD	Million Imperial Gallons per Day
MOCCEW	Ministry of Climate Change and Environment and Water
MPA	Marine Protected Area
MSDS	Material Safety Data Sheet
MSF	Multi Stage Flash
NaOCl	Sodium hypochlorite

Abbreviation	Meaning
NILU	Norwegian Institute for Air Research
NOAA	National Oceanic and Atmospheric Administration
ODC	ozone depleting chemicals
RO	Reverse Osmosis
ROPME	Regional Organization for the Protection of the Marine Environment
SOP	Standard Operating Procedures
SSO3	Sulphur Trioxide Including Sulphuric Acid Mist
SWRO	Seawater Reverse Osmosis
TDS	Total Dissolved Solids
TEL	Thresholds Effect Level
TOR	Terms of Reference
TSP	Total Suspended Particles
UAE	United Arab Emirates
UNFCC	United Nations Framework Convention on Climate Change
VOCs	Total Volatile Organic Compounds
WPA	Water Purchase Agreement
WRC	Worker Residence City
5 Capitals	5 Capitals Environmental and Management Consulting

1 INTRODUCTION

The Abu Dhabi Department of Energy (EWEC), formally Abu Dhabi Water and Electricity Authority (ADWEA), has authorised the development of a new Seawater Reverse Osmosis (SWRO) Plant within the Taweelah Power and Water Complex. The proposed development will have a production capacity of 200 million imperial gallons per day (MIGD), equivalent to 909,216 m^3/day.

Following the submission of bids to EWEC during 2018, ACWA Power was announced as the preferred bidder in January 2019. Following technical evaluation of the Bid and confirmation of compliance with the RFP and MFS, the Taweelah IWP Project was awarded to ACWA Power and a Water Purchase Agreement was signed with EWEC in March 2019.

The Taweelah RO Project will be structured as a standalone Independent Water Producer (IWP) and will be developed on a build, own and operate basis by the Taweelah RO Project Company, which will be established as a joint stock company or LLC under the laws of the UAE and the Emirate of Abu Dhabi. ACWA Power will hold forty percent (40%) of the shares and Taweelah RO Local Holding Company sixty percent (60%) of the share capital.

The proposed schedule for the mobilization to the site is planned to commence in June 2019. Construction is anticipated to run for a duration of 41 months with works to be completed and the plant commissioned in October 2022. The anticipated lifespan of the project is in the region of 30 years.

1.1 Project Development Rationale

Abu Dhabi Water and Electricity Company (ADWEC) has identified the need for additional Reverse Osmosis (RO) production capacity in the Emirate of Abu Dhabi. The Statement of Future Capacity Requirements 2008 – 2030 Report (ADWEC, 2008) sets out the anticipated growth in water demand in the Emirate. The analysis was based on a review of historical demand profiles and an assessment of the capabilities of existing cogeneration plants to produce high water outputs at low power outputs. On the basis of the analysis, ADWEA identified the requirement for 251 MIGD of additional RO capacity to be made available by 2022.

The introduction of nuclear units in the electricity mix will impose constraints on water production during the winter period (ADWEC, 2008). When all four (4) nuclear reactors of the Barakah Nuclear Energy Plant are fully commissioned, they will provide almost all of Abu Dhabi's power demand during the winter period. Conventional gas combustion cogeneration units currently make up the majority of installed power and potable water generation capacity in the Emirate.

The contribution of the existing co-generation thermal desalination units will subsequently be markedly reduced during the winter period. A minimum amount of power production is required for these conventional plants to produce their maximum water output. As the cogeneration plants scale back power production, the effective water production capability of the thermal desalination plants will suffer as a result. This will create a need for additional stand-alone desalination capacities that are not constrained by the need for any associated power production. Although standalone water production is theoretically achievable with Multi Stage Flash (MSF) and Multi-effect Distillation (MED) technologies coupled to dedicated boilers, the most economical solution to achieve this is to use RO technology.

Additional RO desalination capacity is required in 2020/21 to ensure security of supply to the Emirate. On a systemic basis, RO is now significantly more efficient than thermal desalination technologies (ADWEC, 2008). Investment in new RO capacity will also enhance operational flexibility, enabling Abu Dhabi's current gas-fired IWPP fleet to be operated more efficiently, allowing a reduction in reliance on gas as a fuel source. The adoption of RO also delivers significant benefits in improved dispatch flexibility, which will be essential as inflexible nuclear power and renewable energy form a larger portion of Abu Dhabi's installed generation capacity. The development of the proposed SWRO plant at Taweelah, with an operational potable water generation of 200 MIGD, is one of the primary components of the EWEC's strategy to diversify the water generation sector and meet the anticipated growth in potable water demand.

1.2 Background and Context

In September 2017, EWEC submitted a proposal to the Executive Council for approval in principle to commence feasibility studies for 2 x 100 MIGD RO plants at Taweelah. EWEC then approached EAD regarding the proposed location and the potential environment impacts. EAD advised that they had no objection to the commencement of the project as long as an EIA was carried out to assess the cumulative impacts of existing projects in the area (Ref: letter ref: OUT-L/2017/EQS/0227).

In March 2018 EWEC appointed ILF as Technical Consultant for the Project and HDR was appointed as the Environmental Consultant. A draft EIA was prepared and submitted to EAD for comments which were addressed and subsequently a Conditional Approval was issued on 10th October 2018 (Ref: EMS/18/ESRF/10016_Appendix A).

ACWA Power appointed 5 Capitals Environmental & Management Consulting ("5 Capitals") to work with modellers HR Wallingford to assess a new optimal intake/outfall design for the ACWA Power Bid and subsequently to prepare the ESIA for submission to the Lenders. 5 Capitals has in turn appointed HDR in February 2019 to undertake the additional surveys requested by EAD and to submit an updated EIA with ACWA Power specific project design to the Abu Dhabi Environmental Regulator.

Table 1-1Key Project Information

Project Title	Taweelah 200 MIGD IWP Seawater Reverse Osmosis Plant, Abu Dhabi, UAE.
Project Proponent	Abu Dhabi Department of Energy /EWEC
Project Developer	ACWA Power
EPC Contractor	SEPCO3 and ABENGOA
Operation and Maintenance Company	First National Operation & Maintenance Co. Ltd (NOMAC)
Environmental Consultant	5 Capitals Environmental and Management Consulting PO Box 119899 Dubai, UAE Tel: +971 (0) 4 343 5955 Fax: +971 (0) 4 343 9366 www.5capitals.com
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1.3 Project Alternatives

EWEC conducted a feasibility assessment prior to confirming the decision to proceed with the project development. This section presents a summary of the options considered, the "No Development" alternative and selection of alternative sites in the UAE other than Taweelah.

1.3.1 "No Development" Option

The "No Development" option was rejected by the Project Proponent on the basis that ADWEC has identified a strategic requirement for additional potable water generation in order to meet anticipated growth in demand and reduced output from existing water generation facilities. On the basis of the analysis, ADWEC identified a requirement for 251 MIGD of additional potable water. A failure to supply the additional water required would result in constraints for planned growth and severe humanitarian, economic and social impacts. In addition, it is envisaged that the development of the Project will contribute to the overall growth in the UAE's Gross Domestic Product (GDP) through the creation of job opportunities both during construction and operational phases.

1.3.2 Coupled Power Generation and Water Production Alternative

The majority of the UAE's desalination capacity to date has chosen coupled power generation and thermal desalination technologies. The projected change in composition of Abu Dhabi's power generation sector will create a need for additional stand-alone desalination capacities that are not constrained by any associated power production.

Although standalone water production is theoretically achievable with Multi Stage Flash (MSF) and Multi-effect Distillation (MED) technologies coupled to dedicated boilers, the most economical solution to achieve this is to use RO technology.

The additional RO desalination capacity is required in 2020/21 to ensure security of supply to the Emirate. On a systemic basis, RO is now significantly more efficient than thermal desalination technologies. Table1-2 below shows that thermal desalination requires up to double the energy for desalination compared to the reverse osmosis method. RO will enhance operational flexibility, enabling Abu Dhabi's current gas-fired thermal desalination plants to be operated more efficiently, allowing additional savings of gas and reduced combustion emissions including carbon dioxide. The adoption of RO also delivers significant benefits in improved dispatch flexibility, which will be essential as inflexible nuclear power and renewable energy form a larger portion of Abu Dhabi's installed generation capacity.

Table 1-2 Energy use in Desalination (sourced from Cherfane, 2009)

	Desalination Technology		
	MSF	**MED**	**Reverse Osmosis**
Operating Temperature	<120°C	<70°C	Ambient
Main Energy Source	Heat	Heat	Electric
Thermal Energy Demand per m^3	12 kWh	6 kWh	None
Electrical Energy Demand per m^3	3.4 kWh	1.5 kWh	4 – 7 kWh
Total Energy per m^3	**15.4 kWh**	**7.5 kWh**	**4 – 7 kWh**

Meeting the anticipated growth in potable water demand using RO technology rather than traditional coupled thermal desalination technology also provides economic and strategic benefits. Thermal plants in the UAE currently rely on gas combustion driven turbines and heat recovery systems. The ADWEC analysis indicates that for all possible gas prices, water production cost of RO are lower than the specific cost of the existing fleet. Use of RO technology also reduces reliance on fluctuating fuel prices.

In light of the above, SWRO was selected as the most suitable technology for the new desalination plant.

1.3.3 Alternative Site Selection

A site selection feasibility study was conducted by EWEC in the advance planning stages of the project development. It is understood that the feasibility study has been shared with EAD by EWEC. A brief summary of the feasibility study has been included below.

The feasibility study considered existing desalination complexes in the Emirate of Abu Dhabi and Fujairah as potential development sites. This sites of Umm Al Nar, Taweelah, Fujairah, EMAL and Mirfa sites were also considered.

The assessment of each shortlisted site at Umm Al Nar, Taweelah, Fujairah, EMAL and Mirfa showed that all sites are in general suitable for development of RO plants in a standalone environment. The assessment found that the technical recommendations provided for each of the sites in order to cope with the particular local conditions related to environmental constraints and/or seawater quality. For all sites ambient seawater salinity and temperature is already elevated. Large scale RO capacity can be developed on each site ranging from 80 MIGD to as much as 260 MIGD in Taweelah, the capacity at the EMAL site, however, is limited to some 40 MIGD. A larger capacity is expected to exceed salinity limits in combination with existing EMAL facilities.

The financial analysis found that sites at Fujairah and Mirfa were less financially viable as a consequence of the higher CAPEX required to expand the existing potable water network. Finally, the Taweelah sites also offered the advantage of being able to meet the additional water demand within the timeframe required. In the light of this, the competent Abu Dhabi authorities selected Taweelah as the most suitable site for this strategic expansion of water capacity.

1.4 ESIA Consultations and Stakeholder Engagement

Stakeholder identification and consultation has been an ongoing process for the Taweelah Project for the last two years, even before the project bidding stage (reference Table 1-3 for the list of stakeholders identified and the dates of consultation meetings). The methods used for the on-going stakeholder engagement process include bilateral meetings, emails and telephone calls. Public consultations and public meetings are not allowed under the UAE national law although for this project there has been in-depth consultation with government entities and commercial interested parties to ensure that any project concerns are addressed within the project design and this ESIA.

Since the IWP will be located in the Taweelah Complex under the security of Critical Infrastructure & Coastal Protection Authority (CICPA) the impact on receptors other than commercial/industrial is limited to Al Hanjurah Estate which is understood to be under the Abu Dhabi Royal family and as such, consultation is expected to have occurred at the highest government level. Access to this estate is restricted and occupancy is unknown although nearest buildings are between 400m and 500m from the south-western boundary with the IWP site, beyond the cooling water channel for the Taweelah Complex.

A Stakeholder Engagement Plan (SEP) will be prepared for the Taweelah Project describing the proposed engagement process to be undertaken during the construction and operational phases of the project. The scope of the SEP will provide the project with methods of efficiently managing and facilitating future engagements with stakeholders through various stages of the project lifecycle.

The SEP will align with the requirements of Equator Principles 5 and 6 that describes Stakeholder Engagement and Grievance Mechanism respectively, and the IFC Performance Standards, with particular relevance to IFC Performance Standard 1 on "Assessment and Management of Environmental and Social Risks and Impacts" which describes the stakeholder's engagement requirements in more depth. However, it is recognised that elements of stakeholder engagement are included in all IFC Performance Standards.

Table 1-3 List of Stakeholder Identified and Consulted

ID	Name	Reason for inclusion	Yes/No	Dates of Meetings/Letters
1.	UAE Ministry of Climate Change & Environment	Mission is to work with Partners to Protect the Environment, Preserve and Develop their Resources and Invest in them Efficiently to Ensure their Sustainability.	Yes	Project approval would have been obtained from the consultation within UAE government ministries as part of strategic planning process.
2.	UAE Ministry of Energy and Industry	Organizing and developing energy, water, mining and industry sectors through setting and developing public policies, legislation, strategies and building partnerships in cooperation and coordination with concerned entities.	Yes	• Several times during the bid and at post bid stage
3.	Environment Agency Abu Dhabi	EAD governs all matters directly relating to the environment in Abu Dhabi	Yes	• 4th March 2019 – EAD Office – ACWA, 5 Capitals, HDR and HR Wallingford met with EAD to review the updated to the project EIA • 23 April 2019: Site Clearance issue • 22nd May 2019-EAD offices- to discuss the marine modelling report (EAD, ACWA Power, HR Wallingford, HDR, 5 Capitals)
4.	Abu Dhabi Department of Energy	Project Proponent with interest in the development of the project	Yes	• Several times during the bid and at post bid stage
5.	Abu Dhabi Department of Transportation	Interest in the development of the project (e.g. the transportation routes to be used by construction & operation vehicles, impacts of increased vehicle flow etc.)	Yes	• 5 May 2019: EPC Contractor registration
6.	Department of Urban Planning and Municipalities	Plays an important role in driving and supporting Abu Dhabi's urban development strategy	Yes	• 20 April 2019: OSHAD registration
7.	Abu Dhabi Department of Economic Development	Plays an important role in leading the economic agenda in the Emirate of Abu Dhabi.	Yes	• 14 April 2019: EPC Contractor for Commercial registration
8.	Taweelah Desalination and	The proposed project will be a direct	Yes	• 4th April 2019: Meeting for interface between

ID	Name	Reason for inclusion	Yes/No	Dates of Meetings/Letters
	Power Complex	neighbour of the Taweelah Desalination and Power Complex and may require items of common management such as co-ordination for emergency planning.		the Project and Taweelah Existing Facilities
9.	Critical Infrastructure & Coastal Protection Authority (CICPA)	Authority responsible of providing security and safety all critical infrastructure and establishments across Abu Dhabi	Yes	• Since 7th Feb 2019, several times for CICPA entry permits
10.	Dolphin Energy	The Dolphin Gas Pipeline corridor measuring approximately 20 meters in width transports natural gas and is located south west of the project site	Yes	• Since 23rd April 2019, several times for Dolphin NOC application and interface management between the Project and Dolphin facilities
11.	Emirates Water and Electricity Company (EWEC)	Authority in charge of water production and energy generation in Abu Dhabi	Yes	• Many times, regarding the development of the Project
12.	Abu Dhabi Ports/KIZAD	The Khalifa Port is located 2km from the project site and has an operational outfall on the southern boundary of the Khalifa Port. Future expansion of the port may have potential effects on the proposed plant.	Yes	• Since Feb 2019, several times for marine modelling data and site clearance NOC application • 11th March 2019 – KIZAD office – ACWA, 5Cs and HR Wallingford met with ADP/KIZAD environmental team • 2nd April 2019 – ADP HQ – ACWA and HR Wallingford met with ADP/KIZAD
13.	Emirates Global Aluminium (EGA)	Located 4km northeast of the proposed project and is the predominant user of the Abu Dhabi Port outfall. EGA discharges waste brine effluent and cooling water from its industrial processes.	Yes	• 2nd April 2019 – EGA provided intake and outfall characteristics by email to ACWA • 3rd April 2019 – EGA provided further clarifications on intake and outfall characteristics by email to ACWA

1.5 Assessment Methodology

The impact assessment has been undertaken in accordance with the methodology presented in the Abu Dhabi Technical Guideline for Environmental Impact Assessment (EAD-EQ-PCE-TG-02, Rev No. 01. April 2014) using the following criteria:

- Magnitude of impact (geographical scale of the impact):
  - Change or effect only within the project site;
  - Change or effect to local conditions or to areas immediately outside; and
  - Regional, national, or international changes or effects.
- Permanence of impact (condition is temporary or permanent):
  - No change (i.e., not applicable);
  - Temporary; and
  - Permanent.
- Reversibility of the impacted condition (impacted condition can be changed or reversed):
  - No change (i.e., not applicable);
  - Reversible; and
  - Irreversible.
- Extent that the impact is cumulative:
  - No change (i.e., not applicable);
  - Non-cumulative (i.e., single); and
  - Cumulative.

2 LEGAL FRAMEWORK AND STANDARDS

This chapter presents the regulatory requirements this ESIA has considered for the project in accordance with Federal and international regulations and standards. Applicable environmental legislative framework considered includes:

- National and local environmental legislation, regulations and standards (Abu Dhabi & UAE Federal Law); and
- International and Regional Conventions and Protocols signed/or ratified by the UAE.

2.1 Federal Regulatory Framework

The UAE Ministry of Climate Change and Environment and Water (MOCCEW) is the federal government agency responsible for the regulation and enforcement of environmental standards and development of environmental policies in the UAE. The MOCCEW, formally the Ministry of Environment and Water, delegates its regulatory roles in close coordination with the respective local environmental agencies of the Emirates. In the case of Abu Dhabi, the designated environmental regulator is The Environment Agency – Abu Dhabi (EAD).

Federal Law No. 11 of 2002 – Concerning Regulating and Controlling the International Trade in Endangered Species of Wild Fauna and Flora

This Law regulates the import, export, as well as the introduction by sea, unloading and re-shipping of endangered species in the UAE. It has been enacted in support to the international Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

The provisions of this law may not directly apply to the Project; however, it is recommended that the Project should support and adhere to this law's primary aim to conserve any endangered species.

Federal Law No. 23 of 1999 – Concerning Exploitation, Protection and Development of the Living Aquatic Resources in the Waters of the UAE

This law governs the fishing trade, import and export of aquatic organisms in the UAE. It intends to ensure the protection and conservation of aquatic resources, particularly fish stock, in the UAE.

Given the nature and location of the Project, efforts are to be made to ensure negative adverse impacts on marine ecology are minimized or, where feasible, eliminated. This law provides a number of prohibitions with regards to destruction of aquatic resources.

Federal Law No. 24 of 1999 and Law No. 37 of 2006 – Concerning the Protection, Development and Amendments of the Environment

This law relates to the protection of the environment by preserving diversity and natural equilibrium through prevention of all forms of pollution. The intent of the law is to provide a coordinated approach to addressing environmental issues throughout the UAE. This law aims to achieve the following goals:

- Protection and conservation of the quality and natural balance of the environment;
- Control of all forms of pollution and avoidance of any immediate or long-term harmful effects resulting from economic, agricultural, industrial, development or other programs aiming at improving life standards and co-ordination among the Agency, Competent Authorities and Parties concerned with the protection of the environment and conservation of the quality, natural balance and consolidation of environmental awareness and principles of pollution control;
- Development of natural resources and conservation of biological diversity in the region of the state and the exploitation of such resources with consideration of present and future generations;
- Protection of society, human health and the health of other living creatures from activities and acts, which are environmentally harmful or impede authorized use of the environmental setting;
- Protection of the State environment from the harmful effects of activities undertaken outside the region of the State; and
- Compliance with international and regional agreements ratified or approved by the State regarding environmental protection, control of pollution and conservation of natural resources.

In line with the above objectives, this law provides 101 articles dealing with the following environmental aspects:

- Environmental Impact Assessment (EIA) of projects and establishments applying for license;
- Sustainable development;
- Combat to environmental disasters;
- Protection of water environment;
- Protection of soil;
- Protection of air from pollution;
- Handling of hazardous substances, hazardous wastes and medical wastes;
- Establishment of natural reserves; and
- Liability and compensation for environmental damages.

Executive Order issued by Council of Ministers Decree No. 37 of 2001 on Regulation Concerning Environmental Impacts of a Project

In line with objectives of Federal Law No. 24 of 1999, all projects that have the potential to impact the environment will be required to perform an EIA. The EIA forms the basis for the issuance of environmental permits from the relevant regulatory agency, which in the case of this Project is The Environment Agency – Abu Dhabi (EAD).

Executive Order issued by Council of Minsters Decree No. 12 of 2006 on Regulation Concerning the Protection of Air from Pollution

This Minsters Decree was enacted in line with the air pollution control objective of the Federal Law No. 24 of 1999. It provides maximum allowable limits of air pollutants emitted from different source installations, in work areas and in the ambient air. It also specifies allowable levels of ambient noise in accordance with different land use classifications.

The ambient air quality standards, allowable emission limits from stationary sources and allowable noise limits stipulated in the said Regulation are shown in the tables below.

Table 2-1 Maximum Allowable Emission Limits of Air Pollutants Emitted from Stationary Sources

SUBSTANCE	SYMBOL	SOURCES	MAXIMUM ALLOWABLE EMISSION LIMITS (MG/NM3)
Visible Emissions	-	Combustion Sources Other Sources	250 None
Carbon Monoxide	CO	All Sources	500
Nitrogen Oxides (expressed and nitrogen dioxide)	NOx	Combustion Sources Material Producing Industries Other Sources	See Table 12 1500 200
Sulphur Dioxide	SO2	Combustion Sources Material Producing Industries Other Sources	500 2000 1000
Sulphur Trioxide Including Sulphuric Acid Mist (expressed as Sulphur Trioxide)	SSO3	Material Producing Industries Other Sources	150 50
Total Suspended Particles	TSP	Combustion Sources Cement Industry Other Sources	250 50 150
Ammonia and Ammonium Compounds (expressed as ammonia)	NH3	Material Producing Industries Other Sources	50 10
Benzene	C6H6	All Sources	5

SUBSTANCE	SYMBOL	SOURCES	MAXIMUM ALLOWABLE EMISSION LIMITS (MG/NM3)
Iron	Fe	Iron and Steel Foundries	100
Zinc and its compounds (expressed as Zinc)	Zn	Electroplating / Galvanizing Industries	10
Lead and its compounds (expressed as Lead)	Pb	All Sources	5
Antimony and its compounds (expressed as Antimony)	Sb	Material Producing Industries Other Sources	5 1
Arsenic and its compounds (expressed as Arsenic)	As	All Sources	1
Cadmium and its compounds (expressed as Cadmium)	Cd	All Sources	1
Mercury and its compounds (expressed as Mercury)	Hg	All Sources	0.5
Nickel and its compounds (expressed as Nickel)	Ni	All Sources	1
Copper and its compounds (expressed as Copper)	Cu	All Sources	5
Hydrogen Sulphide	H2S	All Sources	5
Chloride	Cl-	Chlorine Works Other Sources	200 100
Hydrogen Fluoride	HF	All Sources	2
Silicon Fluoride	SiF4	All Sources	10
Fluoride and its Compounds Including HF & SiF4 (expressed as fluoride)	F-	Aluminium Smelters Other Sources	20 50
Formaldehyde	CH2O	Material Producing Industries Other Sources	20 2
Carbon	C	Odes Production Waste Incineration	250 50
Total Volatile Organic Compounds (expressed as total organic carbon (TOC))	VOCs	All Sources	20
Dioxins & Furans	--	All Sources	1 (ng TEQ/m3)

Table 2-2 Maximum Allowable Emission Limits of Air Pollutants Emitted from Hydrocarbon Fuel Combustion Sources

SUBSTANCE	SYMBOL	SOURCES	MAXIMUM ALLOWABLE EMISSION LIMITS (MG/NM3)
Viable Emissions	-	All Sources	250
Nitrogen Oxides (expressed as nitrogen dioxide (NO_2))	NOx	Fuel Combustion Units: -gas fuel -liquid fuel	 350 500
		Turbine Units: -gas fuel -liquid fuel	 70 150
Sulphur Dioxide	SO2	All Sources	500
Total Suspended Particles	TSP	All Sources	200
Carbon Monoxide	CO	All Sources	500

Table 2-3 UAE Federal Ambient Air Quality Standards

PARAMETER	FEA MG/NM^3 UNLESS STATED		
	1-HOUR	24-HOUR	ANNUAL
PM_{10}	-	150	-
Nitrogen Dioxide	400	150	-
Sulphur Dioxide	350	150	60
Ozone	200	120 (8hr)	-
Carbon Monoxide	30 mg/m3	10 mg/m3 (8hr)	-
TSP	-	230	90
Lead	-	-	1

* Source: Ambient Air Quality Standards, Air Protection System, Federal Cabinet of Ministers Decree No (12) of 2006, E. (1) Emission levels are at 6% O2 v/v dry basis (0°C and 1 atm')

Table 2-4 Federal Maximum Allowable Limits for Noise Level in Different Areas.

RECEPTOR AREAS	ALLOWABLE LIMITS OF NOISE (DBA)	
	DAYTIME (7AM -8 PM)	EVENING (8PM-7AM)
Residential Areas with Light Traffic	40-50	30-40
Residential Areas in Downtown	45-55	35-45
Residential Areas with some workshops & Commercial or near highways	50-60	40-50
Commercial areas & Downtown	55-65	45-55

Receptor Areas	Allowable Limits of Noise (dBA)	
	Daytime (7am -8 pm)	Evening (8pm-7am)
Industrial Areas (Heavy Industry)	60-70	50-60

Source: Cabinet Decree No. 12 of 2006 concerning Protection of Air from Pollution, Annex (6)

Executive Order issued by Council of Ministers Decree No. 37 of 2001 on Regulation for Handling Hazardous Materials, Hazardous Wastes and Medical Wastes

This Ministers Decree provides the classification categories / criteria for hazardous materials (Schedule 1.1 of Annex 1) and waste (Schedule 1.2 of Annex 1). It also provides regulatory requirements for the storage, management, transport and disposal of hazardous materials and wastes. The following are provisions of this Decree, which are relevant to the generation of hazardous waste:

- No import of hazardous materials specified in Schedule 1.1 of Annex 1 is allowed unless a Permit is acquired from the Competent Authority;
- Only licensed contractors should be engaged to collect hazardous waste;
- Entities responsible for the production and handling of waste must take all necessary measures to ensure that no damage to the environment occurs;
- Entities responsible for the production and handling of waste and must keep a register of all wastes generated by the entity, volumes transported and disposed of off the site owned / operated by the entity;
- Hazardous wastes are prohibited from being be transported via land or sea without a permit from the relevant regulatory agency;
- Hazardous materials and waste are classified in accordance with Schedules 1.1 and 1.2 of Annex 1;
- Segregation requirements are to be maintained when storing hazardous material (Schedule 1.3 of Annex 1); and
- The specifications for the burial of hazardous wastes in specially equipped burial holes isolated from other environment elements.

2.2 Federal Policies

UAE Green Agenda 2015-2030

The UAE is seeking to manage greenhouse gas emissions from major sectors including the heavy industries, oil and gas, building and transportation sectors, under a national green growth framework titled Green Agenda 2015-2030. The Agenda consists of five (5) strategic objectives, 12 main programmes and 31 sub-programs.

UAE National Climate Change Plan

National Climate Change Plan will coordinate efforts to manage greenhouse emissions, minimise risk and increase ability to adapt to the climate, while sustaining economic growth. Given the nature of the project, the UAE National Climate Change Plan is to be consulted during the EIA phase.

2.3 Regulatory Framework in Abu Dhabi

Law No. 16 of 2005 – Pertaining to the Reorganization of the Abu Dhabi Environmental Agency

The EAD was established in 2005 under Law No. 16 of 2005 Pertaining to the Reorganisation of the Abu Dhabi Environment Agency to replace the Environmental Research and Wildlife Development Agency (ERWDA). EAD was established as an independent juridical entity concerned with the environmental affairs in the Emirate of Abu Dhabi. This law holds EAD responsible for protecting the environment and the wildlife along with its biological diversity in its natural environment in the emirate through offering suggestions, making recommendations, conducting environmental studies and monitoring, and creating social awareness. All government departments and other agencies are to adhere to this law by cooperating and coordinating with EAD in matters relating to research, studies, and programs associated with the environment and wildlife in Abu Dhabi.

Law No. 5 of 2016 – Concerning the Regulation of Groundwater in the Emirate of Abu Dhabi

The law stipulates that groundwater in the emirate is a natural asset wholly owned by Abu Dhabi, and Environment Agency-Abu Dhabi (EAD) subject to rules and regulations issues its extraction and exploitation. The law bans contaminating and polluting groundwater.

The law also stipulates that the activities of groundwater well dredging, water transport or installation of water desalination units for non-drinking purposes cannot be practised without obtaining permits from EAD. The legislation also stipulates the following:

- Owners of groundwater wells or water desalination units will be committed to installation of a water meters on the well and registration of all wells.
- Owners of groundwater wells are not to exceed the maximum amount of water prescribed for extraction and conduct regular maintenance of wells, pumps, meters and related appliances.
- It is not permitted to sell groundwater and owners of wells should adhere to all obligations as prescribed by the law.

The law also streamlines the requirements for digging wells in the emirate and obligations applicable to drilling contractors.

Abu Dhabi Environmental Permitting Guidelines

EAD is the Competent Authority to review and approve environmental permits for development, infrastructure and industrial projects. According to Federal Law No. 24 of 1999 for the Protection and Development of the Environment, various industrial / commercial facilities and development projects require an environmental permit or No Objection Certificate prior to the commencement of site activities. In addition, certain environmental studies1 may be required in order to process the permit. The following Standard Operating Procedures (SOP) and technical guidance documents, published by the EAD, are considered relevant to the Project:

- SOP for Permitting of Development and Infrastructure Projects in Abu Dhabi, April 2014;
- Technical Guidance Document for Construction Environmental Management Plan, April 2014;
- Technical Guidance Document for Environmental Action Plan (EAP), April 2014;
- Technical Guidance Document for Environmental Audit Reports, January 2011;
- Technical Guidance Document for Submission of Environmental Permit Applications and Environmental Studies, April 2014;
- Technical Guidance Document for Discharges from Construction Activities, April 2014;
- Technical Guidance Document for Storage of Hazardous Materials, April 2014;
- Technical Guidance Document for Fugitive Dust Control Plan, April 2014; and
- Technical Guidance Document for Leak Detection and Repair Plan, April 2014.

Law No. 21 of 2005 – Regarding Waste Management in the Emirate of Abu Dhabi

[1] Depending on the nature and the impacts of the project, the environmental studies may include Preliminary Environmental Review, Strategic Environmental Assessment, Environmental Impact Assessment, Construction Environmental Management Plan, Operation Environmental Management Plan, and Decommissioning Environmental Management Plan.

This law provides guidelines to ensure effective management of waste at all stages, from the source points to the transportation of waste and final disposal. As a minimum requirement, waste generators are required to comply with the following:

- Reduce the amount of waste generated by implementing the regulations, methods, techniques and alternatives approved in the Emirate for classifying, sorting, reusing or recycling of waste;
- Classify the waste generated in terms of hazardous and non-hazardous waste;
- Adhere to the relevant occupational health and safety regulations, guidelines and codes of practice; and
- Ensure that waste is transported in accordance with relevant codes of practice and appropriate licenses.

Decree No. 17 of 2008 for Establishing the Centre of Waste Management of Abu Dhabi

The Tadweer, Centre of Waste Management-Abu Dhabi (CWM) was established in 2008 in order to serve as the lead agency in controlling and coordinating the waste management activities throughout the Emirate of Abu Dhabi. This includes implementing the Waste Management Strategy and all aspects of service delivery required to establish a full cycle for an integrated waste management system.

The CWM issued the technical guidelines relating to waste management in the Emirate of Abu Dhabi. The guideline most applicable to this project is as follows:

Technical Guidance Document on Standards and Limits for Pollution to Air and Marine Environments, Occupational Exposure and Pesticides and Chemical Use

EAD has established a number of air emission limits and air quality standards in support of the above regulations. They are contained in the above Technical Guidance Document. The first part covers emissions from stationary sources, ambient air quality and noise (see sections above on Federal Standards). Also included are Recommended Ambient Marine Water Quality Objectives (AWQOs) for Abu Dhabi Emirate and limits for Characteristics of Treated Industrial Wastewater at Point of Discharge to the Sea.

Table 2-5 Recommended Ambient Marine Water Quality Objectives for Abu Dhabi

PARAMETERS	PROPOSED MAXIMUM CONCENTRATIONS	UNITS OF MEASUREMENTS
Physical Indicators		
Floating Particles / Floatable / Debris	Nil	mg/m3
Temperature	+-3	Delta °C of background concentration
Turbidity	10	NTU
Transparency / Clarity	>=10	Meter of Secchi

PARAMETERS	PROPOSED MAXIMUM CONCENTRATIONS	UNITS OF MEASUREMENTS
		Depth.
Salinity	< 5	% of background concentration
BOD_5	5	mg/L (5 day at 20 °C Annual Average)
Odour	Not objectionable	Not objectionable
Colour	No change from background	No change from background
Chemical Indicators		
Ammonia (Free as N) or Ammonia NH_3-N	0.004	mg/L
Arsenic As	0.005	mg/L
Cadmium Cd	0.001	mg/L
Chlorine Residual Cl_2	0.01	mg/L
Chromium Cr	0.01	mg/L
Copper Cu	0.01	mg/L
Cyanide Cn	0.004	mg/L
Lead Pb	0.01	mg/L
Mercury Hg	-	mg/L
Oil and Grease	Not visible	mg/L
Petroleum Hydrocarbons	5	ppm or mg/L
Dissolved Oxygen (DO)	>4	mg/L
Total Suspended Solids (TSS)	<33	mg/L
Si-SiO_3	890	Microgram/L
PH	6.5 – 8.5	mg/L
Phenols	0.001	mg/L
Phosphorus Total as (P)	0.001	mg/L
Phosphate PO4	34	Microgram/L
Sulfides (S)	0.004	mg/L
Total Organic Carbon (TOC)	2.5	mg/L
Zinc Zn	0.01	mg/L
Nickel Ni	20	Microgram/L
Iron Fe	0.3	mg/L
Vanadium V	9.4	Microgram/L
Nitrate NO_3-N	95	Microgram/L
NO_2	34	Microgram/L
Biological Indicators (Bacteriological)		
Total Coliform	70	MPN/100ml

Table 2-6 Characteristics of Treated Industrial Wastewater at Point of Discharge to the Sea

Constituents/parameters	Suggested limits
Physical Properties	
Floating Particles	None
pH	6 – 9
Temperature	±5°C
Total Suspended Solids (TSS)	50 mg/L
Total Dissolved Solids (TDS)	1500 mg/L
Turbidity	75 NTU
Inorganic Chemical Properties	
Ammonia – Total (as N) (NH_4^+)	2 mg/L
Biochemical Oxygen Demand (BOD5-20)	50 mg/L
Chemical Oxygen Demand (COD)	100 mg/L
Chlorine – Residual (Cl^-)	1 mg/L
Cyanide (CN^-)	0.05 mg/L
Dissolved Oxygen	>3 mg/L
Fluoride (F^-)	20 mg/L
Kjeldahl Nitrogen – Total (as N)	10 mg/L
Nitrate (NO_3-N)	40 mg/L
Phosphorus – Total (as P) (PO_4^{3-})	2 mg/L
Sulfide (S^{2-})	0.1 mg/L
Trace Metals	
Aluminum (Al)	20 mg/L
Antimony (Sb)	0.1 mg/L
Arsenic (As)	0.05 mg/L
Barium (Ba)	2 mg/L
Beryllium (Be)	0.05 mg/L
Cadmium (Cd)	0.05 mg/L
Chromium – Total (Cr)	0.2 mg/L
Chromium VI (Cr^{6+})	0.15 mg/L
Cobalt (Co)	0.2 mg/L
Copper (Cu)	0.5 mg/L
Iron (Fe)	2 mg/L
Lead (Pb)	0.1 mg/L
Manganese (Mn)	0.2 mg/L
Mercury (Hg)	0.001 mg/L
Nickel (Ni)	0.1 mg/L
Selenium (Se)	0.02 mg/L
Silver (Ag)	0.005 mg/L
Zinc (Zn)	0.5 mg/L
Organic Chemical Properties	
Halogenated Hydrocarbons and Pesticides	Nil

CONSTITUENTS/PARAMETERS	SUGGESTED LIMITS
Hydrocarbons	15 mg/L
Oil & Grease	10 mg/L
Phenols	0.1 mg/L
Solvent	None
Total Organic Carbon	75 mg/L
Biological Properties	
Total Coliform	1000 MPN / 100 ml
Faecal Coliform bacteria	1000 cells / 100 ml
Colon Group	5000 units per 100 cm2
Egg Parasites	None
Warm parasites	None

Technical Guideline on Requirements and Procedures for Disposal of Hazardous Waste

Hazardous waste will be generated during the construction of the Project, as such and the Technical Guideline will apply. Waste generators are required to:

- Engage CWM Registered Service Providers2 for the collection / transport, treatment and / or disposal of hazardous waste;
- Obtain CWM approval (i.e. one-time or annual) for the disposal of hazardous waste. The waste generator will be required to provide information on the characteristics of the hazardous waste (e.g. Waste Material Data Sheet, MSDSs and analysis report);
- Ensure that hazardous waste containers are not stored near a sewerage or water network, stormwater network, marine environment, marine outfalls or channels; and
- Submit monthly records (RSP Register) along with waste test reports and copies of all waste manifests for the month, within five working days of the following month.

The Technical Guideline also sets out the documentation procedure (i.e. use of Waste Manifest) for tracking hazardous waste from the point of collection to the disposal or treatment facility.

This Technical Guideline defines hazardous wastes as those specified in the Basel Convention (refer to Section 2.5).

[2] https://www.nadafa.ae/en/ESPAcc.aspx

2.4 Regulation Supervision Bureau Regulations

The Regulation and Supervision Bureau (RSB) is the independent regulator of the water, wastewater and electricity sector in the Emirate of Abu Dhabi. It enforces the relevant laws primarily through licensing of regulated activities including the:

- Generation, transmission, distribution and sale of electricity; and
- Production, transmission, distribution, sale and treatment of water including wastewater products.

RSB regulations that could be applicable to the Project are outlined below.

Trade Effluent Control Regulations (2010)

These regulations are required under Article (63) of Law No (2) of 1998, as amended, and establish a framework for the efficient and safe collection and treatment of trade effluent. Trade effluent is non-domestic wastewater discharged by industrial and commercial premises.

The regulations require sewerage service licensees to consent to all trade effluent discharges. The consent will define the permitted composition and quantity of the discharge and the regulations empower sewerage service licensees enforce compliance with consents through inspection and monitoring activities.

The Fuel Storage Tank Regulations 2009 (for Water and Electricity Sector - Emirate of Abu Dhabi)

RSB requires registration of all fuel storage tanks with a capacity of 50,000 imperial gallons or more within 30 days of coming into service. The Regulations further specify requirements on:

- Design parameters for storage tanks including secondary containment and corrosion protection;
- Management procedures for release prevention and detection, maintenance and inspection;
- Reporting of spills (> 200 imperial gallons);
- Fuel release emergency response plan; and
- Decommissioning of tanks.

2.5 International Conventions, Protocols and Standards

The UAE is signatory to a number of international conventions and protocols considered to be relevant to the Project construction and operational activities. The conventions relevant to the Project are discussed below.

Marine Pollution (MARPOL) Control

MARPOL 73/78 International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto

MARPOL 73/787 is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. Specific regulations of this Convention are provided in the following annexes:

- Annex I Regulations for the Prevention of Pollution by Oil;
- Annex II Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk;
- Annex III Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form;
- Annex IV Prevention of Pollution by Sewage from Ships; and
- Annex V Prevention of Pollution by Garbage from Ships.

The operation of any marine vessels for the construction of the Project will be required to adhere to the requirements of this Connection.

Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matter (LDC) (1972) including its Amendments

This Convention originally prohibits dumping of certain hazardous wastes that can potentially cause marine pollution. However, in 1996 Parties adopted a Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (known as the London Protocol) that entered into force in 2006. This Protocol prohibits all dumping, except for possibly acceptable wastes, contained in an annex to the Protocol, which would still require permits from the relevant authority designated by the Contracting Parties.

Other key requirements of this Protocol include:

- Precautionary approach requiring that "appropriate preventative measures are taken when there is reason to believe that wastes or other matter introduced into the marine environment are likely to cause harm even when there is no conclusive evidence to prove a causal relation between inputs and their effects".
- Direct responsibility of polluter such that "the polluter should, in principle, bear the cost of pollution".
- Requirement for Contracting Parties to "ensure that the Protocol should not simply result in pollution being transferred from one part of the environment to another".

Climate Change and Air Pollution Control

Vienna Convention for the Protection of the Ozone Layer (1985)

The Vienna Convention established mechanisms for international co-operation in research into the ozone layer and the effects of ozone depleting chemicals (ODCs). This convention seeks to protect human health and the environment against adverse effects that impact on and modify the ozone layer.

Montreal Protocol on Substances that Deplete Ozone Layer (1987)

On the basis of the Vienna Convention, the Montreal Protocol on Substances that Deplete the Ozone Layer was established to call for the Parties to phase out the use of CFCs, halons and other man-made ODCs. The most recent schedule for the phase out of each controlled substance has been agreed during the 9th Meeting of the Parties in September 1997.

The UAE is a signatory to the Montreal Protocol and operates under Article 5(1). In line with its commitments, the UAE has enacted a national decree called the Federal Decree No. 13 of 1999 Concerning Regulation of Ozone depleting Substances in the UAE.

United Nations Framework Convention on Climate Change (1992)

The Convention on Climate Change sets an overall framework for intergovernmental efforts to tackle the challenge posed by global warming and climate change believed to have been caused by industrial and other emissions of carbon dioxide and other greenhouse gases (GHG).

Under the Convention, governments:

- Gather and share information on greenhouse gas emissions, national policies and best practices;
- Launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries; and
- Cooperate in preparing for adaptation to the impacts of climate change.
- The UAE acceded to the convention in December 1995.

Kyoto Protocol to the United Nations Framework Convention on Climate Change (1997)

The Kyoto Protocol was developed in line with the objectives and institutions of the Convention on Climate Change. The main difference to the Convention is that the Protocol commits rather than encourage the signatory parties to stabilise their GHG emission.

Under the Protocol, the Annex I countries have committed to reduce their emissions by an average of 5% against the 1990 levels over the period of 2008 to 2012. As a non-Annex I country, the UAE is not required to reduce its emissions below 1990 levels. However, the UAE ratified the Protocol on January 2005 and has submitted its First and Second Communications to the United Nations Framework Convention on Climate Change in

January 2007 and January 2010, respectively. This initial communication presents options and initiatives that the UAE may undertake in order to reduce its GHG emissions.

Paris Protocol to the United Nations Framework Convention on Climate Change (2016)

The Paris Agreement is an agreement within the United Nations Framework Convention on Climate Change (UNFCCC) dealing with greenhouse gas emissions mitigation, adaptation and finance starting in the year 2020. The legally binding framework for an internationally coordinated effort to tackle climate change stipulates a global warming goal of well below 2°C on pre-industrial averages. It requires countries to formulate ambitious climate targets, which are consistent with this goal.

The Paris Agreement establishes the main framework for cooperative action on climate change beyond 2020 and will replace the Kyoto Protocol. It provides the framework under which the Paris Agreement is adopted, it contains guidance on pre-2020 climate action, it regulates and organizes action that needs to be taken before the Paris Agreement enters into force but is relevant for the implementation of the Agreement (e.g. the formulation of guidance and modalities for the Agreement) and it contains detail and guidance on how to develop and formulate NDCs.

Waste Management

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989)

The Basel Convention was established primarily to set up a framework for controlling the "transboundary" movements of hazardous wastes. Hazardous wastes covered by the Convention include toxic, poisonous, explosive, corrosive, flammable, ecotoxic and infectious.

The Convention has developed the criteria for "environmentally sound management", which involves strong controls from the generation of waste to its storage, transport, treatment, reuse, recycling, recovery and final disposal. It also promotes hazardous waste minimisation whenever possible, as well as control of hazardous waste as close to where these are produced as possible.

Under this Convention, transboundary movement of hazardous wastes or other wastes is allowed only under conditions below:

- If the state of export does not have the capability of managing or disposing of the hazardous waste in an environmentally sound manner; and
- Upon prior written notification by the state of export to the designated authorities of the state of import and transit, where appropriate.

Each country that is a party to the Convention is required to report on its hazardous waste generation and movement. The UAE signed the Basel Convention on September 1989.

Chemicals and Dangerous Goods

Stockholm Convention on Persistent Organic Pollutants (2001)

The Stockholm Convention is a global treaty, which aims to protect human and the environment from the so-called Persistent Organic Pollutants (POPs). POPs are "chemicals that remain intact in the environment for long periods, become widely distributed geographically and accumulate in fatty tissue of human and wildlife" (Stockholm Convention website). Recognizing the serious effects of POPs to human health, the Convention requires Parties to take measures to eliminate or reduce the release of POPs into the environment. Lists of chemicals categorized as POPs are presented under Appendices of the Convention.

The UAE signed this Convention on May 2001 and subsequently ratified on July 2002.

Biodiversity

The Convention of Wetlands on International Importance – The Ramsar Convention (1971)

Ramsar is the oldest of the modern global intergovernmental environmental agreements. The treaty was negotiated throughout the 1960s with engagement from both national governments and non-governmental organizations concerned about the increasing loss and degradation of wetland habitat for migratory waterbirds. The convention was formalised in the Iranian city of Ramsar in 1971 and came into force in 1975.

The UAE ratified the convention and it entered into force across the UAE on 29th December 2007. The United Arab Emirates currently has five (5) sites designated as Wetlands of International Importance (Ramsar Sites), with a combined surface area of 20,278 hectares. None of the Ramsar sites are located within the Emirate of Ras Al Khaimah. It is not known whether the recent move to protect areas of mangrove and intertidal habitat will include submitting applications for designation as Ramsar sites of international importance to migratory bird species.

Convention on Biological Diversity (1992)

The UAE signed this Convention in 1992 and subsequently ratified this in 2000.

The Convention on Biological Diversity promotes the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from the use of genetic resources.

In April 2002, the Parties to the Convention committed themselves to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national level.

Regional Conventions

Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution, 1978

During the Kuwait Regional Conference in 1978, the eight coastal states of the Gulf Region including the UAE (along with Bahrain, Islamic Republic of Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia) adopted the following documents to coordinate a common action towards protection of their common marine environment:

- Kuwait Action Plan for the Protection and Development of the Marine Environment and Coastal Areas;
- Kuwait Regional Convention for the Co-operation on the Protection of the Marine Environment; and
- Protocol concerning Regional Co-operation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency (1978).

The Kuwait Action Plan mainly covers activities relating to oil pollution, industrial wastes, sewage and marine resources. Programs include coastal area management, fisheries, public health, land-based activities, sea-based pollution, biodiversity, oceanography, marine emergencies, GIS and remote sensing, environmental awareness and capacity building.

Milestones include the creation in 1979 of the Regional Organization for the Protection of the Marine Environment (ROPME), the establishment in 1982 of the Marine Emergency Mutual Aid Centre (MEMAC), and the adoption of the following four protocols addressing marine emergencies, hazardous wastes, land-based activities and sea-based pollution:

- Protocol concerning Marine Pollution resulting from Exploration and Exploitation of the Continental Shelf (1989);
- Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources (1990);
- Protocol on the Control of Marine Transboundary Movements and Disposal of Hazardous Wastes and Other Wastes (1998); and
- Protocol concerning the conservation of biological diversity and the establishment of protected areas.

The concept of environmentally sound and sustainable development has been promoted by ROPME since its establishment.

2.6 Lender Requirements

2.6.1 Equator Principles

The Equator Principles have been detailed in 'The ESIA Process' section herein. As per Equator Principle 3, an Equator Principle aligned ESIA is required to assess environmental and social impacts in accordance with the IFC Performance Standards on Environmental & Social Sustainability and IFC EHS Guidelines.

2.6.2 IFC Performance Standards on Environmental and Social Sustainability

The IFC Performance Standards are a key component of the IFC's Sustainability Framework and directed towards clients (i.e. party responsible for implementing and operating the project that is being financed), providing guidance on how to identify risks and impacts. The IFC Performance Standards are designed to help avoid, mitigate, and manage risks and impacts throughout the life of a project as a way of doing business in a sustainable way, including stakeholder engagement and disclosure obligations of the client in relation to project-level activities.

The 2006 version of the IFC Performance Standards was reviewed and made applicable to all new projects from 1st January 2012. The updated IFC PSs reflect IFC's stronger commitment to climate change, business and human rights, corporate governance and gender equality as well as strengthening the due diligence process for IFIs. Such updates include comparable labour terms for migrant and non-migrant workers, clarification of levels of stakeholder engagement, monitoring of supply chains and an enhanced focus on energy efficiency.

IFC is a shareholder in ACWA Power, and therefore all ACWA Power projects must comply with the IFC Performance Standards and IFC EHS Guidelines.

The following presents the IFC Performance Standards (2012) and their main characteristics:

Table 2-7 IFC Performance Standards (2012)

Performance Standard	Details and Requirements
PS 1	**Assessment and Management of Environmental and Social Risks and Impacts** It underscores the importance of managing environmental and social performance throughout the life of a project. It requires the Client to conduct a process of environmental and social assessment, and establish and maintain an Environmental and Social Management System (ESMS) appropriate to the nature and scale of the project and commensurate with the level of its environmental and social risks and impacts. The ESMS must be a dynamic and continuous process initiated and supported by management, and involves engagement between the client, its workers, local communities directly affected by the project (the Affected Communities) and, where appropriate, other stakeholders. • Requires stakeholder engagement beyond Affected Communities; Clarifies levels of stakeholder engagement under different circumstances;

Performance Standard	Details and Requirements
	- Requires development of a formal environmental and social policy reflecting principles of the Performance Standards; - Introduces participatory monitoring (when appropriate) as an option during implementation; and - Requires periodic performance reviews by senior management.
PS 2	**Labour and Working Conditions** Recognizes that the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental1 rights of workers. The requirements set out in this PS have been in part guided by a number of international conventions and instruments, including those of the International Labour Organization (ILO) and the United Nations (UN) - Establishes requirement for comparable terms and conditions for migrant workers compared to non-migrant workers; - Introduces quality requirements for workers' accommodation; - Requires ongoing monitoring of working conditions for workers under the age of 18 years old; - Requires establishing policies and procedures to manage and monitor compliance of third parties with this PS; - Requires alternatives analysis in case of retrenchment; and - Requires ongoing monitoring and "safety' trigger in primary supply chain.
PS 3	**Resource Efficiency and Pollution Prevention** Outlines a project-level approach to resource efficiency and pollution prevention and control in line with internationally disseminated technologies and practices. During the project life-cycle, the client will consider ambient conditions and apply technically and financially feasible resource efficiency and pollution prevention principles and techniques that are best suited to avoid, or where avoidance is not possible, minimize adverse impacts on human health and the environment.3 The principles and techniques applied during the project life-cycle will be tailored to the hazards and risks associated with the nature of the project and consistent with good international industry practice (GIIP). - Introduces a resource efficiency concept for energy, water and core material inputs; - Strengthens focus on energy efficiency and greenhouse gas measurement; - Reduces greenhouse gas emissions thresholds for quantification and reporting to IFC from 100,000 tons of CO_2 to 25,000 tons of CO_2 per year; - Introduces concept of "duty of care" for hazardous waste disposal; and - Requires determination of accountability with regards to historical pollution.
PS 4	**Community Health, Safety and Security** Addresses the client's responsibility to avoid or minimize the risks and impacts to community health, safety, and security that may arise from project related-activities, with particular attention to vulnerable groups. This PS addresses potential risks and impacts to the Affected Communities from project activities. Occupational health and safety requirements for workers are included in PS 2, and environmental standards to avoid or minimize impacts on human health and the environment due to pollution are included in PS 3.

Performance Standard	Details and Requirements
	• Requires evaluation of the risks and impacts to the health and safety of the Affected Communities during the project life- cycle and the establishment of preventive and control measures consistent in line with GIIP • Considers risks to communities associated with use and/or alteration of natural resources and climate change through an ecosystems approach.
PS 5	**Land Acquisition and Involuntary Resettlement** Recognizes that project-related land acquisition and restrictions on land use can have adverse impacts on communities and persons that use this land. Involuntary resettlement refers both to physical displacement (relocation or loss of shelter) and to economic displacement (loss of assets or access to assets that leads to loss of income sources or other means of livelihood) as a result of project-related land acquisition and/or restrictions on land use. Where involuntary resettlement is unavoidable, it should be minimized and appropriate measures to mitigate adverse impacts on displaced persons and host communities3 should be carefully planned and implemented. • Extends scope of application to restrictions on land use; • Strengthens requirements regarding consultations; and • Introduces a requirement for a completion audit under certain circumstances.
PS 6	**Biodiversity Conservation and Sustainable Management of Living Natural Resources** Addresses how clients can sustainably manage and mitigate impacts on biodiversity and ecosystem services throughout the project's lifecycle in order to protect and conserve biodiversity; to maintain the benefits from ecosystem services; and to promote the sustainable management of living natural resources through the adoption of practices that integrates conservation needs and development priorities. • Clarifies definitions of and requirements for various types of habitats; • Introduces stronger requirements for biodiversity offsets; and • Introduces specific requirements for plantations and natural forests as well as for management of renewable natural resources.
PS 7	**Indigenous People** It requires clients to anticipate and avoid adverse impacts of projects on communities of Indigenous Peoples, or when avoidance is not possible, to minimize and/or compensate for such impacts and to promote sustainable development benefits and opportunities for Indigenous Peoples in a culturally appropriate manner. It also requires the client to establish and maintain an on-going relationship based on Informed Consultation and Participation (ICP) with the Indigenous Peoples affected by a project throughout the project's life-cycle. • Expands consideration of Indigenous Peoples' specific circumstances in developing mitigation measures and compensation; • Introduces requirement for land acquisition due diligence with regards to lands subject to traditional ownership or under customary use; and • Introduces the concept of Free, Prior and Informed Consent under certain circumstances.
PS 8	**Cultural Heritage** Aims to ensure that clients protect cultural heritage from the adverse impacts of

Performance Standard	Details and Requirements
	project activities and support its preservation and promote the equitable sharing of benefits from the use of cultural heritage in line with the Consistent with the Convention Concerning the Protection of the World Cultural and Natural Heritage.

2.6.3 World Bank and IFC EHS Guidelines

The World Bank Group and IFC Environmental, Health and Safety Guidelines (EHS Guidelines) are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP), as defined in IFC's PS 3: Resource Efficiency and Pollution Prevention. IFC uses the EHS Guidelines as a technical source of information during project appraisal activities.

The World Bank Group International Finance Corporation (IFC), Environmental, Health and Safety (EHS) General Guidelines of April 2007 superseded the World Bank Handbook issue of 1998. The updated EHS Guidelines serve as a technical reference source to support the implementation of the IFC Performance Standards, particularly in those aspects related to PS 3: Resource Efficiency & Pollution Prevention, as well as certain aspects of Occupational and Community Health and Safety. The General EHS Guidelines contain information on crosscutting environmental, health, and safety issues potentially applicable to all industry sectors. On the other hand, there are industry sector guidelines that have been developed and are relevant to the SWRO plant such as the EHS Guidelines for Water and Sanitation.

The General EHS Guidelines contain the performance levels and measures that are normally acceptable to IFC, and that are generally considered to be achievable in new facilities at reasonable costs by existing technology.

2.7 ESIA Requirements

2.7.1 Local Requirements

In accordance with Federal Environmental Law No. 24 of 1990, Article 3 states that "The Agency, in consultation with the competent authorities and concern parties will to set the standards, specifications, principles and regulations for the assessment of environmental impact of the projects and establishment applying for license and will specially undertake the following:

- Identification of categories of projects, which due to their nature may cause harm to the environment.
- Identification of areas and sites of special environmental importance or sensitivity such as historical and archaeological sites, wet lands, coral reefs, natural reservations and public parks.

- Identification of natural resources and major environmental problems of special importance.

In addition to this, Article 4 states that "No project or establishment will start the activity before obtaining the license aforementioned in the previous article including environmental impact assessment."

2.7.2 Lender Requirements

It is understood that ACWA Power is seeking project finance from International Lenders who are likely to be signatories to the voluntary set of guidelines for managing environmental and social risks, known as the Equator Principles. As such there are a number of separate requirements for the Environmental Impact and Social Assessment of the project as set out below.

The Equator Principles 2013 (EPs) form the baseline for the assessment and management of environmental and social risks in project financing. They also stipulate the reporting and monitoring requirements to be met by a project for the Equator Principles Financial Institutions (EPFIs).

Based on the Equator Principles, Taweelah 200 MIGD SWRO Independent Water Project is located in a Non-Designated Country (UAE), the project will therefore be required to undergo an assessment process. The assessment process evaluates compliance with the then applicable IFC Performance Standards on Environmental and Social Sustainability (Performance Standards) and the World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines).

The Equator Principles consist of the following 10 Principles:

Table 2-8 Equator Principles III (2013)

EQUATOR PRINCIPLE	DETAILS
Principle 1	**Review and Categorisation** EPFIs will categorise a project proposed for financing based on the magnitude of its potential impacts and risks in accordance with the environmental and social screening criteria of the International Finance Corporation (IFC). These categories are: **Category A-** Projects with potential significant adverse social or environmental risks and/or impacts that are diverse, irreversible or unprecedented; **Category B** – Projects with potential limited adverse social or environmental risks and/or impacts that are few in number, generally site-specific, largely reversible and readily addressed through mitigation measures; and **Category C** – Projects with minimal or no social or environmental risks and/or impacts.
Principle 2	**Environmental and Social Assessment** For all Category A and Category B Projects, the EPFI will require the client to conduct an Assessment process to address, to the EPFI's satisfaction, the relevant environmental and social risks and impacts of the proposed Project

EQUATOR PRINCIPLE	DETAILS
	(which may include the illustrative list of issues found in Exhibit II). The Assessment Documentation should propose measures to minimise, mitigate, and offset adverse impacts in a manner relevant and appropriate to the nature and scale of the proposed Project. The Assessment Documentation will be an adequate, accurate and objective evaluation and presentation of the environmental and social risks and impacts, whether prepared by the client, consultants or external experts. For Category A, and as appropriate, Category B Projects, the Assessment Documentation includes an Environmental and Social Impact Assessment (ESIA). One or more specialised studies may also need to be undertaken. Furthermore, in limited high-risk circumstances, it may be appropriate for the client to complement its Assessment Documentation with specific human rights due diligence. For other Projects, a limited or focused environmental or social assessment (e.g. audit), or straightforward application of environmental siting, pollution standards, design criteria, or construction standards may be carried out
Principle 3	**Applicable Environmental and Social Standards** The Assessment process should, in the first instance, address compliance with relevant host country laws, regulations and permits that pertain to environmental and social issues. EPFIs operate in diverse markets: some with robust environmental and social governance, legislation systems and institutional capacity designed to protect their people and the natural environment; and some with evolving technical and institutional capacity to manage environmental and social issues. The EPFI will require that the Assessment process evaluates compliance with the applicable standards as follows: • For Projects located in Non-Designated Countries, the Assessment process evaluates compliance with the then applicable IFC Performance Standards on Environmental and Social Sustainability (Performance Standards) and the World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines) (Exhibit III). • For Projects located in Designated Countries, the Assessment process evaluates compliance with relevant host country laws, regulations and permits that pertain to environmental and social issues. Host country laws meet the requirements of environmental and/or social assessments (Principle 2), management systems and plans (Principle 4), Stakeholder Engagement (Principle 5) and, grievance mechanisms (Principle 6). The Assessment process will establish to the EPFI's satisfaction the Project's overall compliance with, or justified deviation from, the applicable standards. The applicable standards (as described above) represent the minimum standards adopted by the EPFI. The EPFI may, at their sole discretion, apply additional requirements.
Principle 4	**Environmental and Social Management System and Equator Principles Action Plan** For all Category A and Category B Projects, the EPFI will require the client to develop or maintain an Environmental and Social Management System (ESMS). Further, an Environmental and Social Management Plan (ESMP) will be prepared by the client to address issues raised in the Assessment process and incorporate actions required to comply with the applicable standards. Where the applicable standards are not met to the EPFI's satisfaction, the client and

Equator Principle	Details
	the EPFI will agree an Equator Principles Action Plan (AP). The Equator Principles AP is intended to outline gaps and commitments to meet EPFI requirements in line with the applicable standards.
Principle 5	**Stakeholder Engagement** For all Category A and Category B Projects, the EPFI will require the client to demonstrate effective Stakeholder Engagement as an on-going process in a structured and culturally appropriate manner with Affected Communities and, where relevant, Other Stakeholders. For Projects with potentially significant adverse impacts on Affected Communities, the client will conduct an Informed Consultation and Participation process. The client will tailor its consultation process to: the risks and impacts of the Project; the Project's phase of development; the language preferences of the Affected Communities; their decision-making processes; and the needs of disadvantaged and vulnerable groups. This process should be free from external manipulation, interference, coercion and intimidation. To facilitate Stakeholder Engagement, the client will, commensurate to the Project's risks and impacts, make the appropriate Assessment Documentation readily available to the Affected Communities, and where relevant Other Stakeholders, in the local language and in a culturally appropriate manner. The client will take account of, and document, the results of the Stakeholder Engagement process, including any actions agreed resulting from such process. For Projects with environmental or social risks and adverse impacts, disclosure should occur early in the Assessment process, in any event before the Project construction commences, and on an on-going basis.
Principle 6	**Grievance Mechanism** For all Category A and, as appropriate, Category B Projects, the EPFI will require the client, as part of the ESMS, to establish a grievance mechanism designed to receive and facilitate resolution of concerns and grievances about the Project's environmental and social performance. The grievance mechanism is required to be scaled to the risks and impacts of the Project and have Affected Communities as its primary user. It will seek to resolve concerns promptly, using an understandable and transparent consultative process that is culturally appropriate, readily accessible, at no cost, and without retribution to the party that originated the issue or concern. The mechanism should not impede access to judicial or administrative remedies. The client will inform the Affected Communities about the mechanism in the course of the Stakeholder Engagement process.
Principle 7	**Independent Review** ***Project Finance*** For all Category A and, as appropriate, Category B Projects, an Independent Environmental and Social Consultant, not directly associated with the client, will carry out an Independent Review of the Assessment Documentation including the ESMPs, the ESMS, and the Stakeholder Engagement process documentation in order to assist the EPFI's due diligence, and assess Equator Principles compliance. The Independent Environmental and Social Consultant will also propose or opine on a suitable Equator Principles AP capable of bringing the Project into compliance with the Equator Principles, or indicate when compliance is not possible. ***Project-Related Corporate Loans*** An Independent Review by an Independent Environmental and Social Consultant is required for Projects with potential high-risk impacts including, but not limited to, any of the following:

EQUATOR PRINCIPLE	DETAILS
	• Adverse impacts on indigenous peoples • Critical Habitat impacts • Significant cultural heritage impacts • Large-scale resettlement In other Category A, and as appropriate Category B, Project-Related Corporate Loans, the EPFI may determine whether an Independent Review is appropriate or if internal review by the EPFI is sufficient. This may consider the due diligence performed by a multilateral or bilateral financial institution or an OECD Export Credit Agency, if relevant.
Principle 8	**Covenants** An important strength of the Equator Principles is the incorporation of covenants linked to compliance. For all Projects, the client will covenant in the financing documentation to comply with all relevant host country environmental and social laws, regulations and permits in all material respects. Furthermore, for all Category A and Category B Projects, the client will covenant the financial documentation: a) To comply with the ESMPs and Equator Principles AP (where applicable) during the construction and operation of the Project in all material respects; and b) To provide periodic reports in a format agreed with the EPFI (with the frequency of these reports proportionate to the severity of impacts, or as required by law, but not less than annually), prepared by in-house staff or third-party experts, that i) document compliance with the ESMPs and Equator Principles AP (where applicable), and ii) provide representation of compliance with relevant local, state and host country environmental and social laws, regulations and permits; and c) To decommission the facilities, where applicable and appropriate, in accordance with an agreed decommissioning plan. Where a client is not in compliance with its environmental and social covenants, the EPFI will work with the client on remedial actions to bring the Project back into compliance to the extent feasible. If the client fails to re-establish compliance within an agreed grace period, the EPFI reserves the right to exercise remedies, as considered appropriate.
Principle 9	**Independent Monitoring and Reporting** ***Project Finance*** To assess Project compliance with the Equator Principles and ensure on-going monitoring and reporting after Financial Close and over the life of the loan, the EPFI will, for all Category A and, as appropriate, Category B Projects, require the appointment of an Independent Environmental and Social Consultant, or require that the client retain qualified and experienced external experts to verify its monitoring information which would be shared with the EPFI. ***Project-Related Corporate Loans*** For Projects where an Independent Review is required under Principle 7, the EPFI will require the appointment of an Independent Environmental and Social Consultant after Financial Close, or require that the client retain qualified and experienced external experts to verify its monitoring information which would be shared with the EPFI.
Principle 10	**EPFIs Reporting** ***Client Reporting Requirements*** The following client reporting requirements are in addition to the disclosure requirements in Principle 5. For all Category A and, as appropriate, Category B Projects:

Equator Principle	Details
	• The client will ensure that, at a minimum, a summary of the ESIA is accessible and available online. • The client will publicly report GHG emission levels (combined Scope 1 and Scope 2 Emissions) during the operational phase for Projects emitting over 100,000 tonnes of CO2 equivalent annually. Refer to Annex A for detailed requirements on GHG emissions reporting. ***EPFI Reporting Requirements*** The EPFI will report publicly, at least annually, on transactions that have reached Financial Close and on its Equator Principles implementation processes and experience, taking into account appropriate confidentiality considerations. The EPFI will report according to the minimum reporting requirements detailed in Annex B.

Based on the project type and surrounding environment of the proposed development, the 200 MIGD SWRO project may be classified under Category B project according to Equator Principle 1, as there is a potential for limited adverse social or environmental risks and /or impacts that are few in number, generally site-specific, largely reversible and readily addressed through the implementation of mitigation measures.

Additional Lenders Requirement

The following section provides specific lender's requirements that are applicable to the proposed project with respect to air, noise and vibration, marine, souls and groundwater etc.

WHO Ambient Air Quality Standards

WHO ambient air quality standards as adopted by the IFC General EHS Guidelines are presented in the table below.

Table 2-9 WHO Ambient Air Quality Standards (μg/m³ unless stated)

Parameter	WHO Standards	
	24 hour	Annual
PM_{10}	150 (Interim target 1)	70 (Interim target 1)
	100 (Interim target 2)	50 (Interim target 2)
	75 (Interim target 3)	30 (Interim target 3)
	50 (guideline)	20 (guideline)

Parameter	WHO Standards	
	24 hour	Annual
$PM_{2.5}$	75 (Interim target 1)	35 (Interim target 1)
	50 (Interim target 2)	25 (Interim target 2)
	37.5 (Interim target 3)	15 (Interim target 3)
	25 (guideline)	10 (guideline)
Nitrogen Dioxide	200 (1 hour)	40
Sulphur Dioxide	125 (Interim target 1)	500 (10-minute guideline)
	50 (Interim target 2)	
	20 (guideline)	
Ozone	100 (8 hour daily maximum guideline)	-

WHO Noise Standards

The projects lenders will require compliance with the IFC Performance Standards and IFC EHS Guidelines. The IFC EHS General Guidelines (2007) reference the World Health Organisation (WHO) noise standards that indicate the maximum allowable noise levels to be received at nearby receptors, which depends on receptor classification.

It is stated within the WHO noise standards that noise impacts should not exceed the levels which are presented in the table below or result in a maximum increase in background levels of 3dB at the nearest off-site point of reception.

Table 2-10 WHO Noise Standards (At off-site Receptors)

Receptor	One Hour Leq (dB(A))	
	Daytime 07:00 – 22:00	Night time 22:00 – 07:00
Residential, Institutional, Educational	55	45
Industrial, Commercial	70	70

Furthermore, the following requirements have also been specified in the IFC EHS noise guidelines:

- No employee should be exposed to a noise level greater than 85 dB (A) for duration of more than 8 hours per day without hearing protection. In addition, no unprotected ear should be exposed to a peak sound pressure level (instantaneous) of more than 140 dB(C).

- The use of hearing protection should be enforced actively when the equivalent sound level over 8 hours reaches 85 dB (A), the peak sound level reaches 140 dB(C), or the average maximum sound level reaches 110 dB (A). Hearing protective devices provided should be capable of reducing sound level at the ear to at least 85 dB (A).
- For every 3 dB(A) increase in sound levels, the allowed exposure period or duration should be reduced by 50%.
- Where feasible, use of acoustic insulating materials isolations of the noise source and other engineering controls should be investigated and implemented prior to the issuance of hearing protection devices as the final control mechanism.
- Medical hearing checks on workers exposed to high noise levels should be performed

EHS Guidelines for Water & Sanitation

The EHS Guidelines for Water and Sanitation (2007) include information relevant to the operation and maintenance of potable water treatment and distribution systems. The guidelines include applicable recommendations including, but not limited to, the following:

- Limit maximum through-screen design intake velocity to limit entrainment of aquatic organisms;
- Measures to manage solid wastes from water treatment including disposal of lime, ferric and alum sludges;
- Treat and dispose of reject streams, including brine, consistent with national and local requirements;
- Recycle filter backwash into the process if possible;
- Store sodium hypochlorite in cool, dry, and dark conditions for no more than one month, and use equipment constructed of corrosion-resistant materials;
- Minimize the amount of chlorination chemicals stored on site while maintaining a sufficient inventory to cover intermittent disruptions in supply

Soil and Groundwater Standards

The IFC Performance Standards requires adherence to IFC Performance Standard 3 on 'Resource Efficiency and Pollution Prevention' requires the client and/or the Project to:

- Avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities; and

Prevent the release of pollutants to water and land due to routine, non-routine, and accidental circumstances, or when not feasible, minimize and/or control the intensity and mass flow.

As there are no defined soil and groundwater standards for Abu Dhabi or the UAE, the use of the 'Dutch Soil Guideline' or Dutch standards can be considered as a good practice standard for the analysis of soils and groundwater, as they are considered a good international practice.

The Dutch Standards identify maximum allowable concentrations for contaminants in soil and groundwater. The soil intervention values indicate when the functional properties of the soil for humans, plants and animals is seriously impaired or threatened. They are representative of the level of contamination above which a serious case of soil contamination is deemed to exist.

Groundwater target values provide an indication of the benchmark for environmental quality in the long term, assuming that there are negligible risks for the ecosystem. The Dutch Standards for the most significant pollutants are presented in Table 2-11. Where a parameter is not covered by Dutch Standards, other appropriate international standards will be used.

Table 2-11 Dutch Soil and Groundwater Standards

PARAMETERS	SOIL (MG/KG DRY MATTER)		GROUNDWATER (µG/L)	
	TARGET VALUE*	INTERVENTION VALUE	TARGET VALUE	INTERVENTION VALUE
Heavy Metals				
Arsenic	29	76	10	60
Barium	160	-	50	625
Cadmium	0.8	13	0.4	6
Chromium	100	-	1	30
Chromium III	-	180	-	-
Chromium IV	-	78	-	-
Cobalt	-	190	20	100
Copper	36	190	15	75
Lead	85	530	15	75
Mercury	0.3	36 (inorganic) 4 (organic)	0.05	0.3
Molybdenum	3	190	5	300
Nickel	35	100	15	75
Zinc	140	720	65	800
Aromatic Compounds				
Benzene	0.01	1.1	0.2	30
Ethyl benzene	0.03	110	4	150
Toluene	0.01	32	7	1000
Xylene (sum)	0.1	17	0.2	70
Styrene (vinylbenzene)	0.3	86	6	300
Phenol	0.05	14	0.2	2000

Parameters	Soil (mg/kg dry matter)		Groundwater (µg/l)	
	Target value*	Intervention value	Target value	Intervention value
Cresols (sum)	0.05	13	0.2	200
Chlorinated Hydrocarbons				
Volatile Hydrocarbons				
monochloroethene (vinyl chloride)	0.01	0.1	0.01	5
dichloromethane	0.4	3.9	0.01	1,000
1,1-dichloroethane	0.02	15	7	900
1,2-dichloroethane	0.02	6.4	7	400
1,1-dichloroethene	0.1	0.3	0.01	10
1,2-dichloroethene (sum)	-	1	0.01	20
Dichloropropanes (sum)	-	2	0.8	80
Trichloromethane (chloroform)	0.02	5.6	6	400
1,1,1-trichloroethane	0.07	15	0.01	300
1,1,2-trichloroethane	0.4	10	0.01	130
Trichloroethene (Tri)	0.1	2.5	24	500
Tetrachloromethane (Tetra)	0.4	0.7	0.01	10
Tetrachloroethene (Per)	0.002	8.8	0.01	40
Chlorobenzenes				
Monochlorobenzene	-	15	7	180
Dichlorobenzenes (sum)	-	19	3	50
Trichlorobenzenes (sum)	-	11	0.01	10
Tetrachlorobenzenes (sum)	-	2.2	0.01	2.5
Pentachlorobenzene	-	6.7	0.003	1
Hexachlorobenzene	-	2.0	0.00009	0.5
Chlorophenols				
Monochlorophenols (sum)	-	5.4	0.3	100
Dichlorophenols (sum)	-	22	0.2	30
Trichlorophenols (sum)	-	22	0.03	10
Tetrachlorphenols (sum)	-	21	0.01	10
Pentachlorophenol		12	0.04	3

Waste Management

International financial institutions providing project finance will likely require adherence with the IFC General EHS Guidelines. With regard to waste, these guidelines require that projects:

- Establish waste management priorities at the outset of activities.
- Identify EHS risks and impacts with regards to waste generation and its consequences.
- Establish a waste management hierarchy that considers prevention, reduction, reuse, recovery, recycling, removal and finally disposal of wastes.

- Avoid or minimize the generation waste materials, as far as practicable.
- Identify where waste generation cannot be avoided but can be minimized or where opportunities exist for, recovering and reusing waste.

Where waste cannot be recovered or reused, identify means of treating, destroying, and disposing of it in an environmentally sound manner.

Archaeology and Cultural Heritage

Since the project will receive funding from International Financial Institutions, the lenders will require the project to adhere to IFC Performance Standard 8, which requires the identification and protection of features of cultural heritage value and "… *recognise the importance of cultural heritage for current and future generation and aims to ensure that clients protect cultural heritage in the course of their project activities*".

Community Health and Safety

International Financial Institutions (IFIs) will require adherence to IFC Performance Standard 4 on Community Health, Safety and Security. The objectives of PS 4 are to:

- To anticipate and avoid adverse impacts on the health and safety of the Affected Community during the project life from both routine and non-routine circumstances;
- To ensure that the safeguarding of personnel and property is carried out in accordance with relevant human rights principles and in a manner that avoids or minimises risks to the Affected Communities.

Workers Conditions & Occupational Health and Safety

The IFC Performance Standards that aim to identify and ensure that social and economic impacts of a project are addressed in the relevant areas is the IFC PS 2: Labour and Working Conditions. In line with PS 2, the following conventions must be complied with:

- ILO Convention 29 on Forced Labour;
- ILO Convention 105 on the Abolition of Forced Labour;
- ILO Convention 138 on Minimum Age (of Employment);
- ILO Convention 182 on the Worst Forms of Child Labour;
- ILO Convention 1000 on Equal Remuneration;
- ILO Convention 111 on Discrimination (Employment and Occupation);
- UN Convention on the Rights of the Child, Article 32.1; and
- UN Convention on the Protection of the Rights of all Migrant Workers and Members of their Families.

2.8 Permits Issued by Regulator (EAD)

An approval has been obtained on 7th July 2019 for the onshore construction works as shown in Figure below. In addition, a preliminary approval for the offshore construction activities for the proposed Project has been obtained from EAD on 8th August, 2019 (Letter ref: EAD/EQS/2019/1234). The approval is limited to three (3) months and valid to 31st October 2019. The conditions of the preliminary approval are shown in the Letter below (reference: EAD/INC/2019/968.

Figure 2-1 EAD Onshore Construction Activities Approval

هيئة البيئة - أبوظبي
Environment Agency - ABU DHABI

التاريخ: 2019/07/07
المرجع: EAD/EQS/2019/1019

السيد /إسحاق حسن الحمادي المحترم
المدير العام -دولة الإمارات العربية المتحدة
اكوا باور

تحية طيبة وبعد،

الموضوع: الشروط البيئية للعمليات الإنشائية البرية لمحطة الطويلة لتحلية مياه البحر بالتناضح العكسي

تهديكم هيئة البيئة أطيب التحيات، وتثمن دوركم في الحفاظ على البيئة بإمارة أبوظبي وتنميتها، وبالإشـارة إلى الموضـوع أعلاه وتبعاً لمراسلتكم بتاريخ 23 يونيو 2019، تعلمكم هيئة البيئة بموافقتها على طلبكم بدء العمليات الإنشائية البرية بناء على التعهدات التي تم تقديمها من قبلكم.

أما بالنسبة للعمليات الإنشائية البحرية، فلا يجب البدء بها إلا بعد إصدار الموافقة النهائية على دراسة تقييم الأثر البيئي المعدّلة، بما فيها التصـميم المعدّل لأنبوب تصـريف المياه المركزة للبحر، والقيام بتحديث تقرير النمذجة الرياضـية لحركة المياه والقياسـات والدراسات المطلوبة، والتي ستصلكم عبر رد الهيئة على دراسة تقييم الأثر البيئي المعدّلة.

وتقبلوا فائق الاحترام والتقدير،

شيخة أحمد الهوسني
مدير تنفيذي - قطاع جودة البيئة

هيئة البيئة - أبوظبي
Environment Agency - Abu Dhabi

Figure 2-2 EAD Offshore Construction Activities Preliminary Approval

هيئة البيئة - أبوظبي
Environment Agency - ABU DHABI

التاريخ: 2019/08/08
المرجع: EAD/EQS/2019/1234

السيد/ إسحاق حسن الحمادي المحترم
المدير العام - دولة الإمارات العربية المتحدة
أكوا باور

تحية طيبة وبعد،

الموضوع: الموقف المبدئي لشركة مياه وكهرباء الإمارات على مشروع المياه المستقلة في الطويلة

[illegible] 2019/07/23 [illegible] 2019/08/01 [illegible]

وتقبلوا فائق الاحترام و التقدير،

خالد الهاجري
مدير قسم - الامتثال والتطبيق

Figure 2-3 EAD Offshore Construction Activities Preliminary Approval Conditions

Attachment A: EAD Comments and Recommendations

Project Name:	Taweelah 200 MIGD Independent Water Project (IWP)
Project Proponent:	ACWA Power
Environmental Consultant:	HDR
Type of Study:	Other
Task ID	EAD/INC/2019/968

	The request for preliminary approval to begin offshore construction activities for the Taweelah 200 MIGD Independent Water Project is granted under the following conditions:
1.	The approval is as per the defined activities listed in the letters dated 23rd July 2019, 1st August 2019 and in the clarification email dated 6th August 2019. This is limited to: o Pushing fill material from the beach out into the marine environment to create a construction platform from which the open intake channel can be excavated, o Dredging of the open intake channel and associated breakwater toe trench, o Start of construction of the rock revetment protecting the open intake channel (i.e. placement of quarry run core material placed using dumper trucks and excavators)
2.	The scope of this preliminary approval is limited to three months (ending 31st October 2019).
3.	This preliminary approval is not renewable.
4.	The project must adhere to the timeframe for the construction activities submitted 1st August 2019.
5.	The project must adhere to the monitoring plans submitted 1st August 2019.
6.	This preliminary approval does not affect the review and approval process for the EIA and associated studies prior to issuing the permit for this project.
7.	No borrow areas are included in this preliminary approval.
8.	Any modifications to the activities, schedule or scope of work for the duration of this preliminary approval must be communicated to EAD for review and approval before implementation.
9.	Any modifications to the activities, schedule or scope of work must be incorporated into the environmental assessments for EAD approval.
10.	EAD must be immediately notified in the event of any environmental incidents and a close out report must be submitted within 30 calendar days.
11.	The project proponent must provide online real time monitoring for turbidity to EAD as discussed in the meeting dated 1st August 2019.
12.	An environmental audit report must be submitted to EAD before October 31st 2019 regardless of the permitting and assessment status of the project at that time.
13.	The environmental audit report must be prepared by an EAD approved third party environmental consultant as per the Technical Guidance Document for Environmental Audit Report.
14.	All construction activities must adhere to the management plans included as part of the letter received 1st August 2019 from ACWA Power.
15.	In the event that the environmental studies are approved and the permit is issued before October 31st 2019, the project proponent and their assigned contractors must adhere to the approved measures described in the environmental studies and the environmental permit conditions. This preliminary approval will then be considered null and void.
16.	As per the clarifications made during the call between the proponent, the environmental consultant and EAD on 6th August 2019, no temporary jetty will be constructed and thus it is not part of the scope included in this preliminary approval.

3 Project Description

3.1 Statement of Need

EWEC Statement of Future Capacity Requirements 2018 – 2024 Report has identified the need for additional Reverse Osmosis (RO) production capacity in the Emirate of Abu Dhabi in order to meet anticipate growth in potable water demand. On the basis of the analysis, EWEC identified the requirement for 251 MIGD of additional RO capacity to be available by 2022.

The projected change in composition of Abu Dhabi's power generation sector will create a need for additional stand-alone desalination capacities that are not constrained by any associated power production. Although standalone water production is theoretically achievable with Multi Stage Flash (MSF) and Multi-effect Distillation (MED) technologies coupled to dedicated boilers, the most economical solution to achieve this is to use RO technology.

The additional RO desalination capacity is required in 2020/21 to ensure security of supply for the Emirate. On a systemic basis, RO is now significantly more efficient than thermal desalination technologies. RO will enhance operational flexibility, enabling Abu Dhabi's current gas-fired IWPP fleet to be operated more efficiently, allowing additional savings of gas. The adoption of RO also delivers significant benefits in improved dispatch flexibility, which will be essential as inflexible nuclear power and renewable energy form a larger portion of Abu Dhabi's installed generation capacity.

Meeting the anticipated growth in potable water demand using RO technology rather than traditional coupled thermal desalination technology also provides economic and strategic benefits. Thermal plants in the UAE currently rely on gas combustion driven turbines and heat recovery systems. The EWEC analysis indicates that for all possible gas prices, water production cost of RO are lower than the specific cost of the existing fleet. Use of RO technology also reduces reliance on fluctuating fuel prices.

3.2 Project Location and Scale

The proposed development site is situated within the Taweelah Power and Water Complex, located in the Al Taweelah area of the Emirate of Abu Dhabi. The existing Taweelah

Complex commenced development in the 1970s and has grown rapidly since the 1990s. The complex now contains three (3) combined gas cycle power generation and thermal desalination (MSF/MES) plants. The existing complex has a total net power generation capacity of 4,113 MW and a net water production capacity of 294 MIGD (ADWEC, 2017[3]).

Plates 3-1 Taweelah Power and Generation - A View from the Northern Project Boundary

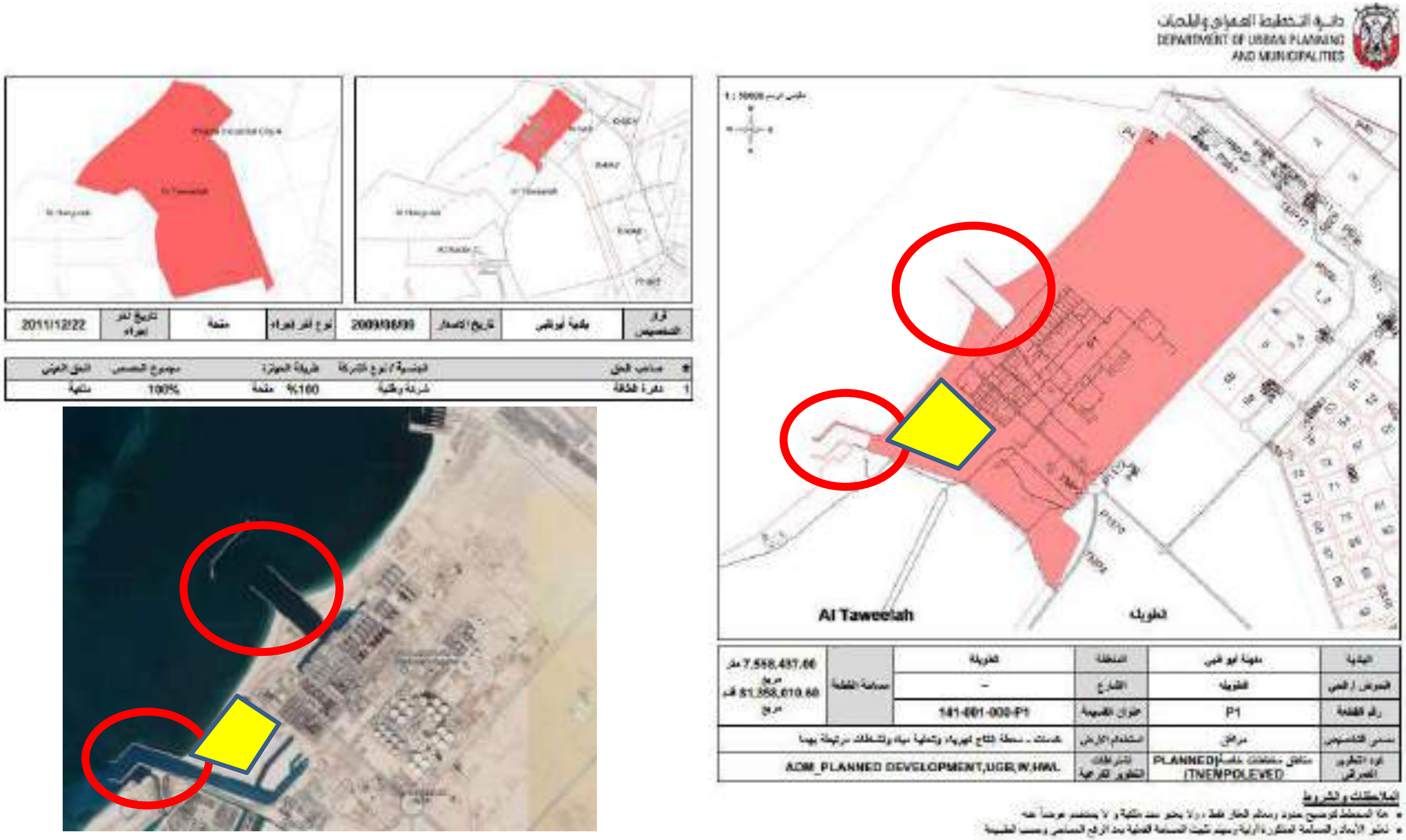
The existing Taweelah Complex abstracts a significant volume of water through an open shoreline intake located to the north of the Project site. Cooling water and brine effluent from the Complex is discharged through a single discharge channel located to the south of the Project site. Data provided by EWEC in 2018 indicate intake volumes of 693,720 m^3 / hr with outfall flows of 640,440 m^3 / hr. The excess temperature at point of discharge is in the region of 6-7°C. Excess salinity was not reported but ΔS is also significant at the point of discharge. As such, the existing Taweelah Complex operations exert a significant influence over the nearshore waters adjacent to the Project site.

[3] http://www.adwec.ae/existing.html

The plot, located in the southern portion of the Taweelah Power and Water Complex, has a footprint area of approximately 379,000 m^2. The site is bordered to the south and west by the Taweelah outfall channel that transports thermal and brine effluent from the power generation and desalination process to the Arabian Gulf, located approximately 50 metres to the northwest of the site boundary. The site affection plan for Taweelah Power and Water Complex is presented in Figure below. The plot for the RO plant is highlighted in yellow.

Figure 3-1 Project Location in relation to Taweelah Complex

Figure 3-2 Affection Plan of Taweelah Complex



The site is devoid of any buildings other than a small open-sided shade structure. The south west of the project site contains a gas pipeline corridor measuring approximately 20 metres in width. This portion of the site contains the Dolphin Gas Pipeline transporting natural gas from the gas processing and compression plant at Ras Laffan. The pipeline was commissioned in 2007 and has the capacity to transport up to two (2) billion cubic feet of natural gas per day from Qatar to the UAE. In addition to the Dolphin Gas Pipeline there is also documented evidence of a CICPA/Etisalat submarine communications cable that runs to the west of the Project site.

Figure 3-3 Location of Dolphin Gas Pipeline and Submarine Cable

Figure 3-4 Project Site Showing the Boundary Site Coordinates

The site consists of coastal sand sheet with covering of imported excavated marine dredged spoil (see Figure 3-3 and Plate 3-2). The site shows scars from historical cut and fill operations and sparse coverage of halophytic shrubs. The vegetation has naturally colonized the site since 2008 when historical aerial imagery shows the majority of the site to be largely devoid of vegetation.

Plates 3-2 View of the Project Site from the Northern Corner Towards the South

A review of publicly available historical aerial imagery of the proposed development site, obtained from Google Earth, indicates that the site has been utilized as a storage area for dredged material (Figure 3-4). It is understood that the excavated material was stockpiled at the site during dredging of the Taweelah outfall channel that runs parallel to the southern site boundary.

Two (2) large stockpiles are evident in the first detailed image of the site, taken in 2007.

The 2008 image shows a temporary office complex at the northern boundary of the site which is assumed to have been the offices for the contractor carrying out the Taweelah B Plant expansion, completed in October 2008. The area around the office site was also used as a stockpile / laydown area.

The image from 2012 shows the stockpiles to have been reduced in size with scars from excavators evident across the majority of the site. The site shows minimal change between 2012 and the most recent image, taken in November 2017.

Figure 3-5 Historical Aerial Imagery of the Site

2007

2008

2012

2017

(Source: Google Earth Pro, 2018)

Land use surrounding the Taweelah Complex is predominantly industrial to the north and east. The Khalifa Port is 2 km to the north whilst the Emirates Global Aluminium (EGA) alumina refinery is located 4 km northeast of Taweelah. Immediately to the west of the EGA refinery, the Shaheen Bauxite Refinery is currently under construction.

Both the EGA smelter and the bauxite refinery sit within the footprint of Khalifa Industrial Zone Area A (KIZAD A). KIZAD is under development and is expected to be the industrial and logistical hub of the Emirate of Abu Dhabi by 2030. The entire KIZAD A area has been prepared for development. As such, the majority of the area has undergone site enabling works with extensive cut and fill operations and construction of infrastructure. As such, the terrestrial ecology of the area has been significantly degraded.

Immediately to the north of the Taweelah Complex boundary is the Emirates Heritage Club marina that occupies a small parcel of land between the Taweelah complex and the Khalifa Port. On the southern boundary of the Khalifa Port there is an operational outfall that is operated by Abu Dhabi Ports. The outfall predominantly discharges waste brine effluent and cooling waters from the Emirates Global Aluminium (EGA) smelter, located within Khalifa Port, with other operators discharging small volumes of industrial effluent into the discharge line. Information provided by Abu Dhabi Ports to HR Wallingford suggest a flowrate of 33,480 m^3/hr with a ΔT of +3.6°C and a ΔS of +3.9 PSU (HR Wallingford, 2019).

To the south of the Taweelah Complex boundary is the area of Al Hanjurah which is predominantly privately owned land that includes forestry plantations and private residences believed to belong to members of the Abu Dhabi Royal Family. The figure below presents the areas of critical habitat in the vicinity of the project site as per the EAD "EnviroPortal" GIS resource.

Figure 3-6 Areas of Environmental Sensitivity

Source: EAD, 2018

The key areas of note and distance from the project site are as follows:

- Fringing coral reef (purple):
  - Coverage starts approximately 1 km southwest of the site boundary beyond the existing Al Taweelah outfall

- Fringing reef to the south of the Project site which has historically been dominated by macroalagal assemblages. Areas to the north east in Ras Ghanada, support regionally significant coral assemblages.

- Areas of seagrass coverage (light green):

- Shallow marine waters adjacent to the Taweelah Complex seawater intake channel. Coverage starts approximately 300 metres from the proposed site boundary.

- Ras Ghanada Marine Protected Area -MPA (red outline):

- Located to the north of Khalifa Port, the MPA contains extensive areas of coral and seagrass beds that are regionally significant. The MPA is located approximately 7 km northeast of the proposed site.

3.3 Local Receptors and Sensitivities

Satellite imagery and site visits undertaken at the project site identified commercial, residential and industrial receptors external to the SWRO project as shown in the table and figure below.

Table 3-1 Potential Local Receptors

Receptor	Receptor Type	Distance from the Project Site
Taweelah Complex	Industrial	Borders the project site to the north.
Khalifa Port	Commercial	Approximately 2km north of the project site.
Emirates Global Aluminium (EGA) alumina refinery	Industrial	Approximately 4km northeast of the project site.
KIZAD Area A	Commercial	Approximately 2.5 km northeast of the project site
CICPA/Etisalat submarine	Commercial	Approximately 45 m northwest of the project site
Dolphin Gas Pipeline	Industrial	Cuts across the extreme south of the project site
Emirates Heritage Club marina	Commercial	Approximately 3km north of the project site
Al Hanjurah	Residential	Buildings within Hunjura are located approximately 400-500 m south of the project site.
Marine Protected Area	Ecological	Approximately 7 km north east of the project site

Figure 3-7 Sensitive Receptors near the project site

3.4 Project Description

The proposed development will employ Seawater Reverse Osmosis (SWRO) technology to produce up to 200 MIGD potable water, equivalent to 909,216 m^3/day with production capacity of 37,884 m^3/hr.

The process of seawater reverse osmosis involves the intake of seawater from the marine environment. Following physical filtration and pre-treatment to remove biological impurities, this feedwater is then passed through pressured trains containing multiple thin-film composite membranes that are partially permeable. The high pressure in the filter train and partial permeability of the membranes means that water is forced against the osmotic gradient whilst salts are excluded. Modern commercially available membranes can offer up to 99.8% salt rejection, though the precise values are dependent upon the nature of the feedwater. The by-product of the desalination process is concentrated brine with high concentrations of salts. This brine effluent is typically discharged back into the marine environment. The product of the desalination process is water with a very low salt content. This is then treated to make the water suitable for consumption and transported to the distribution network.

The operational requirements for feedwater have been provided by ACWA Power. The threshold limits for critical parameters in ambient seawater required to guarantee suitable quality and quantity of potable water are provided in the table below.

Table 3-2 Production Design Limits

PARAMETER	UNITS	THRESHOLD VALUES
Total Dissolved Solids (TDS)	mg/L	42,000 - 48,000
Total Suspended Solids (TSS)	mg/L	<10
Temperature	°C	19 – 37
Algal Content	cells/ml	<10,000
Boron	mg/L	<6
Oil and Grease	mg/L	<1

3.5 Project Components

A site plan for the proposed development is provided in the figures below. The IWP site layout plan shows the intake/outfall and RO Plant, together with the water storage tanks and construction laydown area. Once construction has been completed roof-top PV panels will be installed on top of the water storage tanks and laydown area, and surrounding the RO Plant (Figure 3-7). The ACWA Power site plan (Figure 3-8) shows the intake structure and associated buildings, the RO Plant buildings diagonally across the site surrounded by PV panels (blue, green, pink) and the infrastructure corridor. The following sub-sections provide details various facility components.

Figure 3-8 Taweelah IWP Layout and Associated Facilities

Figure 3-9 Taweelah IWP - ACWA Power Site Plan

3.5.1 Open Seawater Intake

The facility will have a combined seawater intake and pumping system that will be required to draw in 2,482,944 m^3 of seawater each day. This volume will provide sufficient seawater to meet the production demand at all possible operating points, including the most adverse seawater conditions in the design envelope (refer to table 3-1). The intake velocity, as per current design specifications, will be 0.15 m/s (as per IFC guideline) up to a maximum of 0.2 m/s (ACWA Power, 2019).

The location of the intake channel was pre-set by EWEC at the concept design stage. Given the intake volumes required, initial design calculations conducted at the concept design phase estimated that using a submerged pipe intake to draw water in to the facility would require 6 intake lines each with a 2 metre diameter. In light of this, an intake channel was preferred. Use of the existing intake channel was also considered as an option. The intake volumes required by the new facility render this option non-viable on the basis that intake velocities in the channel will exceed the threshold at which physical screening can operate effectively, with potential impacts to operation of both the Project and the neighbouring Taweelah Complex. The preferred configuration of the open intake channel is shown in the figure below.

The open seawater intake system will include breakwater facilities allowing the seawater to enter into an open intake channel. The breakwaters will be designed to protect the calm basin from the predominant wave cycle from the north and northwest.

Figure 3-10 Open Intake Channel Configuration

The open intake channel will lead to a stilling basin (intake bay). As feedwater is drawn into the plan, intake waters will be physically screened. The screening system will be composed of five screening channels (each capable of handling 25% of the total flow), each one equipped with bar screens (space between bars 30~50 mm) and travelling band screen (mesh opening size 5 mm).

The screening system will be capable of screening solids (e.g. floating matter, algae, mussels, fish or jellyfish) down to at least five (5) mm in size. The screening trains will be designed so that failure will not cause the facility to cease operation. The intake screening and filtration is required to ensure that intake waters can still be drawn into the plant even during the most unfavourable conditions with regard to seawater level, pollution, and clogging of some of the intake screens. Solid waste filtered out by the physical screens will be transferred to a standardized waste container. Solid wastes will be treated as organic waste and stored and transferred off the site in accordance with Abu Dhabi Centre for Waste Management (Tadweer) Regulations.

Revolving bar screens and travelling band or drum screens will be constructed of seawater resistant material, will have an automatic cleaning system. The installations of each screening channel as well as other equipment installed in the pumping station, including related embedded parts, will be equipped with fully automatically controlled cathodic corrosion protection systems.

3.5.2 Intake Pumps and Pre-Treatment

The screens and seawater pumping station will be designed to allow particular pipes and associated pumps to be operated independently from each other. All hydraulic structures will be designed to ensure favourable flow, in order to prevent dead water areas, reverse currents, flow separation and eddies. The intake pumping station will be arranged in such a way that it will be possible to sectionalize, close and empty for maintenance and / or cleaning.

A forebay preceding the pump pits will be designed to ensure non-turbulent flow of seawater to the pumps. Five pumps, four in operation and one standby, will draw water into the intake chamber and pump feedwater on to the facility. The delivery line of each pump discharges the seawater in a common header that is then divided in two lines satisfying hydraulic performance. The pumping station will be designed as a gravity structure, which will be non-buoyant by its own weight in the event of the whole pumping station being emptied.

A hydraulic model for the proper working of the pumping station will be specified and tests carried out by a specialized laboratory. The pump performance and flow conditions within the pumping station will be investigated for different combination of:

- Open or close of different screening trains;
- Water levels; and
- Operation of various pumps.

3.5.3 Dissolved Air Floatation (DAF) Filtration

A Dissolved Air Floatation (DAF) system will provide additional filtration of the feedwater should this be required. Under normal operating conditions, when there are no excessive blooms of algae, there is no oil or floating grease (below 0.1 ppm) and TSS is lower than 10 ppm, the DAF system will not be utilised. Should any of the thresholds be exceeded, the DAF system will be utilized to remove potential contaminants or impurities that could not be removed by the physical screening process. Two blocks of DAF will be supplied, each serving 100 MIGD of water production. Each group will be comprised of 18 units as shown in the figures below.

Figure 3-11 Plan View of Proposed DAF System

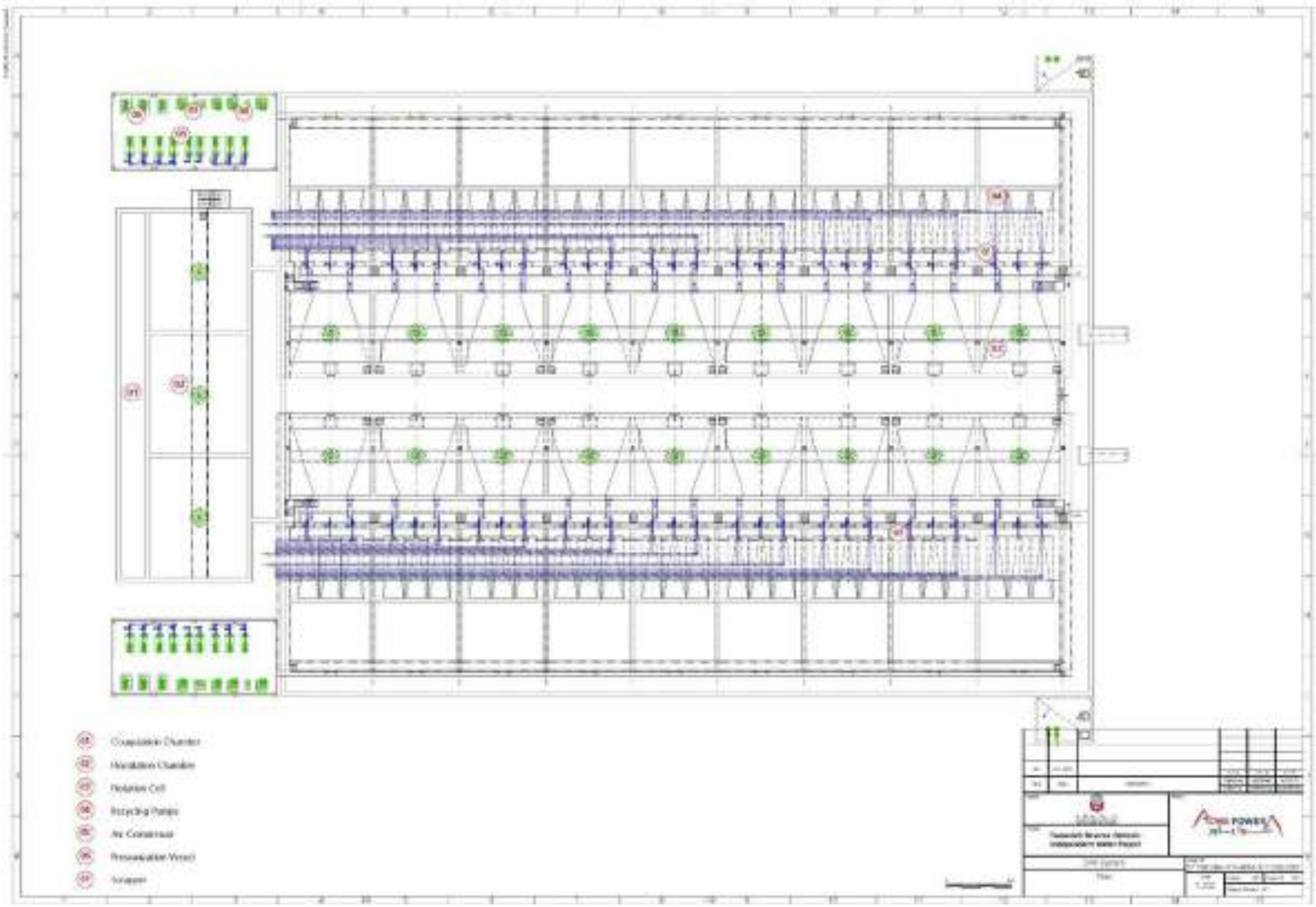
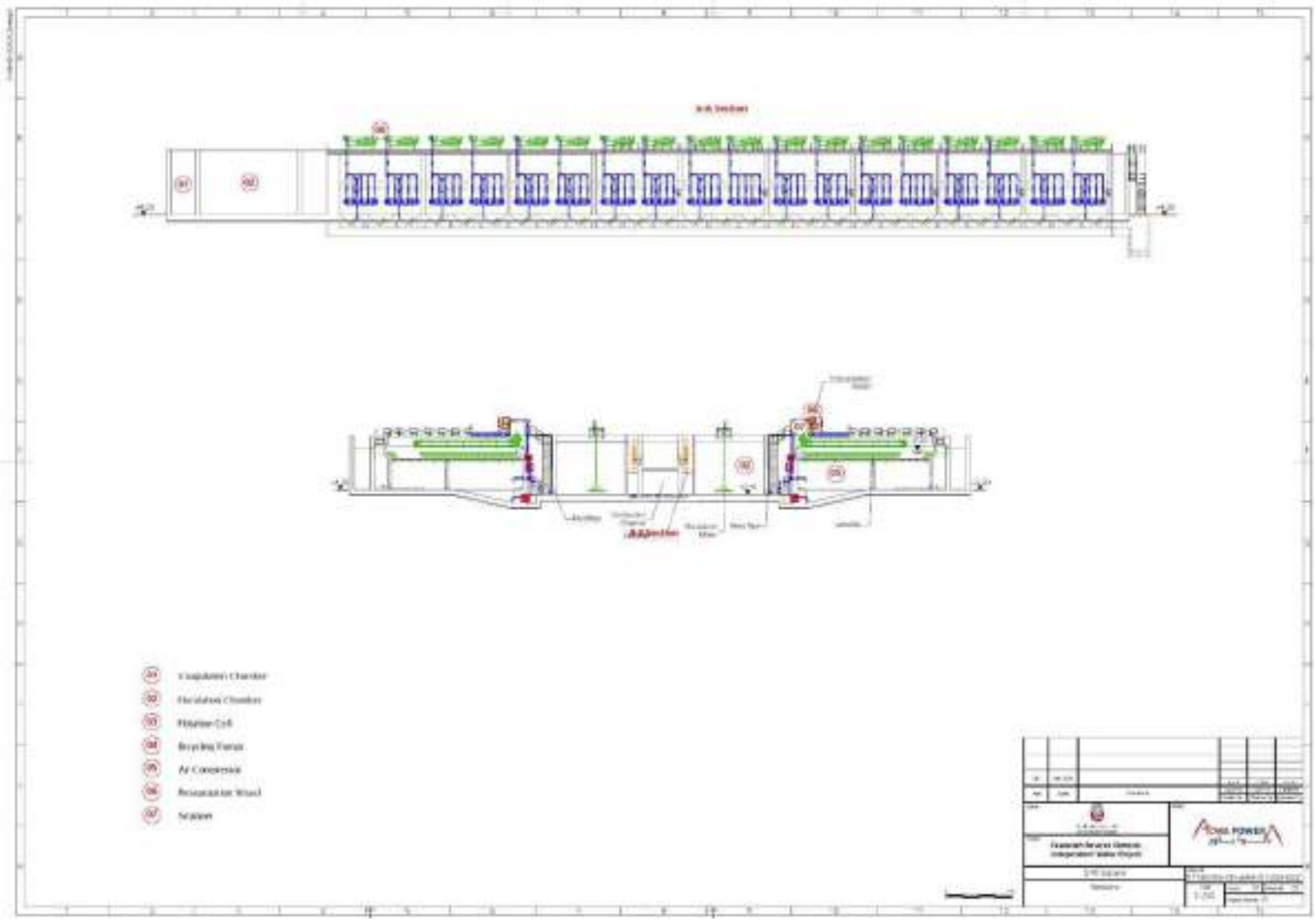


Figure 3-12 Cross Section of Proposed DAF System



Contaminants are removed in the DAF system by dissolving air in the feedwater under pressure and then releasing the air at atmospheric pressure in a flotation tank. When the dissolved air comes out of solution in the form of micron-sized bubbles it attaches to target contaminants. The bubbles and contaminants rise to the surface and form a floating bed of material that is removed by a surface skimmer into an internal hopper for further handling. The DAF system includes a number of individual units equipped with flocculation chambers, pressurization reactor, depressurization injectors and floating cells.

Pressurization reactors are fed by recycling pumps. Thirty-six recycling pumps will be installed, one pump per DAF unit. Iron chloride ($FeCl_{3)}$ is added to enhance coagulation with a view to enhancing the retention of the waste solids. Sulphuric acid is also added to adjust feedwater pH to further optimise coagulation in the DAF.

The floating sludge will be collected by a paddle conveyor installed in the surface of the floating cells and discharged in to a drainage channel transfers waste solid to two sludge pits built at each side of the DAF structures. Settled sludge will also be collected by a bottom scraper and discharged in the sludge pits. Within the sludge pits, submersible pumps will pump the sludge to a main sludge collector that connects them to sludge homogenization tanks for the dewatering.

Each homogenization tank will be constructed of reinforced concrete. DAF sludge and the sludge produced in the lamellar settling tank will be mixed and transferred to a centrifuge decanter by volumetric pumps. Polyelectrolyte solution will be dosed at the centrifuge suction to enhance the dryness of the sludge after centrifugation. The polyelectrolyte solution is prepared in an automatic dilution station and it is injected at each centrifuge suction. The dewatering pumps will have a combined capacity of 135 m^3/hr of sludge and will produce dewatering effluent and solid, dewatered waste. The clarified water produced by the decanters will be discharged to a drain pit before being transferred to a backwash tank which will be further treated if required, prior to discharge to the marine environment as a constituent component of the facility's marine discharge.

The waste solid material will mainly consist of fine inorganic and organic particles. The precise chemical composition will depend on the contaminants present in the feedwater, and is may be subject to characterization during the operational phase of the plant operation. Waste solids will be periodically transferred for off-site disposal under license from the Abu Dhabi Centre for Waste Management (Tadweer). The volumes of waste generated will depend on the frequency with which the DAF system is in operation, which in turn depends on the quality of the feedwater.

3.5.4 Dual Media Filters

DMF is another pre-treatment process that the sea water will go through prior to reverse osmosis, after it has been treated in the DAF. Generally, within the context of desalination, the filter is comprised of a dual layer of pumice (porous volcanic material) and quartzite sand, which act as the filtration media inside the system.

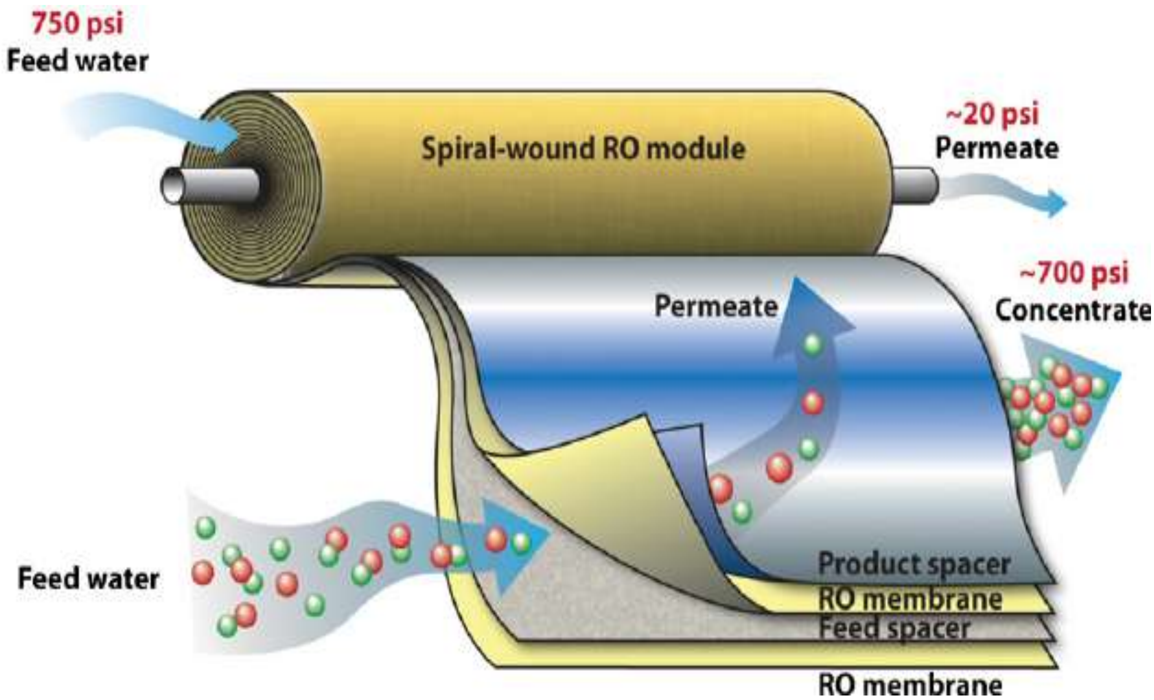
The DMF has been designed for a maximum of one backwash per day, in order to remove the accumulated material. The backwash will be executed with the RO first pass brine, which will be stored for this purpose in a dedicated DMF backwash water tank. The backwash waste water produced during the washing cycle extracts the retained suspended solids out of the filtration media and has a high suspended solids and iron concentration. Backwash water is directed to a wastewater treatment facility prior and, after treatment, is mixed with reject brine and discharged to the marine environment via the effluent outfall.

3.5.5 Reverse Osmosis

Reverse Osmosis (RO) is a water purification system that uses a semi-permeable membrane to remove salts and other larger particles from the seawater. Osmosis is a naturally occurring process, where a weaker saline solution will migrate to a stronger saline solution through a semi-permeable membrane to reach the same ion content in both solutions – diluting the stronger saline solution. A semi-permeable membrane is a membrane that allows some atoms or molecules to pass, but not others. The process of RO overcomes the natural osmosis by applying pressure in excess of the osmotic pressure to the strong saline solution, thereby forcing the seawater through the semi-permeable membrane to obtain fresh water. The natural osmotic pressure of seawater is approximately 27 bar. The filtered seawater in this Project will be pressurized up to 65 bar for the 1st pass RO (to be confirmed during the further stages of the design process). This allows the water to pass on to the other side of the membrane without the salt content, which is then directed in to the desalinated water pipeline.

The RO system is composed of end-to-end placed RO modules, forming the RO 'trains' and 'racks'. Each RO module is composed of layers of semi-permeable membranes which are connected at one open end to a tube. There are spaces between each layer in order to allow water to flow across the membranes. The layers of membranes are then spiral-wound around the permeate tube as shown in the figure below.

Figure 3-13 Typical Layering System in RO Module



Each RO Train will comprise a dedicated high pressure pump or in alternative a maximum of three trains can be fed by the same high pressure pump, a feed booster pump to the high pressure pump (as required), an energy recovery device booster pump, a dedicated membrane skid and dedicated energy recovery devices.

The RO flux for the first pass will be designed for an average flux not exceeding 14.5 l/m^2/hr and 17 l/ m^2/hr. The recovery rate will be selected considering the required quality and the reliability of the system; however, the recovery rate of the first pass will in no case exceed 43%. The second pass of RO section will not exceed 35 l/ m^2/hr.

CIP system-Flushing System

The CIP system is a method of cleaning the interior surface of closed systems without disassembly, which in this case will be used to clean the RO membranes. This system has been designed for the separate cleaning and sterilization of at least one train of the RO system (either the first pass or second pass). Sulfuric acid and sodium oxide are typically used for the CIP cleaning solution.

The CIP system will be composed by a preparation mixing / recirculation tank, electric heater, cooling arrangement, pumps, valves and piping, online temperature indicator and switch, cartridge filter, isolation valves, pressure gauge. The CIP system will be permanently connected to all the RO Trains and will ensure cleaning of first pass SWRO as well as second pass RO Trains.

RO Chemical Dosing System

Antiscalant dosing will be provided as required, in order to achieve reliable performance at minimum RO membrane cleaning frequency. Sodium metabisulphite dosing will be provided, in order to remove any residual chlorine from the seawater feed and protect the RO membranes. Sodium metabisulphite solution will be prepared on-site each day, due to its instability. The solid form will be stored in bags (2,850 kg) in the appropriate storage area with storage not exceeding 14 days.

A bund beneath each chemical tank to retain any possible spill will be provided. All pumps, valves, trays, and other equipment, are kept out of this bund to avoid damages in case of a spill. The bund volume has been selected to contain 110% of the entire contents of the storage tanks. The bund will have a sump pit, to pump out any possible spill and will have canopy roof to protect piping and instruments from sun light.

To enhance the Boron rejection efficiency in the second pass RO membranes, a sodium hydroxide dosing system will apply doses as required. in the chemical storage area, with a capacity covering 14 days storage.

The RO Chemical Cleaning Interval depends on the water quality that is coming into the system. The manufacturers usually recommend the Chemical Cleaning twice a year, both with the acid and the basic solutions. A list of cleaning solutions and indicative volumes are provided in the figure below.

Cartridge filters will be provided within the main sodium bisulphite dosing pipework for the dosed sodium bisulphite solution, to remove particulate matter present within the sodium bisulphite storage / dosing tank.

Sodium hydroxide may be added to modify the pH if necessary. Non-oxidising biocides, such as DBNPA, will be stored on the site should they be required.

Figure 3-14 SWRO Chemical System

The quantities listed below are to be added to 100 U.S gallons (379 liters) of dilution water.

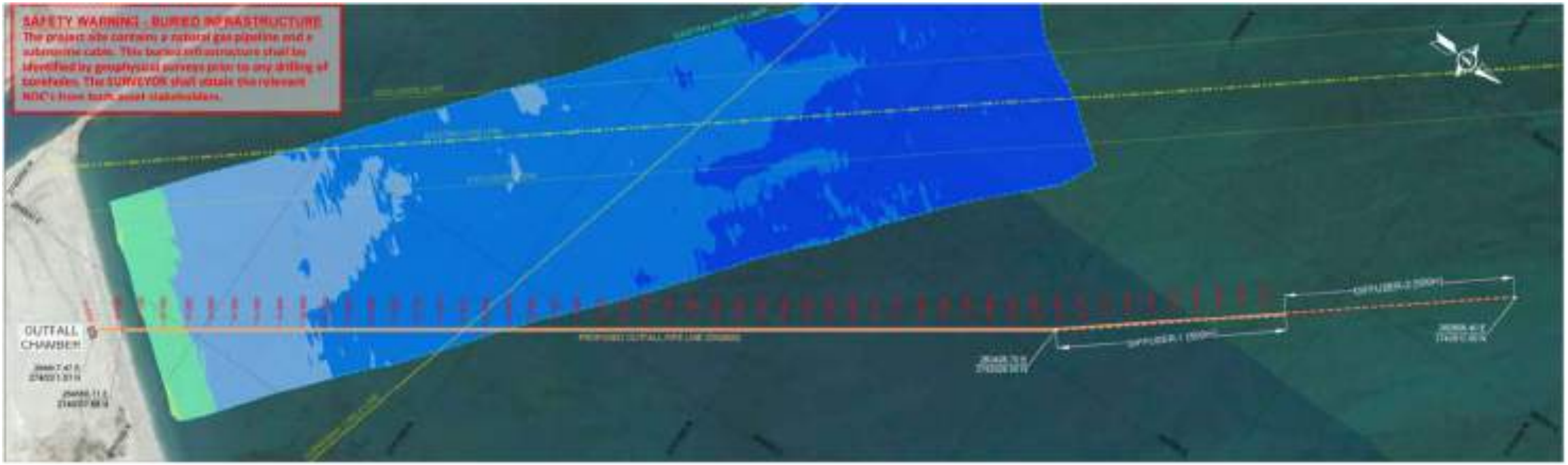
Cleaning Solution	Bulk Ingredients	Quantity	Target [1] pH Adjustment	Target [1] Temp.
1	**Citric acid** (as 100% powder)	17.0 pounds (7.7 kg)	No pH adjustment is Required.	104 F (40 C)
2	**STPP** (sodium tripolyphosphate) (as 100% powder) **Na-EDTA** (Versene 220 or equal) (as 100% powder)	17.0 pounds (7.7 kg) 7.0 pounds (3.18 kg)	Adjust to pH 10.0 with sulfuric or hydrochloric acid.	104 F (40 C)
3	**STPP** (sodium tripolyphosphate) (as 100% powder) **Na-DDBS** Na-dodecylbenzene sulfonate	17 pounds (7.7 kg) 0.21 pounds (0.1 kg)	Adjust down to pH 10.0 with sulfuric or hydrochloric acid.	104 F (40 C)
4	**HCl acid** (hydrochloric acid (as 22° Baume or 36% HCL)	0.47 gallons (1.78 liters)	Slowly adjust pH down to 2.5 with HCL acid. Adjust pH up with sodium hydroxide.	95 F (35 C)
5	**Sodium hydrosulfite** (as 100% powder)	8.5 pounds (3.86 kg)	No pH adjustment is required.	95 F (35 C)
6	**NaOH** (sodium hydroxide) (as 100% powder) (or as 50% liquid) **SDS** (sodium dodecylsulfate)	0.83 pounds (0.38 kg) 0.13 gallons (0.49 liters) 0.25 pounds (0.11 kg)	Slowly adjust pH up to 11.5 with sodium hydroxide. Adjust pH down to 11.5 by adding HCL acid.	86 F (30 C)
7	**NaOH** (sodium hydroxide) (as 100% powder) (or as 50% liquid)	0.83 pounds (0.38 kg) 0.13 gallons (0.49 liters)	Slowly adjust pH up to 11.5 with sodium hydroxide. Adjust pH down to 11.5 by adding HCL acid.	86 F (30 C)

3.5.6 Brine Effluent Outfall

The proposed brine effluent outfall pipeline configuration is shown in the figure below. The first pipe will be 2.5 km long, with a diffuser section over the final 500 m section. The second pipe will be 3 km long, with a diffuser section over the final 500 m section. As the two pipes are close together, this essentially makes a single diffuser section, approximately 1 km long. The first pipe will have with 30 single-port risers, equally spaced along the diffuser section, and the second will have 31 ports (that is, 61 ports for the combined outfall). Port diameters are about 0.35 m, which gives exit velocities of around 2.9 m/s. For this stage of modelling, we have assumed that the centre point of each diffuser port is located around 1 m above the seabed. This is to increase the trajectory lengths of the jets, and to minimise their interaction with both the sea surface and seabed.

This length of outfall has been selected to take advantage of currents through the Port, reduce recirculation into Taweelah and IWP intakes and avoid the "shadow" effect of the KIZAD Port structures from 4 km and beyond and the future expansion of the Port.

Figure 3-15 Proposed Brine Effluent Outfall Configuration



3.6 Project Construction Requirements

A detailed works method statement has not yet been prepared for the construction of the facility and the associated infrastructure. It is anticipated that this will not be available until the detailed design phase is completed and a construction contractor has been appointed. As such, the project Construction Environmental and Social Management Plan (CESMP) will be required to cover detailed construction methodologies, equipment requirements and timeframes. However, anticipated construction steps required for the Project development are provided in the following sub-sections. A detailed works method statement will be developed during the Project Execution Phase.

Land-side Site Enabling and Construction Works

The steps required for the construction of the SWRO Plant and all associated land-side infrastructure and facilities are as follows:

- Site enabling works:
  - Grading of site and removal of all vegetation;
  - Taking site levels;
  - Cut and fill operations to level site to design specifications; and
  - Setting up of temporary construction facilities such as site offices, access roads, temporary diesel storage and septic tanks.
- Excavation of building foundations;
- Pumping concrete for foundations;
- Excavation of utility corridors;
- Installation of infrastructure for potable water, irrigation and sewage transfer systems, electricity distribution and telecommunication infrastructure;
- Backfilling with previously excavated material, grading and profiling;
- Construction of the SWRO Plant buildings and structures; and
- Installation of hard landscaping and soft landscaping.

Marine Construction Works

Marine construction works will be required for the installation of the open intake channel and the outfall pipelines. Whilst exact construction methodologies have not been finalized, the zone of impact of the marine construction works is estimated to total 150,000 m^2. The majority of the 3 km outfall alignment will require dredging to provide stable footing for the outfall lines and the intake channel will also require excavation. It is estimated that a total of 275,000 m^3 of material will be excavated from the outfall alignment with an additional 85,000 m^3 dredging to allow for access to the marine construction fleet. This is considered necessary given the shallow depths in which the outfall is being constructed.

A footing trench along the length of the 3 km outfall alignment will be excavated to provide stability to the outfall and diffuser lines. Trench excavation along the outfall alignment will be undertaken using barge mounted hydraulic excavators or bucket excavators. Dredged material will be placed directly into flat barges or split barges. It is currently proposed that dredged material will be side cast beside the trench. Material placed in split-barges will be deposited in designated side cast storage areas parallel to the footing trench alignment. The side cast material will later be utilized as backfill to stabilize the outfall line in the footing trench. Any excess dredged material that is not required as backfill will be loaded onto flat barges and will be transferred to a temporary loading jetty at Khalifa Port. Dumper trucks will then transfer the material to a designated storage area, as shown in the figure below.

Once the footing trench is excavated to the requisite depth, bedding material will be placed in the trench and levelled. Bedding material will be transported to the excavation area by flat barge with dumper trucks and hydraulic excavators used to move and place the material.

Glass Reinforced Polyester (GRP) pipe sections will then be lifted in to place by a barge-mounted crane. Divers will connect the respective pipeline sections and these will then be places on the bedding material. Backfill material will be collected from the side cast stockpiles and will be placed into the footing trench. A number of layers of rip rap armour rock will be placed over the sediment backfill to provide protection to the alignment.

Breakwaters protecting the open channel will be constructed as rubble mount structures armoured with quarry rock and concrete units. The design of the required rock classes for breakwater construction will be optimized in such a way that:

- Overlap rock grading are not required insofar possible; and
- The entire quarry production up to the maximum required rock size is utilized for construction.

The breakwaters will be constructed from the shoreline utilizing exclusively land-based construction equipment. For land-based operation the construction equipment will be able to gain access to the crest of the breakwater's core. The crest of the core should rise above high water and be accessible during the tidal cycle. The width of the core's crest will be sufficient for practical execution of the works. Core material around and above the waterline is vulnerable to wave attack during construction and the next armour layers will be placed shortly after construction of the core.

The intake channel will be excavated to the desired depth. It is assumed that some of the excavation works will need to be undertaken using barge mounted cranes. Marine excavations will be limited as far as is feasible to limit the volume of access dredging that is required. It is estimated that 20,000 m^3 material will be excavated from the intake channel.

This figure and the precise method of excavation to be employed will be confirmed following appointment of a marine construction contractor.

Figure 3-16 Location of Temporary Jetty and Dredge Material Stockpile Area

Vehicles, Equipment and Heavy Machinery Requirements

During the construction phase of the project the Contractor/ sub-contractors will use different kinds of vehicles, equipment and heavy machinery. The specific details of equipment to be used on site have not been provided at this stage. However, anticipated engines (vehicles, and equipment) likely to be used during the site preparation and construction activities include cranes, excavators, dredgers, lorries, dump trucks, bulldozers, concrete pumps, generators, piling equipment, pavers and graders amongst other equipment.

Chemical and Hazardous Materials Storage

Storage of chemicals and hazardous materials during the construction phase of the project will be undertaken by relevant Contractors/sub-contractors. The requirements for the storage of such materials will be set out in the site-specific Construction Environmental and Social Management Plan (CESMP) by the EPC Contractor together with specific procedures for storage required for implementation by the relevant sub-contractors.

Waste Management

All types of wastes generated during the construction activities will be collected, managed and transported by companies who are registered/approved by Abu Dhabi Waste Management Center – Tadweer. Waste quantities will be monitored and reported monthly including general, inert and hazardous waste. Aggregate, wood, metal and packaging waste will be re-used and/or recycled where suitable facilities exist within Abu Dhabi.

Temporary Construction Facilities

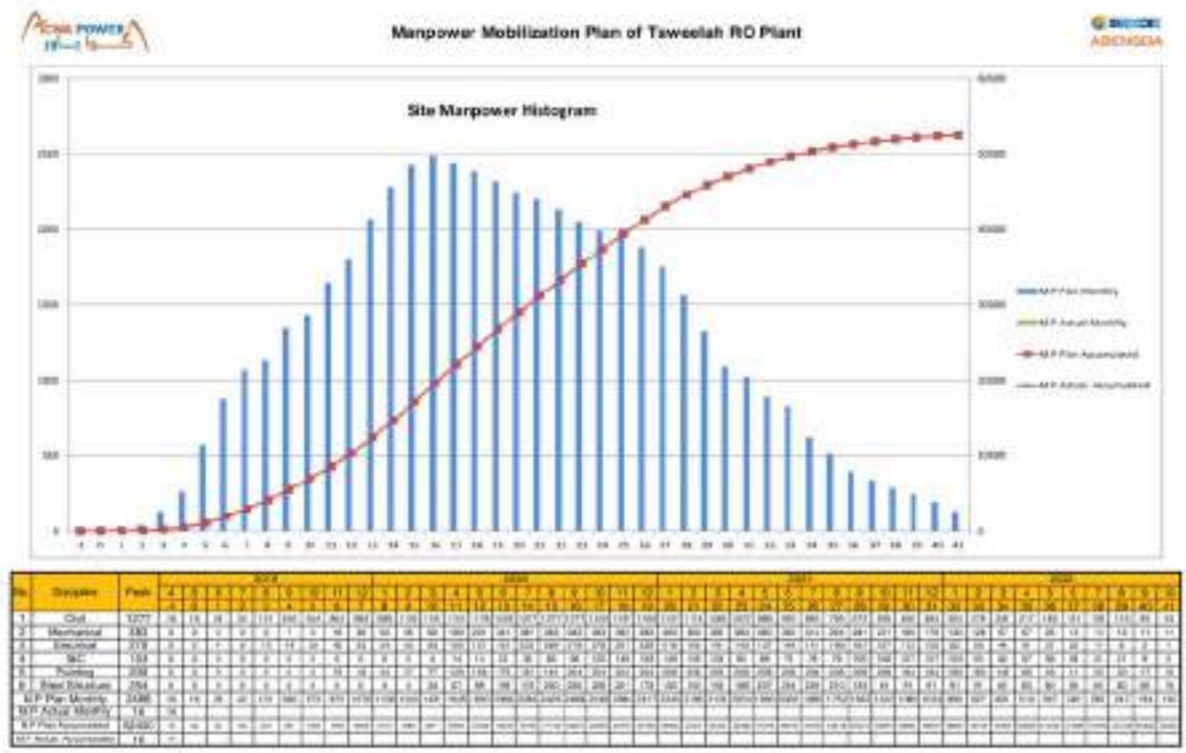
The laydown area will be located southeast of the project site. The laydown area is expected to include temporary construction facilities required to enable works (materials storage, staging areas), as well as construction administration facilities.

Manpower Requirements

It is estimated that the project workforce will be approximately 2,700 staff and labourers. The EPC Contractor will build accommodation facilities southeast of the project site to accommodate the project staff and labourers as shown in Figure below. The total area of the accommodation plot is approximately 120,000 m^2. The accommodation facilities will occupy only 50,000 m^2 of the land while the remaining of the plot may be used as laydown area.

The number of shifts will vary depending on the workload; however, the majority of the works will be carried out over one (1) shift and during peak construction periods, the works will be carried out over two (2) shifts. All shift workers will be housed on site in order to meet security requirements of Taweelah Complex. Figure below presents the manpower histogram for the Project construction.

Figure 3-17 Manpower Histogram



Approvals for the accommodation facilities will be requested from Worker Residence City (WRC) and the Civil Defense in Abu Dhabi. Approval for the land used for the accommodation facilities will be acquired from Abu Dhabi Municipality (ADM).

It should be noted that the worker accommodation facilities will be in line with IFC and EBRD guidance note for '*Workers' Accommodation: Process and Standards' (IFC, EBRD, 2009)*. The EPC Contractor is contractually obliged to comply with these standards.

Figure 3-18 Proposed Location of Laydown Area in relation to Taweelah Complex

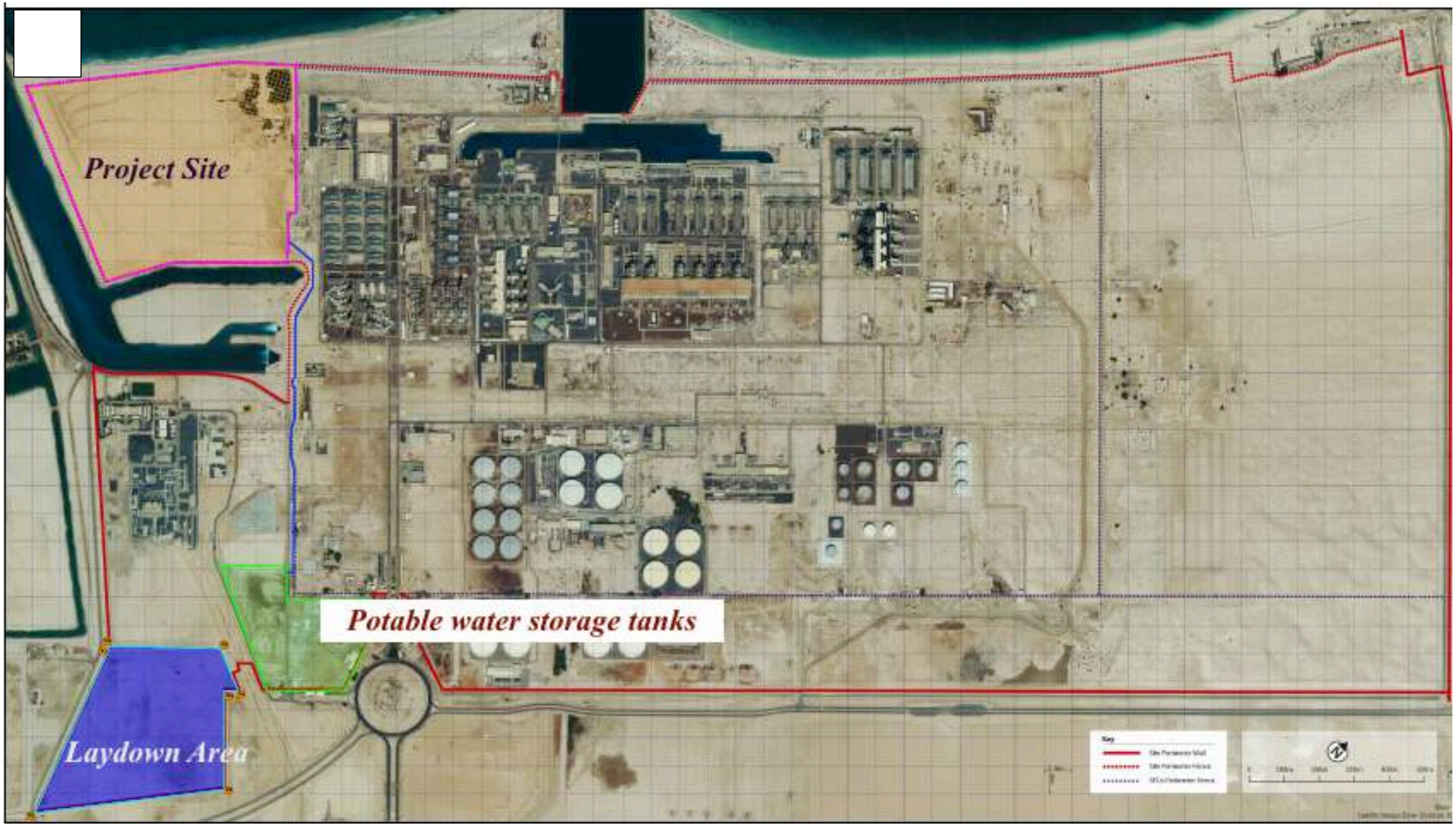


Figure 3-19 Proposed Location of Accommodation

3.7 Operational Phase

Power Requirements and On-site Power Generation

During operation the plant will have an anticipated energy demand of 4.2 – 4. kWh / m^3 depending on seawater conditions. Renewable Power generation capacity has been incorporated into the plant design through the installation of both ground and roof-mounted PhotoVoltaic (PV) power generation modules. Roof mounted PV will utilise monocrystalline module-420M-frame, with nominal power of 420W. With 27 modules in a string, a total of 1,852 roof mounted strings are proposed. The project produced energy is estimated at 3,4997 MWh from roof mounted modules in the first year. Using a similar specification, it is estimated that 1,852 ground-mounted strings will have the capacity to generate 34,997 MWh in the first year of operation. All other power requirements not met by the PV installation will be supplied by the neighbouring Taweelah Power Generation Complex.

In order to produce 200 MIGD, 117.88 MW of electricity at RSC needs to be supplied. The Captive Basic PV Plant will generate 3.62 MW (3%) and Auxiliary PV will generate 7.84 MW (7%). 106.42 MW (90%) will be supplied from the grid.

Potable Water Storage Tanks

During operation, there will be 9 potable water storage tanks located to the east of the project site. The specification of the tanks are as follows:

- Ground supported flat bottom water storage tanks 1
  - Diameter: 105 m
  - Height: 17.8 m
  - Networking capacity: 11.450 m^3
  - Units: 6
- Ground supported flat bottom water storage tanks 2
  - Diameter: 77 m
  - Height: 17.5 m
  - Networking capacity: 66.168 m^3
  - Units: 3

The tanks and all their components will be designed to safely withstand the maximum stresses to which they may be subjected during erection and operation. The design will be able to withstand external loads such as wind and seismic loads.

The potable water quality will be in accordance with the table below which is in accordance to Part II of the RfP (General Technical Specifications) issued by the Department of Energy.

Table 3-3 Potable Water Quality Requirements (RFP)

PARAMETER	UNIT	VALUE
Maximum content of TDS	ppm	200
Minimum content of TDS	ppm	100
Chloride	ppm	Max. 100
Boron	ppm	<2.4
Increasing HCO_3 content by	mol/m^3	Target value 1.0 Permissible range 0.8 to 1.5
Increasing Ca^{++} content by	mol/m^3	Target value 0.5 Permissible range 0.4 to 0.7
pH	-	Permissible range 7 to 9.2
Maximum content of Residual Chlorine down-stream remineralization	ppm	1
$[c(Cl)+2c\ (SO_4^{2-})]/c(HCO_3)$	mol/mol	<2
$C(HCO_3)/\ c(SO_4)$	Mol/mol	<2
Saturation Index according to DIN 38404-1, calculation mode 2	-	Permissible range 0.0 to 0.5
Turbidity 9including suspended solids)	NTU	Max 4.0

All other characteristics of the potable water quality will be in accordance with Water Quality Regulations-Forth Edition as issued by the Department of Energy (formerly RSB) in July 2013.

Figure 3-20 Potable Water Storage Tanks

Waste Streams

The principal waste stream produced during the operational phase will be brine. The planned rates of discharge are not anticipated to exceed 1.6 million m^3/day. Effluent waters may have a maximum salinity of 80 PSU. The discharge to the marine environment will include all liquid wastes generated from the RO system. As well as process effluent, discharges will include neutralized chemical wastes generated from the DMF and chlorination. The effluent is also likely to include trace metals caused by corrosion of the pipes.

With regards waste removed from the site for disposal to the municipal waste management network, the plant is expected to generate comparatively small volumes of domestic and operational waste streams. The most significant volume of solid waste will be generated by the dissolved air filtration system which will produce sludge. The operational sludge will require treatment and temporary on-site storage prior to off-site disposal. Sludge will be dewatered on-site using a dedicated sludge treatment system where the moisture content is removed by thickening (settlers) and dewatering using centrifuges and through the addition of polymer aids. The target dewatering will be 20% sludge final dryness as a minimum. Dewatered sludge will be transferred off-site to a landfill site under license from the Abu Dhabi Centre for Waste Management (Tadweer).

3.8 Project Schedule

An outline delivery schedule highlighting important milestones for the project is provided in the table below and is further detailed in the following gantt chart showing activities and duration in relation to "Construction Stage 1" and "Construction Stage 2" .

Table 3-4 Outline of the Project Schedule

IMPLEMENTATION MILESTONE	TENTATIVE DATE*
Effective Date of Taweelah WPA	28th February 2019
WPA Closing Date	28th May 2019
Financial Closing Date	28th May 2019
Notice to Proceed to EPC Contractor	28th May 2019
Start of Mobilization	26th June 2019
Start of Site Installation	31st July 2019
Scheduled Project Commercial Operation Date	31st October 2022
Scheduled Provisional Acceptance Date	31st October 2022

IMPLEMENTATION MILESTONE

Taweelah 900 MLD LNTP (feb-may) Rev.3b

Activity ID	Activity Name	Original Duration	Start	Finish
Construction stage 1				
Temporary works				
Mobilisation				
Staff mobilisation				
A2490	VISA agreement	11	2019-02-27	2019-03-13
A2470	First mobilisation	15	2019-03-14	2019-04-03
A2480	Mobilisation to site	60	2019-04-04	2019-06-26
Temporary facilities				
A2500	Temporary facilities contract	11	2019-04-30	2019-05-14
A2510	Design	11	2019-05-15	2019-05-29
A2520	Construction	40	2019-05-30	2019-07-24
Maritime Works				
A2600	Maritime works / Subcontractor / mobilisation	22	2019-08-16	2019-09-16
A5050	Intake & Outfall Works	297	2019-09-17	2020-11-04
A5051	End of Marine Works	0		2020-11-04
Site preparation #1				
A2730	Site preparation	10	2019-07-31	2019-08-13
A2720	Earthmoving & improvement civil works / execution	44	2019-08-14	2019-10-14
Intake				
A2700	Intake Pump Station Civil Works	230	2019-10-15	2020-08-31
A2710	Intake / Pump & Screening Installation	44	2020-09-03	2020-11-03
DAF				
A2950	DAF Civil Works	230	2019-08-14	2020-06-30
A2960	DAF Equipment Installation	110	2020-07-01	2020-12-01
Gravity Filter & IPS				
A2970	DMF Civil Works	272	2019-08-14	2020-08-27
A2980	DMF Equipment Installation	68	2020-08-28	2020-12-01
RO Building				
A3030	RO Building Foundation	100	2019-08-14	2019-12-31
A3040	RO Building Erection	170	2020-01-01	2020-08-25
A3060	RO Equipment Installation	222	2020-02-26	2020-12-31
A3050	Steel Piping Spooling & Installation	188	2020-04-14	2020-12-31
A3410	2 HP Pumps on Site	0		2020-09-24
A3420	End of RO Equipment Installation	0		2020-12-31
Post Treatment Area				
A2990	Post Treatment Civil Works	155	2020-07-01	2021-02-02
A3020	Post Treatment Equipment Installation	44	2021-02-04	2021-04-06

Implementation Milestone

Taweelah 900 MLD LNTP (feb-may) Rev.3b

Activity ID	Activity Name	Original Duration	Start	Finish
Potable water tank farm				
A2740	Product Water Tanks Civil Works	120	2019-10-15	2020-03-30
A2750	Product Water Tanks Equipment & Piping Installation	280	2020-03-31	2021-04-26
Electrical Systems				
A3350	Installation & Internal Testing GIS Substation	85	2020-04-30	2020-08-26
A3360	Installation Electrical Equipment & Cabling	262	2020-04-30	2021-04-30
A3370	Energization and Power Available from Transco	0	2020-11-04	
A3430	PV system installation and commissioning	190	2021-11-05	2022-07-28
Construction stage 2				
DAF				
A3540	DAF Civil Works	230	2020-07-01	2021-05-18
A3550	DAF Equipment Installation	110	2021-05-19	2021-10-19
Gravity Filter & IPS				
A3560	DMF Civil Works	272	2020-07-01	2021-07-15
A3570	DMF Equipment Installation	68	2021-07-16	2021-10-19
RO Building				
A3600	RO Building Foundation	100	2020-07-08	2020-11-24
A3610	RO Building Erection	170	2020-11-25	2021-07-20
A3620	Steel Piping Spooling & Installation	252	2020-12-09	2021-11-25
A3630	RO Equipment Installation	222	2021-01-20	2021-11-25
Post Treatment Area				
A3580	Post Treatment Civil Works	155	2021-02-03	2021-09-07
A3590	Post Treatment Equipment Installation	44	2021-09-16	2021-11-16
Potable water tank farm				
A3510	Product Water Tanks Civil Works	120	2020-03-31	2020-09-14
A3520	Product Water Tanks Equipment & Piping Installation	280	2020-09-15	2021-10-11
Commissioning stage 1				
A2850	Commissioning Intake	20	2020-11-05	2020-12-02
A3000	Commissioning Pretreatment	106	2020-12-03	2021-04-29
A3010	Commissioning RO System	126	2021-01-01	2021-06-25
A3070	Commissioning Post Treatment	56	2021-04-07	2021-06-23
A3080	Commissioning Tank Farm	42	2021-04-27	2021-06-23
A3081	Trial Run	1	2021-06-28	2021-06-28
A3082	Performance Test	1	2021-06-29	2021-06-29
A3083	Reliability Test	18	2021-06-30	2021-07-23
A3084	Group 1 COD	0		2021-07-26
Commissioning stage 2				
A4520	Commissioning Tank Farm	42	2021-10-12	2021-12-08
A4490	Commissioning Pretreatment	106	2021-10-20	2022-03-16
A4500	Commissioning RO System	122	2021-11-26	2022-05-16
A4510	Commissioning Posttreatment	56	2022-01-18	2022-04-05
A4530	Trial Run	1	2022-05-17	2022-05-17
A4540	Performance Test	1	2022-05-18	2022-05-18
A4550	Relibiality Test	18	2022-05-19	2022-06-13

IMPLEMENTATION MILESTONE

A4540	Performance Test	1	2022-05-18	2022-05-18
A4550	Relibiality Test	18	2022-05-19	2022-06-13
A4560	Group 2 COD	0		2022-06-14
Commissioning stage 3 & Final COD				
A4590	Final Works	20	2022-06-15	2022-07-12
A4580	Commissioning Complete Plant	47	2022-07-13	2022-09-15

A3460	Trial Run	1	2022-09-16	2022-09-16
A3470	Performance Test	1	2022-09-19	2022-09-19
A3480	Reliability Test	30	2022-09-20	2022-10-31
A3820	RO Plant COD	0		2022-10-31

4 Climate, Meteorology and Ambient Air Quality

4.1 Description of the Environment

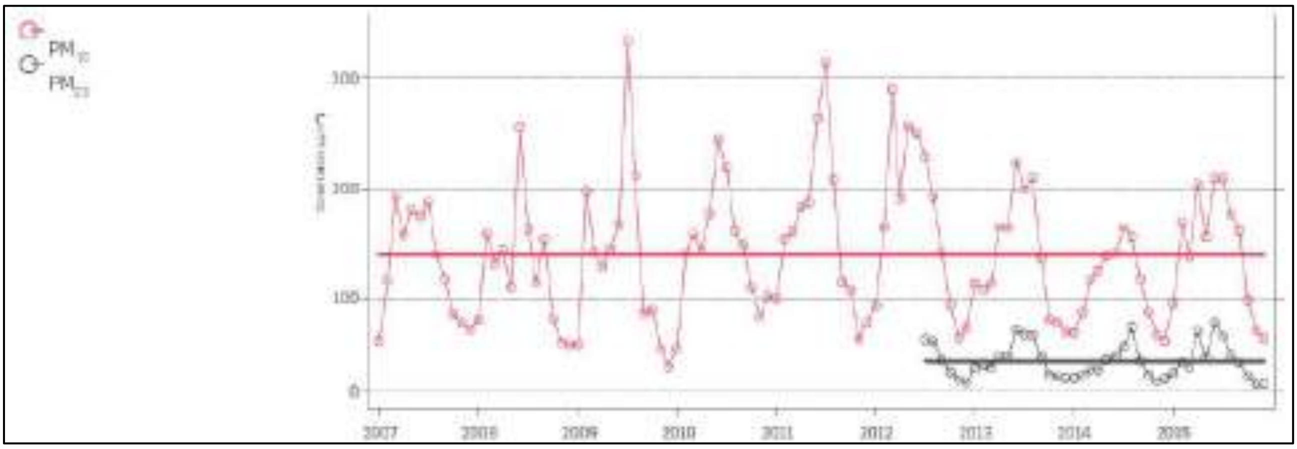
4.1.1 Regional Context

The UAE is located in the tropical dry region. The Tropic of Cancer runs through the southern part of the Emirate of Abu Dhabi, giving its climate an arid nature characterized by relatively high temperatures throughout the year, especially in summer. The Emirate's high summer temperatures are associated with high relative humidity, especially in coastal areas. Abu Dhabi receives scant rainfall and has warm winters with occasionally low temperatures. There is a variation in temperature between the coastal strip, the desert interior and areas of higher elevation that together make up the topography of the Emirate. Seasonal northerly winds, referred to as the Shamal, blow across the country, helping to ameliorate the weather when they are not laden with dust. Occasional moisture-laden south-easterly winds bring sporadic, localised precipitation to areas of the country. Prevailing winds often vary between southerly, south-easterly, westerly, northerly and north westerly.

Air quality in the UAE is commonly characterized by elevated levels of particulate matter (PM). PM_{10} levels frequently exceed the UAE Federal Guideline 24 hour average limit of 150 µg/m^3 (EAD, 2015). This is largely attributable to the fact that the UAE is located in an arid desert environment. The country has naturally low coverage of vegetation and fine-grained sandy soils. During periods of high winds, levels of airborne particulates are naturally elevated. During the summer, the strong Shamal winds contribute to increases in atmospheric particulates with dust transported south from the northern Arabian Gulf. Data collected at Abu Dhabi Airport and Al Ain Airport between 2017 and 2015 indicates that the frequency of days with elevated airborne PM peaks during the summer months of May to August (EAD, 2017).

These natural phenomenon are however, exacerbated by the impacts of rapid economic growth in the UAE. Large-scale, rapid urbanization has been accompanied by removal of large areas of natural vegetation. Increased construction activity, vehicle movements on unpaved roads and off-road driving combined with significant increases in combustion emissions, both from transport and industrial sources, contribute to localised increases in concentrations of airborne particulates. $PM_{2.5}$ is associated with greater human health impacts given the ability for the smaller particles to enter into the lungs. To date it is estimated that 54%-67% of $PM_{2.5}$ generated in the Abu Dhabi Emirate is as a direct consequence of anthropogenic activity (EAD, 2015). Data published by EAD in 2017 indicates that the long-term trends of both PM_{10} and $PM_{2.5}$ recorded by the EAD air quality-monitoring network remain relatively stable as shown in the figure below.

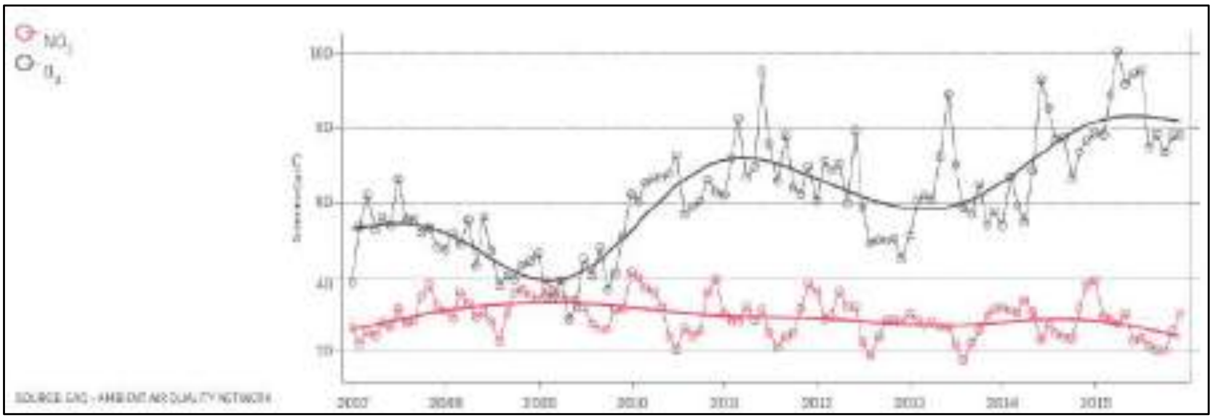
Figure 4-1 Monthly Average Concentrations of Airborne PM in the Emirate of Abu Dhabi



Source: EAD, 2017

Tropospheric, or ground-level, ozone at urban air quality monitoring stations also frequently exceeds the Federal Guideline limit for eight (8) hour periods (120 µg/m3) (EAD, 2015). Ground-level ozone is a secondary pollutant that forms in the atmosphere as a result of reactions between precursor pollutants, such as nitrogen oxides (NO_x) and Volatile Organic Compounds (VOCs), in the presence of UV radiation. The main sources of these precursor compounds are combustion emissions from transportation, predominantly road traffic and international shipping, and industrial activity. The presence of heavy industrial complexes at Taweelah and EGA combined with increasing road traffic and the shipping terminal at Khalifa Port means that the area is likely a strong source of NO_x. The prevailing trend within the Emirate of Abu Dhabi from 2007 to 2017 is towards an increase in the concentrations of ground-level ozone.

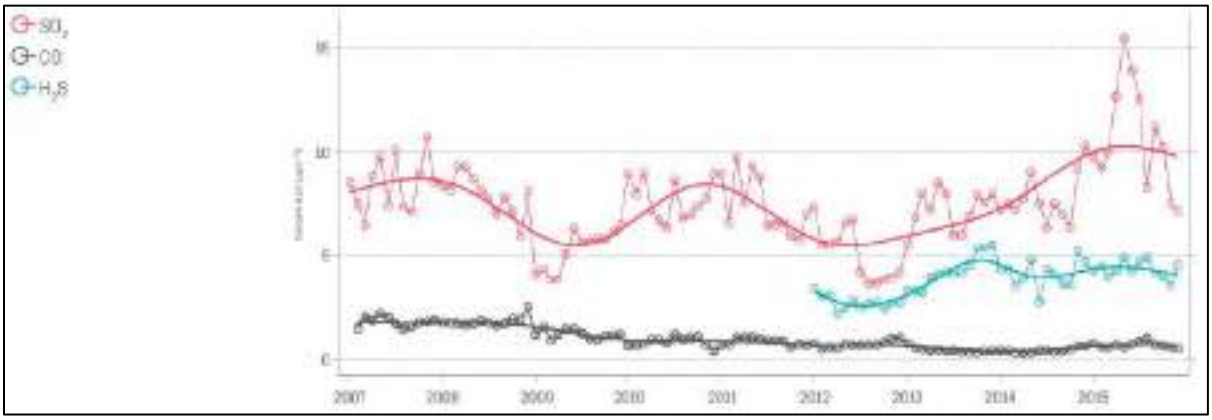
Figure 4-2 Monthly Average Concentrations of Airborne PM in the Abu Dhabi Emirate



Source: EAD, 2017

Other contaminants commonly recorded in monitoring of ambient air quality in the UAE are sulphur oxides (SO_x) and carbon monoxide (CO). Both are largely present as a result of hydrocarbon combustion. Concentrations typically vary with proximity to areas of significant industrial activity, inclusive of power generation and water production, oil and gas production, shipping ports and road transport infrastructure. Data published by the EAD indicates that trends of both CO and NO_2 have remained relatively stable whilst concentrations of SO_2.

Figure 4-3 Monthly Average Concentrations of Airborne PM in the Abu Dhabi Emirate



Source: EAD, 2017

The Abu Dhabi Statistics Centre (2016) identifies power generation, industrial processes and transport as the primary source of Greenhouse Gas Emissions (GHGs) in the Emirate of Abu Dhabi. Direct GHGs of primary concern in the Emirate of Abu Dhabi include Carbon Dioxide (CO_2), methane (CH_4), Nitrous Oxide (N_2O) and Perfluorocarbons (PFCs). A preliminary assessment of the main sectors of the Abu Dhabi economy (ADQACC, 2015) has revealed that the main activity sources, as shown in the figure below where these GHGs are emitted are:

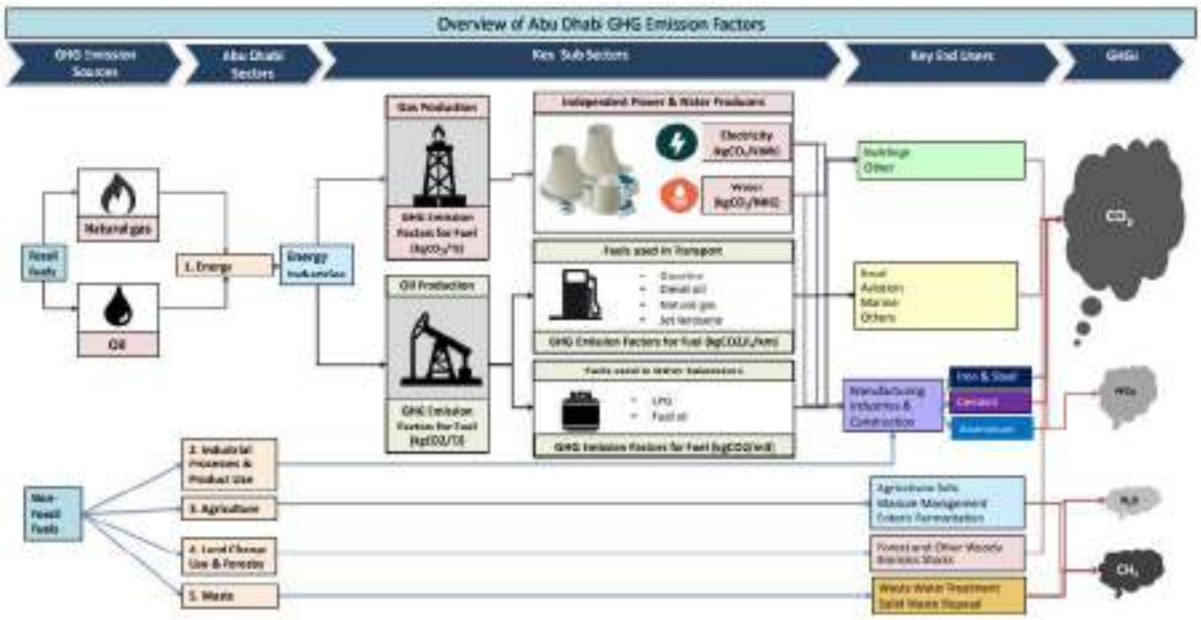
- Fuel (mainly natural gas) combusted to generate electricity and produce desalinated water;
- Transportation fuels derived from the oil and gas sector processing activities;
- Chemical reactions from industrial processes; and
- Waste degradation.

The 2010 Abu Dhabi GHG Inventory reported that CO_2 comprises around 79% of total GHG emissions. The Abu Dhabi Quality and Conformity Council (ADQACC) Technical Report – Greenhouse Gas Emission Factors estimates that CO_2 accounts for 94% of energy sector emissions with methane and nitrous oxide responsible for the balance (ADQACC, 2015).

Non-Fossil Fuel GHG emissions refer to emissions that result from manufacturing industries physical and chemical reactions, waste degradation in landfills and wastewater treatment processes, agricultural soils, livestock and manure, and deforestation. The main industrial process where non-fossil fuel GHG emissions are released is the alumina electrolytic reduction process where perfluorocarbons (PFCs) are released. In the Abu Dhabi's 2010 GHG Inventory it was estimated that 92% of waste emissions were due to solid waste disposal in the landfills, and about 8% were due to wastewater handling and treatment. The dominant direct emission was CH_4 (ADQACC, 2015).

Principal sources of GHG emissions in the vicinity of the project site are likely to be the Taweelah Power and Water Generation Complex, EGA and Khalifa Port.

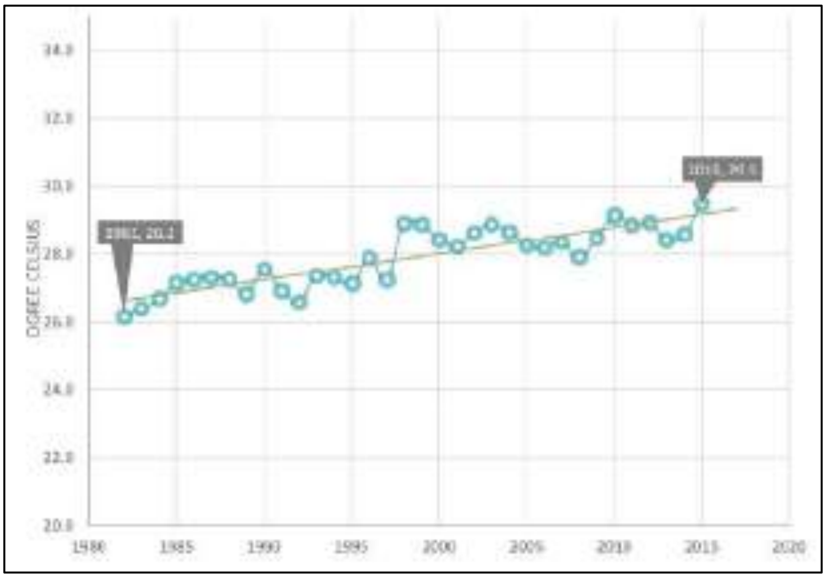
Figure 4-4 Overview of Abu Dhabi GHG Emission Factors



Source: ADQACC, 2016

Data published by the Abu Dhabi Statistics Centre in 2016 shows that average temperatures in the Emirate of Abu Dhabi have shown an increase of 3.3°C (8.5%) between 1982 and 2015. With the continued population expansion and the growth of the respective sectors, emissions of GHGs increased in Abu Dhabi between 2010 and 2012, and have likely continued to grow from 2012 to present further contributing to local and transboundary climate change.

Figure 4-5 Annual Average Temperature Measured at Abu Dhabi International Airport



Source: Abu Dhabi Statistics Centre, 2016

As part of the Al Taweelah A10 Extension Project EIA (Jacques Whitford, 2006) an ambient air quality survey was undertaken. Measurements were recorded at four (4) survey locations with a view to assessing and characterizing the ambient air quality in the area proximal to Taweelah and at one (1) reference site further inland. Locations 1, 2 and 3 were all within 3 km from the proposed SWRO plant site. While location 4 was situated 8.5 km away along a service road. The air quality monitoring at each of the other stations were surveyed for approximately two (2) to three (3) months each. A summary of the results of this survey is shown in the tables below.

Table 4-1 Summary of Taweelah Ambient Monitoring from A10 EIA (2006).

LOCATION ID	COORDINATES	MONITORING PERIOD
Loc 1	265916E, 2739726N	May 15 2005 – July 15 2005
Loc 2	267445E, 2741164N	October 3 2005 – December 5 2005
Loc 3	266861E, 2738975N	December 14 2005 – February 17 2006
Loc 4	269584E, 2732925N	March 3 2006 – May 22 2006

Table 4-2 Summary of Taweelah A10 EIA Ambient AQ Data (2006)

CONTAMINANT	LOC 1	LOC 2	LOC 3	LOC 4	CONTAMINANT
SO_2 (μg/m³)	Max Hourly	86	47	137	24
	Max Daily	22	16	17	10
	Annual Avg	5.5	7.8	6.2	5.7

NO_2 (µg/m³)	Max Hourly	100	95	108	96
	Max Daily	37	40	51	43
	Annual Avg	15	16	29	15
CO (mg/ m³)	Max Hourly	2.1	2.1	3.1	2.7
	Max Daily	1.5	1.7	1.8	1.9
	Annual Avg	1.3	1.4	1.1	1.3
Ozone (µg/m³)	Max Hourly	168	162	118	201
	Max Daily	112	98	84	110
	Annual Avg	57	42	52	69
PM_{10}	Max Daily	418	168	558	1090
	Annual Avg	140	62	79	135

During the 2005-2006 survey period, no exceedances of relevant air quality criteria were measured at any of the locations for the following parameters:

- Sulphur dioxide;
- Nitrogen oxide; and
- Carbon monoxide.

The results do, however, indicate that air quality at Tawelah during the survey period (2005-2006) was characterized by periods of elevated concentrations of ozone and PM_{10} . It is noted that the data presented above predates the development of KIZAD and Khalifa Port and, as such, may not exactly mirror current conditions in the area. The data does, however, provide an indication of the wider trends that are characteristic of long-term air quality monitoring studies in the UAE.

4.1.2 Baseline Data Collection

The local Environmental Consultant in Abu Dhabi (HDR) field scientists deployed a compact air quality monitoring station (Aeroqual, AQM65) on the Project site in accordance with the EAD approved TOR Report (HDR, 2018) (Appendix B). The air quality monitoring station (AQMS) was operational for the duration of 4 continuous weeks, with monitoring commencing on the 18th of June 2018 (Calibration certificates of equipment used are presented in Appendix C). The AQMS was protected from on-going activities, and was installed at the coordinates as shown in the table and figure below.

Table 4-3 Coordinates of the Installed AQMS (2018)

STATION NAME	LATITUDE	LONGITUDE

AQU_01	24.758816°	54.676768°

The AQMS recorded the following parameters for the duration of the survey:

- Carbon Monoxide (CO);
- Nitrogen Dioxide (NO_2);
- Volatile Organic Compounds (VOC);
- Ozone (O_3);
- Sulphur Dioxide (SO_2);
- Hydrogen Sulphide (H_2S);
- Particulate Matter (PM_{10} and $PM_{2.5}$);
- Temperature; and
- Relative Humidity.

Figure 4-6 Location of the Air Quality and Meteorology Stations

Title: Air Quality and Met Stations for the Baseline EIA Study

Job Number: 10108598
Revision: Rev 1
Date: 15 July 2018

Table 4-4 Summary Table of Ambient Air Quality Results

Parameter	Units	Averaging Period	Federal Standard	Average Concentration	Percentage Exceedance (%)	Maximum	Minimum
CO	mg/Nm³	1 hour	30	0.56	0	1.73	0.14
		8 hour	10	0.48	0		
NO_2	µg/m³	1 hour	400	39.95	0	383	0
		24 hour	150	24.68	0		
O_3	µg/m³	1 hour	200	78.77	0.59	215.2	0
		8 hour	120	84.30	14.28		
SO_2	µg/m³	1 hour	350	32.56	0	76.14	0
		24 hour	150	9.04	0		
PM_{10}	µg/m³	24 hour	150	188.61	58.82	1172.26	38.03
$PM_{2.5}$	µg/m³	24 hour	25*	381.01	100	463	280
H_2S	ppm	-	-	0.01	-	0.02	0
VOC	ppm	-	-	0.39	-	0.58	0.14
Temperature	°C	-	-	35.68	-	48.78	26.95
Relative Humidity	%	-	-	56.17	-	91.4	10.6

* US EPA Standard – No EAD or National standards are available

The results of ambient air quality monitoring, recorded continuously over a period of 1 month, indicate that the 1-hour and 8-hour concentrations of CO, NO_2, and SO_2 were all below the UAE Federal standards. Periodic exceedances of federal guideline values for O_3 and PM_{10} were recorded at the frequencies detailed in the table above. The National Ambient Air Quality Standards for the UAE do not include guideline limits or standards for $PM_{2.5}$. Thus, the US EPA guideline standard for $PM_{2.5}$ (25 $\mu g/m^3$ / 24 hours) is utilized in this study as a basis for comparison (US EPA, 2016). The full set of results is provided in Appendix D.

The exceedances of airborne particulates are attributable to a combination of the naturally high concentrations of airborne dust and combustion emissions from the existing Taweelah complex. The site predominantly consists of unconsolidated sandy soils with dust particles mobilized during periods of high winds. Vehicle movements across the site and on nearby access tracks increase the volume of airborne particulates that are mobilized at the site. Background concentrations of airborne dust are also naturally elevated. When combined with the combustion emissions from the water production and power generation facilities that source energy from combustion of fossil fuels, the PM concentrations at the site are subsequently elevated above the Federal (PM_{10}) standard for 59% of the time (24 hour average) and the US EPA ($PM_{2.5}$) standard 100% of the time (24 hour average).

Airborne particulate matter affects more people than any other pollutant measured (WHO, 2016). PM are usually composed of sulphate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water. $PM_{2.5}$ is of a size that is most damaging to human lungs. Chronic exposure to such particles contributes to the risk of developing cardiovascular and respiratory diseases, as well as of lung cancer (WHO, 2016).

Ground level ozone was also recorded at concentrations in excess of the Federal air quality standards. Ozone forms in the atmosphere as a result of reactions between nitrogen oxides (NOx) and VOCs in the presence of sunlight. Therefore, ozone concentrations are directly linked to concentrations of nitrogen oxides and VOC. The main sources of these precursor compounds are combustion emissions from transportation – predominantly road traffic – and industrial activity. The proximity of industrial facilities in the Taweelah complex and high incidence of UV at the site both contribute to ozone formation at the Project site.

NO_2 can cause significant inflammation of the airways in humans. The major sources of anthropogenic emissions of NO_2 are combustion processes such as heating, power generation and engines in vehicles. Given the location of the AQMS within the existing Taweelah complex, it is not unexpected to measure exceedances of the Federal standards given the large-scale industrial complex that surrounds the site and the large number of emission sources within a relatively small radius from the site.

4.2 Environmental Impact Prediction and Evaluation

4.2.1 Construction Phase Impacts

Mechanical dust sources result due to the movement of equipment or plant machinery, as opposed to wind erosion emissions, which result from the action of wind disturbing and displacing particles into the atmosphere. Mechanical emissions of particulates will likely generate some of the primary air quality impacts on a local level during the construction phase. Activities that are anticipated to generate mechanical particulate emissions include:

- Earthworks (top soil removal, excavations, grading, bulldozing and compaction);
- Vehicle movements on unpaved tracks;
- Wind erosion on unpaved surfaces and stockpiles; and
- Fill material transfer and hauling.

The generation of the following emissions during construction phase is also expected to have impacts:

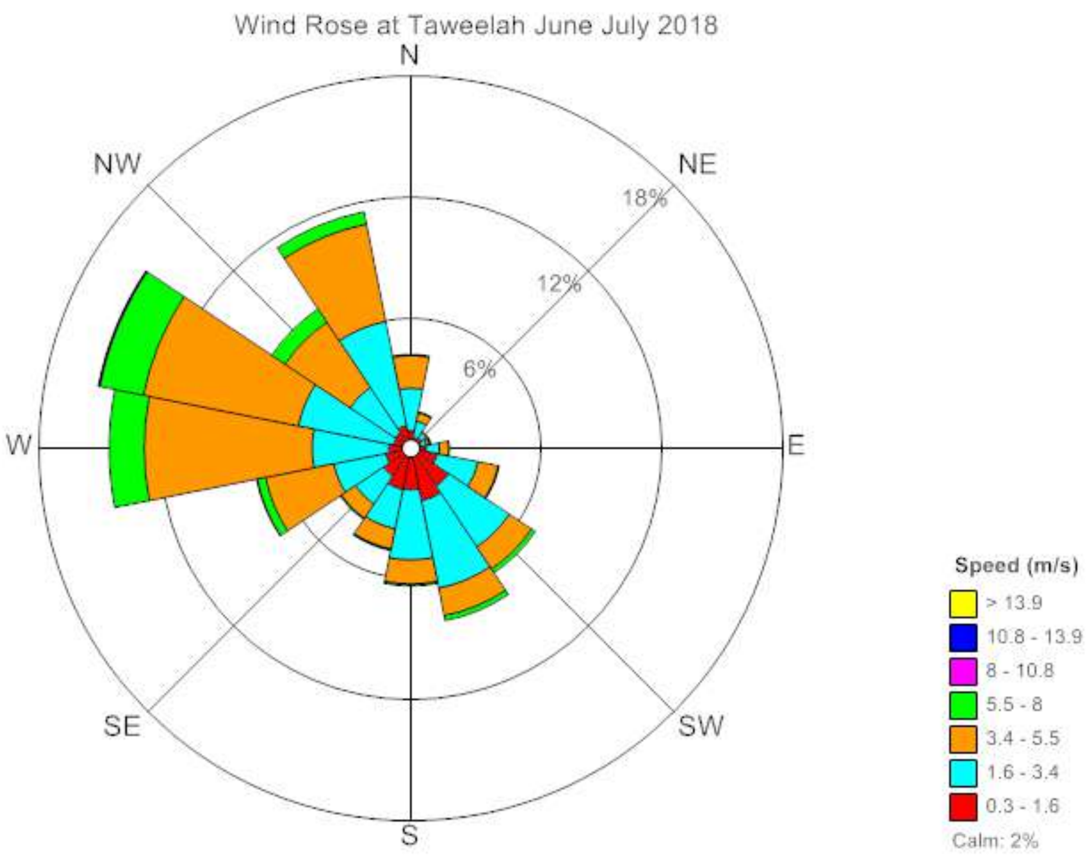
- Emission of combustion gasses from construction vehicles and equipment, generators, and vehicles accessing and working on the project site;
- Volatile Organic Compounds (VOCs) emitted from open chemical containers and fugitive emissions from hydrocarbon storage areas on the site; and
- Odour from sanitary and waste disposal facilities.

Airborne Particulate Matter

Construction will involve the operation of vehicles such as loaders, bulldozers, compactors and trucks to move, deposit and spread material on site. The on-site activity of such vehicles will result in mobilization of dust particles. During the construction phase, the existing vegetation on site will also be removed; reducing stability of the surface sediment in some portions of the site, and increasing volumes of airborne particulates. The wider Project area is frequently used by vehicles moving across or near to the site on a daily basis. As a consequence, given the baseline conditions already exhibit elevated concentrations of airborne particulates (averages of PM_{10} and $PM_{2.5}$ 126 and 86 µg/m^3, respectively), and the existing anthropogenic activity at the site, the impacts associated with removal of vegetation at the site are not anticipated to generate significant long-term detrimental impacts on local or regional air quality. The dust emissions generated from the construction works on site will, however, contribute to short-term increases in the concentrations of PM_{10} and $PM_{2.5}$ generated at the site.

A proportion of the airborne dust mobilized during the construction works will likely be deposited in the nearby marine environment. The volume deposited is likely to be dependent upon the direction of the wind and extent of dust generation during construction. Dust deposited into the marine environment may lead to increased nutrient loading and increased turbidity in the marine environment. It is noted that dust mobilization will be greatest during the initial phases of construction. Given the prevailing wind direction is from the NNW, blowing in towards the site off the sea, the volume of dust deposited into the marine environment is not expected to be significant as shown in the figure below. This is especially true when considered in the context of ambient conditions where high background airborne dust levels, particularly during the summer months, which would be expected to deposit significantly higher volumes over an extended period of time into the marine environment. The cumulative impact of construction dust is also not anticipated to be significant.

Figure 4-7 Wind Rose for Baseline Air Quality Monitoring Period June to July 2018



In summary, dust generation during construction will be temporary, short term and reversible as soon as the Project construction is complete.

Volatile Organic Compounds (VOC)

The operation of fuel-operated construction equipment, vehicles and tools will release exhaust gasses in to the ambient environment. These gases will include SO_2, NO_2, CO, Volatile Organic Compounds (VOCs) and carbon dioxide (CO_2). Carbon dioxide is a greenhouse gas known to cause global climate change. The reaction between nitrogen oxide, VOCs and sunlight (including ozone) is likely to generate increased ground level ozone. It is noted that baseline sampling and historical data collected at and proximal to the existing Taweelah facility (Jacques Whitford, 2006) indicates that the site is already characterized by elevated concentrations of ground-level O_3. The source of NOx is from the point emissions sources located throughout the existing Taweelah complex. It is noted that the construction works are unlikely to contribute to significant increases in the emissions of NOx or VOCs. As such, there may be a minor, localized increase in the generation of ground-level O_3 at the Project site during the construction phase. In view of the short scale of the construction phase and the relatively small scale of the works proposed, it is not anticipated that the combustion emissions and VOC emissions associated with the construction phase will have a significant, long-term impact on local or regional ambient air quality.

The project emissions are likely continued to grow from 2012 to present further contributing to local and transboundary climate change.

Odour

Potential sources of odour, prior to mitigation, may include the following facilities that are likely to be installed on-site:

- Fuel and other volatile materials stored at the site;
- Portable toilets (sewage), inadequate maintenance of septic tanks; and
- Inadequate waste management.

Strong and distinct odours may be objectionable or could pose a nuisance to some sensitive receptors. Odour emissions from putrescible materials (e.g. food waste) may affect the site occupants and sensitive receptors nearby the Project site in the event that these materials are not regularly collected. In addition, putrescible materials may also affect other off-site sensitive receptors during transport to the disposal facility. Odour emissions during the construction of the Project are considered to be likely due to the waste generation and presence of a septic tank and portable toilets on site.

4.2.2 Operational Phase Impact

Potential air quality impacts during the operational phase are likely to be associated with the following:

- Combustion emissions as a consequence of the additional vehicle trips to the area;
- Fugitive emissions from chemical and hydrocarbon storage areas / tanks; and
- Odour generation from the waste treatment system, sludge storage and possible defects in the sewage waste transfer and storage system.

Airborne PM

The operational phase is not anticipated to generate significant volumes of traffic to the site. It is highly unlikely that the traffic to the site will place excessive demands on the existing road infrastructure within the existing Taweelah complex, causing congestion and associated increases in combustion gasses and particulate emissions. There will inevitably be minor increases in combustion emissions as a result of the vehicle traffic travelling to and from the site due to employee trips, waste disposal and delivery of supplies required to operate the Facility.

There are no permanent point emission sources proposed on the Project site. All power will be sourced from the main Taweelah complex and there is no power generation anticipated at the Project site apart from renewable energy (solar PV) which will account for 10% of the plant's energy requirements. It is anticipated that there may be back-up diesel generators on the site, however, even if this option was exercised, these would only operate for short periods during emergency conditions.

VOCs

Odour may potentially become an issue in the event of sewage leaks and / or inadequate waste management. Use of substandard TSE also has the potential to generate odour-causing nuisance to occupants on-site and the immediate surroundings. Monitors should be installed in the sewerage and TSE network to monitor pressure in the system and provide immediate indications in the event of a leak. Inadequate waste storage and irregular removal of organic putrescible waste from the site can also generate disagreeable odour. It is assumed that the organic sludge removed by the DAF system has the potential to generate the majority of odour issues associated with the production process if not appropriately managed. Should regular inspection and maintenance of the facilities be implemented, the impacts associated with odour generation are expected to be negligible.

Hypochlorination

The hypochlorination systems are self-contained to avoid chlorine emissions into the ambient air. However, there are safety measures that must be implemented at the facility. These measures include implementing personnel safety procedures and equipment where the chlorine is most used. These include leak detectors, gas respirators, protective clothing, atmospheric monitoring instrumentation, repair kits, and eyewash, shower and related alarms. In general, the concentration of chlorine gas in the ambient air should be less than 3 milligrams per normal cubic metre (mg/Nm^3) in the hypochlorination processing area[4].

Impact Summary

The primary source of operational emissions from the completed development will be the vehicles on the roads. In the event of minor spills or leaks from the sewage transfer network, there may be short-term issues with odour until the damage can be resolved.

4.2.3 Cumulative Impacts

The potential for cumulative air quality impacts during the construction phase will be associated primarily with PM generation, small-scale vehicle emissions from the site and the generation of additional traffic trips to and from the site. During the operational phase, traffic associated combustion gas emissions are anticipated to be the primary contributor to cumulative impacts on ambient air quality. Given the scale and duration of the construction works required, the absence of point source emissions during the operational phase, and the comparatively small volumes of traffic that will be generate during both construction and operational phases, the contribution of the proposed project to cumulative air quality impacts is anticipated to be negligible

4.3 Mitigation Measures

4.3.1 Potential Mitigation Measures

Impacts on ambient air quality resulting from the construction activities can be controlled through the implementation of the mitigation measures detailed in this section. The mitigation measures proposed generally include control-at-source, management procedures, and the provision of control structures to limit negative impacts as far as is feasible.

[4] Environmental Guidelines for Chlor-Alkaline Industry, Multilateral Investment Guarantee Agency: http://www.miga.org/sites/default/files/archive/Documents/ChlorAlkali.pdf

Table 4-5 Air Mitigation Measures

Impact Description	Mitigation Measures	Regulations/Standards
Construction Phase		
Dust Emissions (PM10 and PM2.5)	• Any land grading, excavations and moving of uncovered waste/materials will be undertaken during periods of low winds (e.g. < 15 km/h is recommended as a threshold when a review of works is conducted) • Defined haul routes to be used at all times. • Prompt mitigation of visible dust emissions, which may involve a combination of: • Stabilisation of surface silt content through application of water sprays; • Provide impervious covers to stockpiles of all materials that might generate airborne PM • Limit the height and slope of stockpiles and situate away from potentially sensitive receptors • Where stockpiles are too large to cover, alternative dust suppression measures (i.e. spraying with water to dampen surface) to be employed • Control of mechanically induced dust emissions by application of water sprays; • Awareness of operational areas more frequently exposed to higher winds. Temporary wind barriers may be employed; • Review weather updates, to give warning of likely strong winds to assist with management of windblown dust; and • All haulage vehicles are to have their loads covered at all times when leaving site. • Continuous measurement of ambient air quality (PM_{10} and $PM_{2.5}$) concentrations will be undertaken by means of the deployment of a continuous particulate matter analyser at a fixed single location in construction area. A meteorological station will be installed to provide continuous measurement of wind speed and wind direction at the same location as the measurement of PM_{10} & $PM_{2.5.}$ • Workers at risk to be provided with Respiratory Protective Equipment (RPE) half face masks (preferably RPE rated to FFP-2) during dust generating activities and elevated PM events or when standards are exceeded. • Damping down of construction roads will be undertaken twice daily as a minimum. This may need to be increased at times should the particulate standards be exceeded. • Dust arising from transfer of dry materials	Federal Law No. 24 of 1999 - Concerning Protection and Development of the Environment and its Executive Order issued by Council of Ministers Decree No. 37 of 2001. Council of Minister Decree No. 12 of 2006 (under Federal Law No. 24) including Regulation concerning Protection of Air from Pollution. WHO Ambient Air Quality Standards

	to/from stockpiles must be controlled by damping of materials to avoid wind-blown dust into areas where workers are present. • Adequate hand and face washing facilities to be provided and observe good hygiene habits.	
Vehicle Exhaust emissions (NO_2, SO_2, CO, VOCs)	• Develop appropriate work schedules and methodologies to avoid double handling and minimise emissions. • Provide instructions to operators to turn off equipment when not in use. • Use cleaner types of fuel, where possible (i.e. low sulphur diesel, ultra-low sulphur diesel fuel). • Install equipment with pollution control devices such as diesel oxidation catalyst or particulate filter. • Provide appropriately sealed containers for fuel to control VOC emission. • Provide adequate ventilation in work areas where volatile materials will be handled. • Regularly maintain construction vehicles and machinery on site. • Open burning of construction waste is strictly prohibited.	As above.
Control of Odour	• Locating portable toilets, sewage storage tanks and waste storage facilities away sensitive receptors. • Ensure toilets and septic tanks are well maintained and frequently cleaned. Leaks should be fixed as soon as possible. • Waste bins holding putrescible waste should be covered to minimise odour emission and attraction of vectors. • Regular off-site disposal of waste should be arranged by Tadweer - Centre of Waste Management. licensed waste disposal contractor.	
Operational Phase		
Dust emission (PM_{10} and $PM_{2.5}$)	• Maintain road cleanliness to reduce dust emitting into ambient environment. •	Ambient Air Quality Standards stipulated in the Council of Ministers Decree No 12 of 2006 WHO Ambient Air Quality Standards
Exhaust emissions (NO_2, SO_2, CO, VOCs)	• Planting of trees that could absorb air pollutants. • A Traffic Management Plan will be developed and implemented to limit vehicle access and speed, as well as to ensure the smooth flow of traffic going in and out of the Project area. • Carry on with the existing ambient air	Ambient Air Quality Standards stipulated in the Council of Ministers Decree No 12 of 2006 WHO Ambient Air Quality Standards

	monitoring nearby the Project site.	
Control of Odour	• Maintenance of wastewater storage to minimise risks of any leakage to groundwater and the exposure of operational staff to odours. Where practical, pressure monitors should be installed in the sewerage to monitor for indications of leaks in the system. • Housekeeping and sanitary conditions should be well maintained at the waste management facilities. Bins for putrescible waste should be kept covered. Waste on site and at the waste management facilities to be removed from site regularly to avoid over accumulation of waste.	

4.4 Greenhouse Gas Emissions (GHG) – Scope 2

The Taweelah IWP will require 114.26 MW for operation of the RO Plant. However, 13.32 MW will be generated from solar PVs onsite, thereby requiring 100.94 MW to be provided through the Abu Dhabi grid.

The Scope 2 - estimated CO_2 emissions have been calculated based on assumed gross efficiency of Abu Dhabi grid of 40%. This is likely to be a worst case scenario as this does not take account of the renewable energy within the power mix for Abu Dhabi. The nuclear power plant will become operational in 2021, adding 5.6 GW to the grid and this will considerably reduce the CO_2 emissions for Taweelah IWP. Table below presents the input used for the GHG emissions calculations.

Table 4-6 GHG Emissions Input Data

INPUT	VALUE
Efficiency	40%
% of Carbon in Natural Gas	75%
Heat Rate	(3600/efficiency) x100 KJ/KWH 9,000 Kj/KWh
Net Calorific Value of Gas	46 KJ/SCF
Specific Gas Consumption	(Heat Rate/Net Calorific Value) 0.1957 Kg/KWH
Carbon on 0.1957 Kg of gas	(0.1957 x 0.75) 0.1468 Kg

- $C + O_2 = CO_2$.
- Atomic weight of carbon= 12
- Molecular weight of Oxygen = 16 ×2=32
- Molecular weight of Carbon dioxide =44.
- 12 Kg of carbon by burning can produce = 44 Kg of CO_2.
- 0.1468 Kg of Carbon by burning can generate= (44/12) ×0.1468=0.5383 Kg of CO2.
- While burning gas almost 92 % gas will convert in to Carbon dioxide, so actual carbon dioxide emission per KWh= 0.5383×0.92=0.4952 Kg/Kwh.
- CO_2 emission by generating 100 MW= 100×1000×0.4952=49520 Kg/h=49.52 tons/h.
- CO_2 emission annually = 8760 ×49.52=433795 tons./year Roughly in GHG nearly 82 % is CO_2.
- So GHG emission annually= (433795/0.82)=529018tons/year.

Based on the calculations above, the Scope-2 GHG emissions for the Taweelah IWP is 529,018 tons/year.

The ADWEC statistical data for 2017 is shown in the Figures below which identifies 16,500 MW of installed capacity in Abu Dhabi together with calculated emissions of 37,831,634 tons of CO2 from power plants in 2017.

Figure 4-8 ADWEC Generation Capacity and CO_2 Emissions for Abu Dhabi

Company	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Bainounah Power Company (BPC)	574,232	-	-	-	-	-	-	-	-	-	-
Al Mirfa Power Company (AMPC)	[illegible]	1,018,313	1,175,858	1,213,188	1,214,342	987,233	716,819	713,343	[illegible]	[illegible]	[illegible]
Gulf Total Tractebel Company (GTTPC)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Emirates CMS Power Company (ECPC)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3,733,115	[illegible]	[illegible]	[illegible]
Taweelah Asia Power Company (TAPCO)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shuweihat CMS International Power Company (SCIPCO)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ruwais Power Company (RPC)					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shuweihat Asia Power Company (SAPCO)							137,418	[illegible]	[illegible]	[illegible]	[illegible]
Arabian Power Company (APC)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Shams 1							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mirfa International Power Company (MIPCO)											[illegible]
Emirates SembCorp Water & Power Company (ESWPC)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fujairah Asia Power Company (FAPCO)					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Emissions in Abu Dhabi Plants	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Emissions in North East Plants	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Emissions in ADWEA Plants (Global)	[illegible]	26,227,412	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

5 MARINE WATER, SEDIMENT AND ECOLOGY

5.1 Description of the Environment

5.1.1 Regional Context

Bathymetry, Seabed Topography and Coastal Features

The intertidal area of Al Taweelah consists of a crescent shaped north-west facing, sloping beach, backed by a low consolidated sand cliff. The sediment is medium course coral/shell sand with a low fines content. The slope of the beach decreases to the north-eastern and southwestern flanks, forming a wider intertidal area. The construction of breakwaters and other shoreline features has resulted in complex localised current patterns. To the west of the site, the shoreline typically comprises medium-fine sand, forming a large embayment. Erosion has occurred in the eastern shadow of the outfall breakwater, whilst there has been significant accretion on the western side of the intake breakwater. Ras Hanjurah is located to the southwest and Ras Ghanada to the northeast. Within these two areas there are both natural and manmade channels and features. Extensive coastal engineering works have been undertaken in the last ten years. Most notably, the construction of the Khalifa Port will have had significant impacts on coastal hydrodynamics in the vicinity of the project site.

The topography of the seabed is a gently sloping shelf reaching approximately 7 m below chart datum BCD at 4 km northeast from the discharge. Adjacent to Ras Ghanada and Ras Hanjurah the seabed is shallower with a more extensive (2 km) shallow (2-3 m depth) platform, which shelves to approximately 7 m depth further offshore. Sediment transport is indicated by sand ripples parallel to the shore indicating that bedload transport is generally onshore rather than longshore (Delft 1997).

Figure 5-1 Nautical Chart for Taweelah Area

Source: Navionics, 2018

Hydrodynamic Regime

In order to collect site specific data on current and tidal water movements in the study area, HDR installed two (2) Nortek Aquadopp Current Profilers in May of 2018. One was installed for two full tidal cycles (i.e. two (2) x 15-day deployments) and one was installed for a single full tidal cycle. The Aquadopps were mounted in steel frames and were deployed and recovered from a fully equipped survey vessel. The frame was moored in place on the seabed at the required location with two (2) anchors and chains. This minimized the possibility of theft by third parties, snagging by fish nets, or displacement by wave action. The deployment positions of the Aquadopps and tide gauge are shown in Figure 5-2 and Table 5-1.

Figure 5-2 Locations of the Two Aquadopp Current Profilers and the Tide Gauge

Table 5-1 GPS Coordinates of the Aquadopps

STATION NAME	LATITUDE	LONGITUDE
AQUA_01	24.768524°	54.656070°
AQUA_02	24.777672°	54.631092°

The following parameters were recorded for the whole survey duration:

- Temperature;
- Current speed at profiled depths; and
- Current direction at profiled depths.

In addition, during the 2018 study, one tidal gauge was deployed at the small fishing harbour to the south of Khalifa Port and as indicated in Figure 5-2.

Figure 5-3 Measured Water Depth During 30 Day Aquadopp Deployment

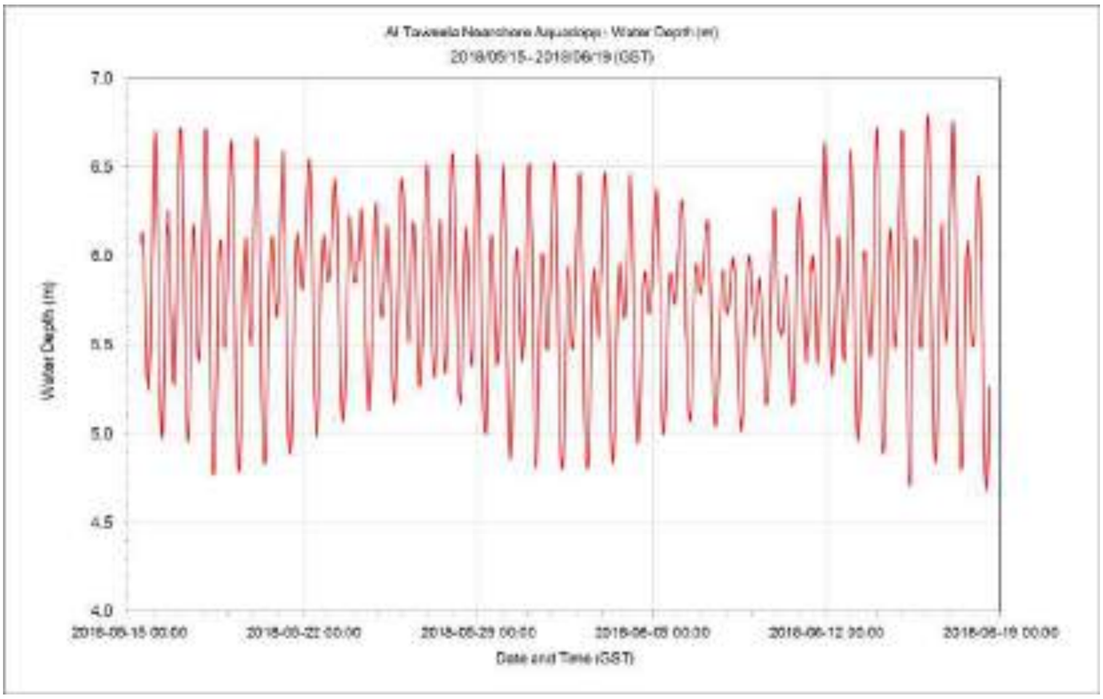


Figure 5-4 Measured Current Speeds at Base of Water Column

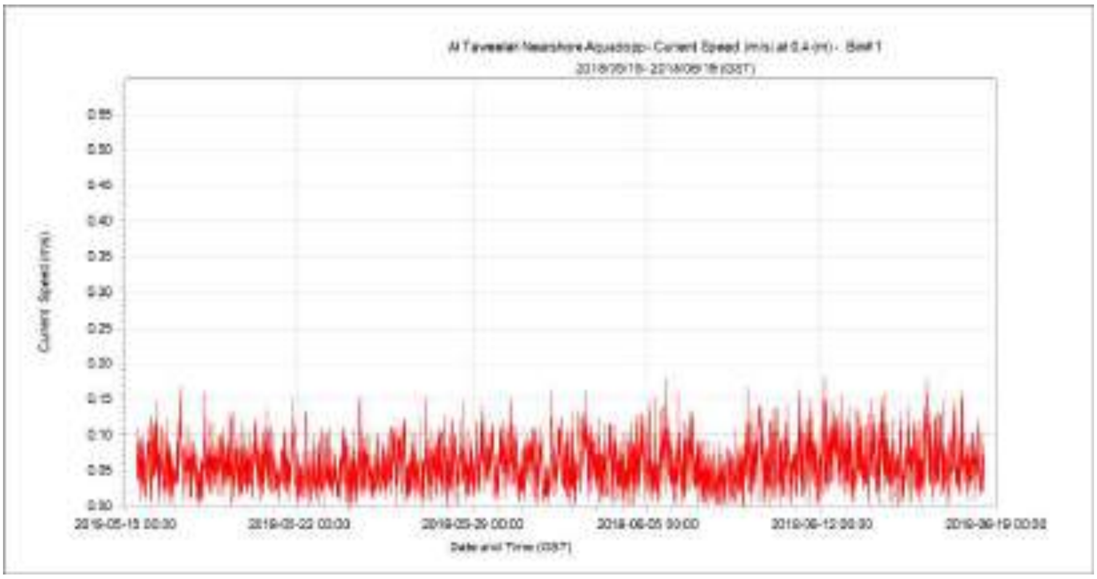
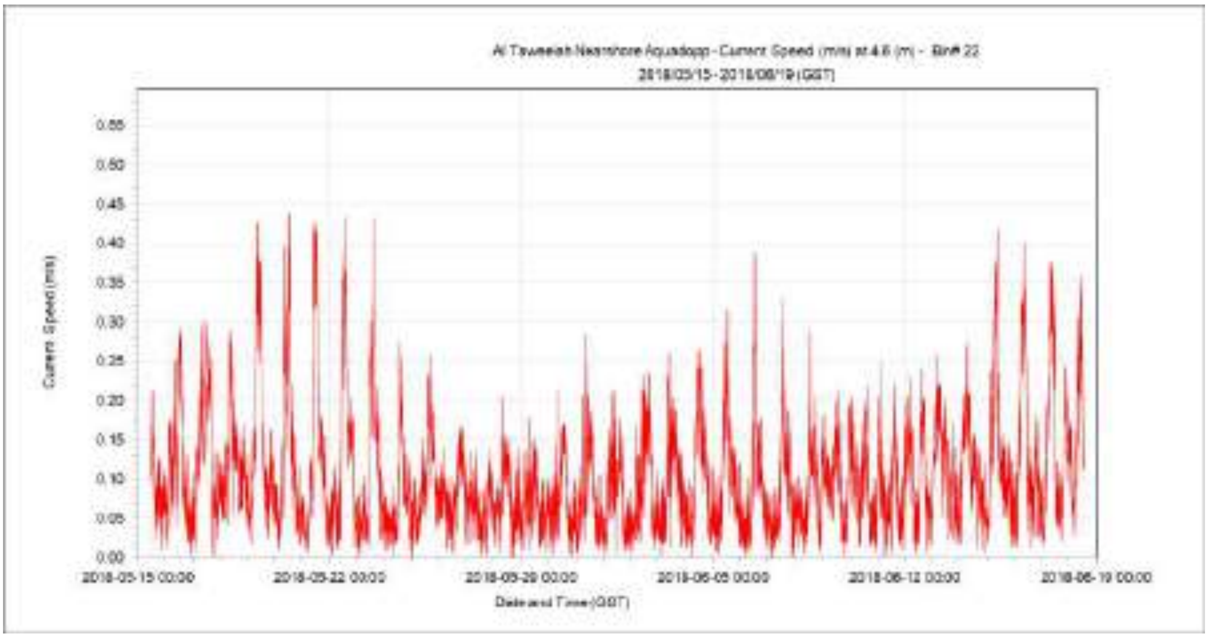


Figure 5-5 Measured Surface Current Speeds



Marine Waters

Seasonal changes in hydrodynamic and physicochemical water processes cause pronounced periodic shifts in water quality throughout the Gulf. A key driver of these processes is the Gulf salinity front. This front changes according to ambient temperature driven by seasonal (summer/winter) changes, and creates a distinctive and dynamic thermo-saline isopleth. In winter, circulation of warmer, less saline waters entering the Gulf from the Strait of Hormuz is restricted to the southern Gulf. During the summer months less saline, and subsequently less dense, waters enter the Gulf through the Strait of Hormuz. The less dense waters flow in the upper surface of the water column and circulate along the Iranian coast before reaching the Arabian coasts in a broadly anticlockwise flow, resulting in enhanced circulation (Kampf and Sadrinasab, 2005).

The Gulf waters have high salinity that typically ranges between 38 - 45‰ (PSU). Shallow embayments or areas with restricted circulation, such as the Gulf of Salwa, exhibit substantially higher salinity, often exceeding 55 PSU during the summer months. Water temperature ranges can be extreme, fluxing from less than 17°C in the winter season to in excess of 32°C in shallow coastal waters during the summer. The elevated seawater temperatures and salinity have important effects on water quality by reducing the capacity for oxygen to remain dissolved in water. Prevailing winds and tidal currents work in combination to increase wave action, which in-turn oxygenates surface waters and is considered an important process for maintaining marine life in the Gulf. The high salinity in the Arabian Gulf also results in increased precipitation of calcium carbonate ($CaCO_3$) in seawater, which reduces its buffering capacity against increases in acidity. As a consequence, marine waters in the Arabian Gulf tend to be more alkaline than well flushed, less saline marine waterbodies and oceans.

Ambient water temperatures and salinity values vary in the UAE's coastal waters throughout the year. Water temperatures typically range between 19°C and 35°C whilst salinity ranges from 32 to 42 PSU (Abdessalaam, 2007). In the summer months, seawater temperatures and salinity values are higher as a consequence of increased evaporation rates.

Data reported by the Taweelah Power Plant in 2006 (Jaques Whitford, 2007) suggests that salinity levels in the vicinity of the plant ranged from 38.2 to 44.6 PSU during the summer months. During the same June to August reporting period, seawater temperatures ranged between 32.2 and 36.7°C. It is noted that this data was reported without reference to the monitoring location, both in terms of proximity to the project site and depth in the water column. A marine survey conducted in 2006 as part of the Taweelah A10 Extension Project conducted *in situ* marine water quality sampling at 10 survey locations in the Taweelah outfall channel, adjacent to the exit of the outfall channel and at the entrance to the intake channel. Results indicate water temperature ranged from 31.7 to 40.79°C. These datasets show that the marine water quality has been subject to influence from the operations of the Taweelah Complex for more than 12 years prior to the start of this study.

Multiple marine water quality surveys have been conducted in the vicinity of the Taweelah Complex (Dome & Marubeni, 2004, Dome & Marubeni, 2005 and Marubeni, 2007). All of the reports provided by the Project Proponent provide an indication that existing shoreline effluent discharge plume mixes and dilutes at a slow rate and conditions above ambient are detectable a number of kilometres from the point of discharge. There is also evidence of notable variation with depth through the water column. *In situ* water quality profiles conducted in previous studies have recorded signature water quality measurements of elevated water temperature and salinity at the base of the water column up to 3.5 km from the discharge point at the seabed, with similar conditions restricted to 1.6km during the same survey (Dome & Marubeni, 2005). Historical data indicates that the temperature at the sea surface within the 3km closest to the shore of Taweelah fluctuates between 3-6°C cooler than the temperatures recorded at the seabed (Dome & Marubeni, 2005). This pattern is also evident for salinity where salinities vary from around 42 PSU at the surface to up to 45.8 PSU at the seabed (Dome & Marubeni, 2005).

The most recent targeted analytical water quality survey (before HDR's 2018 and 2019 surveys) within the survey area was conducted in 2006 (Jaques Whitford, 2007). Marine water samples were collected during and were analysed for parameters including anions, BOD, COD, TSS, TDS, nutrients, metals and hydrocarbons. Though only providing a snapshot of conditions on a single day, the results do suggest that waters within the Taweelah Complex outfall channel at the point of discharge are characterized by elevated concentrations of heavy metals (iron, copper, zinc, chromium and lead). Metal concentrations in samples collected outside the channel were significantly lower, suggesting that metals may settle out of the water column by the time the discharge effluent exits the common discharge channel into the Arabian Gulf.

Marine Sediments

Sediments in the Gulf show marked regional differences with carbonate sands predominating throughout the Saudi Arabian – UAE coast (Al-Ghadban, 2002). Carbonaceous sediments of biological origin (derived mainly from microfauna, especially foraminifera) make up the majority of the substrate in Abu Dhabi's coastal waters. On a local scale, sediment compositions are influenced by a number of factors such as water depth, water agitation, light penetration, origin of sediment (whether autochthonous, allochthonous, calcareous or terrigenous) and hydrodynamic processes and proximity to sources of anthropogenic pollutants (Al-Ghadban et al, 1998).

Historical data from before the Khalifa Port was constructed at Taweelah (Marubeni, 2007) shows that sediment cover in the marine environment of the survey area is dynamic and there is evidence of sediment bedload transport. Granular sediments range from fine, silty material at the mouth of the Taweelah outfall channel to poorly sorted medium coarse sand with shell fragments and a low fines content for the majority of the coastal areas. Further offshore and to the east the sediments form a thin veneer on a bedrock substrate. The substratum in the middle of the bay consists of poorly sorted medium sand with little or no fines. To the northeast and southwest, the substrate is predominantly flat limestone bedrock, covered with a thin, mobile sand veneer, leaving ridges of exposed rock in places. This provides the greatest opportunity for larval settlement and subsequent growth of epibenthic invertebrates and an attachment for marine algae. To the west of the outfall channel, finer, deeper sands are more characteristic, and shifting sand bars have developed both nearshore and several kilometres offshore. These conditions are less favourable for the survival of epibenthos, but potentially provide habitat for benthic infauna and seagrasses.

The most recent historical sediment quality survey undertaken in the area (Marubeni, 2007) was conducted before the Kahlifa Port was constructed. During this survey a number of samples were collected for analysis of heavy metals, TPH, residual chlorine, TSS, PSD and organic contamination. Results showed that for heavy metals, the bio-accumulative heavy metal lead was below detection limits at all locations sampled and if present would have only been in trace amounts and therefore beyond any deleterious levels to marine organisms. Similarly, cadmium was not detected at any of the locations apart from 1 station. For the less cytotoxic elements, nickel and zinc, their concentrations were also present below any levels known to cause behavioural changes in benthic vertebrates such as fish. Additionally, the microbiocidal heavy metal copper was present only in concentrations, which would not be considered acutely harmful to microbial life.

Diesel Range Hydrocarbon (DRH) and heavy fraction values fell below the minimum detection limits (MDL) (Marubeni, 2007). Gasoline range hydrocarbon (GRH) gave recorded values above the MDL at some sites, but only those that were in close proximity to the dredging operations that were underway at the time as part of the Dolphin project. Lead, not detected in either of the previous studies was only detected at one site in very close proximity to the marine operations underway in the area.

Marine Ecology

Marine Habitats

Since the construction of the Khalifa Port, there have not been any publicly available targeted surveys undertaken in the Taweelah area that assess marine ecological components. Prior to the Port construction, survey reports state that the waters directly offshore of the Project site were comprised predominantly of sediment with patchy seagrass beds comprised predominantly of *Halodule uninervis* with occasional *Halophilia ovalis* (Dome & Marubeni, 2005). More densely populated seagrass beds were reported approximately 3km to the southwest of the Project boundary. The most recent habitat map on the EAD portal (EAD, 2018) shows that there is an expanse of fringing coral reef (purple) approximately 1km southwest of the Project site and expanses of seagrass approximately 300m to the northeast of the Project site boundary.

Table 5-2 A Selection of Marine Protected Sites and Sensitive Habitats

ID	Coordinates (Degree Minutes Seconds)		Coordinates (Decimal Degrees)	
	Northing	Easting	Latitude	Longitude
Fringing Reef (within Ras Ghanada Marine Protected Area)				
R1	24°51'46.80"	54°42'43.20"	24.863000°	54.712000°
R2	24°51'3.60"	54°42'3.60"	24.851000°	54.701000°
R3	24°50'6.00"	54°41'34.80"	24.835000°	54.693000°
Patch Reef				
R4	24°41'35.62"	54°35'17.76"	24.693229°	54.588266°
R6	24°38'33.99"	54°31'38.29"	24.642776°	54.527302°
Fringing Reef with Macro Algae				
R5	24°44'42.00"	54°38'20.40"	24.745000°	54.639000°
Sea grass				
SG1	24°49'51.60"	54°42'50.40"	24.831000°	54.714000°
SG2	24°48'10.80"	54°41'56.40"	24.803000°	54.699000°
SG3	24°46'44.40"	54°41'6.00"	24.779000°	54.685000°
SG4	24°42'46.80"	54°36'43.20"	24.713000°	54.612000°
SG5	24°41'42.00"	54°37'44.40"	24.695000°	54.629000°
Mangrove				

M1	24°48'39.60"	54°43'58.80"	24.811000°	54.733000°
M2	24°44'20.40"	54°40'4.80"	24.739000°	54.668000°
Mudflat				
MF1	24°49'4.80"	54°43'19.20"	24.818000°	54.722000°
MF2	24°43'1.20"	54°39'18.00"	24.717000°	54.655000°

Figure 5-6 EAD Portal Areas of Environmental Sensitivity

The growth of seagrass beds in the Arabian Gulf is seasonal. New shoot growth begins in March and reaches maximum levels by June with continued growth throughout the summer followed by a marked decrease by mid-February as a result of decreased temperatures (KFUPM, 2001; Vousden, 1988).

Previous studies undertaken at Taweelah have resulted in habitat classification maps, for example DOME 2005, which shows *"sand"* habitat along the shoreline and *"deeper sediment with seagrass patches"* offshore form the Taweelah intake and discharge channel (see Figure 5-7). A more recent habitat survey (Ref HP/H EIA) describes the same area as *"sand with sparse seagrass patches and occasional macroalge beds on exposed rock"* (see Figure

5-8). Based on the historic habitat surveys, it is evident that the seagrass bed to the north east of the Project site has developed over the past 10 years, since the development of Khalifa Port. This suggests that the seagrass habitat has established whilst within the thermal desalination effluent plume from the Taweelah Complex. Surveys in 2019 observed a good seagrass community.

Figure 5-7 Habitat Classification at Taweelah (DOME, 2005)

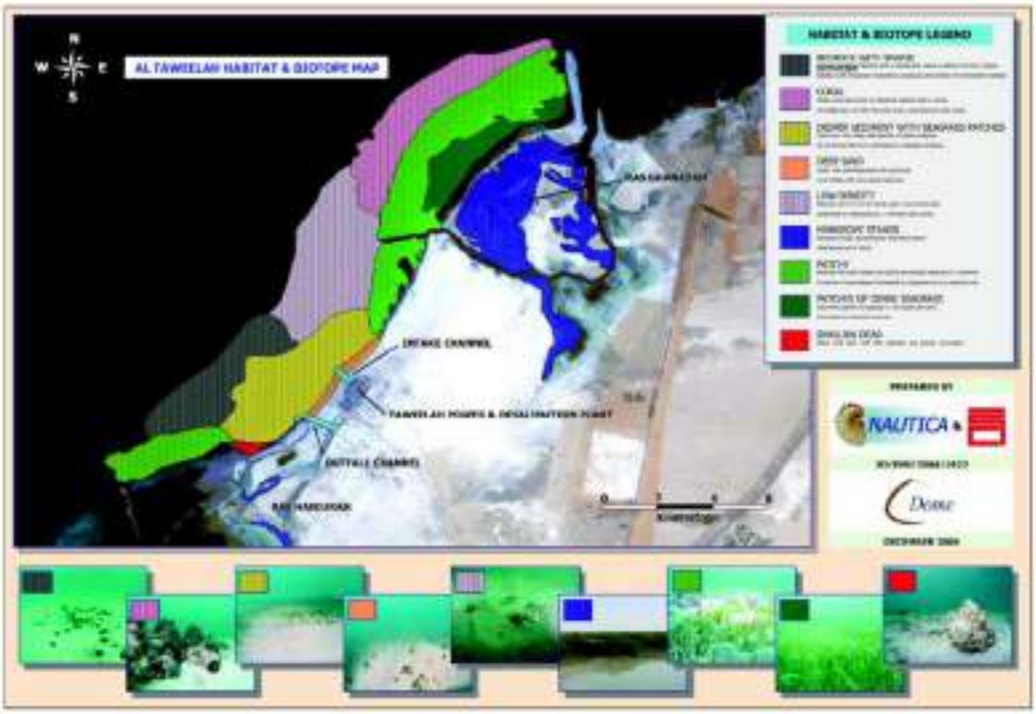


Fig 3-20 Seabed classification and habitat map (Dome, 2005).

Figure 5-8 Habitat Map prepared for the HP/H EIA

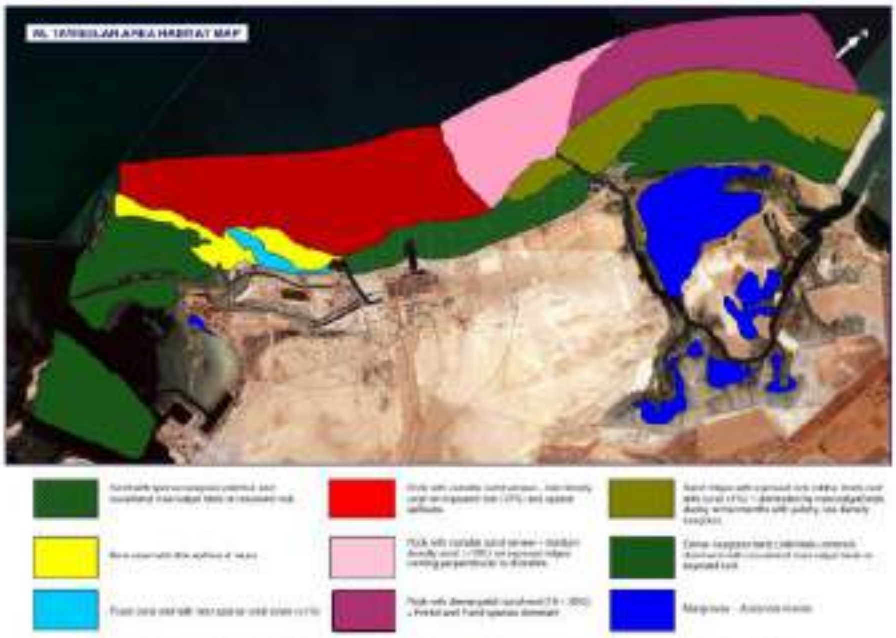


Fig 3-21 Seabed classification and habitat map generated in HP/H EIA.

Marine Icthyofauna

The marine biota of the Arabian Gulf is generally acknowledged to be impoverished due to the limited circulation, shallow depths (average of 35 m) and physicochemical characteristics of the Gulf. Relatively few marine species of animals and plants are able to withstand such a huge variation of sea temperature and some unable to tolerate the high salinity. Due to the shallow-coastal nature of the marine environment in the UAE, corals, seagrass beds and mangroves represent some of the most important nursery grounds for many fish in the region.

A list of reef associated fish, sharks and rays compiled from a wide variety of sources indicates that there are 302 species recorded for the Gulf from 70 families; compared to 3,000 species of fish recorded in the Indo-Pacific region, or 1,200 species present in the Western Atlantic (Helfman, Collette and Facey, 1997). The best represented families in the Gulf are Carangidae (trevally) with 30 species, Gobiidae (gobies) with 28 species, Apogonidae (cardinalfish) with 20 species and Pomacentridae (angelfish / chromis / damselfish) with 16 species (Riegl and Purkis, 2012). Endemism is also low with only 16 species of fish thought to occur uniquely within the Arabian Gulf, although it is acknowledged that their distribution may in fact extend to the Gulf of Oman or beyond (Randall, 1995; Riegl and Purkis, 2012). Counts of reef fishes from underwater visual census surveys in the Arabian Gulf ranged from 71 species in Bahrain, to 106 species in Saudi Arabia, while 103 species were recorded off the coast of Dubai (Randall, 1995; Riegl and Purkis, 2012).

Marine Megafauna

Several key species of marine megafauna with recognised international conservation significance occur either as residents or itinerants on a seasonal basis within Gulf waters. These species include:

- **Sea Turtles**: Of the seven recognized species of marine turtles, five are found in the waters of the UAE including the two most frequently occurring ones the Green Turtle (*Chelonia mydas*) and the Hawksbill Turtle (*Eretmochelys imbricata*) listed as "Endangered" and "Critically Endangered" respectively (IUCN, 2019) the Hawksbill are known to nest in the UAE and there have been unconfirmed reports of the Green turtle nesting on Sir Bu Nair Island. The remaining species include the Loggerhead Turtle (*Caretta caretta*), the Leatherback Turtle (*Dermochelys coriacea*) and a fifth species, the Olive Ridley turtle (*Lepidochelys olivacea*) that is known from neighbouring Oman but is almost certainly a visitor to UAE waters (Baldwin and Gardner, 2005).
- **Odontocete:** Ten different species of toothed whales and dolphins, the odontocetes, have been recorded in the UAE:

- Finless porpoise (*Neophocaena phocaenoides*);
- Indo-Pacific humpback dolphin (*Sousa chinensis);*
- Indo-Pacific bottlenose dolphin (*Tursiops aduncus);*
- Indo-Pacific common bottlenose dolphin (*Tursiops. truncatus);*
- Spinner dolphin (*Stenella longirostris);*
- Long-beaked common dolphin (*Delphinus capensis);*
- False killer whale (*Pseudorca crassidens);*
- Killer whale (*Orcinus orca);*
- Risso's dolphin (*Grampus griseus);* and
- Sperm whale (*Physeter macrocephalus)*.

The finless porpoise finds retreat in coastal shallows, whereas the sperm whale, the largest of the toothed whales (up to 20 meters in length), is recorded in deeper waters (Robert Baldwin, 2005).

- Mysticeti (baleen whales): A number of mysticeti's have been observed within the Arabian Gulf. These include the brydes whale, fin whale (endangered), pygmy blue whale and humpback whale (vulnerable) (Baldwin, 1995; Gillespie, 2006).
- Dugongs: Dugongs (*Dugong dugon*) belong to the monotypic order Sirenia and are the only herbivorous marine mammals, feeding directly on seagrasses.

During surveys conducted in the 2001, Wijsman and Riegl (2001[5]) reported Indopacific Humpback dolphin (*Sousa chinensis*) and Green Turtles (*Chelonia* mydas) in the vicinity of the Taweelah Complex intake breakwaters. During the EIA for the Taweelah B extension phase (Dome & Marubeni, 2005) a total of 22 dugongs, dolphins and turtles were observed over a nine (9) day survey period within the area proximal to Taweelah. This indicates the historical significance of the wider Taweelah area for these marine mammal and reptile species, however similar survey effort in 2018/2019 did not identify any mammals or reptiles. The presence of extensive seagrass to the north-east (Ras Ghanada) and south-west of the Project site is likely to provide grazing, foraging, breeding and sheltering habitats for a range of marine mammal, reptile, icthyofaunal and invertebrate populations. However, while the seagrass bed adjacent to the new intake has the potential as a feeding area, no records of this being used for feeding are known in recent years including the 2018/2019 surveys.

[5] Wijsman, J. and Riegl, B. (2001) Fact finding mission and ecological survey Al Taweelah. November 2001. Delft Hydraulics. Abu Dhabi. UAE.

Benthic Infauna

Ecosystem changes, as reflected by shifts in the composition and distribution of sedimentary infauna, are predicted in normal environments (Pinnegar *et al*., 2000). Measurements of change in infaunal communities have been widely used in identifying and monitoring man-made impacts on the sea (Poore and Kudenov, 1978; Ashton and Richardson, 1995). This is largely due to the relative immobility of many infaunal organisms and how the effects of pollutants can therefore accumulate in organsims over time (Warwick, 1993). This relative lack of mobility makes infauna particularly vulnerable to direct physical disturbances, such as dredging and reclamation which alters the sedimentary structure (Hall, 1994).

Historical infaunal data collected during a survey in December 2004 indicates that diversity and abundance of infaunal species were relatively low in the areas adjacent to the Taweelah Complex. An infauna survey was conducted in 2005 along a series of 3km long transects oriented away from the opening of the discharge channel (Dome & Marubeni, 2005). The prevalent type of substrate present proximal to the Taweelah facility was reported as being the main factor contributing to such a paucity of infaunal abundance and species diversity. The report states that many of the sampling sites were characterized by thin sediment veneer over bedrock. In some areas the sediment was stabilized by patches of seagrass (mainly *Halophila uninervis*), however, even these patches seem to be ephemeral and undergo seasonal die-back during the winter season. Periods of strong winds, particularly *Shamal* winds from the northwest, would cause significant suspension and movement of sediment. Added to this, the coarse, sharp nature of the sediment probably favours harder bodied and/or faster moving species. Tube-dwelling polychaete species were found mainly in stations where seagrass stabilized the sediment. However, most of the sampling stations located closer to the mouth of the outfall channel showed lower than expected abundances and diversity, despite the presence of relatively deep (>10cm) sand. This indicates that sedentary infaunal communities are negatively impacted by the hypersaline effluent plume that is discharged from the outfall. It is noted that the previous infaunal communities survey did not record any species that are considered to be rare across the Arabian Gulf (Dome & Marubeni, 2005).

Globally, only a small portion of marine habitats have been sampled for macrobenthos. The number of described infauna is around 100,000 worldwide. Global estimates of macro benthic species are in excess of 10,000,000. Less than 1% of these species are described, and global syntheses of patterns of individual taxa and biodiversity are few and based on limited samples (Snelgrove, 1998). Currently there is little published data or any standardized database for the marine macro benthic species in the Arabian Gulf. Therefore, data collected cannot be compared to known baselines in the region.

Plankton

The zooplankton community in the Arabian Gulf along the coast of the UAE is characterized by low species diversity. Copepods are the most dominant group of zooplankton species in the surface waters of the UAE, forming 65.5% of the total zooplankton community. The Emirate of Dubai has the highest density of zooplankton compared to all of the other Emirates within the UAE (El Serehy, 1999). This pattern is most likely to be observed due to the presence of Dubai Creek, which is known to display unusually high nutrient levels with sharp fluctuations and wide spatial and temporal variations (Abu-Hilal *et al*., 1994). Dubai has experienced a rapid expansion of its urban population in the past 10 to 15 years. This has been associated with subsequent increases in human-induced pollution, which creates high-nutrient conditions in coastal waters. Anthropogenic pollution sources include several wastewater outlets and recreational activity facilities.

The UAE displays seasonal variations in zooplankton abundance, with the main peak being recorded in winter, and the lowest density in September. Increased densities of zooplankton in the winter are attributed to the increased numbers of planktonic larvae such as copepods, polycheates, cirripeds, molluscs, echinoderms and fish larvae. In addition, as the summer approaches, the plankton density in the Arabian Gulf waters of the UAE decreases as the surface waters become more hostile due to increasing temperature / salinity (El Serehy, 1999).

Marine Water Quality (2018)

In 2018, a baseline marine water quality assessment was undertaken by HDR's team of marine scientists on the 3rd of June. Nine (9) marine baseline sampling sites were identified. At each site, marine water samples were collected at two depths; one (1) m above seabed and one (1) m below the sea surface. *In-situ* water quality profiles were also taken at 1m intervals throughout the water column. Sampling protocols were EAD.

Figure 5-9 Locations of the Marine Monitoring Stations (2018)

In situ Water Quality Results

The nine (9) marine sampling sites (Figure5-9) were sampled over the course of 15 days between 11th and the 28th May 2018. The results of *in situ* water quality measurements recorded through the water column at each site are presented as depth profiles of mean, minimum and maximum values in Figure 5-10 to Figure 5-12). A summary of the readings recorded and the implications of the data is as follows:

- Temperature ranged from 40.2°C (Surface at MAR 02) to approximately 30°C (Surface at most stations). The absence of temperature stratification at the existing intake location, MAR 01, MAR 02 and at MAR 03 is notable as there was discernable temperature gradients at the remainder of sites surveyed. The minimum, mean and maximum values recorded at MAR 02, inside the existing open outfall channel, are significantly higher at 36°C, 37°C and slightly over 40°C, respectively. These results reflect the Taweelah Complex cooling water and brine effluent discharges into the open outfall channel. At the mid-range and farfield sites (MAR 04 to MAR 09) a slight increase is noted in the deeper layers indicating that the presence of the effluent discharge plume. The site situated furthest from the outfall (MAR 07) is approximately 3.5 km from the point of discharge where the outfall plume signature is still detectable. The greater salinity, and subsequently the higher density, of the effluent plume explains why the warmer water flows along the seabed, rather than affecting surface waters.

- Salinity ranged from 39.5 PSU (MAR 09) to 47.02 PSU (throughout the water column at MAR 02, open channel outfall). The greatest range at a single station was recorded in the open outfall channel where the highest salinity was detected at the base of the water column (~43 PSU at surface versus ~47 PSU at the base). It is interesting to note that the smallest range was detected at the mouth of the existing open channel intake and at location MAR 03. These two sites are outside of the effluent plume mixing zone and, as such, not influenced by the saline waters of the discharge plume. The mid-range and far field sampling sites (MAR 04 to MAR 09), however, do show salinity signatures that indicate the influence of the Taweelah discharge on ambient water quality. Though not as extreme as in the open channel outfall, the ranges of minimum to maximum show higher salinity readings, even at MAR 09 situated ~3 km offshore from the outfall channel. At location MR 06, which sits ~700m from the outfall channel opening, bottom water salinity exceeds 46 PSU.
- pH ranged from 7.5 to a high in excess of 8.9 throughout the domain. The pH at the intake channel (MAR 01) and location MAR 03 show no stratification pH ranging between 7.8 and 8.3. Inside the outfall channel, the pH was highest, ranging between 8.5 and a maximum of 8.9 with no clear vertical trend. The spatial impact of the high pH in the outfall is reflected in all stations impacted by the effluent plume. Except for the intake and location MAR 03, the pH footprint of the effluent seems to affect all mid-range and far-field stations, including MAR 09 which is located furthest away from the outfall channel.
- Dissolved oxygen concentrations and saturation measurements show no indication of the development of hypoxic or anoxic conditions at any of the survey sites. None of the readings fall below the 4 mg/L ADS 2017 WQOs. Measurements ranged between 4.5 mg/L and 7.0 mg/L.
- Chlorophyll concentrations were low across all survey sites. Measured concentrations ranged between 0.01 µg/L and 4 µg/L with a mean concentration of 1.5 µg/L. Those readings do not indicate high levels of primary productivity and reflect ambient Arabian Sea conditions. It is noteworthy however that the Abu Dhabi Quality & Conformity Council sets the maximum allowable concentrations of chlorophyll in ambient water at 1 µg/L. This level is below most reported chlorophyll levels in the Arabian Gulf. Also note that the average chlorophyll concentrations inside the open outfall channel is about 0.03 µg/L which is significantly lower than all other locations suggesting that high salinity, high temperature conditions are likely inhibiting algal growth.

Table 5-3 Summary of In-Situ Water Quality Measurements

PARAMETER	UNIT	AWQOs	STUDY RANGE
Temperature	°C	± 3°C background	30 - 40
Salinity	PSU	<5% of background	39.7 – 47.2
Dissolved Oxygen	%	-	80 - 119
	mg/L	> 4 mg/L	4.5 – 7.5
Turbidity	NTU	10	1 - 14
pH	-	-	7.4 – 8.9
Chlorophyll	µg/L	-	0.01 – 4.0

The distinct trend observed in the water temperature and salinity variations is attributed to the influence of effluent discharged from the existing Taweelah operations through the open outfall channel. The high volumes of heated, negatively buoyant saline water are of higher density than the receiving waters. The effluent subsequently sinks to the base of the water column as the effluent plume disperses. This is most apparent at sites closest to the outfall.

Figure 5-10 Temperature profiles (min, mean, max) of all daily measurements

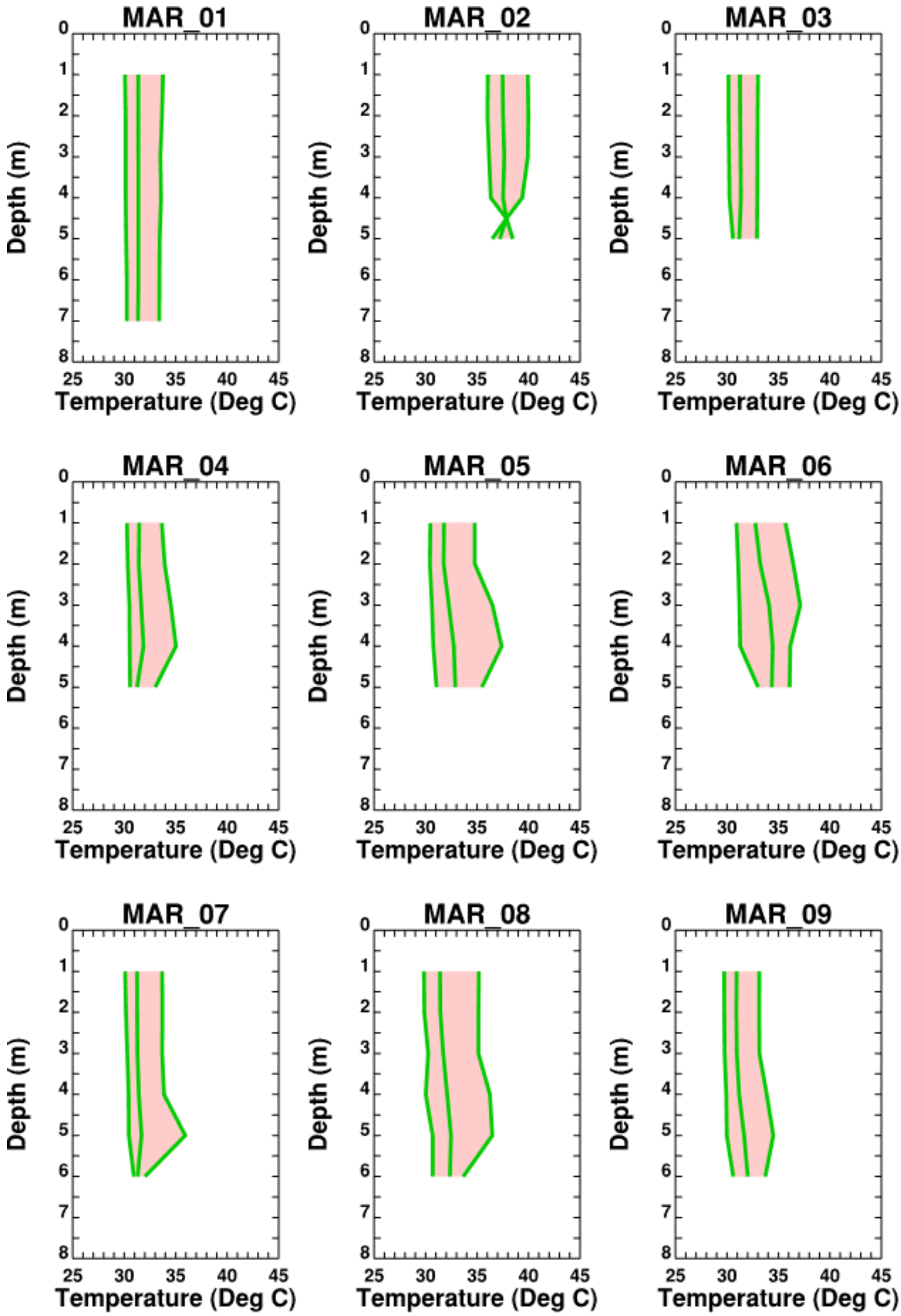


Figure 5-11 Salinity profiles (min, mean, max) of all daily measurements

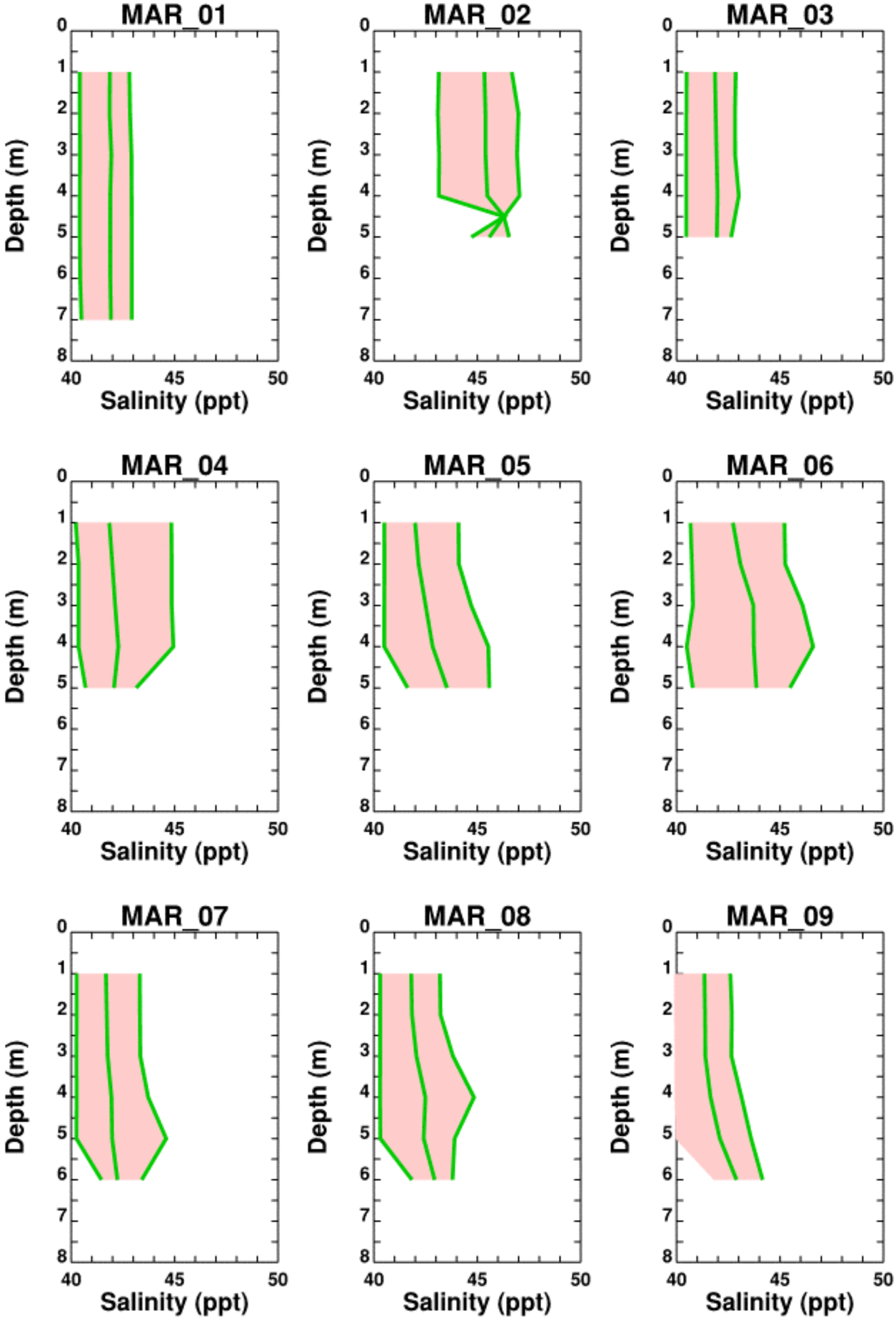


Figure 5-12 pH profiles (min, mean, max) of all daily measurements

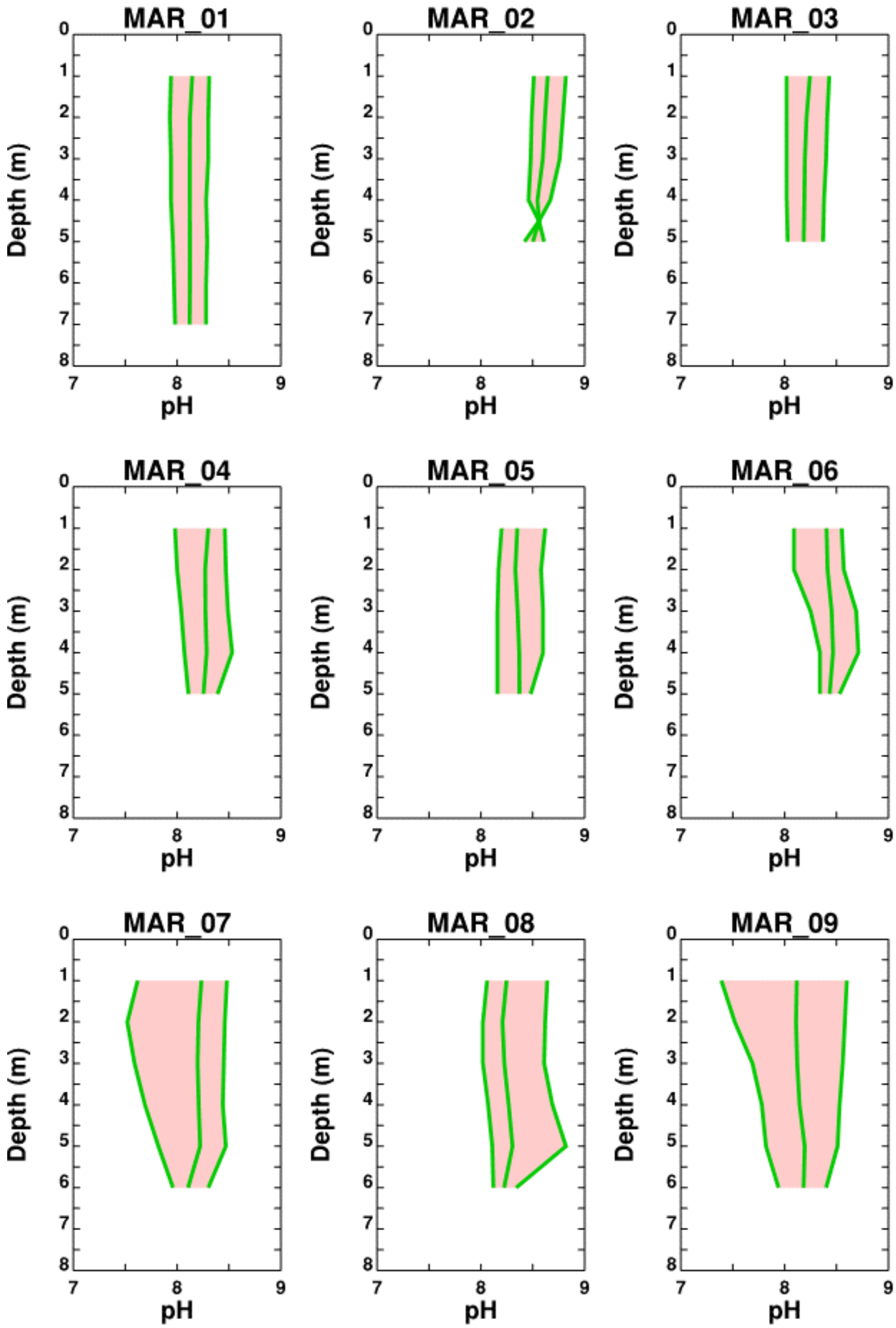


Figure 5-13 Percentage DO profiles (min, mean, max) of all daily measurements

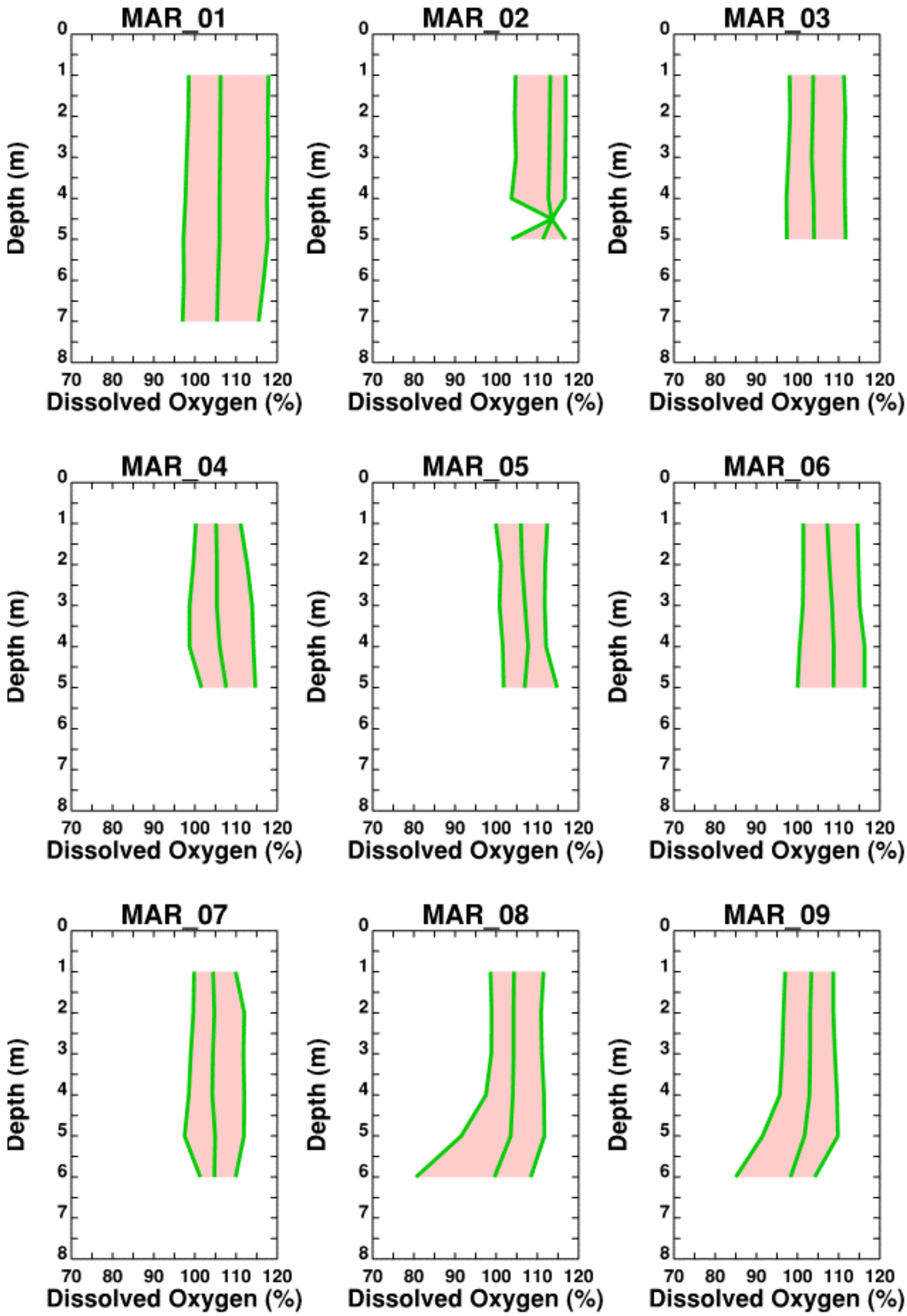
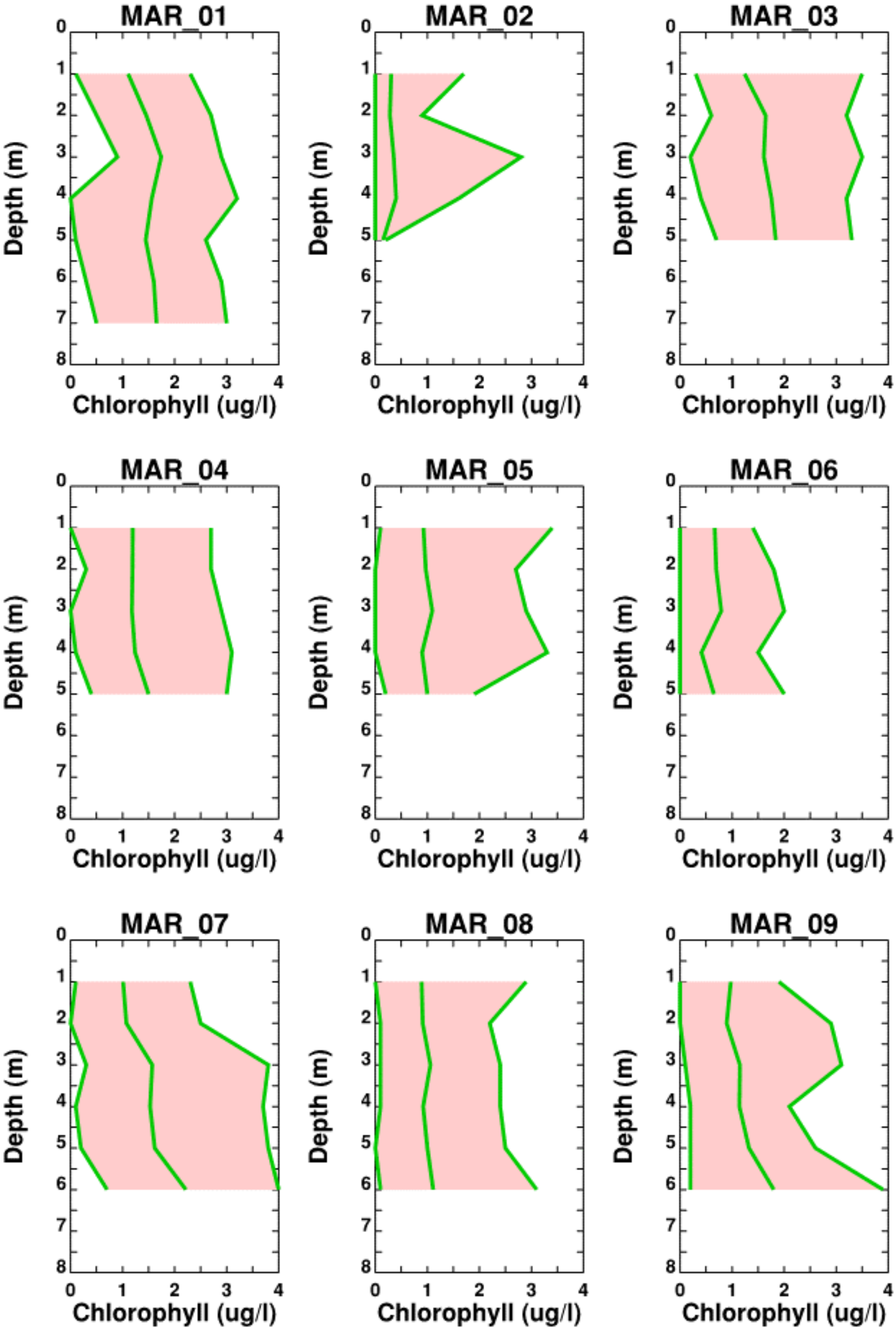


Figure 5-14 Chlorophyll A profiles (min, mean, max) of all daily measurements



Marine Water Quality (2019)

In April of 2019, an additional baseline marine water quality assessment was undertaken by HDR's team of marine scientists. During that study, *In-situ* water quality profiles were taken at half (0.5) meter intervals throughout the water column at thirty-one (31) sites and marine water samples were collected at two depths; one (1) m above seabed and one (1) m below sea surface at seven (7) sites. Sampling protocols were as per the EAD approved TOR (HDR, 2018) (refer to Appendix B). The complete in situ dataset and the respective laboratory analysis results collected by HDR are provided in Appendix E for reference.

Figure 5-15 Location of the in-situ Monitoring Stations in 2019

In situ Water Quality Results

The thirty one (31) marine sampling sites were sampled mainly on the 29th of April 2019 with a few sampled on the 2nd of May. Twenty one (21) sites sampled were along the projected outfall path; six (6) sites sampled were within the intake channel footprint, and four (4) sites sampled were at sensitive receptor sites. The results for sites sampled along the outfall path are represented as three distinct clusters: Outfall-1km represents sites along the final one kilometer of the outfall pipeline i.e. furthest from shore, Outfall-2km represents sites in the middle one kilometer of the pipeline and Outfall-3km represents the first 1km of the pipeline i.e. closest to shore. Each cluster is made of seven individual sites. Sites sampled within the intake footprint are represented as one cluster due to their proximity to one another. Results for Outfall and Intake clusters are presented as depth profiles of mean, minimum and maximum values in Figures 5-16, 5-17. An additional four (4) In-situ water quality profiles were taken at sensitive receptor sites. The data from the sensitive receptor sites is presented individually as each site is a distinct location and therefore cannot be combined to represent a single area. A summary of the readings recorded and the implications of the data is as follows:

- Temperatures along the outfall path ranged from 25.8°C (TP5 at four meters) to approximately 30.5°C (TP11 at seabed). The largest temperature gradient was seen along Outfall-2km with a difference of 4.41°C between high and low temperatures. It is clear from that there is a distinct and obvious stratification along the outfall path with temperatures increasing at or below 3-4 meter. This is believed to be caused by the warm brine effluent discharge coming from the existing outfall to the south west of the project site. This is also evidenced by the salinity profiles as can be seen in the figures below. Within the intake footprint, temperatures ranged between 26.4°C and 26.7°C, a minor difference due to the sheltered nature of the sites and shallow depths. No major temperature gradients were seen at the sensitive receptor sites except at SR4. The temperature within the top five meters of the water column at SR4 was relatively constant ranging between 26.7°C and 26.9°C after which the temperature rises rapidly to reach 29.7°C at six meters of depth. These results are further evidence of the influence the outfall channel has on project site
- Salinity ranged from 41.1 PSU to 44.7 PSU (seabed at TP11) along the outfall path with the lowest salinity found along Outfall-1km and the highest along Outfall-2km. This falls in line with our findings for temperature. As can be seen in Figure5-17, all three sections of the pipeline exhibit a sharp increase in salinity between 3 to 4 meters of depth further displaying the influence of the Taweelah discharge on ambient water quality. Salinity within the intake footprint ranged between 42.16 PSU and 42.23 PSU displaying a well-mixed homogeneous body of water. As with temperature, salinity at all of the receptor sites, except for SR4, was largely uniform throughout the water

column. Figure 5-18 displays the salinity gradient observed at SR4 with salinity displaying relatively uniform readings throughout the water column and increasing sharply at the bottom.

- Along the outfall path, pH ranged from a low of 7.8 at Outfall -1km to a high of 8.5 at Outfall-2km. As with temperature and salinity, the pH plots exhibit an increase in values at or near the 3-4 meter mark reflecting the impact of the effluent plume along the outfall path. Within the intake footprint, pH ranged between 7.98 and 8.31. The graph displayed in Figure 5-17 a slight decrease of pH with depth at all sites. At the receptor sites, pH was relatively uniform throughout the water column with no distinct gradient for all sites except SR4. pH at SR4 went from 8.13 at the surface to 8.43 at the bottom. These results fall in line with what is observed along the outfall path and can be attributed to the effect of the existing outfall on the area.

Table 5-4 Summary of in-situ Water Quality Measurements (2019)

Parameter	Units	AWQOs	Intake	Outfall-1km	Outfall-2km	Outfall-3km	SR1	SR2	SR3	SR4
Temperature	°C	± 3°C background	26.4-26.7	25.8-28.2	26.1-30.5	26.7-28.1	27.0-27.0	26.7-26.9	27.1-27.4	26.7-29.7
Salinity	PSU	<5% of background	42.2-42.2	41.1-44.4	42.0-44.7	42.1-43.7	42.1-42.4	42.0-42.3	42.2-42.4	41.2-44.6
Dissolved Oxygen	%	-	102-109	99-106	99-117	100-118	104-105	106-119	101-103	101-104
	mg/L	> 4 mg/L	6.5 - 6.9	6.2-6.6	6.2-7.0	6.3-7.2	6.6-6.6	6.7-7.5	6.3-6.4	6.2-6.5
Turbidity	NTU	10	0.8-1.9	2.1-129	0-26.9	0-14	2.5-4	2.6-3.2	2.1-4.3	4.5-21.6
pH	-	-	8.0-8.3	7.8-8.8	7.9-8.5	8.1-8.3	8.1-8.1	7.9-8.0	8.2-8.3	8.1-8.4
Chlorophyll	µg/L	-	0.4-5.5	0.0-17.1	0.4-31.9	0.5-14.1	0.7-1.4	0.5-1.6	0.0-7.3	0.7-4.2

Figure 5-16 Temperature profiles (min, mean, max) of all data in Intake and Outfall (2019)

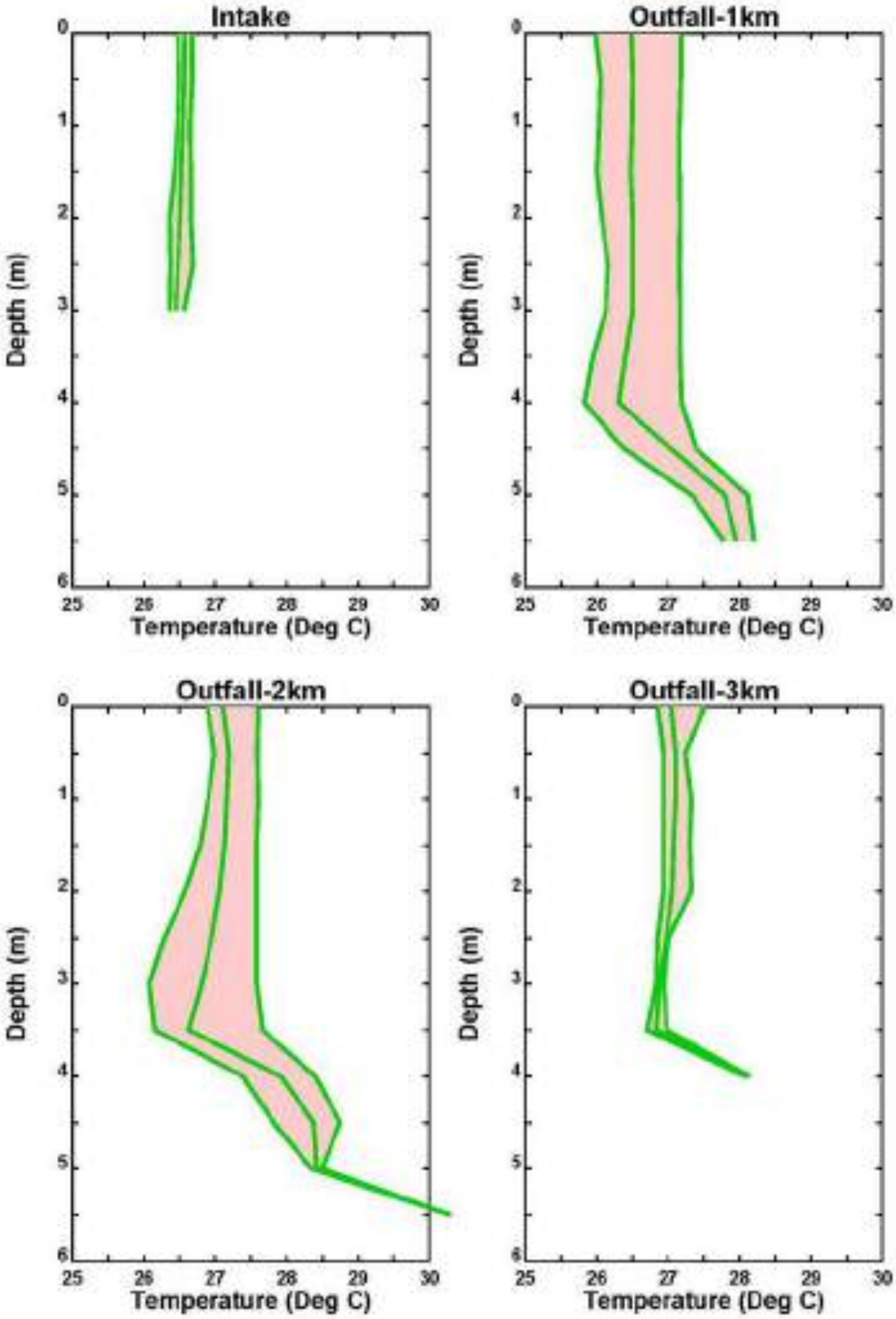


Figure 5-17 Salinity profiles (min, mean, max) of all data in Intake and Outfall (2019)

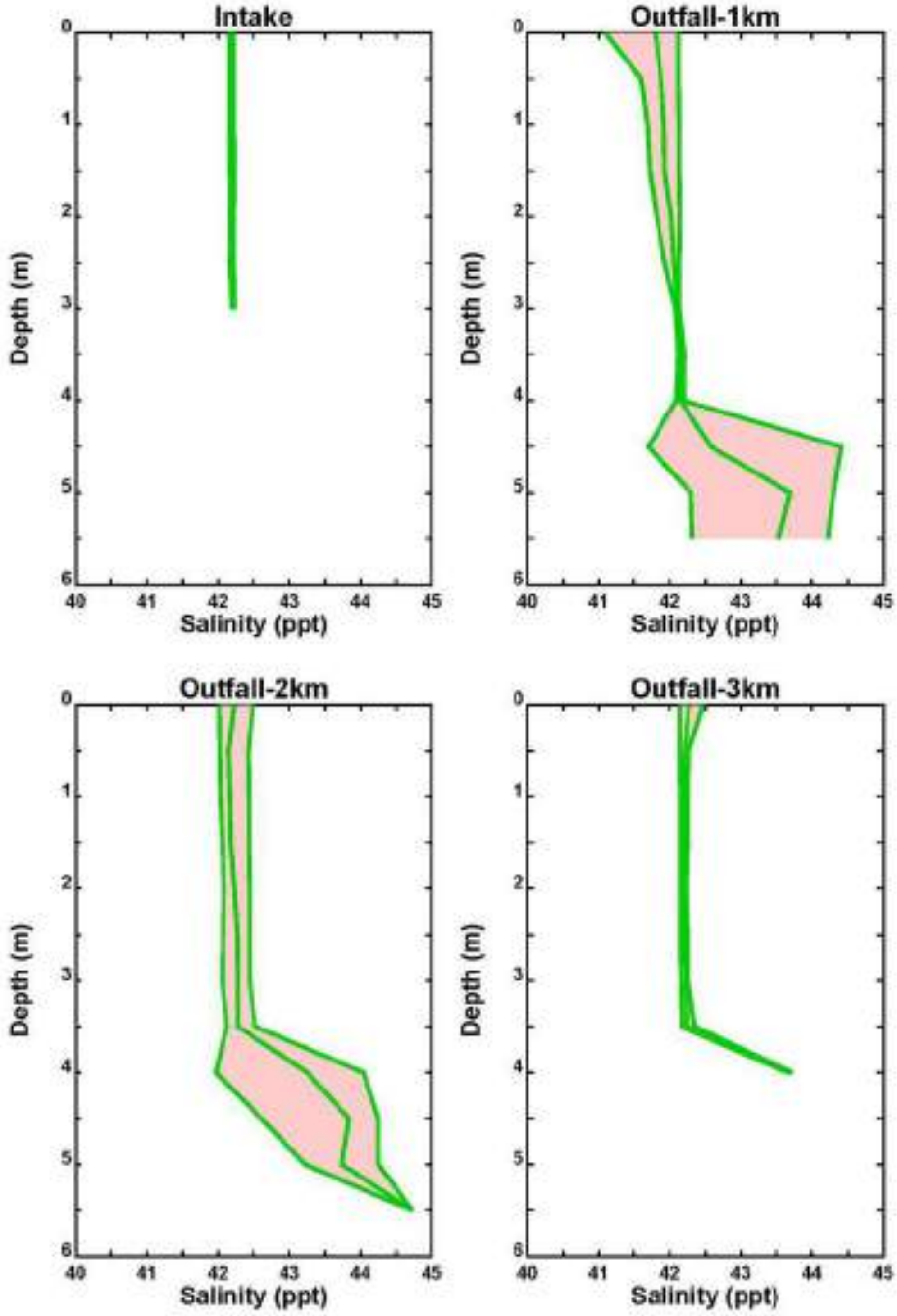


Figure 5-18 Temperature profiles of all Sensitive Receptor sites (2019)

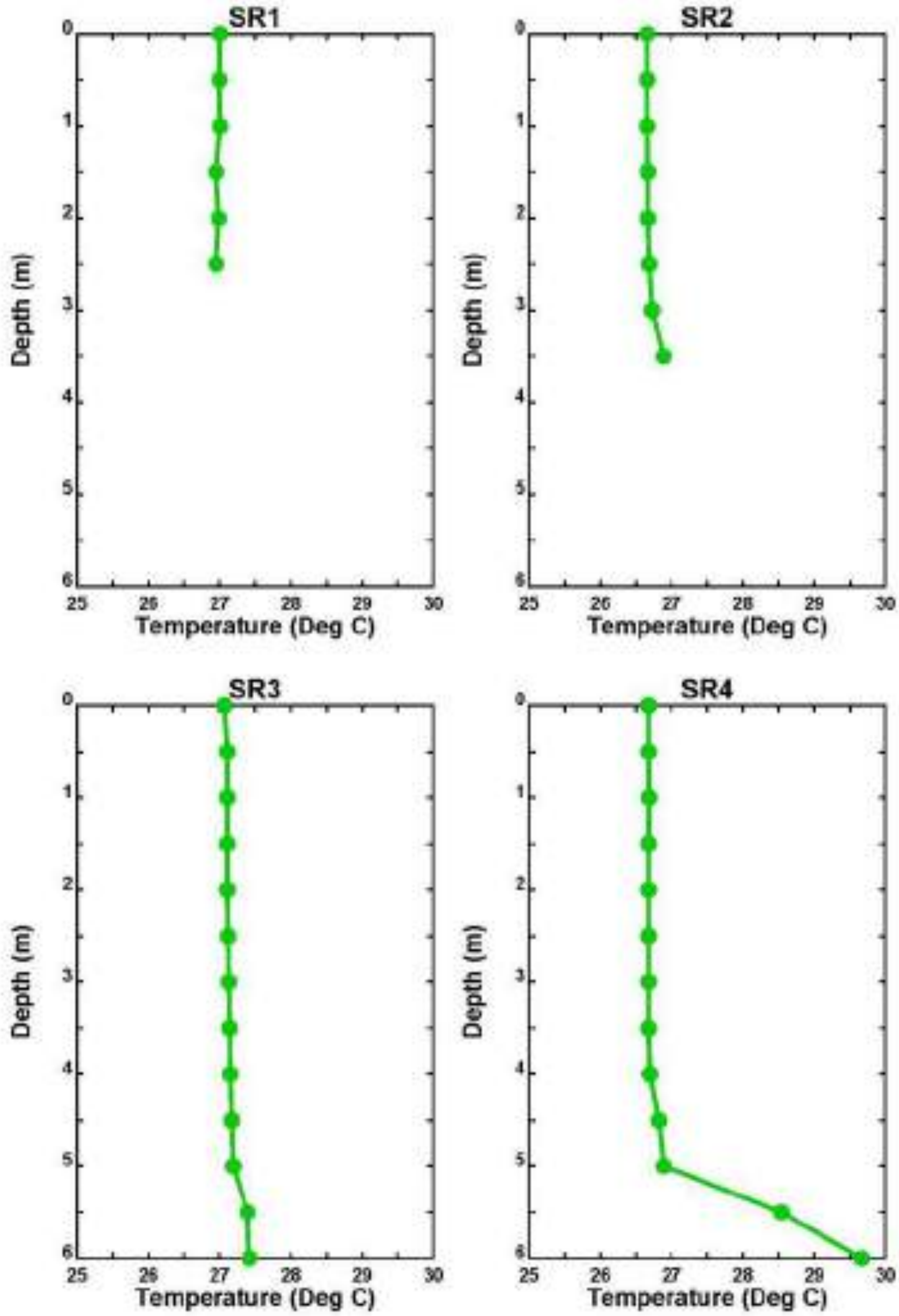
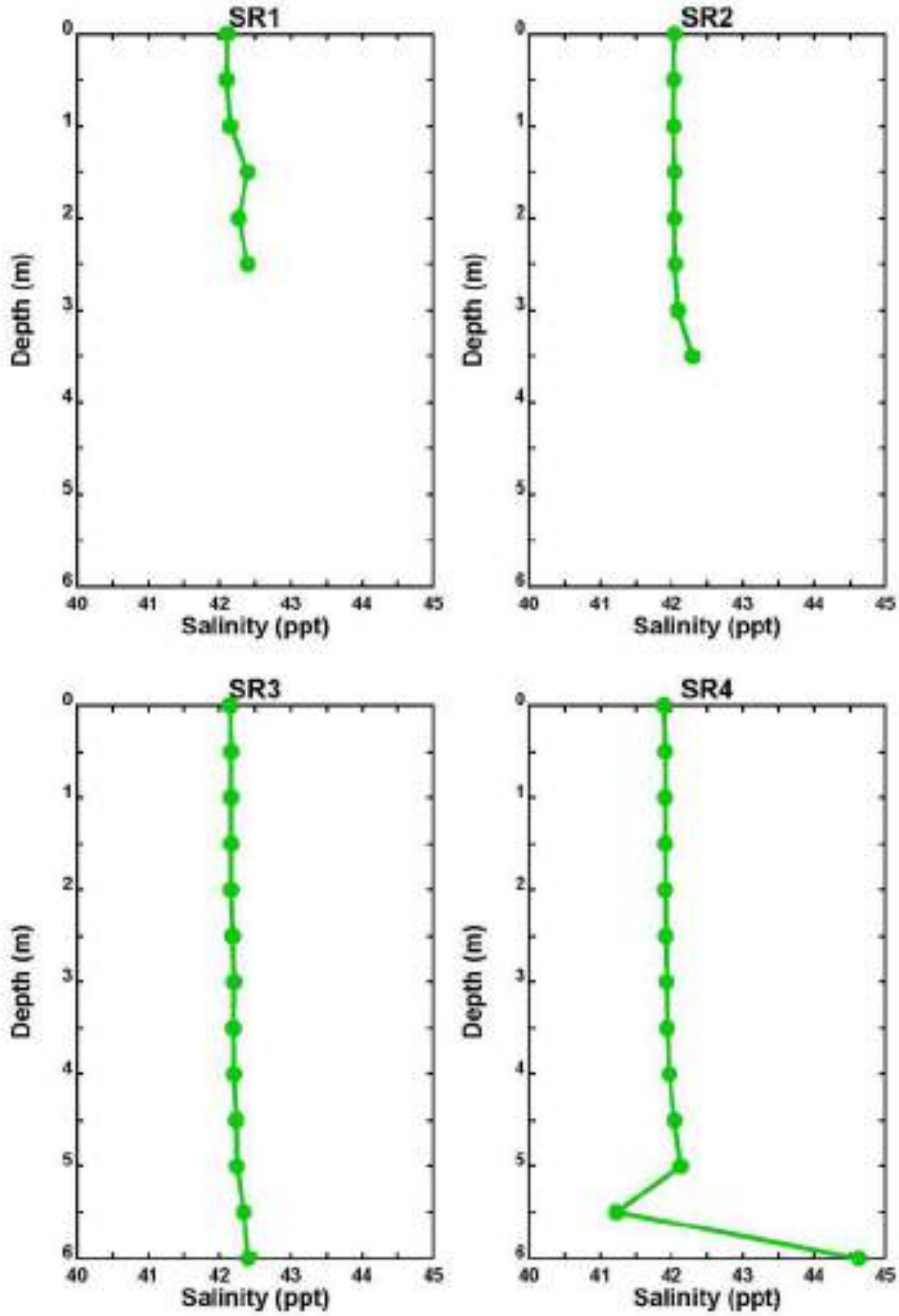


Figure 5-19 Salinity profiles of all Sensitive Receptor sites (2019)



Analytical Water Quality Results (2018 & 2019)

A summary of the analytical laboratory results of the samples collected from all nine (9) sites in 2018 and from seven (7) sites in 2019 at two depths is presented in the table below. The full spreadsheet of results are provided in Appendix E. Phosphate, nitrate, arsenic and silicate were the only parameters to exceed the ADS WQOs in 2018 whereas only nitrate and Extractable Petroleum Hydrocarbons exceeded ADS WQOs in 2019.

Table 5-5 Summary of Seawater Sample Analysis Results (2019)

Parameters	Unit	Lab Detection Limit	ADS WQO	AWQOs	Mean 2018	Mean 2019	Max 2018	Max 2019	Min 2018	Min 2019
Aluminium as Al	mg/L	0.05	0.2	-	-	-	BDL	BDL	BDL	BDL
Arsenic as As	mg/L	0.010	0.005	0.005	0.06	-	0.07	BDL	0.04	BDL
Cadmium as Cd	mg/L	0.05	0.0007	0.001	-	-	BDL	BDL	BDL	BDL
Chromium as Cr	mg/L	0.01	0.0002	0.01	-	-	BDL	BDL	BDL	BDL
Copper as Cu	mg/L	0.05	0.003	0.01	-	-	BDL	BDL	BDL	BDL
Lead as Pb	mg/L	0.05	0.0022	0.01	-	-	BDL	BDL	BDL	BDL
Iron as Fe	mg/L	0.05	0.3	0.3	-	-	BDL	BDL	BDL	BDL
Nickel as Ni	mg/L	0.05	0.007	0.02	-	-	BDL	BDL	BDL	BDL
Manganese as Mn	mg/L	0.05	NA	-	-	-	BDL	BDL	BDL	BDL
Zinc as Zn	mg/L	0.05	0.01	0.01	-	-	BDL	BDL	BDL	BDL
Selenium as Se	mg/L	0.05	-	-	0.07	0.06	0.10	0.06	0.05	0.06
Vanadium as V	mg/L	0.05	0.0094	0.0094	-	-	BDL	BDL	BDL	BDL
Mercury	mg/L	0.300	0.0001	-	-	-	BDL	BDL	BDL	BDL
Silicate	mg/L	0.1	0.89	0.89	1.79	0.14	2.03	0.30	1.27	0.10
Total Suspended Solids	mg/L	3.0	<33	<33	16.43	14.93	20.67	19.00	12.67	10.67
Total Dissolved Solids	mg/L	10.0	-	-	43348	39199	45900	40202	42048	38220
Chemical Oxygen Demands (COD)	mg/L	5.0	-	-	25.35	21.83	32.25	31.49	20.16	16.00
Biochemical Oxygen Demands (BOD)	mg/L	2.0	-	-	-	-	BDL	BDL	BDL	BDL

Parameters	Unit	Lab Detection Limit	ADS WQO	AWQOs	Mean 2018	Mean 2019	Max 2018	Max 2019	Min 2018	Min 2019
Oil and Grease	mg/L	5.0	-	Not Visible	-	-	BDL	BDL	BDL	BDL
Phosphate	mg/L	0.10	0.034	0.034	0.13	-	0.16	BDL	0.11	BDL
Sulphide	mg/L	2.00	-	0.004	-	-	BDL	BDL	BDL	BDL
Sulphate	mg/L	0.50	-	-	3269.4	3593.4	3498.4	3810.1	2950	3097.3
Total Nitrogen	mg/L	5.00	-	-	-	-	BDL	BDL	BDL	BDL
Nitrate Nitrogen	mg/L	0.10	0.095	0.095	0.54	0.47	0.57	0.57	0.51	0.44
Nitrite Nitrogen	mg/L	0.10	0.034	0.034	-	-	BDL	BDL	BDL	BDL
Total Residual Chlorine	mg/L	0.01	0.01	0.01	-	-	BDL	BDL	BDL	BDL
Ammonia	mg/L	0.060	0.004	0.004	-	-	BDL	BDL	BDL	BDL
Ammonium	mg/L	0.064	-	-	-	-	BDL	BDL	BDL	BDL
Escherichia coli	MPN/ 100 ML	1	130	-	33	15.57	42.00	21	25.00	10
EPH C10-C40	mg/L	50.0	-	-	-	87.5	BDL	117	BDL	58
VPH C5-C10	mg/L	7.0	-	-	-	-	BDL	BDL	BDL	BDL

It is noteworthy that some ADS WQOs are at levels that are difficult to achieve in, UAE-based analytical facilities. This applies in particular to cadmium and chromium. As such, whilst the results of all analysis are below the detection limit in all samples collected, compliance with the ADS WQOs for these selected parameters cannot be confirmed.

The results from both, the 2018 and 2019 surveys, indicate that the water quality is largely homogenous across the sites that were surveyed. The results provide no indication of vertical stratification at any of the survey sites. Of the parameters tested, the only parameters that exceeded the ADS WQOs were:

- Phosphate (2018)
- Nitrate (2018 & 2019)
- Silicate (2018)
- Arsenic (2018)
- EPH (2019)

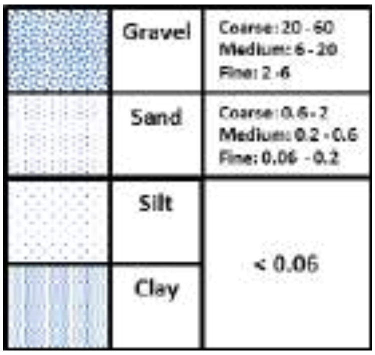
The source(s) of the nutrients are not readily identifiable; however potential sources include re-mineralization of nutrients from freshly dredged sediments, direct inputs from outfalls, inflow of nutrient enriched groundwater or deposition of aeolian sediments. In addition, nutrients can be mobilized from marine sediments during high wind and wave events. Once the sediments are disturbed and exposed to oxidizing conditions nutrients can be released back into the water column. There were no indications, however, of any excessive algal growth or high primary productivity in the area across from the Taweelah facilities during both surveys.

Microbial counts, while still below the threshold of 130 MPN/100 ML, as set by the ADS WQOs, do nonetheless indicate the presence of a possible source of contamination. The source of possible contamination is not clear as there are no known wastewater outfalls in the immediate vicinity of the Project site. It is worth noting that average microbial counts in 2019 were less than half the average in 2018 perhaps indicating a slight improvement in water quality of the general area. Likewise, silicate was found in samples from both surveys but did not exceed AWQOs in the 2019 survey.

EPH was only found at two sites, SR2 and TPSW1, from samples collected at the surface in 2019. TPSW1 falls on the outfall path whereas SR2 is a sensitive receptor site that is semi sheltered with Khalifa port on one side and land on the other. It is highly unlikely that the source of contamination is a continuous presence since EPH was only found at 2 sites and only at the surface. Furthermore, no EPH was found in any sediment sample collected in the area.

<u>Marine Sediments (2018 & 2019)</u>

<u>Particle Size Analysis</u>



Photographs of each of the sediment samples were taken on site, prior to a detailed particle size analysis being undertaken at the analytical laboratory. The full set of particle size analyses are provided in Appendix F.

The distribution of particle size shows the preponderance of medium sand (i.e., 125 µm – 250 µm) throughout the domain in both the 2018 and the 2019 survey). The notable exception was the sample collected from the open channel intake (in 2018) at MAR 01, which was predominantly fine to very fine-grained sand and silt sized particles.

In 2019 a total of six (7) sediment samples were collected for laboratory analysis. Initially a total of 10 samples were planned for collection, 6 along the proposed outfall alignment and 4 from sensitive receptor sites. However, once in the field, three sites (TPSW1, TP11 and TP-Start) along the proposed outfall alignment yielded no samples. The substrate was composed of hard cap rock with a very thin sand cover. More than five attempts to collect samples were tried at each site.

Marine Sediment Quality 2018

Sediment samples were collected by HDR's team of marine scientists on the 3rd June 2018 for physico-chemical analysis. Procedures for sediment collection and parameters analysed were as per the EAD-approved TOR (HDR, 2018) (Appendix B). Analysis results were compared against the ADS Marine Sediment Quality Objectives (ADQCC, 2017) and the NOAA Threshold Effect Level, where there are objectives or limits available for comparison. Plots of selected parameters are presented in the figures below. The complete dataset and certified laboratory analysis reports are included in Appendix F for reference.

A total of 11 metals were included in the sediment analysis. Many metals have the potential to be toxic to organisms (including humans). The variability of their toxicity is reflected in the relevant guideline standard concentration for each parameter. The results of the laboratory analysis of the nine (9) sediment samples collected during the baseline survey are presented in the table below.

Figure 5-20 Particle Size Analysis of the Sediment Samples collected in 2018

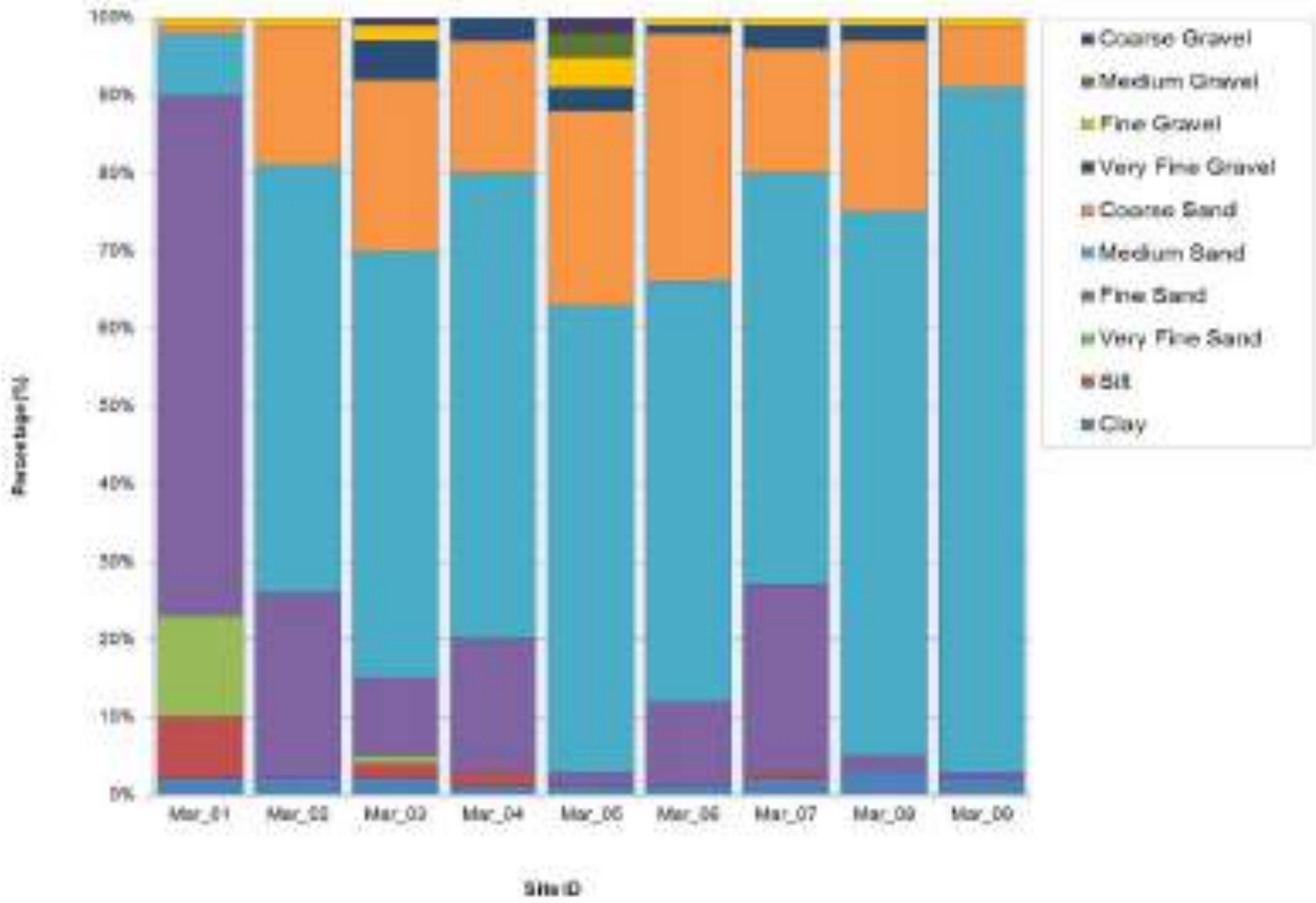


Figure 5-21 Particle Size Analysis of the Sediment Samples collected in 2019

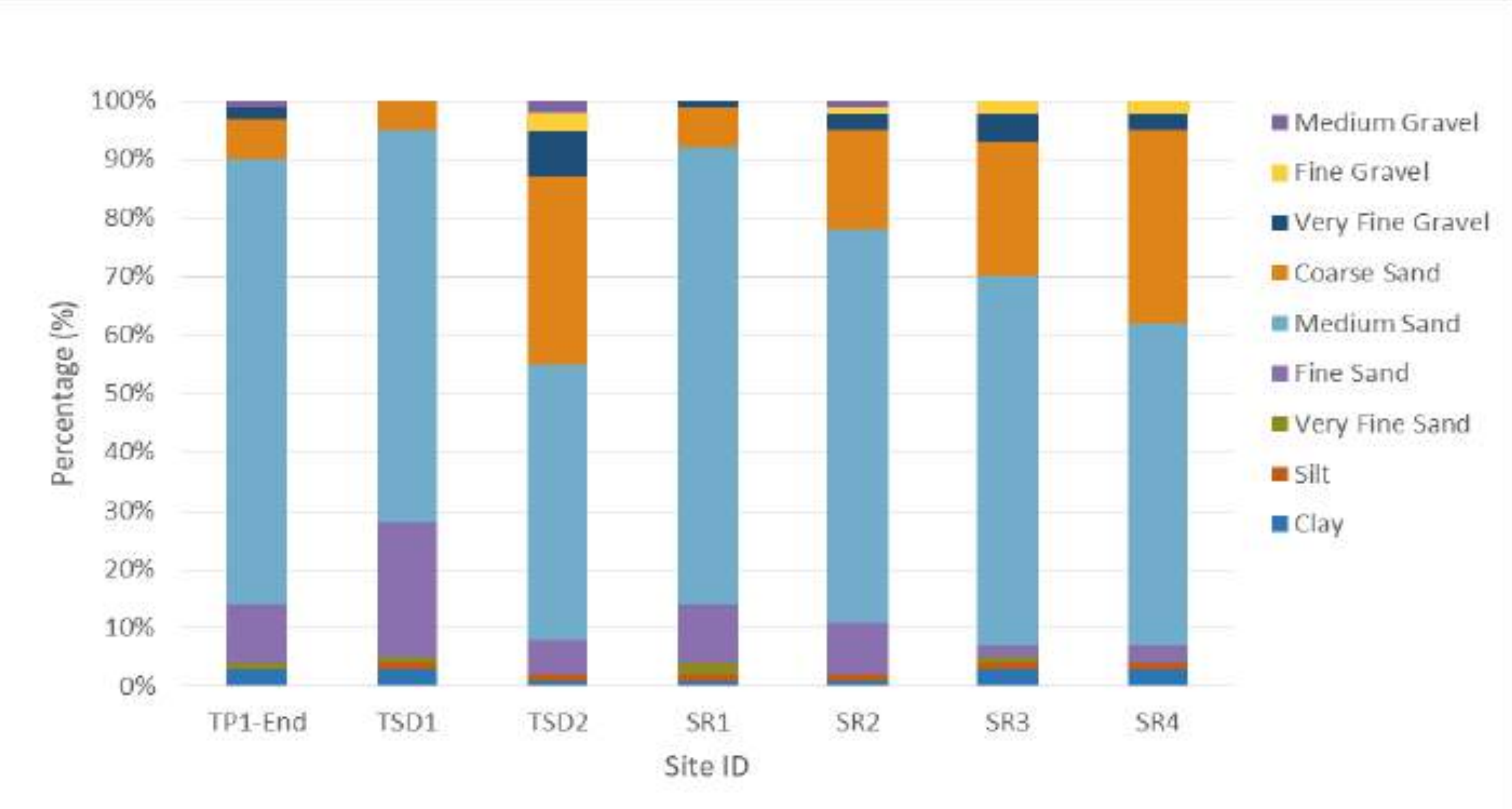


Table 5-6 USA, Canadian, Dutch and Australian/New Zealand Sediment Quality Guidelines (SQGs) in marine environments

	US (NOAA), Canadian, and Australia/New Zealand (mg/Kg)							Dutch (mg/Kg)		
	Predicted toxicity gradient - increasing							Predicted toxicity gradient - increasing		
METALS	T20	TEL	ERL	T50	PEL	ERM	AET	T SQO	M SQO	E SQO
Arsenic (As)	7.4	7.24	8.2	20	41.6	70	35	2.9	55	55
Cadmium (Cd)	0.38	0.68	1.2	1.4	4.2	9.6	3	0.8	2	12
Cobalt (Co)			3				10			
Chromium (Cr)	49	52	81	141	160	370	62	100	380	380
Copper (Cu)	32	18.7	34	94	108	270	390	36	36	190
Iron (Fe)		20,000a				30,000	40,0000c			
Manganese (Mn)	21**					260	460		780	1,100
Mercury (Hg)	0.14	0.13	0.15	0.48	0.7	0.71	0.41	0.3	0.5	10
Nickel (Ni)	15	15.9	20.9	47	42.8	51.6	110	35	35	210
Lead (Pb)	30	30.2	46.7	94	112	218	400	85	530	530
Zinc (Zn)	94	124	150	245	271	410	410	140	480	720

T: Threshold

TEL: Threshold Effect Level (Canadian Interim Sediment Quality Guidelines) ERL: Effect Range Low

PEL: Probable Effect Level (Canadian Interim Sediment Quality Guidelines) ERM: Effect Range Median; AET: Apparent Effect Threshold

T SQO: Threshold Sediment Quality Objective M SQO: Mid-range Sediment Quality Objective

E SQO: Extreme Sediment Quality Objective

T_{20}: 20% probability of observing sediment toxicity

T_{50}: 50% probability of observing sediment toxicity

[a]Threshold Effect Concentration

[b]Median Effect Concentration [c]Probable Effect Concentration

**New Zealand Threshold (Australian and New Zealand Environment and Conservation Council – ANZECC

Table 5-7 Summary of Marine Sediment Analysis Results

Test Parameters	Units	Method Detection Limit	NOAA TEL	ADS Objective	Mean	MAX	MIN
Aluminium	mg/kg	0.05	-	-	4979.55	9838.50	3156.25
Arsenic	mg/kg	0.05	7.24	7	Below MDL	-	-
Cadmium	mg/kg	0.05	0.68	0.7	Below MDL	-	-
Chromium	mg/kg	0.05	52	52	13.15	32.02	5.54
Copper	mg/kg	0.05	18.7	20	6.67	14.70	3.02
Iron	mg/kg	0.05	20,000		2253.67	6378.75	262.39
Lead	mg/kg	0.05	30.2	30	Below MDL	-	-
Manganese	mg/kg	0.05	260		76.57	229.42	27.18
Mercury	mg/kg	0.010	0.13	0.20	0.02	0.03	0.01
Nickel	mg/kg	0.05	15.9	16	7.33	13.65	1.01
Zinc	mg/kg	0.05	124	125	26.15	72.00	15.94
Nitrate Nitrogen	mg/kg	0.10	-	-	7.60	13.02	3.16
Phosphate	mg/kg	0.50	-	-	5.23	14.87	1.42

Test Parameters	Units	Method Detection Limit	NOAA TEL	ADS Objective	Mean	MAX	MIN
Sulphide	mg/kg	10.00	-	-	Below MDL	-	-
Sulphate	mg/kg	0.10	-	-	1008.34	1301.10	760.35
Ammonia Nitrogen	mg/kg	0.25	-	-	8.95	15.00	0.65
Ammonium	mg/kg	0.32	-	-	11.52	19.30	0.84
Total Nitrogen	mg/kg	5.00	-	-	17.61	26.32	7.35
Total Organic Carbon	%	0.10	-	-	-	0.60	0.40

Results from the sample analysis indicates that eight (8) of the 11 sampled metals were present in concentrations above the laboratory MDL. Concentrations of arsenic, cadmium and lead were all below the respective lab detection limits. The remainder of the metals were detected in concentrations below the relevant ADS and NOAA TEL thresholds.

Although none of the sediment guidelines were exceeded, the spatial trend does indicate trace metal concentrations in the vicinity of MAR 03 which is situated within 450 m of the EGA outfall. The sediment sample collected from this location returned the highest concentrations of aluminium, chromium, copper, iron, manganese and mercury of all sediment samples collected. The higher levels measured in the sample collected at MAR 03 compared to all other stations, may indicate a possible link to an existing outfall. It is important to note that the total concentration of metals in marine sediment does not necessarily represent the fraction that is "bioavailable" to marine biota (Hatje et al., 2003). Aluminum toxicity, for example, is directly associated with pH depression. Low pH (5 to 5.5) trigger the mobilization of the metal in the water column[6][7]. However, the prevailing minimum pH at sea across from the outfall is 7.3 and the concentration of aluminum, as well as most other metal concentrations, in the water column were below detection limits, i.e., 0.05 mg/L. In addition, the reported toxicity of aluminum on marine invertebrates reduced a bivalve larvae growth at 0.01 to 1 g/L[8] - as opposed to mg/L. Therefore, the analytical results in the water column were orders of magnitude lowers than that threshold. This would appear to suggest that the marine sediments at MAR 03 are acting as a sink for metals and, at present, these are not remobilizing in to the water column.

None of the other constituents analyzed as part of this study showed any elevated levels. Organic carbon is a natural component of most marine sediments and acts as an important source of food for benthic fauna. However, high total organic carbon percentage by weight (TOC) can cause reductions in species richness, abundance and biomass due to oxygen

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[6] Krewski D, Yokel R.A., Nieboer, E., Borchelt D., Cohen, J., Harry, J., Kacew, S., Lindsay, J., Mahfouz, A. and V, Rondeau. (2007). Human health risk assessment for aluminum, aluminum oxide and aluminum hydroxide. *J. Toxicol Environ Health* B Crit Rev 10 (Suppl1): 1 -269.

[7] ASTDR (2008). Aluminum: potential for human exposure, Agency for Toxic Substances & Disease Registry, US, Chapter 6.

[8] His, E., Beiras, R., Seaman, M.N., Pagano, G., and N. M. Trief (1996). Sublethal and lethal toxicity of aluminum industry effluent toearly developmental stages of the *Crassostrea gigas* oyster. *Arch. Environ Contam. Toxicol*. 30, 3335 – 339.

depletion and the buildup of toxic by-products such as ammonia and sulphides. As such, TOC can be used as an indicative measure of the health of the marine benthic ecosystem. TOC ranged from 0.4% to 0.6% across the nine (9) samples which is considered to be relatively low.

Total Petroleum Hydrocarbons (TPH) and Polycyclic aromatic hydrocarbons (PAH) in the marine environment are the result of the incomplete combustion of organic matter and from oil and fuel leaks from vessels. Concentrations of both TPHs and PAHs were below the Minimum Detection Limit (MDL) in all of the samples

Marine Sediment Quality 2019

Seven (7) sediment samples were also collected by HDR's team of marine scientists on the 22nd and 27th of April 2019. Procedures for sediment collection and parameters analysed were as per the EAD-approved TOR (HDR, 2018) (refer to Appendix B). Analysis results were compared against the ADS Marine Sediment Quality Objectives (ADQCC, 2017) and the NOAA Threshold Effect Level where there are objectives or limits available for comparison. Plots of selected parameters are presented below. The complete dataset and certified laboratory analysis reports are included in Appendix F for reference.

A total of 11 metals were included in the sediment analysis. Many metals have the potential to be toxic to organisms (including humans). The variability of their toxicity is reflected in the relevant guideline standard concentration for each parameter. The results of the laboratory analysis of the seven (7) sediment samples collected during the baseline survey are presented in Table 5-8.

Table 5-8 Summary of Marine Sediment Analysis Results (2019)

Test Parameters	Units	Method Detection Limit	NOAA TEL	ADS Objective	Mean	MAX	MIN
Aluminium	mg/kg	0.05	-	-	412.72	550.74	320.20
Arsenic	mg/kg	0.05	7.24	7	-	-	-
Cadmium	mg/kg	0.05	0.68	0.7	1.44	2.23	0.60
Chromium	mg/kg	0.05	52	52	3.33	4.23	2.41
Copper	mg/kg	0.05	18.7	20	-	-	-
Iron	mg/kg	0.05	20,000	-	587.26	1134.06	358.88
Lead	mg/kg	0.05	30.2	30	-	-	-
Manganese	mg/kg	0.05	260	-	19.41	32.77	10.70
Mercury	mg/kg	0.01	0.13	0.2	-	-	-
Nickel	mg/kg	0.05	15.9	16	2.64	4.23	1.44
Zinc	mg/kg	0.05	124	125	3.69	10.12	1.23
Nitrate Nitrogen	mg/kg	0.1	-	-	3.93	9.04	0.63
Nitrite	mg/kg	0.5	-	-	-	-	-

Nitrogen							
Phosphate	mg/kg	0.5	-	-	3.18	9.39	0.73
Sulphide	mg/kg	10	-	-	-	-	-
Sulphate	mg/kg	0.1	-	-	1982.86	1982.86	1595.68
Ammonia	mg/kg	0.25	-	-	13.80	27.30	2.79
Ammonium	mg/kg	0.32	-	-	14.60	28.90	2.96
Ammonia Nitrogen	mg/kg	0.3	-	-	11.36	22.50	2.30
Total Nitrogen	mg/kg	5	-	-	12.79	13.31	12.18
Total Organic Carbon	%	0.1	-	-	0.34	0.50	0.30

Results from the sample analysis indicates that seven (7) of the 11 sampled metals were present in concentrations above the laboratory MDL. Concentrations of arsenic, copper, lead and mercury were all below the respective lab detection limits. The remainder of the metals were detected in concentrations below the relevant ADS and NOAA TEL thresholds except for cadmium which was detected at all seven sites and exceeded both ADS and NOAA TEL thresholds at five of the seven sites.

The highest readings for all metals detected where consistently found at sites TSD1 and TSD2. These two sites fall along the proposed outfall path as can be seen below. The rest of the sites showed no specific pattern with regards to heavy metal concentrations.

None of the sediment guidelines were exceeded except for cadmium at five of the seven sites. It is worth pointing out that none of the samples collected during the 2018 survey showed any cadmium concentrations. Cadmium exists naturally in the environment but also has varied anthropogenic sources that are mainly linked to industrial processes. The exact source of cadmium cannot be pinpointed but the fact that it wasn't found in any of the samples from last year and in all of the samples this year indicated a possible recent release of the heavy metal.

It is worth mentioning that while mercury and copper where found at all sites sampled during the 2018 survey; none were found in samples collected in 2019.

Total Petroleum Hydrocarbons (TPH) and Polycyclic aromatic hydrocarbons (PAH) in the marine environment are the result of the incomplete combustion of organic matter and from oil and fuel leaks from vessels. Concentrations of both TPHs and PAHs were below the Minimum Detection Limit (MDL) in all of the samples.

Phenols were found at only one site (SR4) at concentration that are well below the Dutch Intervention Standards so as to be of little concern.

None of the other constituents analyzed as part of this study showed any elevated levels.

Marine Ecology

Benthic Infauna

Benthic infauna samples were collected from six (6) survey sites on 3rd June 2018 for preliminary assessment of the site, and samples were then collected from an additional 16 sites from 22nd to 29th of April 2019 in order to ensure that benthic organism populations were assessed along the final proposed outfall alignment as dictated by the Project EPC and also within proximity of the intake structure. Sampling protocols and taxonomic sorting and identification were carried out in accordance with the procedure detailed in the EAD-approved TOR (HDR, 2018) (refer to Appendix B). The only deviation in sampling sites was at Ben_03 and Ben_05 visited during the 2018 survey. Five (5) consecutive grabs failed to recover a sample of 75% or more of the grab at the target survey sites. The survey vessel was subsequently relocated 150m and 80m from the original sites, respectively, where successful grab samples were recovered. Figure 5-22 presents the sites that were sampled during both survey periods (2018 and 2019). The raw dataset is provided in Appendix G for reference. The subsequent sections detail the survey results across each period separately, and a summary of the comparison between 2018 and 2019 is provided at the end of this section.

Taxonomic Composition 2018

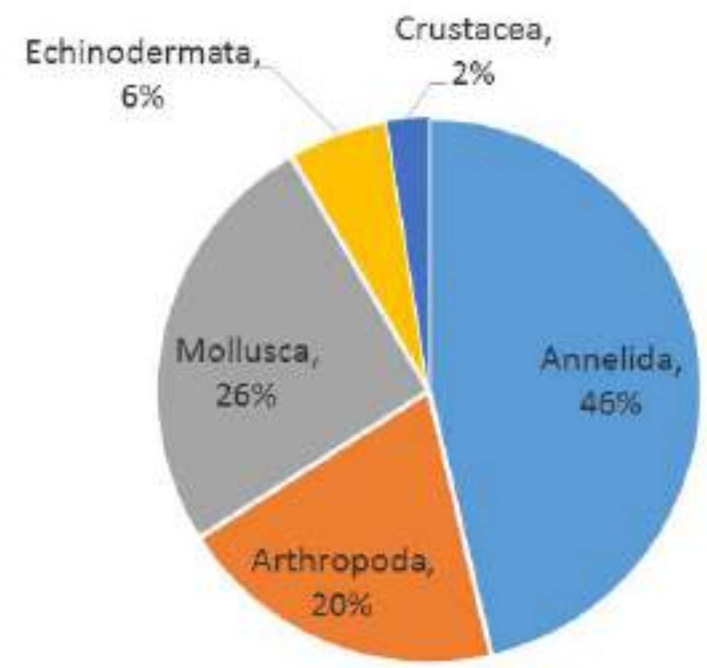
The six (6) samples collected in 2018 contained a total of 367 individual organisms from 45 taxa belonging to the following five (5) phyla:

- Mollusca;
- Annelida;
- Arthropoda;
- Echinodermata; and
- Crustacea.

Figure 5-22 Benthic Infauna Survey Sites

Mollusca, Annelida and Arthropda contributed the greatest proportion of the total abundance in samples collected. The figure below presents the proportional composition by phyla, with only those that contributed greater than 1% of the total individuals displayed.

Figure 5-23 Taxonomic Composition of Phylum



The majority of individuals in the samples collected comprised of molluscs, annelids and arthropods. Annelids were most abundant (170 individuals) with all species being represented by polychaete worms (18 species). *Nephtys polybranchia* was the most abundant species (18 individuals recorded in five (5) of the six (6) samples). Molluscs were represented by 10 species of bivalve and seven (7) species of gastropod.

The arthropods present in the six (6) samples were comprised of amphipods (nine (9) species), ostracods (three (3) species), cumaceans (four (4) species) and brachyurans (four (4) species). Though it is noted that not all individuals were able to be identified to species level, the most abundant of those that could be accurately identified were *Gammarus locusta* and *Paracaprella pusilla* (each of which presented nine (9) individuals).

Crustaceans recorded across the survey area were comprised of anomurans (five (5) species) and penaeids (three (3) species). Although a total of eight (8) species were recorded, the crustacean community was comparatively poorly represented with only one (1) individual of each species recorded. The exception to this was *Metapenaeopsis stridulans,* which was represented by just two (2) individuals.

Echinodermata made up the remainder of the individuals in the samples. 22 individuals of the soft bodied ophiuroid *Ophionotus victoriae* were recorded across each of the six (6) sample sites. The sample collected from the site located furthest away from the existing outfall structure (Ben_05) demonstrated the highest abundance and diversity of benthic infauna. The water quality results collected from directly inside the outfall channel (Mar_02) indicate that the discharge effluent from the Tawelah Complex are characterized by both elevated salinity and temperature. Continuous exposure to these conditions likely creates sufficiently harsh conditions that only a select group of benthic infaunal species are able to tolerate. The low benthic abundance recorded at sites Ben_02 (inside the outfall channel) and Ben_04 (~700 m from outfall channel entrance) is considered likely attributable to the influence of the Taweelah Complex effluent plume.

Nearshore sediments are often highly perturbed by wave action. As a result, emergent sessile epifauna are often absent, while highly mobile, robust, scavengers are dominant (Kaiser et al. 2007). Much of the assemblage in areas exposed to frequent disturbance caused by wind-driven wave action are typically mobile, short-lived polychaetes and rapidly burrowing bivalves. This is evident in the results of the taxonomic analysis of this dataset where a relatively high number of polychaete and bivalve species were recorded.

Taxonomic Composition 2019

The initial results from four of the benthic sampling sites from April 2019 are presented in Figure 5-24 and indicate similar species abundance and species richness. Additional sample results will be provided in the Technical Appendices.

<u>Species Abundance, Richness and Univariate Analysis 2018</u>

Species abundance and species richness across all samples collected in 2018 is presented in the figures below. Data collected from the infauna samples were analysed using Primer-e v7 statistical software (Clark and Gorley, 2015). Univariate statistical analysis (Margalef Species Richness, Pielou Species Evenness and Shannon-Wiener Diversity indices) was undertaken to determine the abundance and diversity indices for sub-tidal benthic infaunal samples. Tabulated results based on the pooled data for the replicate samples collected at each of the survey sites is presented in the table below. Cells highlighted in green indicate higher diversity results.

Figure 5-24 Benthic Fauna at Four Locations (2019)

				TAWEELAH PROJECT BENTHIC SAMPLE IDENTIFICATION			
S.NO.	Faunal group	PHYLUM	SPECIES	SR 3 INF	SP4 INF	TP1 END. INF	TSD1 INF
				Count /sample	Count /sample	Count /sample	Count /sample
1	Polychaeta	ANNELIDA	Capitella capitata	5	3	4	3
2	Polychaeta	ANNELIDA	Prionospio pinnata	2	3	1	1
3	Polychaeta	ANNELIDA	Flabelligera affinis	4	1	1	2
4	Polychaeta	ANNELIDA	Glycera longipinnis	3	2	1	1
5	Polychaeta	ANNELIDA	Sabella penicillus	2	1	2	1
6	Polychaeta	ANNELIDA	Nephtys californiensis	3	1	1	2
7	Polychaeta	ANNELIDA	Maldanella capensis	1	2	1	3
8	Polychaeta	ANNELIDA	Phyllodoce malmgreni	2	1	1	3
9	Polychaeta	ANNELIDA	Eunice tentaculata	2	3	1	1
10	Polychaeta	ANNELIDA	Unknown species	Unk2-1 Unk3-4 Unk4-2 Unk5-1	Unk2-2 Unk3-3 Unk4-1 Unk5-4	Unk1-1 Unk2-2 Unk3-1 Unk4-2	Unk2-1 Unk3-2 Unk4-1 Unk5-1
11	Amphipod	ARTHROPODA	Ampelisca zanzibarensis	2	1	1	3
12	Amphipod	ARTHROPODA	Gammarus salinus	1	2	1	1
13	Amphipod	ARTHROPODA	Leptocheirus pilosus	1	0	1	1
14	Amphipod	ARTHROPODA	Nannonyx goesii	0	0	2	3
15	Amphipod	ARTHROPODA	Paracorophium pusilla	1	1	1	3
16	Amphipod	ARTHROPODA	Unknown species	Unk1-1	Unk1-2 Unk2-1	Unk1-1	Unk1-3
17	Malacostraca	ARTHROPODA	Apseudes latreillii	3	2	1	3
18	Malacostraca	ARTHROPODA	Iphinoe crassipes	0	2	1	3
19	Brachyuran	ARTHROPODA	Portunus sanguinolentus	1	0	1	3
20	Pelecypod	MOLLUSCA	Gari elongata	4	4	2	2
21	Pelecypod	MOLLUSCA	Donax cuneatus	2	3	4	2
22	Pelecypod	MOLLUSCA	Mactra laevis	1	3	2	4
23	Pelecypod	MOLLUSCA	Brachidontes variabilis	1	2	1	1
24	Pelecypod	MOLLUSCA	Lioconcha castrensis	0	1	1	3
25	Pelecypod	MOLLUSCA	Codakia punctata	5	3	2	3
26	Pelecypod	MOLLUSCA	Fragum fragum	4	2	1	5
27	Pelecypod	MOLLUSCA	Paratellina pinguis	2	1	2	2
28	Pelecypod	MOLLUSCA	Donax incarnatus	2	1	2	3
29	Pelecypod	MOLLUSCA	Unknown species	Unk1-3 Unk2-2 Unk3-2	Unk1-4 Unk2-2	Unk1-3 Unk2-4 Unk3-1	Unk1-5 Unk2-3 Unk3-1
30	Holothuroida	ECHINODERMATA	Holothuria scabra	0	1	1	3
31	Anomuran	CRUSTACEA	Pisidia dehaanii	1	0	1	3
32	Penaeid	CRUSTACEA	Metapenaeopsis stridulans	0	0	1	3
33	Gastropod	MOLLUSCA	Turritella attenuata	2	1	2	1
34	Gastropod	MOLLUSCA	Nassarius pullus	0	1	1	3
35	Gastropod	MOLLUSCA	Acteon subfragilis	2	1	1	1
36	Gastropod	MOLLUSCA	Terebra subulata	2	2	1	3
37	Gastropod	MOLLUSCA	Epitonium pallasii	0	1	1	3
38	Gastropod	MOLLUSCA	Fasciolaria papilla	0	0	1	2
39	Gastropod	MOLLUSCA	Unknown species	Unk2-2 Unk3-3 Unk4-1 Unk5-1	Unk1-2 Unk2-1 Unk3-2 Unk4-2	Unk2-1 Unk3-1 Unk4-1 Unk5-2	Unk2-2 Unk3-1 Unk4-3 Unk5-1
	Total			75	80	63	74

Table 5-9 Species Richness, Abundance and Univariate Analysis Results

Site ID	Species Abundance (N)	Species Richness (S)	Margalef Species Richness (d)	Pielou Evenness (J')	S-W Diversity (H')
Ben_01	73	35	7.93	0.953	3.39
Ben_02	41	29	7.54	0.9685	3.26
Ben_03	34	21	5.67	0.9657	2.94
Ben_04	48	27	6.72	0.951	3.13
Ben_05	133	44	8.79	0.9404	3.56
Ben_06	38	21	5.50	0.9484	2.89

Species abundance (N) shows a discernable variation between sites ranging from N=34 (Ben_03) to a maximum of N=133 (Ben_05). Both sites Ben_03 and Ben_05 are situated within areas of 'Unconsolidated Sediment'. Species richness (S) also showed a considerable spread with values ranging from 21 (Ben_03 and Ben_06) to 44 (Ben_05). It is noted that Ben_05 is located furthest away from the outfall plume and, as such, is likely influenced the least by elevated water temperatures and salinity at the base of the water column.

The abundances recorded are considered to be normal and indicative of the community expected within the Project site and at similar sites within the region. Coles and McCain (1990) reported that biomass of infauna associated with seagrass beds in the western Arabian Gulf is approximately three (3) times higher than that for areas of open sediment They also report species richness to range between 8-103 species in seagrass beds compared to 1-70 in areas of open sand.

Figure 5-25 Benthic Infauna Species Abundance Site 2018

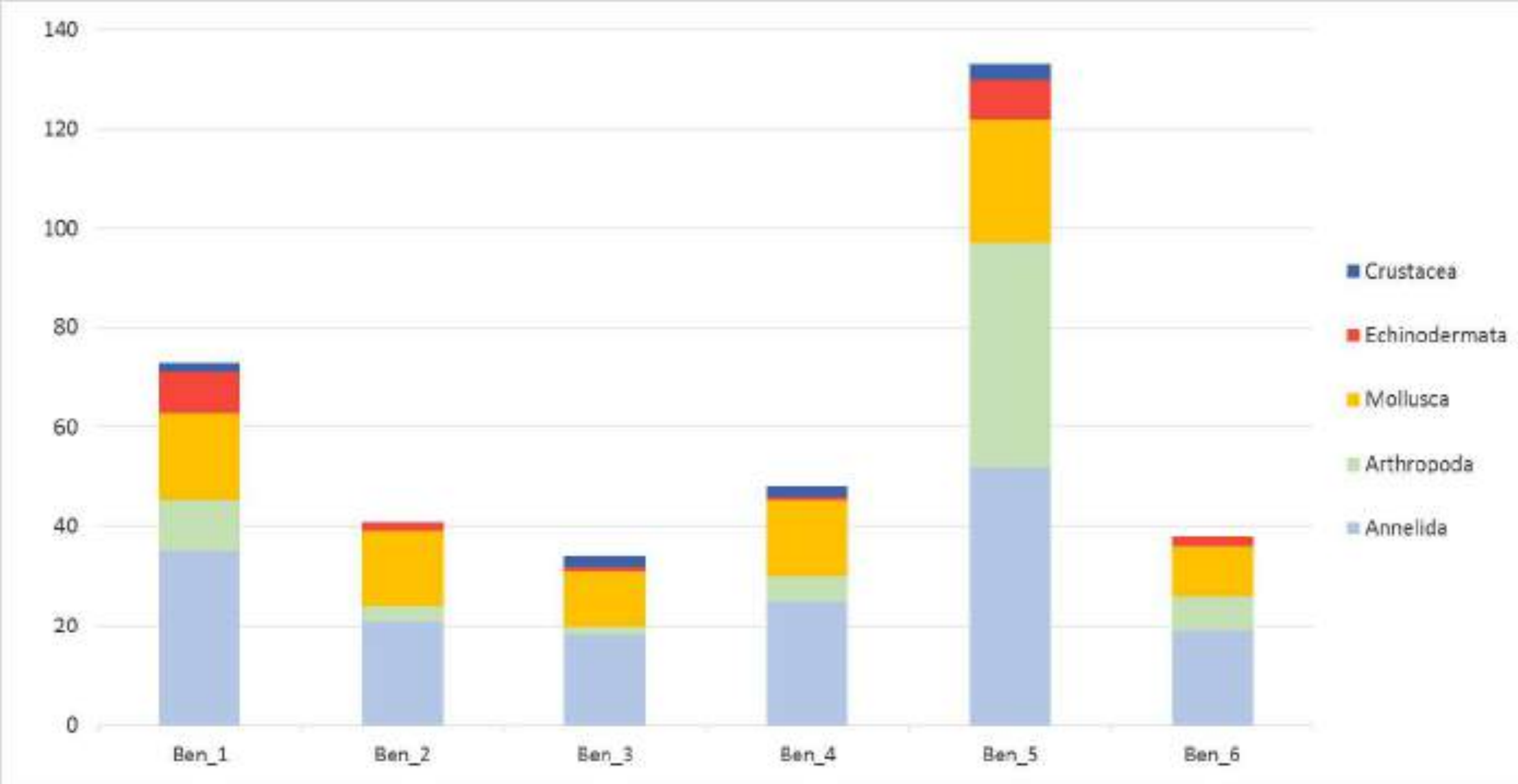
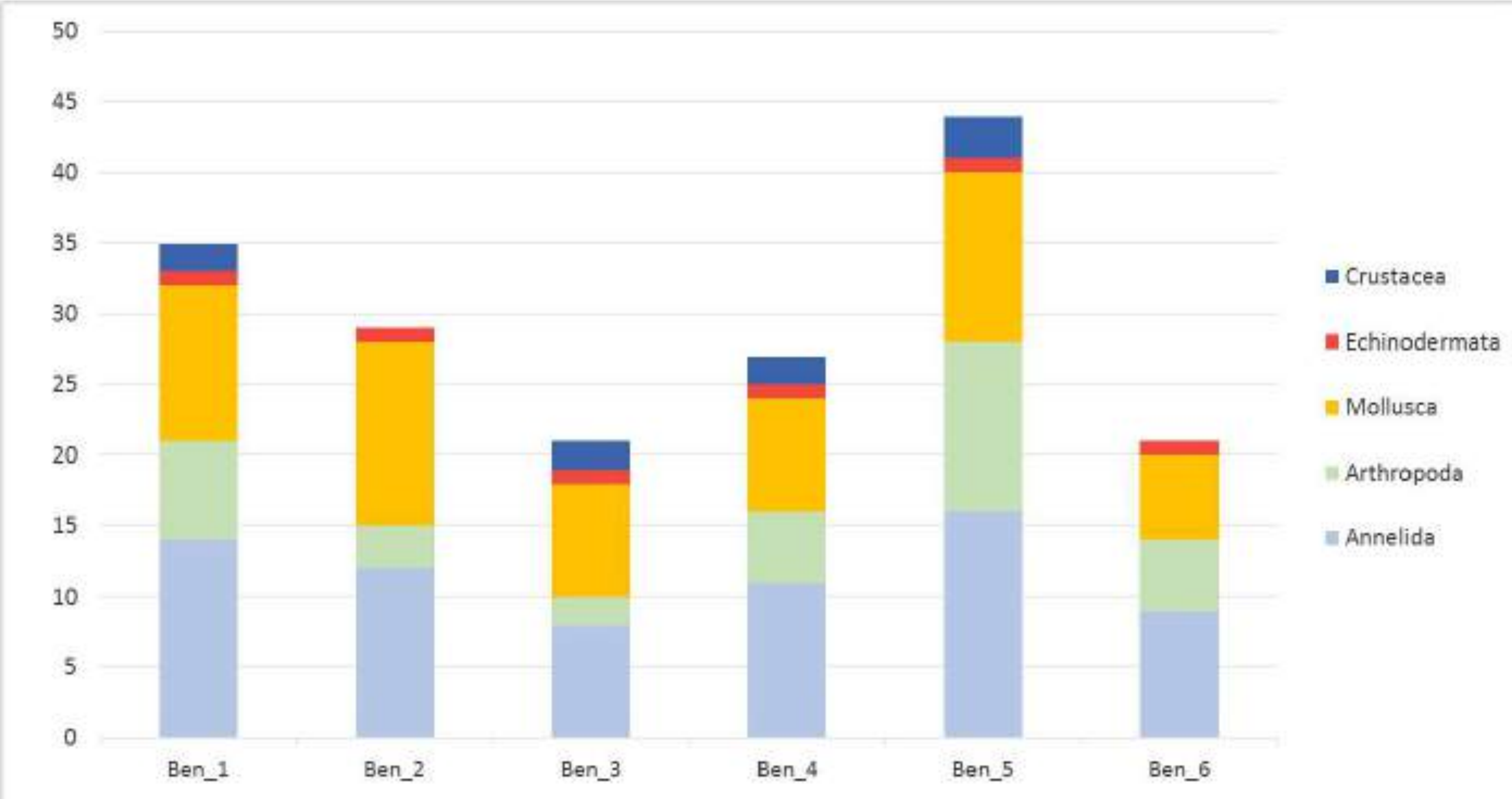


Figure 5-26 Benthic Infauna Species Richness by Site 2018



Margalef Species Richness (d)

The Margalef Species Richness (d) index is used as a measure of biodiversity of species in a given area (Margalef, 1975) and is heavily influenced by the number of species in a sample. Measures of diversity are frequently seen as indicators of the wellbeing of ecological systems (Magurran, 1988). Based on similar studies in the Arabian Gulf, Margalef values below 1.5 are considered to be low whilst values over 5 indicate high species richness in comparison to other coastal sites in the UAE (Nautica, 2014).

Results of univariate analysis show that none of the sites surveyed were below the low richness threshold of d = 1.5. Based on the classification detailed above, all of the six (6) samples collected in 2018 returned a d>5, and can subsequently considered to be of high richness. The highest richness was recorded in the sample collected from Ben_05 (d = 8.79) whilst the lowest was in the sample collected from Ben_06 (d = 5.50).

Pielou Species Evenness (J')

Pielou Species Evenness (J') is used to determine the spread of individuals between species with values between 0 (uneven) to 1 (even). All samples indicate a high degree of evenness indicative of an even spread of species across all of the samples. Results ranged from 0.940 (Ben_05) to 0.968 (Ben_2).

Shannon-Weiner Diversity Index (H')

The Shannon Weiner Diversity index (H') is used to characterize the diversity of species in a given community and is a compound index that aims to combine measures of richness and abundance (Morris et al. 2014). The index represents the probability that two randomly chosen individuals belong to different species and the index increases as diversity intuitively increases (Magurran, 2004).

Using a similar rule of thumb as that used for interpretation of d, samples with H' value of 1 or less are typically classified as low diversity whilst values above 3.5 are considered indicative of high diversity when viewed within the context of sampling results during other coastal studies conducted in the UAE (Nautica, 2014).

The results of the analysis indicate that the benthic community at station Ben_05 is considered to be of high diversity (H'>3.5). The remainder of the samples sit within the medium diversity threshold, with H' ranging from 2.89 (Ben_06) to 3.39 (Ben_01). No stations returned a value below "low" level of diversity threshold (H'<1).

Summary

Given that the Shannon-Weiner Diversity Index (H') accounts for both richness and abundance and it is considered a more reliable indicator of species diversity at the respective sites. In light of this, all samples collected from the project sites during 2018 are considered to be indicative of moderate to high diversity of benthic communities. Results showed similar trends to previous surveys in the vicinity of the Taweelah Complex, where there was a general trend of decreasing diversity with elevated water temperature and salinity (Dome and Marubeni, 2005) from the outfall plume and, as such, is likely influenced the least by elevated water temperatures and salinity at the base of the water column.

The abundances recorded are considered to be normal and indicative of the community expected within the Project site and at similar sites within the region. Coles and McCain (1990) reported that biomass of infauna associated with seagrass beds in the western Arabian Gulf is approximately three (3) times higher than that for areas of open sediment They also report species richness to range between 8-103 species in seagrass beds compared to 1-70 in areas of open sand.

Species Abundance and Richness 2019

Species abundance and species richness across the four (4) available samples collected in 2019 is presented in the figures below. Species abundance (N) does not seem to show much of a discernible variation between sites ranging from N=63 (TP1 End) to a maximum of N=89 (SR3). All sites are situated within areas of 'Unconsolidated Sediment' and all are situated at relatively far distances from the shoreline impacts of the existing facilities. Species richness (S) also showed a minimal spread with values ranging from 33 (TP1 End) to 42 (SR3 and SR4).

The abundances recorded are considered to be normal and indicative of the community expected within the Project site and at similar sites within the region. Coles and McCain (1990) reported that biomass of infauna associated with seagrass beds in the western Arabian Gulf is approximately three (3) times higher than that for areas of open sediment. They also report species richness to range between 8-103 species in seagrass beds compared to 1-70 in areas of open sand – these trends are mirrored in our findings during 2019 so far, where all samples presented here are from open sand.

Figure 5-27 Benthic Infauna Species Abundance by Site 2019

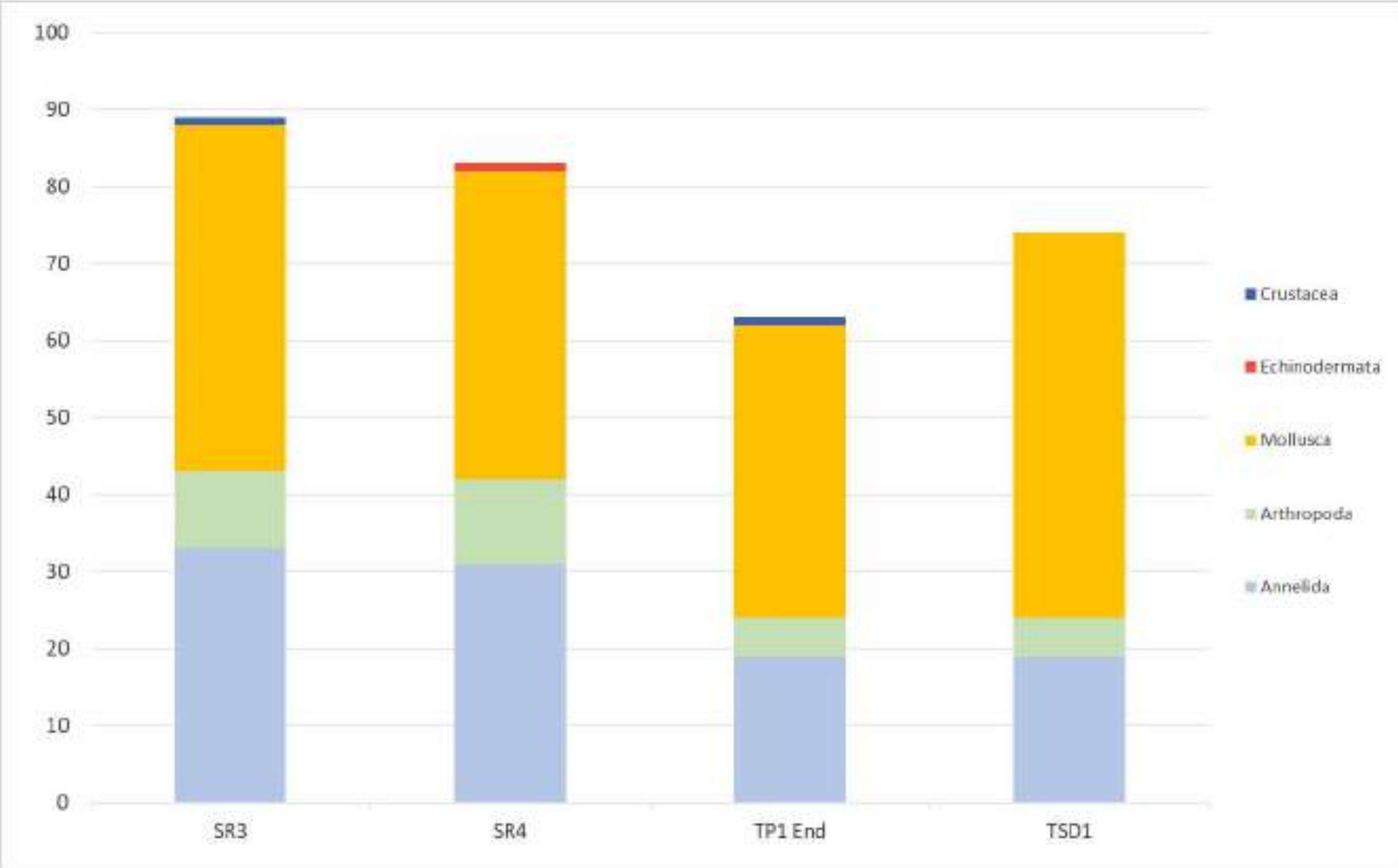
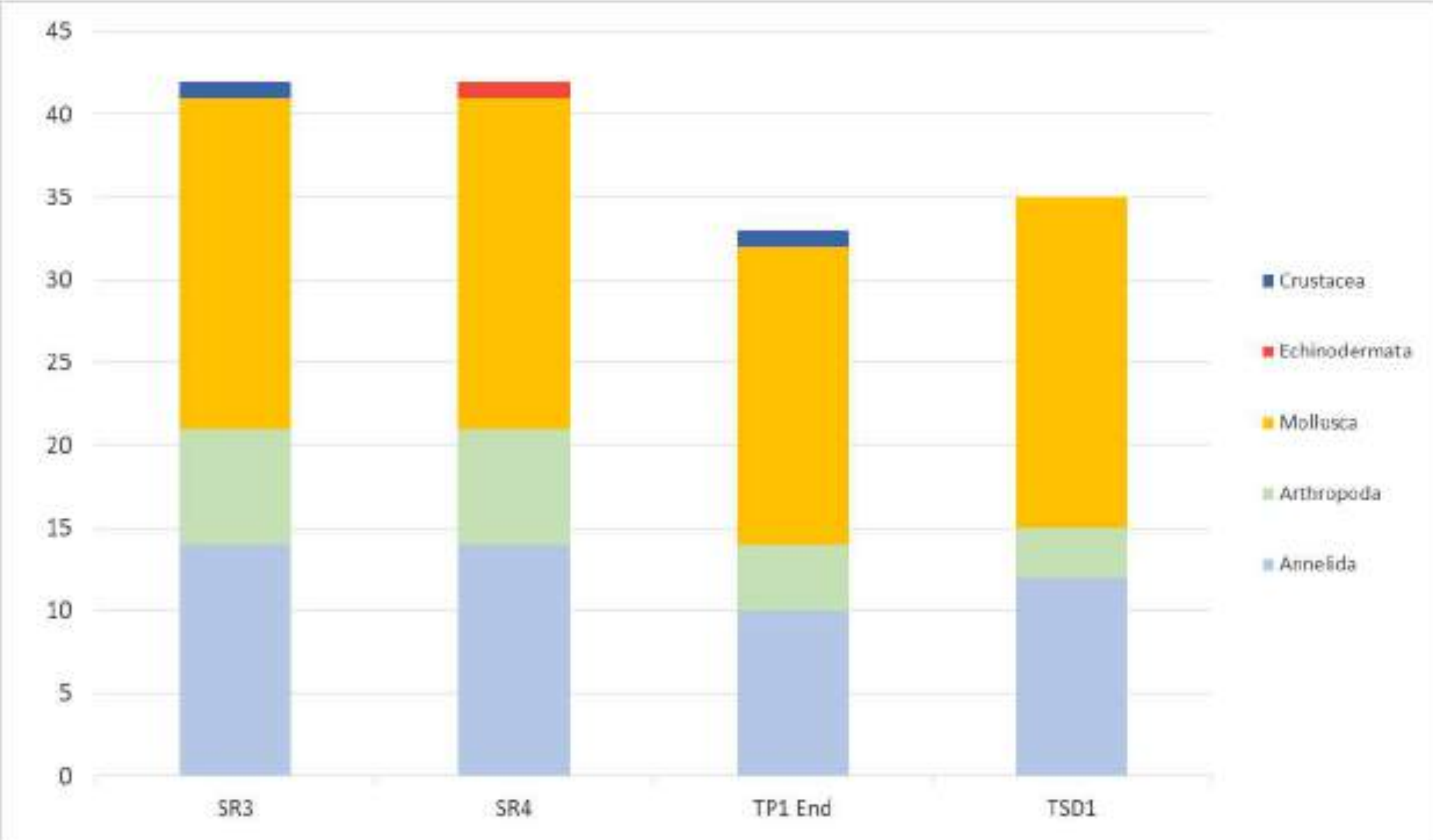


Figure 5-28 Benthic Infauna Species Richness by Site 2019



Community Analysis 2018

Multivariate analysis of the infaunal community, using the statistical software Primer-e v7 (Clarke and Gorley, 2015) were conducted to investigate resemblances between the respective survey sites. In order to reduce the influence of numerically dominant species, a mild square root transformation was applied to the sample abundances. The transformed data was then used to derive a Bray-Curtis (BC) similarity matrix quantifying the difference between samples based on all the species present and their relative abundance. To identify samples or sites which shared a common community type, the BC matrix formed the basis of a SIMPROF (SIMilarity PROFile) analysis. This permutation test identifies samples with a statistically significant ($p<0.05$) level of similarity.

The SIMPROF results are displayed as a dendrogram (Figure 5-28) which connects statistically significant groupings identified in the SIMPROF analysis. Red connections are indicative of statistically significant connections between samples, whilst black connections indicate the lack of a statistically significant similarity. A Multi-Dimensional Scaling (MDS) plot is presented in Figure 5-29.

The SIMPROF analysis shows three groupings of samples from the survey conducted during 2018. Two (2) of the samples (Ben_05) and (Ben_06) are outliers and show no significant relationship to any of the other samples collected. The grouping of Group C and Group D indicate changes in community composition with increasing distance from the shoreline. Samples collected from Ben_01 and Ben_02 show a high level of statistical similarity (84%). Samples collected from Ben_03 and Ben_04, though not as similar as those collected from Ben_01 and Ben_02, are nonetheless statistically similar. Samples Ben_03 and Ben_04 were collected from sites situated between 1 km and 1.5 km from the shoreline. It should also be noted though that all samples show a moderate level of similarity with all being 54% similar to one another.

Figure 5-29 SIMPROF Analysis of Infaunal Samples

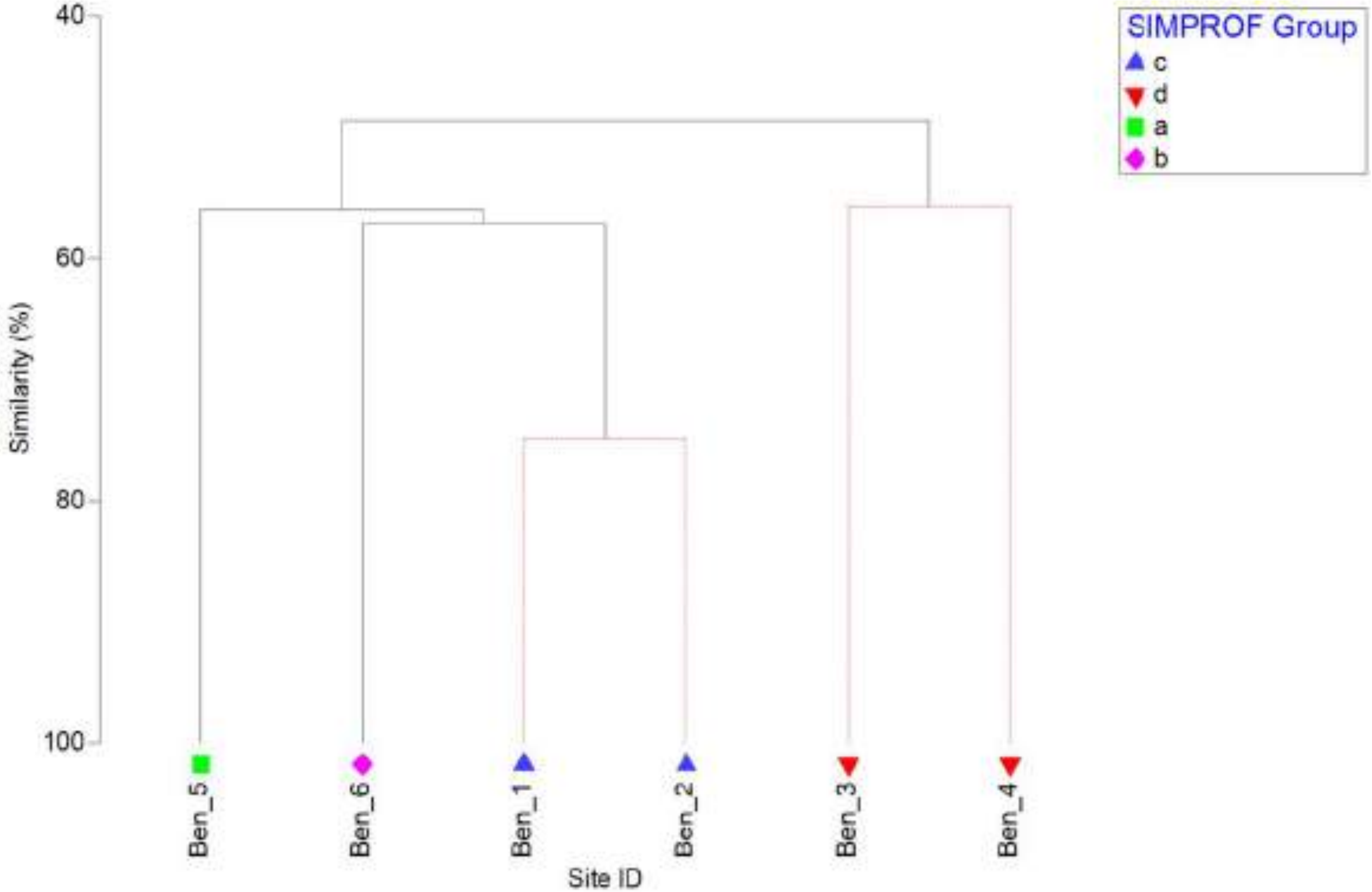
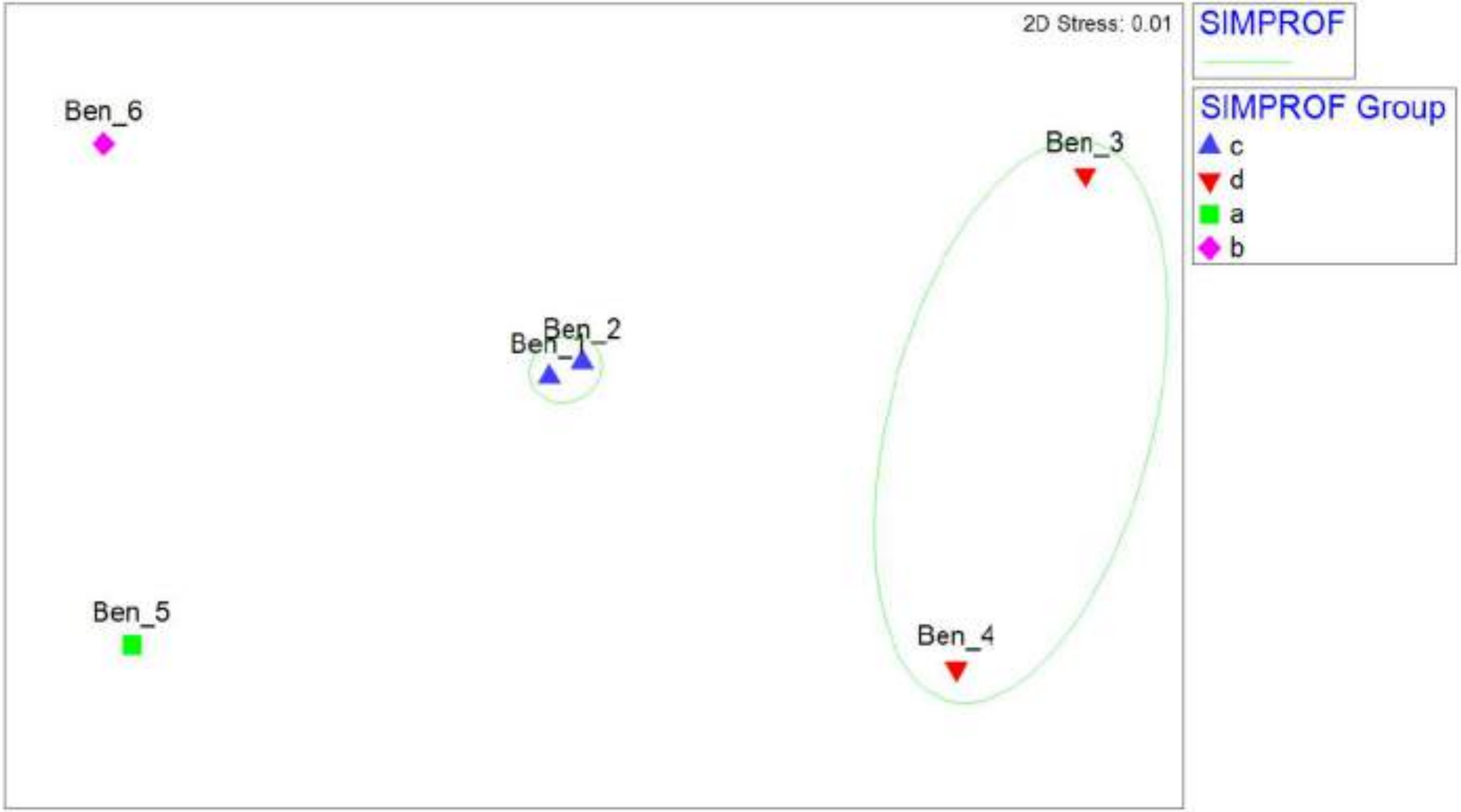


Figure 5-30 Multi-dimensional Scaling (MDS) Plot of Infaunal Communities



Entrainment and Impingement (E&I) Survey

Four (4) locations were sampled for assessment of fish eggs and larvae communities on the 6th of May 2019. The four (4) locations were selected in relation to the planned footprint of the intake structure whereby one was located in the planned mouth of the intake channel, one was located in the main channel itself and two were located up and downstream of the structure. Duplicate samples were collected from each of the four (4) stations so that a total of eight (8) E&I samples were obtained. These samples are intended at this stage of the project to inform a baseline assessment of the representative number of fish eggs and larvae present at the site, where each were identified to genus level or higher. Long term monitoring for fish eggs and larvae needs to be conducted at the Taweelah site so as to fully understand the potential impacts of E&I within the area.

Samples intended for analysis to inform the E&I survey were collected using bongo nets pulled obliquely through the water column whilst the survey vessel was traveling at its lowest speed (approx. 1-2 knots) for a set distance. This method effectively samples the entire water column with the intent of capturing an accurate representation of the ichthyoplankton species residing in the area. Procedures for the entrainment and impingement survey were performed as per the EAD technical guideline (EAD-EQ-PCE-TG-14). Flow meters were situated in the mouths of the nets during each tow so as to enable calculation of the volume of water that passed through the nets during each trawl.

Once the net is brought back on board the survey vessel, the HDR marine scientists use flowing water to rinse the net, thereby flushing the plankton to the bottom of the net, also known as the cod end. The samples are then preserved in buffered formalin prior to their transportation to the analytical laboratory for sorting and identification of all fish eggs and larvae present in each sample.

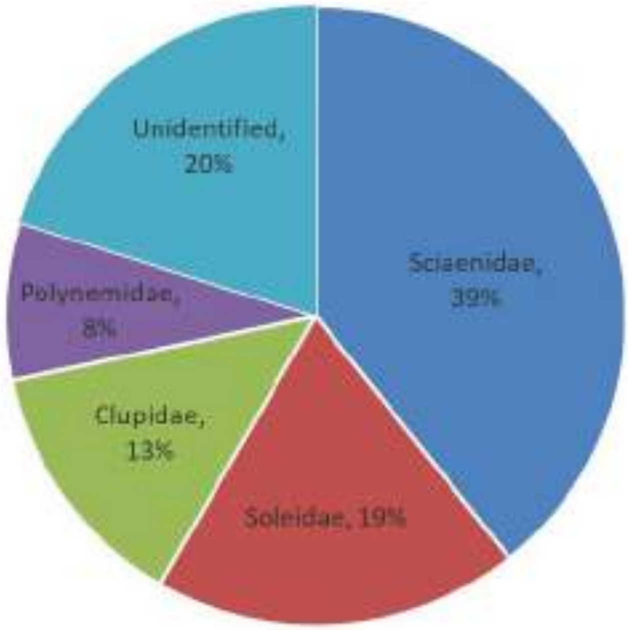
Figure 5-31 Fish Eggs and Larvae Sampling Stations and Proposed Intake Footprint

Taxonomic Composition for E&I

The eight (8) samples collected during the targeted baseline survey for E&I assessment contained a total estimate of 2,247,074 individual organisms from five (5) identified taxa (all of the phylum chordate) when extrapolated to per m^3 estimates. These organisms belonged to the following four (4) genus groups, where Figure 5-31 presents the proportional composition by genus.

- Sciaenidae;
- Soleidae;
- Clupidae; and
- Polynemidae.

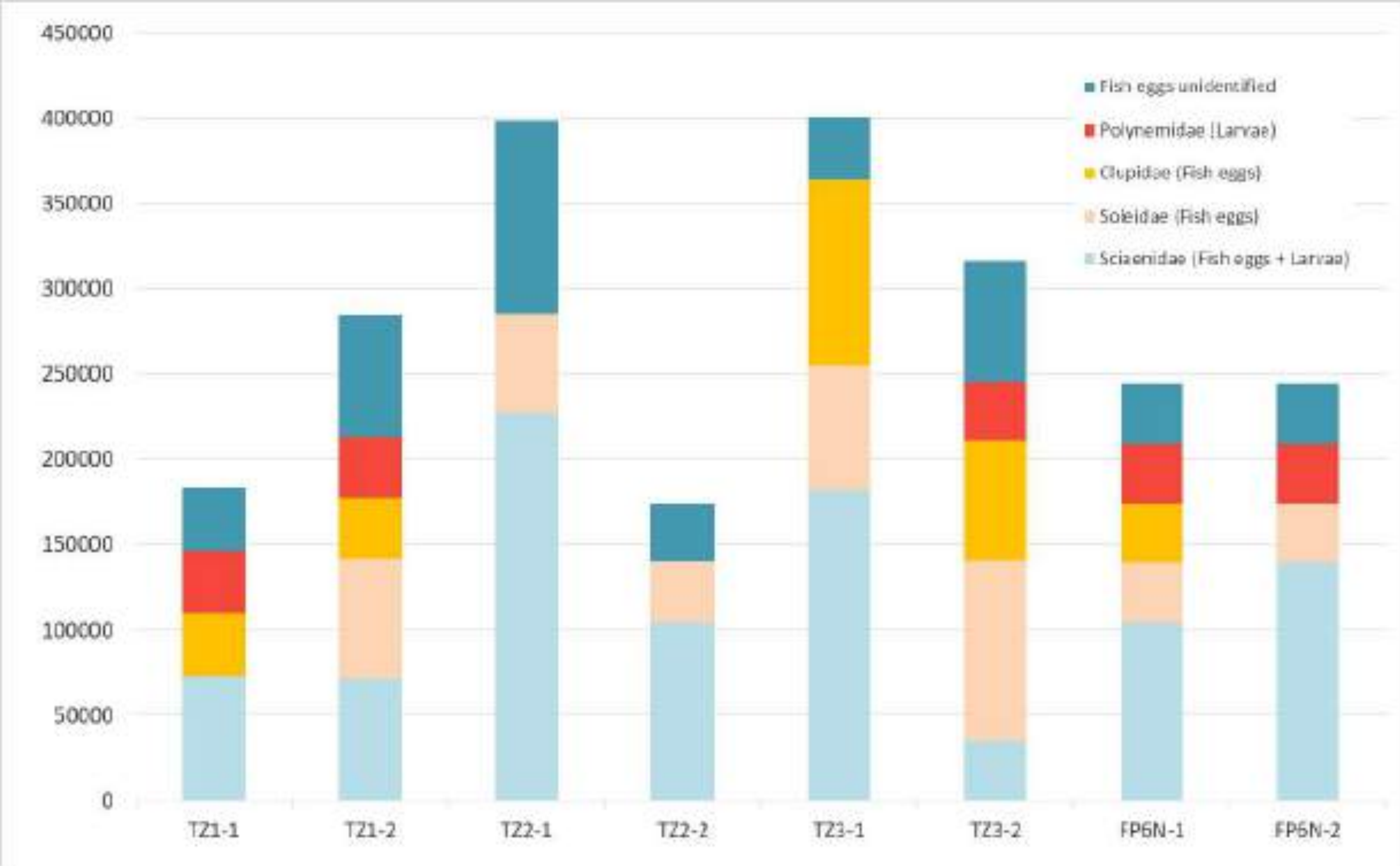
Figure 5-32 Taxonomic Composition of Phylum of Fish Eggs and Larvae



The majority of individuals in the samples collected comprised of sciaenidae (comprised of both eggs and larvae) where 39% of the individuals were of this faunal group. 20% of the individuals (433,213 organisms per m^3) could not be identified to genus level. Soleidae fish eggs made up 19% of the organisms (411,167 individuals per m^3) followed by clupidae fish eggs making up 13% (286,698 individuals per m^3) and polynemidae larvae comprising 8% (177,231 individuals per m^3) of the total. Faunal group abundance (per m^3) across the E&I samples is presented inFigure 5-32. Abundance values (N) do show quite a discernable level of variation between sites ranging from N=174,690 (TZ2-2) to a maximum of N=400,460 (TZ3-1).

This is interesting because although the sites closest to the seagrass bed (TZ1 and FPN6) would be expected to have the highest abundance. They do show the highest levels of richness across taxa where site TZ2, for example which is further away from the seagrass bed exhibits only two (2) of the taxa (Sciaenidae and soleidae) but TZ1 and FP6N exhibit many more taxa groups with counts of five (5) and four (4) respectively. The abundances recorded are considered to be normal and indicative of the community expected within the Project site and at similar sites within the region during this time of year, which is known to be fish spawning season for some key fish species.

Figure 5-33 Fish Eggs and Larvae Faunal Group Abundance (2018)



Zooplankton Survey

Zooplankton tows were conducted at a total of six (6) monitoring locations on the 3rd June 2018 and at a total of four (4) locations (duplicate sampling) on the 6th of May 2019. The predominant purpose of the additional sampling for zooplankton during 2019 was to assess the potential impacts of entrainment and impingement of fish eggs and larvae at the proposed intake location which is discussed in the previous subsection. All sample collection and taxonomic sorting and identification protocols were as per the EAD-approved TOR (HDR, 2018) (refer to Appendix B). Survey sites from both 2018 are presented in the figures above.

Figure 5-34 Zooplankton Survey Sites 2018

Taxonomic Composition 2018

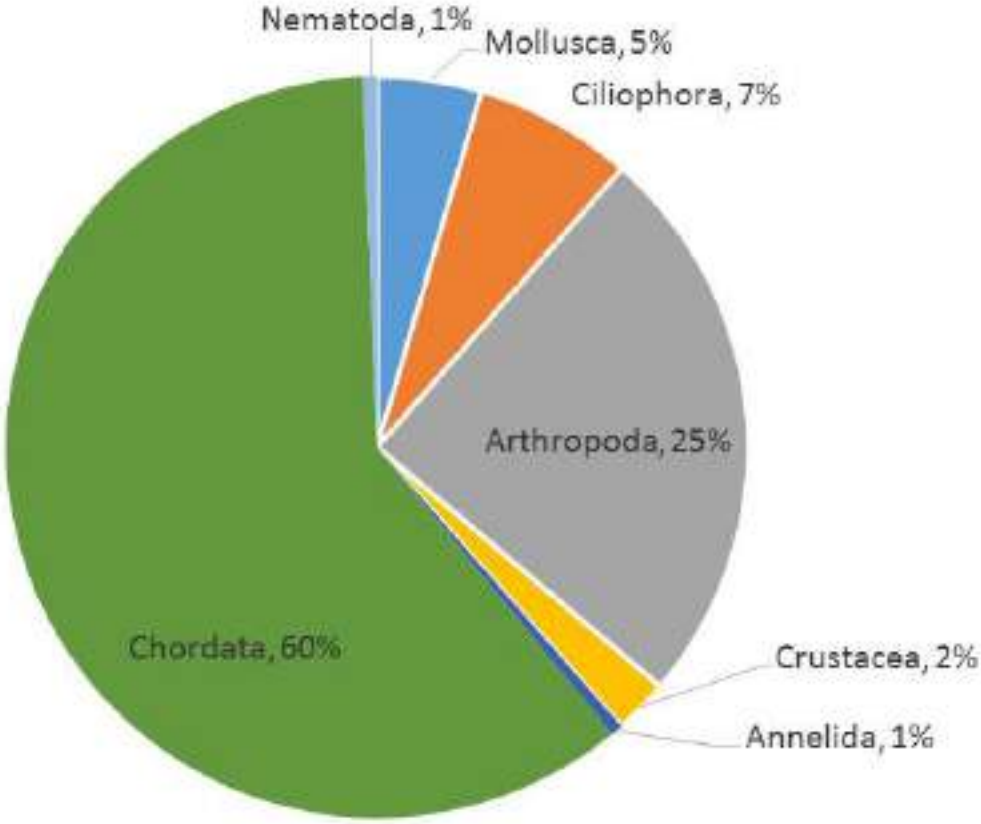
The six (6) samples contained a total of 367 individual organisms from 45 taxa belonging to the following five (5) phyla.

- Mollusca;
- Annelida;
- Arthropoda;
- Echinodermata; and

- Crustacea.

Chordata and arthropoda contributed the greatest proportion of the total abundance in samples collected. Figure 5-35 presents the proportional composition by phyla, with only those that contributed greater than 1% of the total individuals displayed.

Figure 5-35 Taxonomic Composition of Phylum Represented by >1% of Total



The majority of individuals in the samples collected comprised of chordata and arthropoda. Chordata were most abundant (1,114 individuals) with all species being represented by appendicularians (11 species). *Appendicularia sicula* was the most abundant species (224 individuals recorded across all six (6) survey sites). Arthropoda were represented by 16 species of copepod, one (1) species of ostracod and one (1) type of decapod larvae. The most abundant of these was *Paracalanus parvus* (70 individuals).

Interestingly, the site with the highest abundance and the second highest richness was Zoo_2 which was located directly inside the existing outfall channel and the site with the second highest abundance and the highest diversity overall was the site located directly offshore of the outfall (Zoo_6) in an area that the modeling of the existing outfall plume showed was directly impacted by the hot saline water discharged by the existing facilities at Taweelah.

No fish eggs or fish larvae were present within the samples, this is likely due to fish spawning events in the UAE occurring earlier in the year during April and May (Bauman et al. 2014). It is important to note that zooplankton communities are more dynamic than benthic communities, therefore species composition can change depending on time of day and year. The results present only a snapshot in time. Data collected over an extended time period throughout the year would be required to draw definitive conclusions on seasonal and temporal variations in community structure, composition and dynamics.

Species Abundance, Richness and Univariate Analysis 2018

Species abundance and species richness across all samples is presented in the figures below. Data collected from the infauna samples was analysed using Primer-e v7 statistical software (Clark and Gorley, 2015). Univariate statistical analysis (Margalef Species Richness, Pielou Species Evenness and Shannon wiener Diversity index) was undertaken to determine the abundance and diversity indices for zooplankton samples. Tabulated results based on the pooled data for the replicate samples collected at each of the survey sites is presented in 5-10. Cells highlighted in green indicate high diversity results.

Figure 5-36 Zooplankton Species Abundance by Site 2018

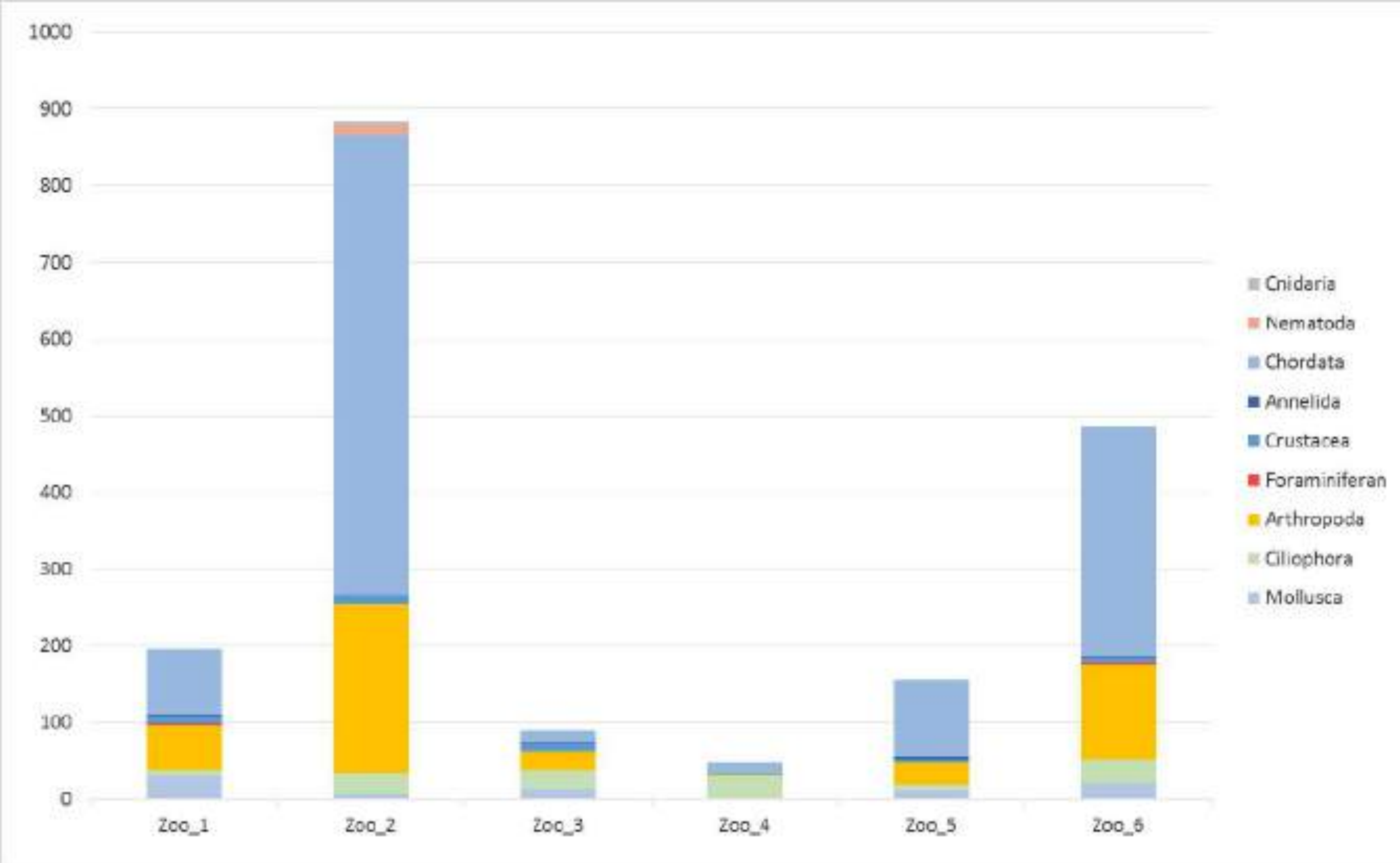


Figure 5-37 Zooplankton Species Richness by Site 2018

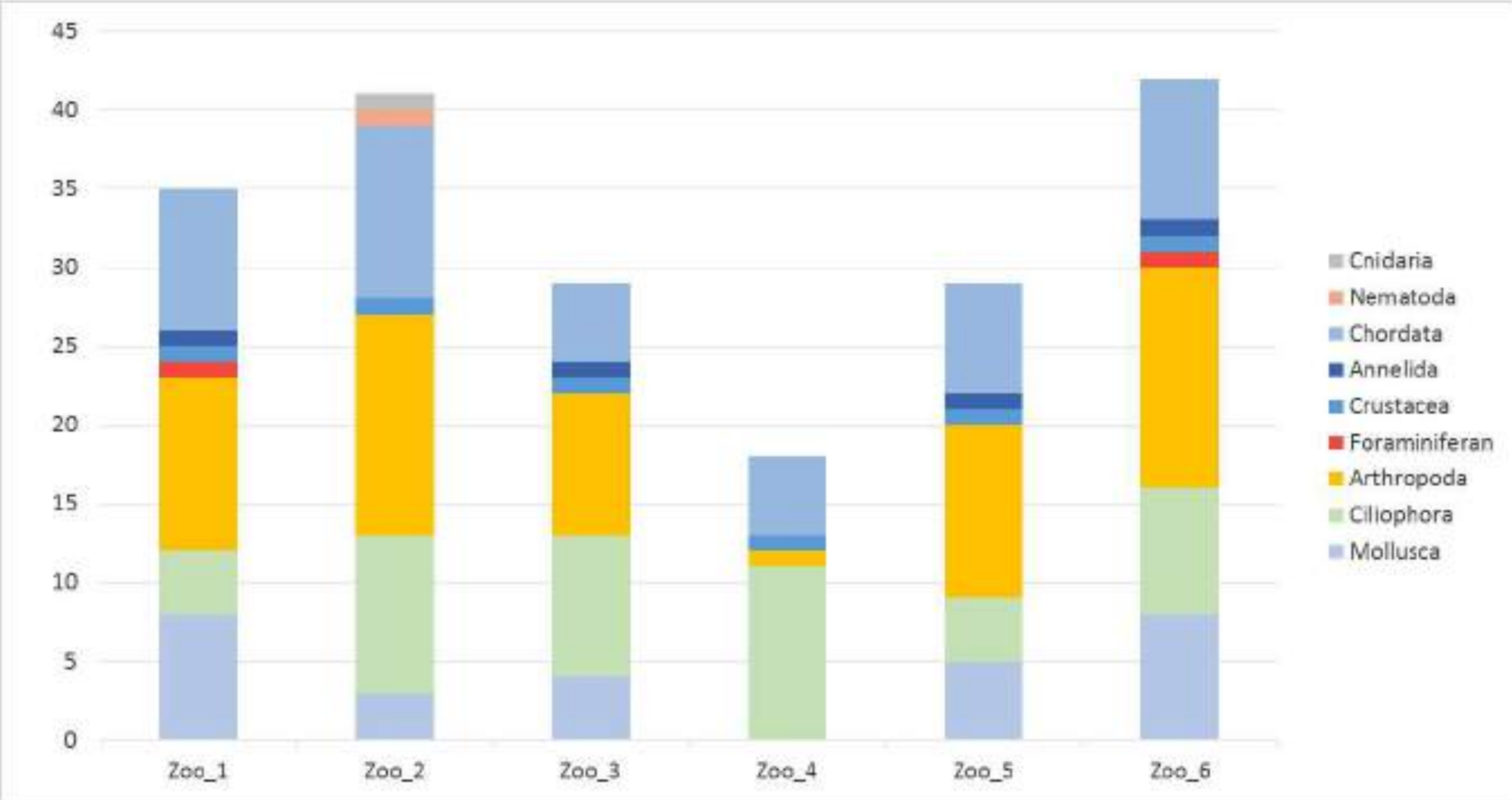


Table 5-10 Species Richness, Abundance and Univariate Analysis Results

Site ID	Species Abundance (N)	Species Richness (S)	Margalef Species Richness (d)	Pielou Eveness (J')	S-W Diversity (H')
Zoo_1	195	35	6.448	0.8805	3.131
Zoo _2	884	41	5.896	0.8441	3.135
Zoo _3	90	29	6.222	0.9358	3.151
Zoo _4	48	18	4.391	0.9683	2.799
Zoo _5	156	29	5.545	0.8605	2.898
Zoo _6	486	42	6.628	0.8453	3.159

Species abundance (N) shows a high variation between sites ranging from N=48 at Zoo_4 to a maximum of 884 at Zoo_6. Similarly species richness (S) showed a wide range with S=48 at Zoo_4 to S=884 at Zoo_2. It is notable that the highest values for both N and S were recorded in the sample collected from the Zoo_2, which is situated within the open outfall channel.

Univariate Analysis Results

Results of univariate analysis show that Margalef Species Richness (d) ranged from d=4.39 (Zoo_4) to d=6.62 (Zoo_6). Pielou Species evenness (J') results ranged from J'=0.844 (Zoo_2) to J'=0.968 (Zoo_4). The Shannon Weiner Diversity index (H') results range from H'=2.80 (Zoo_4) to 3.16 (Zoo_6).

Summary

The results of univariate analysis indicate that, though the sample collected from Zoo_2 contained the highest abundance, the J' of 0.844 suggest this sample contains the least even spread of species and may be dominated by a smaller number of species. This is potentially attributable to the lower number of species that are able to tolerant the high temperatures and salinity in the outfall channel. Diversity was highest in the sample collected from site Zoo_6, adjacent to the mouth of the outfall channel. The highly mobile nature of the marine waters means that, as compared to the sessile benthic communities, that less inferences can be drawn from a single water sample. Instead the results provide a snapshot of conditions at the time of sampling.

Community Analysis 2018

The SIMPROF results are displayed in Figure 5-37. A Multi-dimensional Scaling (MDS) plot is presented inFigure 5-38. The SIMPROF analysis shows two (2) distinct groupings. Group A is comprised of Zoo_1, Zoo_2, Zoo_5 and Zoo_6 while group B is comprised of samples collected at the mid-field distance from shore (approx. 1 km – Zoo_3 and Zoo_4). Group A shows a high level of statistical similarity (64%). It should also be noted though that all samples show a moderate level of similarity with all being 43% similar to one another.

Figure 5-38 SIMPROF Analysis of Zooplankton Samples

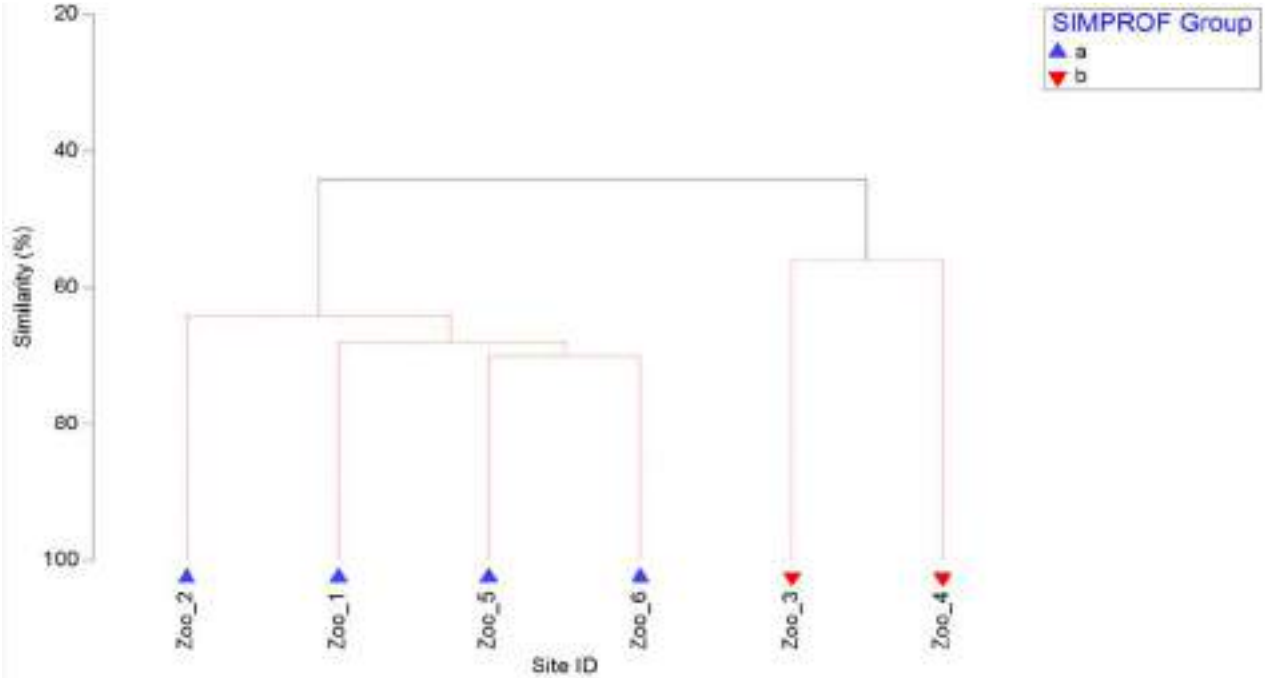
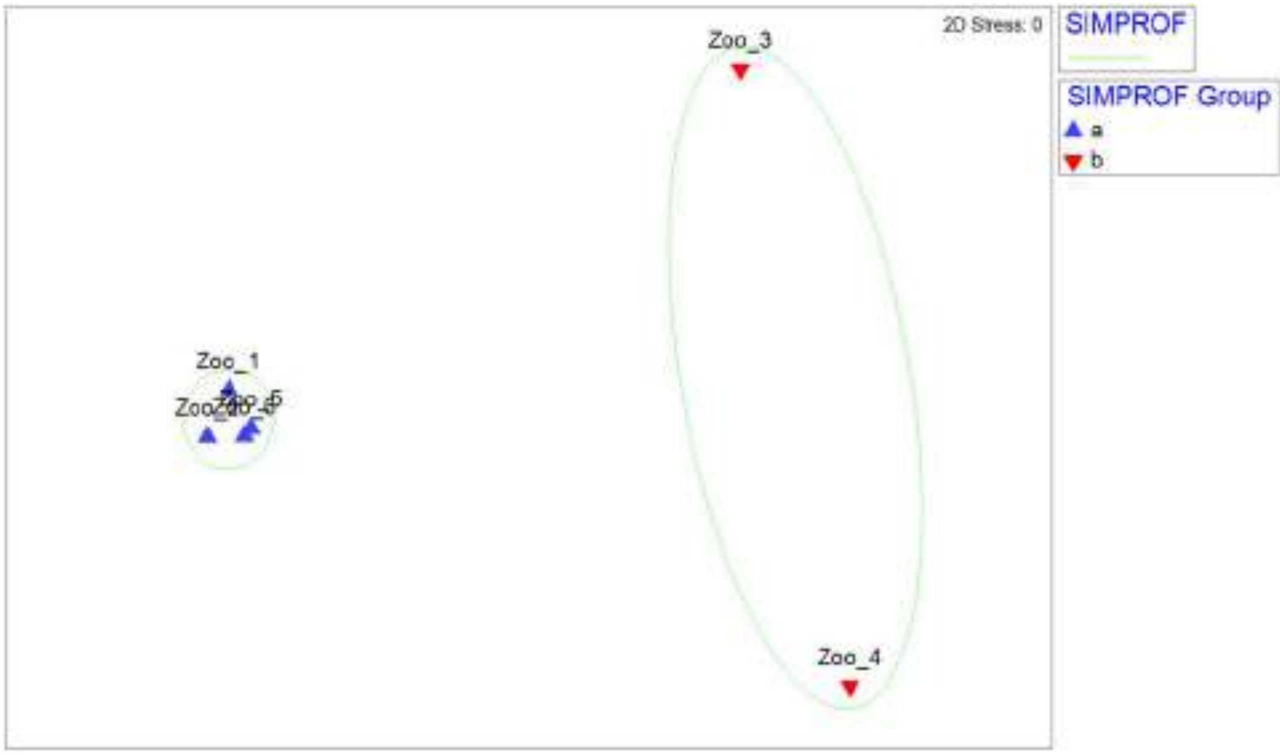


Figure 5-39 Multi-dimensional Scaling (MDS) Plot of Zooplankton Communities



Phytoplankton Survey

Marine water samples for phytoplankton analysis were collected in 2018 only, from approximately one (1) meter below the surface of the water column on the 3rd June. Sample collection methodologies and taxonomic sorting and identification were as per the protocols set out in the EAD-approved TOR (HDR, 2018) (refer to Appendix B). The six (6) survey sites are presented in the figure below.

Figure 5-40 Phytoplankton Survey Sites

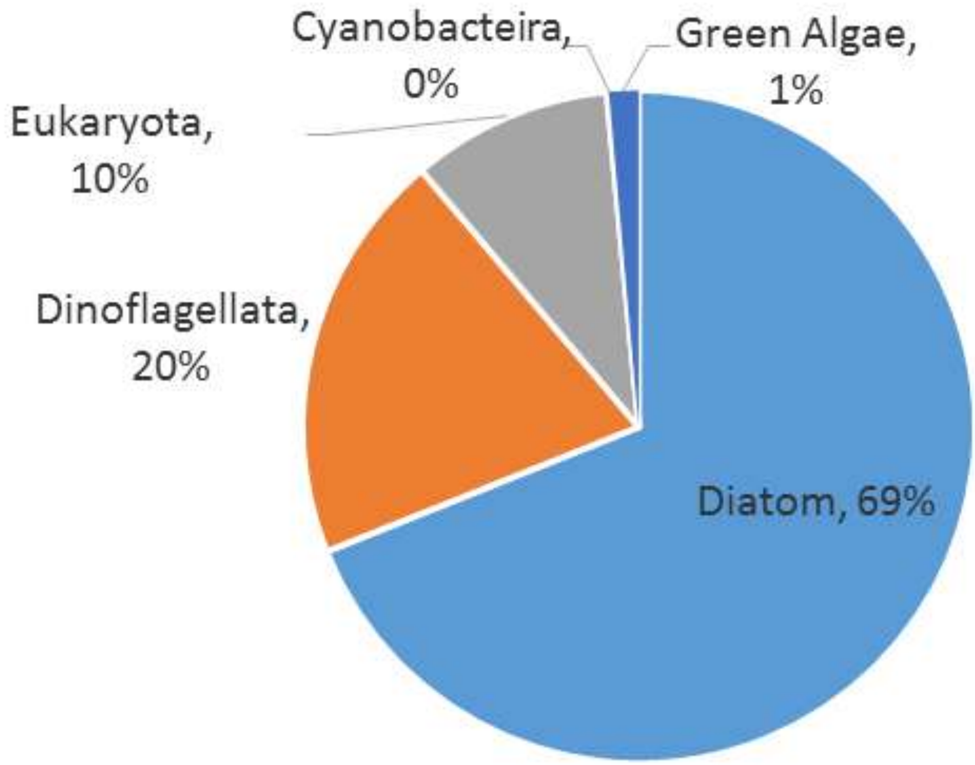
Taxonomic Composition

The six (6) samples contained a total of 1,965 individual organisms (estimated as per/ml values) from 29 taxa belonging to the following five (5) phyla.

- Diatom;
- Dinoflagellata;
- Eukaryota;
- Cyanobacteria; and
- Green algae.

Diatoms and dinoflagellates contributed the greatest proportion of the total abundance in samples collected. Figure 5-40 presents the proportional composition by phyla, with only those that contributed greater than 1% of the total individuals displayed.

Figure 5-41 Taxonomic Composition of Phytoplankton Phylum



The majority of individuals in the samples collected comprised of diatoms and dinfolagellates. Diatoms were most abundant (total of 1,355 individuals per/ml) with the species being represented by navicular, coscinodiscuc, gyrosigma, plagiotrosis, pleurosigma and nitzchia (total of 17 identifiable species). *Coscinodiscus centralis* was the most abundant species (216 individuals recorded across all six (6) survey sites per/ml). The dinoflagellates were represented by four (4) species of ceriatum, and eight (8) species of protoperidinium. The most abundant of the dinoflagellates was *Ceratium inflatum* (150 individuals per/ml).

The sites with the highest abundance were the two (2) nearshore sites Phyto_1 and Phyto_2 which are located closest to the shoreline, inside both the intake and outfall canals.

Species Abundance, Richness and Univariate Analysis

Species abundance and species richness across all samples is presented in the figures below. Data collected from the phytoplankton samples was analysed using Primer-e v7 statistical software (Clark and Gorley, 2015). Univariate statistical analysis (Margalef Species Richness, Pielou Species Evenness and Shannon wiener Diversity index) was undertaken to determine the abundance and diversity indices for zooplankton samples.

Figure 5-42 Phytoplankton Species Abundance by Site

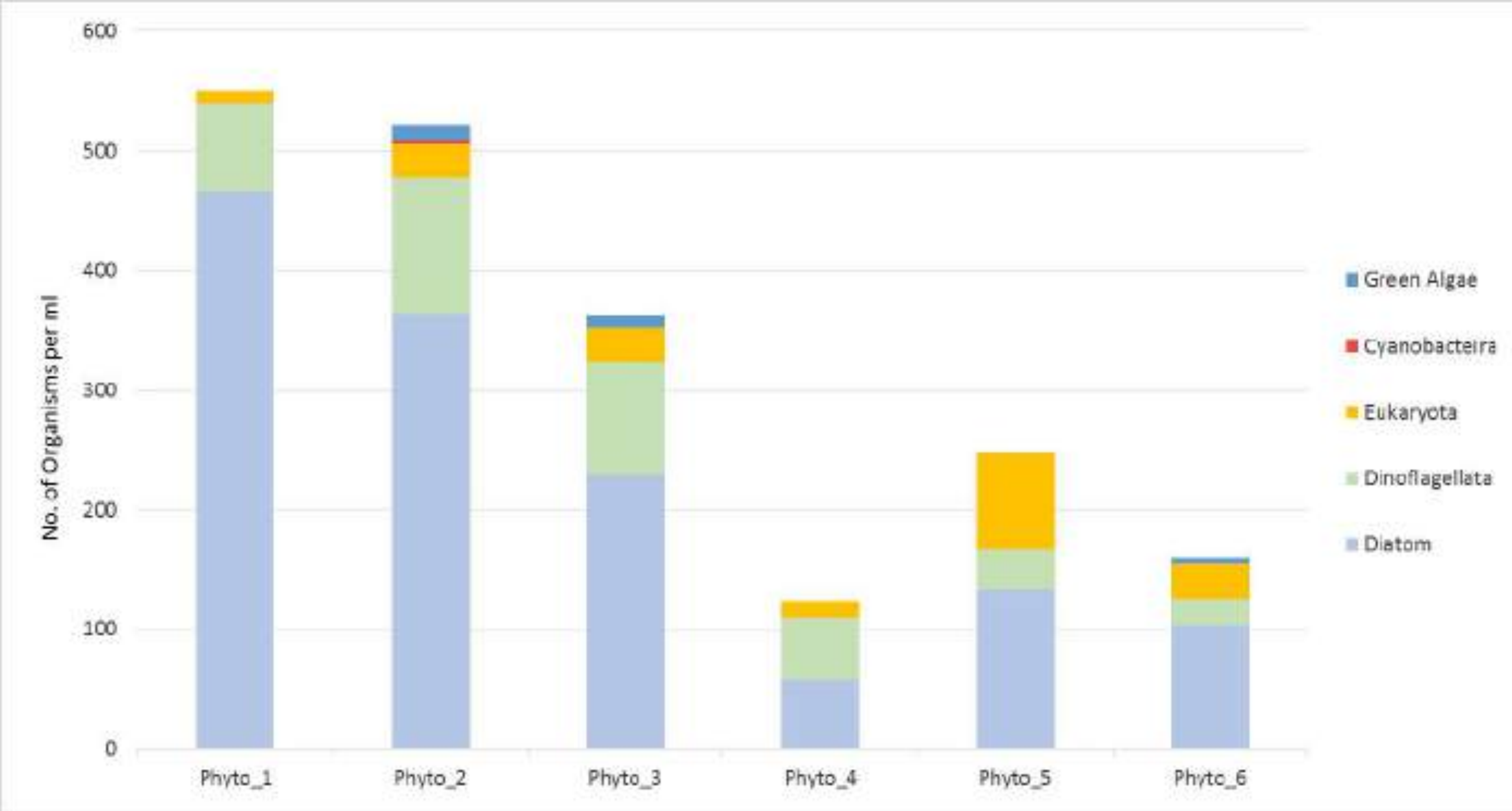
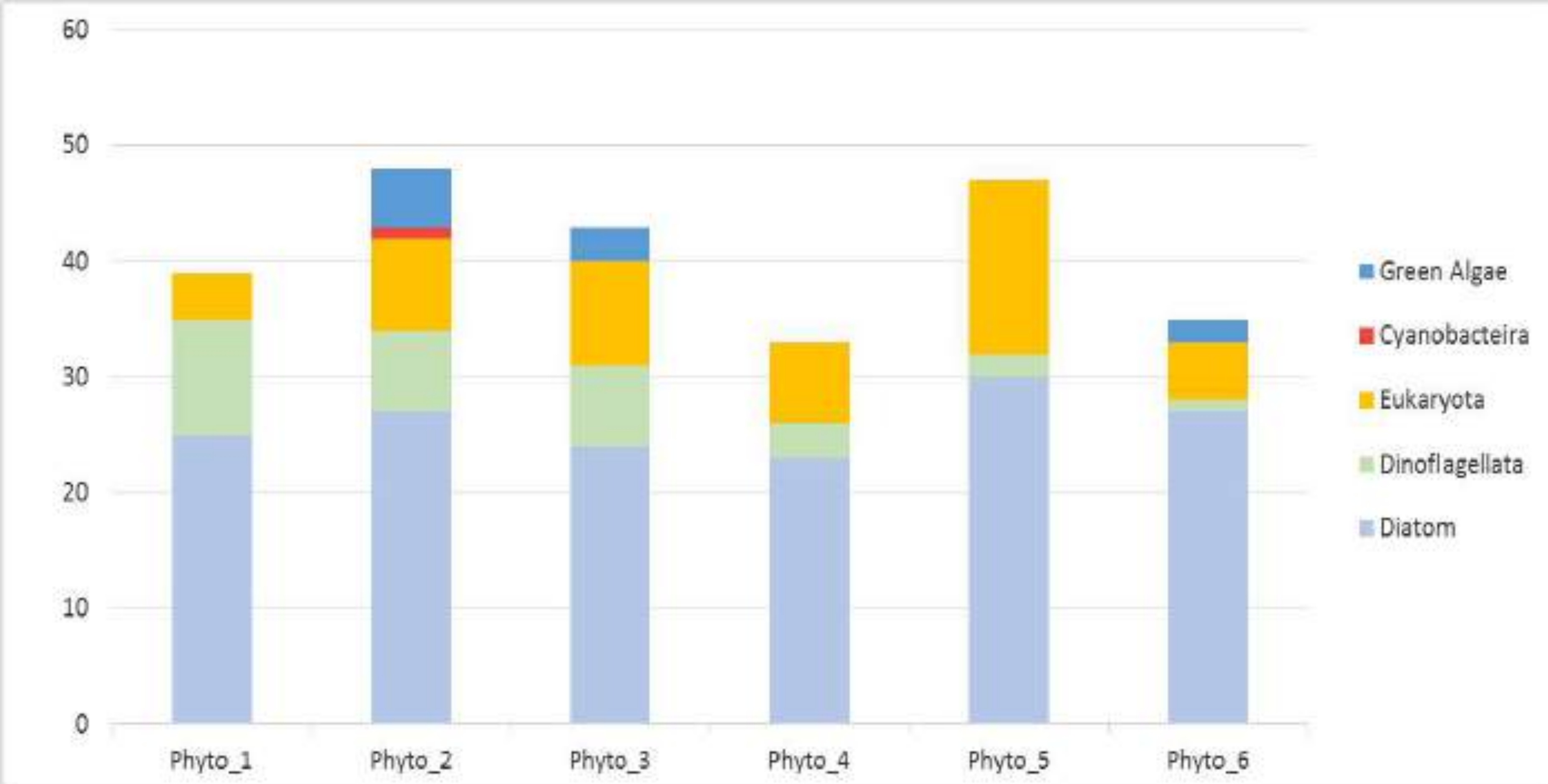


Figure 5-43 Phytoplankton Species Richness by Site



Tabulated results based on the pooled data for the replicate samples collected at each of the survey sites is presented in table 5-11.

Table 5-11 Phytoplankton Species Richness, Abundance and Univariate Analysis Results

Site ID	Species Abundance (N)	Species Richness (S)	Margalef Species Richness (d)	Pielou Eveness (J')	S-W Diversity (H')
Phyto_1	550	39	6.022	0.7884	2.888
Phyto_2	522	48	7.511	0.8199	3.174
Phyto_3	362	43	7.129	0.8127	3.057
Phyto_4	124	33	6.639	0.8406	2.939
Phyto_5	247	47	8.349	0.9286	3.575
Phyto_6	160	35	6.699	0.9013	3.204

Species abundance (N) shows a relatively low level of variation between sites ranging from 124 organisms/ml (Phyto_4) to 550 org/ml (Phyto_1). As with zooplankton, there is a notable difference between the maximum and minimum. Though the highest N is recorded in the sample collected in the intake channel, the result of the analysis collected in the intake channel (N=522) is the second highest. This result is unexpected given the hostile water quality conditions within the outfall channel. Species Richness (S) shows lower variation between samples, ranging from S=33 (Phyto_4) to S=48 (Phyto_2). Again, the high number of species in the outfall channel is unexpected, though the reason for this is not immediately clear.

Univariate Analysis Results

Results of univariate analysis show that Margalef Species Richness (d) ranged from d=6.02 (Phyto_1) to d=8.35 (Phyto_5). Pielou Species evenness (J') results ranged from J'=0.79 (Phyto_1) to J'=0.93 (Phyto_5). The Shannon Weiner Diversity index (H') results range from H'=2.89 (Phyto_1) to H'=3.58 (Phyto_5).

Community Analysis

The SIMPROF results are displayed in Figure 5-43. A Multi-dimensional Scaling (MDS) plot is presented inFigure 5-44. The SIMPROF analysis shows three (3) distinct statistically similar groupings. Group A is comprised of Phyto_4, Phyto_5 and Phyto_6. Group B is comprised of samples collected from Phyto_2 and Phyto_3, whilst the sample collected from Phyto_1 is not statistically similar to any of the other samples collected. There appears to be little spatial correlation between the different groupings.

Figure 5-44 SIMPROF Analysis of Phytoplankton Samples

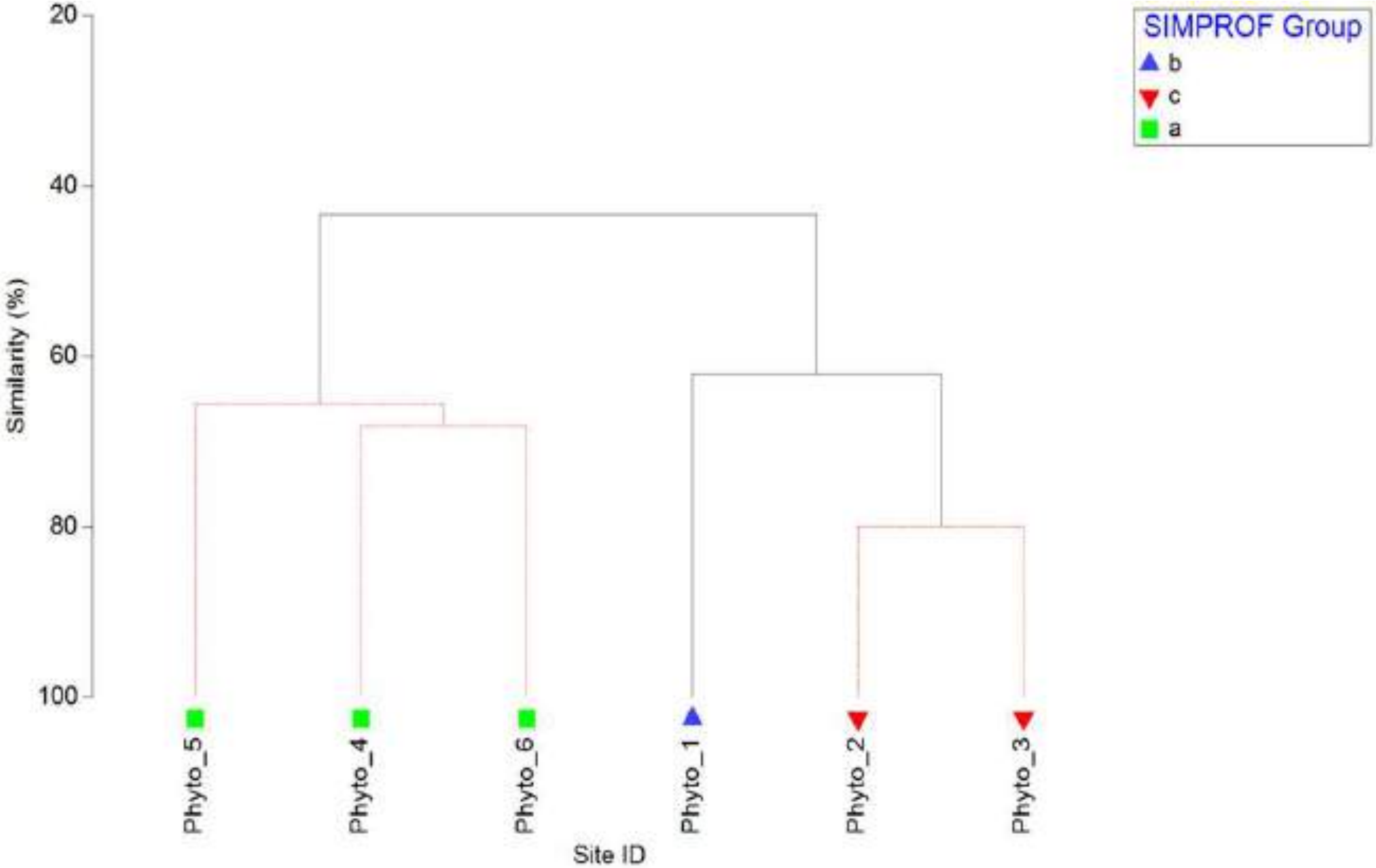
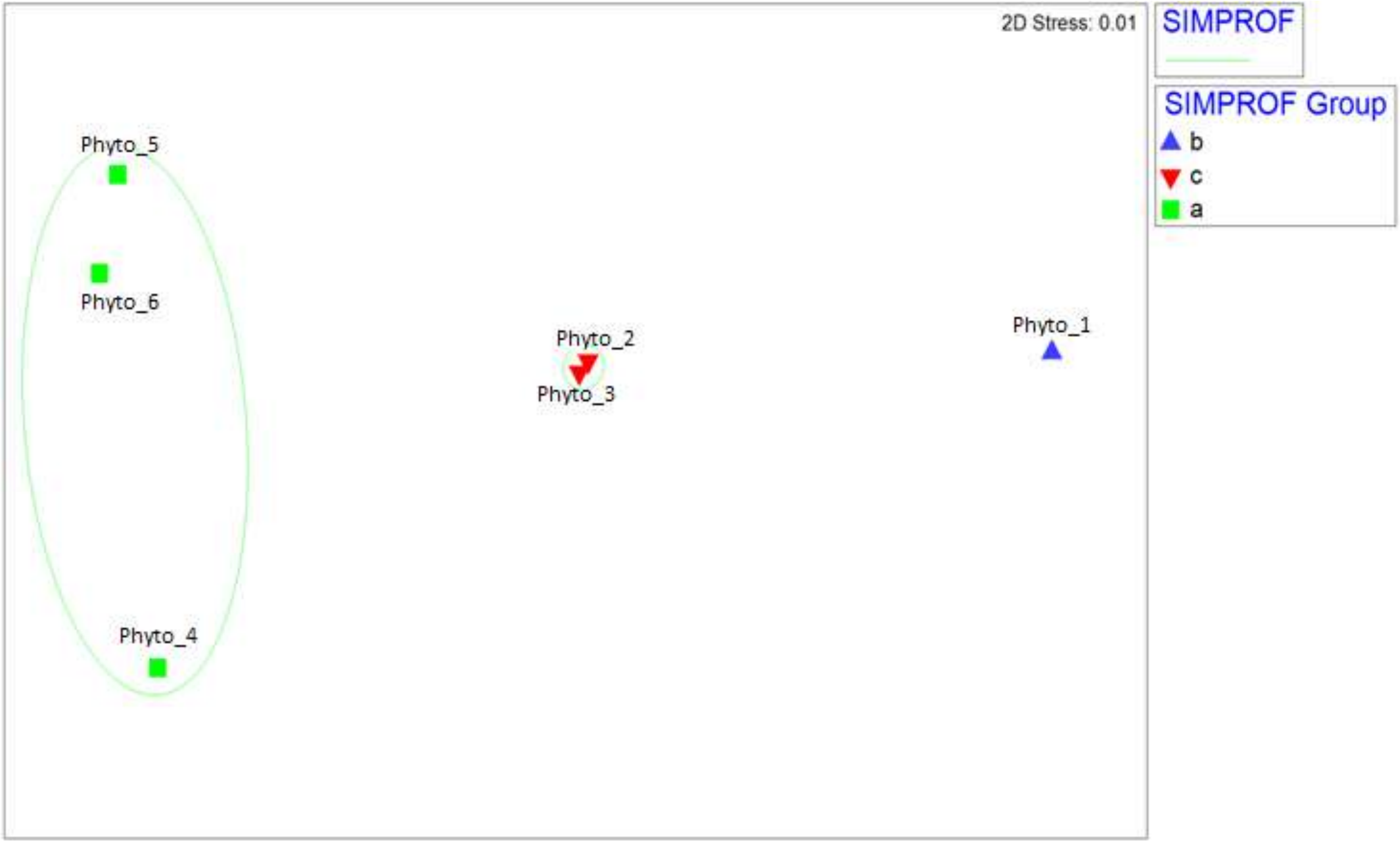


Figure 5-45 Multi-dimensional Scaling (MDS) Plot of Phytoplankton Communities



Remote Habitat Classification

Benthic habitat classification was recorded through remote observation at selected locations using Drop-down camera (DDC) with a view to screening for potentially sensitive habitats. The locations that were visited are shown in the figures below. Two phases of visual surveying were undertaken, the first during June 2018 and the second during April 2019.

The 2018 DDC survey locations were selected on the basis of the original pipeline alignment considered in the Concept EIA. The locations of the 2019 survey were informed based on the planned final design of the SWRO plant, specifically the intake structure and outfall pipeline alignment route.

DDC images were used to classify the general substrate type at each location. All surveyed DDC stations were classified into the following habitat categories:

- Seagrass;
- Unconsolidated sediment;
- Unconsolidated sediment with algae;
- Matrix of hard and sandy bottom; and
- Matrix of hard and sandy bottom with algae.

Habitat types across all sites is summarized and displayed in the figures below. Images of every station that were analysed is provided in Appendix G.

The majority of the sites sampled in 2018 consisted of unconsolidated sandy sediments with low profile (<10cm) ripples caused by wave driven water movement whereas the entirety of the outfall alignment is comprised almost fully of hard and sandy bottomed seabed and appears to be mostly free from critical habitats. The intake channel footprint is mainly unconsolidated sandy sediments with low profile (<10cm) ripples with the exception of its north east corner which encroaches on the edge of a sea grass area that extends from the edge of the proposed intake to the edge of the actual intake).

Figure 5-46 Unconsolidated Sandy Sediments

Figure 5-47 Drop Down Camera Sampling Locations (2018)

Title: Drop-Down Camera Locations for the Baseline EIA Study

Job Number: 10108598
Revision: Rev 1
Date: 15 July 2018

Figure 5-48 Drop Down Camera Sampling Locations (2019)

Figure 5-49 Habitat Classifications at Drop Down Camera Sites

In certain areas, the unconsolidated sediments form a thin veneer which lies over calcerinite caprock. In some areas, the caprock has been exposed (figure 5-50). None of the sites surveyed with exposed caprock were found to support communities of scleractinian corals, though low density macro algal growth was recorded at a small number of sites towards the end (i.e. furthest offshore) of the proposed pipeline alignment (Figure 5-51).

Figure 5-50 Thin Veneer of Sandy Sediments with Exposed Calcerinite Caprock

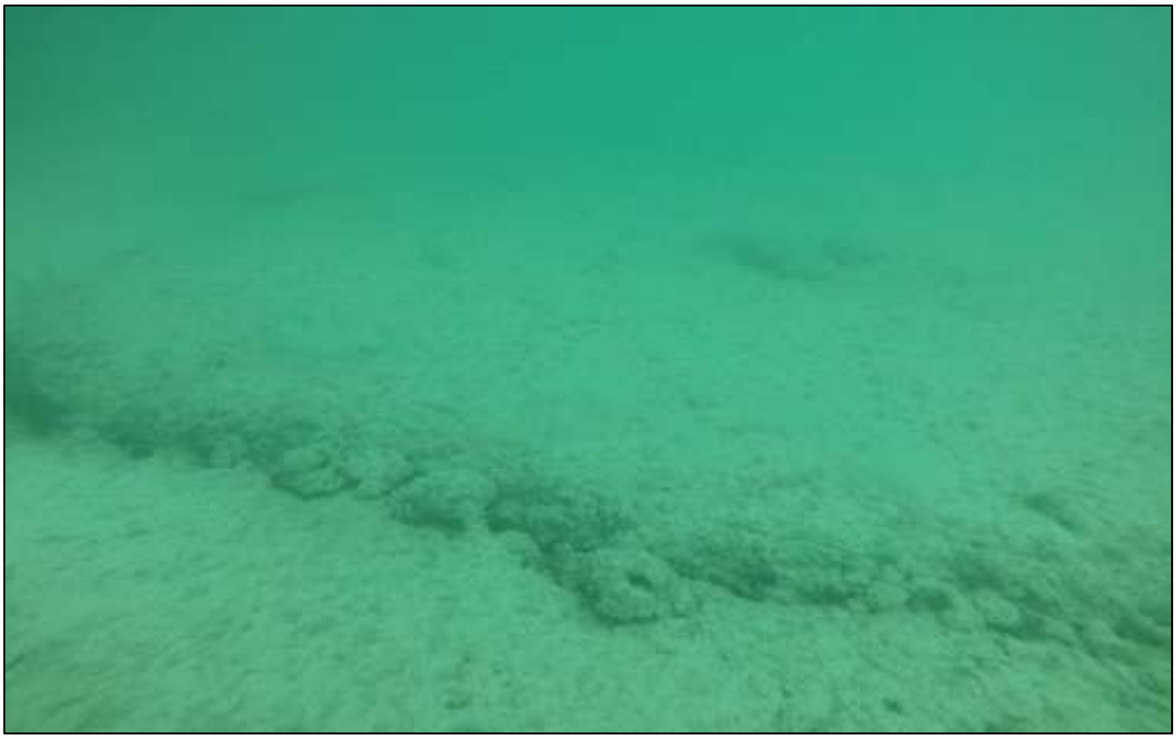
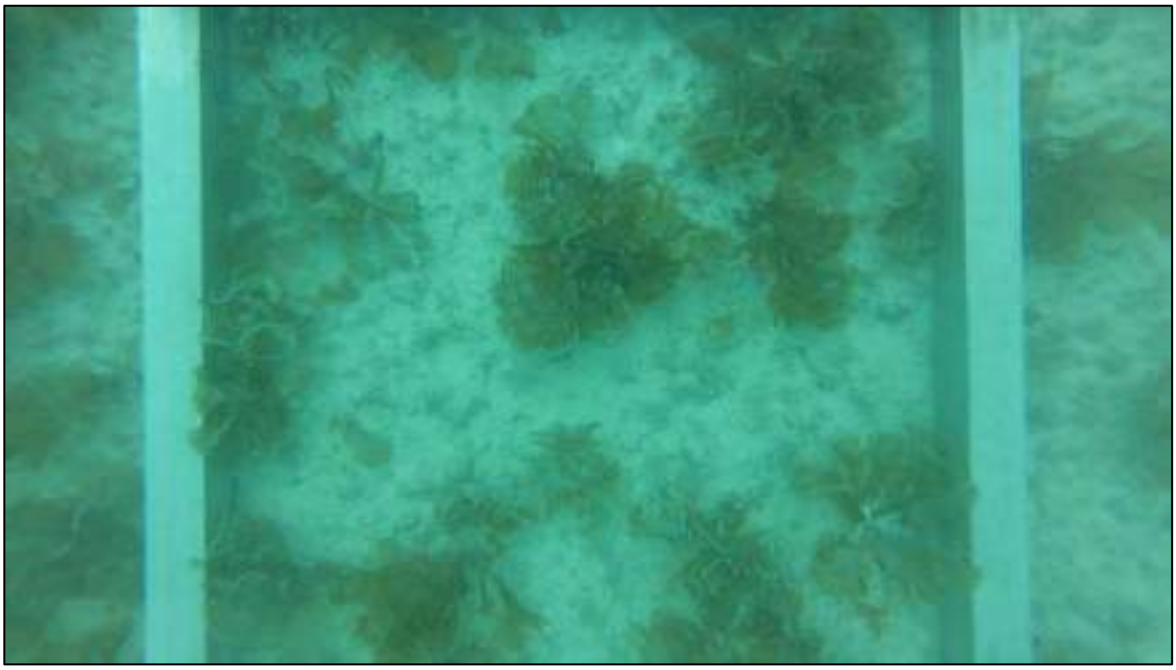


Figure 5-51 Matrix of Hard and Sandy Bottom with Algal Growth



Seagrass beds were recorded in the bays either side of the existing seawater intake channel. Coverage ranged from sparse to dense with *Halodule uninervis* the dominant species. *Halophilia ovalis* was also present in mixed stands.

The UAE's three seagrass species are described as resilient to both physically harsh conditions and disturbance from sedimentation (Erfetmeijer and Shuail, 2012). Seagrass beds are valuable as they provide physical structure in an otherwise relatively homogenous subtidal habitat (Kaiser et al, 2011). Areas of seagrass cover in the Arabian Gulf are classed as critical habitat given their importance for direct grazers, such as sea turtles and dugongs. In addition, seagrass provide important fish and invertebrate nurseries, a physical refuge and are the basis for detritus food chains (UNEP, 2003). Seagrasses provide important physical functions. Root systems stabilize sediments and reduce resuspension of fine particles by wave action. The baffling effects of seagrasses also reduces water speeds, causing increased sedimentation and reducing turbidity in the water column (Kaiser et al. 2011).

The most significant sea grass bed that has the potential to be physically or directly impacted by the construction of the intake or the outfall (red delineation) is mapped in Figure 5-53. The majority of this seagrass bed area is comprised of medium to sparse density seagrass populations where denser patches (such as that shown in Figure 5-52) are rare although it should be noted that the overlapping area with the intake structure as delineated in Figure 5-53 has been classified as "medium to dense" seagrass.

Figure 5-52 Mixed Seagrass Bed Dominated by Halodule uninervis

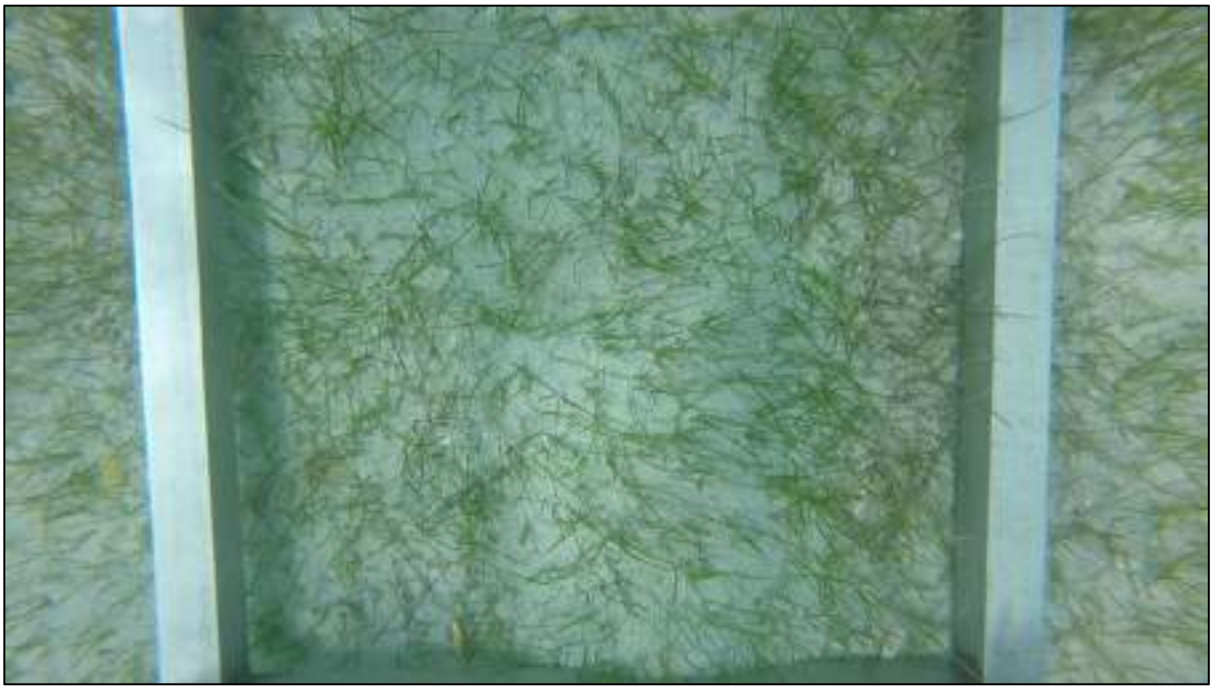


Figure 5-53 Seagrass Bed (white delineation) in Closest Proximity to the Outfall and Intake Development Areas

Remote Underwater Visual Census (UVC)

HDR conducted an Underwater Visual Census (UVC) using Baited Remote Underwater Video Systems (BRUVS). This technique was employed as a non-destructive and non-intrusive method of assessing fish populations in the vicinity of the Project site. HDR's marine survey team deployed 17 BRUVS during June 2018 and three (3) BRUVS during April 2019(Figure 5-54). Each BRUVS was deployed for a period of 30 minutes, with a total of 10 hours of footage recorded. The video footage was reviewed on return to HDR offices with all species counted and, where possible, identified to species level. The records were then analysed to determine species richness and maximum abundance. Maximum abundance was calculated by counting the maximum number of any one species present in any one frame (MaxN).

Figure 5-54 Baited Remote Underwater Video System Sampling Locations

A total of 17 fish species were recorded across all 20 sites. The species richness and abundance for each site is presented in table 5-12. Most of the species recorded are classified as 'Least Concern' on the IUCN Red List of Threatened Species, with one (1) species listed as 'Data Deficient', one (1) species listed as 'Vulnerable', and six (6) species were not listed at all. The Orange-spotted Grouper (*Epinephelus coioides)* is internationally listed as 'Near Threatened' but has a regional classification within the Arabian Gulf as 'Vulnerable'. *E. coioides* is a commercially valuable species, but stock assessments indicate a decreasing population trend and over-exploitation within the Arabian Gulf (Choat et al., 2015). A single individual was recorded in two videos, one of which was recorded adjacent to the breakwater at BR_03 (Figure 5-53) during the 2018 survey and one of which was recorded at TBRUV2 during the 2019 surveys (Figure 5-52). The most abundant species across the 20 BRUVS sites was the Black-spot Snapper (*Lutjanus ehrenbergii*), occurring in 15% of videos analysed, with a total of 33 individuals recorded. The Dory Snapper (*Lutjanus fulviflamma*) appeared in the most videos (25%) with 12 individuals recorded. Large schools of fish (between 20-50 individuals) passed through some videos, but these were not identified due to poor visibility. The fish that were not identified to species level are listed table 5-13, where there was a total of eight (8) potential different species, accounting for 95 individuals.

Figure 5-55 Orange-spotted Grouper (Epinephelus coioides) Pictured at BR_10

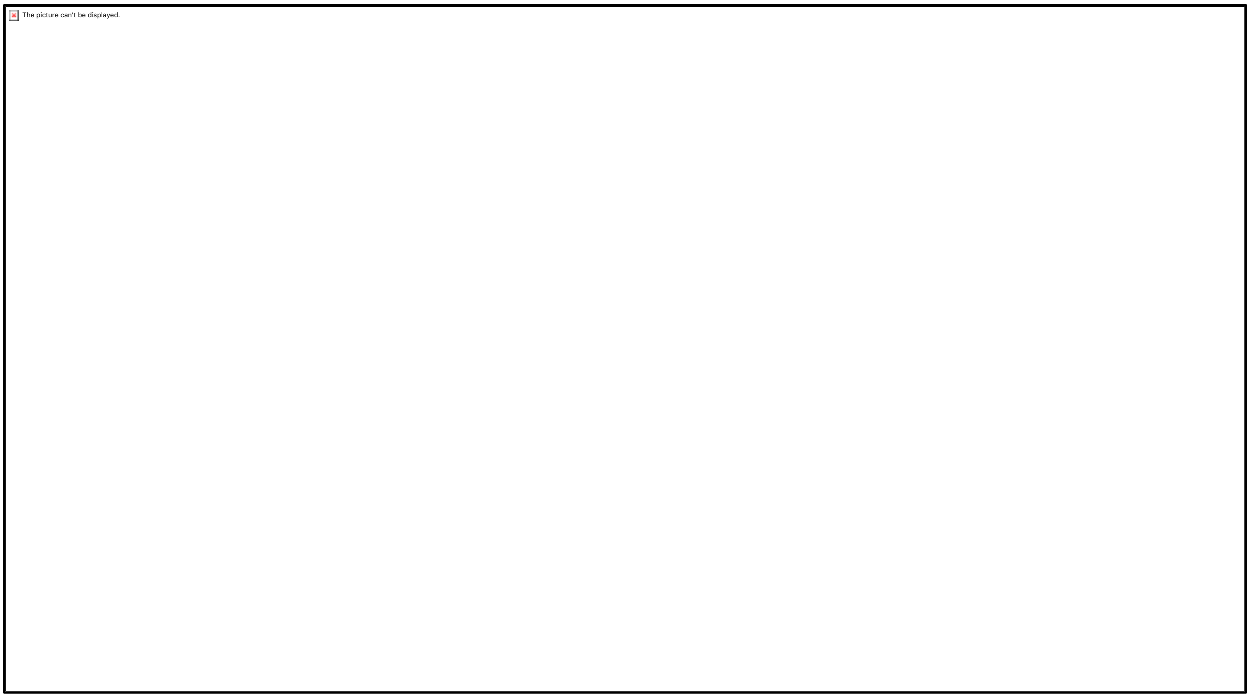


Table 5-12 Recorded Fish Occurrence and Abundance

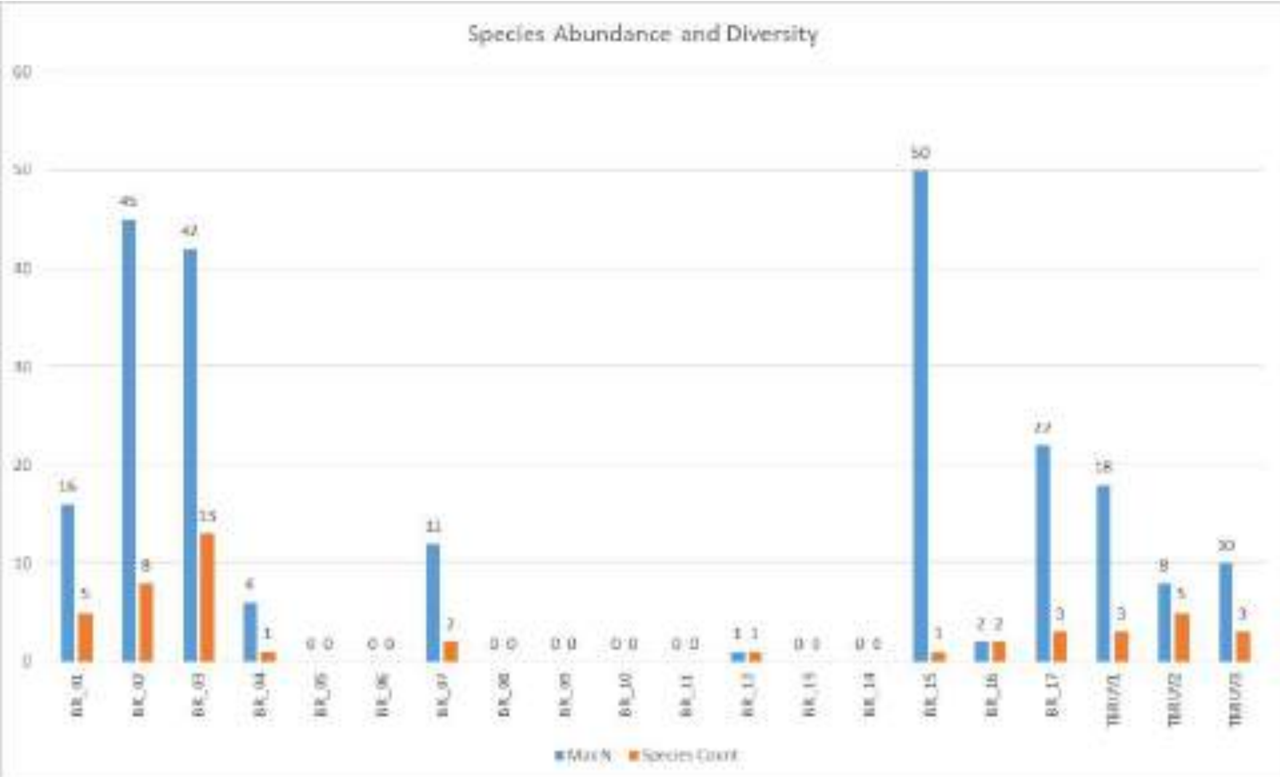
Species	Common Name	IUCN Red List Status	Occurrence	Abundance (N)
Acanthopagrus bifasciatus	Double bar seabream	LC	2	2
Amblygobius albimaculatus	Tailspot goby	No Listing	2	4
Carangoides bajad	Orange Spotted Trevally	LC	3	18
Cheimerius nufar	Santer seabream	DD	1	1
Epinephelus coioides	Orange spotted grouper	VU	2	1
Gnathanodon speciosus	Golden trevally	LC	1	10
Lutjanus ehrenbergii	Black-spot snapper	LC	3	33
Lutjanus fulviflamma	Dory snapper	LC	5	12
Lutjanus lutjanus	Yellowlined snapper	LC	1	6
Parupeneus margaritatus	Pearly goatfish	No Listing	2	9
Plectorhinchus sordidus	Sordid thicklip	No Listing	2	7
Pomacanthus maculosus	Yellowbar angelfish	LC	3	9
Pomacentrus trichourus	Reticulated damselfish	No Listing	1	1
Pseudochromis nigrovittatus	Blackstripe dottyback	No Listing	1	1
Scolopsis ghanam	Arabian monocle bream	No Listing	1	2
Scomberoides lysan	Doublespotted Queenfish	LC	1	3
Siganus canaliculatus	Pearlspotted rabbitfish	LC	2	3
Total				**122**

Table 5-13 Fish Records where identification to species not feasible

Genus or Family	Common Name	Occurrence	Abundance (N)
Gobiidae (Amblyeleotris, Cryptocentrus, or Ctenogobiops sp.)	Shrimp goby	3	4
Nemipteridae	Bream species	1	3
Nemipterus sp.	Threadfin bream	2	7
Pomacentrus sp.	Damselfish species	2	4
Himantura sp.	Ray species	1	1
-	Unidentified fish individuals	1	6
-	Unidentified school of fish	1	50
-	Different unidentified school of fish	1	20
Total			**95**

BRUVS were deployed in a mixture of habitat types. The highest diversity and abundance of fish were recorded in the vicinity of the open intake channel breakwater. The area provides a mixture substrate with neighbouring areas of mature seagrass beds. These areas offer more structural complexity, providing more available habitat locations for fish compared to unconsolidated sediment. Sites classified as unconsolidated habitat types had very few settled fish populations. The fish seen in these areas were generally large schools passing through, accounting for the highest abundance occurring at BR_15. Apart from these schooling populations, resident fish abundance was highest at BR_02, located near a breakwater area. The highest diversity of fish was found at BR_03, also a breakwater area (figure 5-56).

Figure 5-56 Species Abundance and Diversity at BRUVS Locations



It should be stressed that the numbers provided are not intended to provide an exact population estimate, rather it is a record only of species recorded in BRUVs footage within a limited timeframe. The results provide an indication of species present in the study area but results are unlikely to provide a record of all fish species that utilise the artificial substrate or precise population numbers. In fact, given the limited soak times of the BRUVs, it is likely that the actual size of fish populations utilising the study area are considerably higher. The data does, however, provide useful indications of the proportional representation of different species within the study area.

Intertidal Ecological Survey 2019

Intertidal surveys were conducted along the beach situated along the shoreline facing expanse of the proposed construction site on the 28th of April 2019 where the area was surveyed through a walkover of the intertidal and shoreline, and additional collection of two (2) benthic infauna samples from three (3) locations; low, mid and high tide levels (Figure below). The surveyed beach area plus the benthic sampling sites are shown in figure 5-56. The intertidal zone of the project area is fenced off from the rest of the project site with locked access gates every couple of hundred meters. The beach is a relatively smooth, gently sloping terrain that is about 50 to 80 meters from the fence to the low tide mark. A sharp rise of consolidated sand and stone mark the end of the beach and the beginning of the terrestrial area (Figure 5-58). The intertidal zone is relatively free of debris and waste however, above the high tide mark, the beach is littered with plastic wrappers, plastic bottles, wood, neon bulbs, and various other waste products as shown in figure 5-59 & 5-60.

Figure 5-57 Intertidal Benthic Sample Stations and Walkover Survey Area


Project Site
0
250
500
750
1000 m
Legend
Project Site
Open Intake and Outfall
Seagrass Bed
Intertidal Walkover
Turtle Nesting Site

Figure 5-58 Area displaying a change in terrain from unconsolidated sandy area to a more consolidated, compact habitat.

Figure 5-59 Plastic buckets and containers littering the beach

Figure 5-60 Pictures showing waste above the high tide mark

Turtle Nesting

During the intertidal walkover survey on the 28th of April, a number of distinct turtle tracks (Figure 5-60) and likely turtle nesting sites (Figure 5-61) were observed at the two locations shown in figure 5-56. The tracks seemed to have been made relatively recently, where overturned sand was damp. The annual turtle nesting season within this region extends from mid-March and proceeds until mid-June. The incubation period for marine turtle eggs ranges from 45-70 days. The nesting and track patterns observed at the site indicate that the species present was the Hawksbill turtle (*Eretmochelys imbricata*). The Hawksbill is the most common turtle species officially recorded within the Arabian Gulf, however there have been rare unconfirmed sightings of the Green turtle (*Chelonia mydas*). Both species leave quite distinctly different tracks (Figure 5-62), where Hawksbill tracks like those seen at the Taweelah site will show evidence of an alternating crawl pattern, where by flippers move alternately. Tracks made by Green turtles will show a regular, symmetrical repetition of flipper imprints with evidence of the pronounced plastron this species exhibits, running through the middle of the track (Figure 5-62).

Figure 5-61 Turtle Tracks at the Taweelah Beach

Figure 5-62 Probable Turtle Nesting Site

Figure 5-63 Differences between tracks of Hawksbill (left) and Green (right) turtles

Intertidal Infauna Survey

Two (2) intertidal samples of macrobenthos were collected at three (3) locations shown in Figure 5-56 (total 6 samples). These sample sites were determined so as to cover the horizontal distribution of benthic organisms within the footprint of the proposed intake construction area. Two (2) individual samples were collected from each of the following areas: the high-waterline, mid-water line and low-water line where two (2) samples were collected from each area within relatively close proximity to one another (< 2 m away). Samples were collected by sitting a Van Veen sediment grab on the sediment surface so that an imprint was made. Sediment was then scooped up from the area within the imprint of the Van Veen buckets to a depth of approximately 7 cm in mud and 5 cm in sand (Figure 5-64). The faunal samples were then gently decanted into a receiving container (Figure 5-65) and the grab was rinsed thoroughly before redeployment.

Figure 5-64 Intertidal Macrobenthos Sampling Locations

Figure 5-65 Intertidal sample after collection

Figure 5-66 Intertidal sample after sieving and processing

5.2 Environmental Impact Prediction and Evaluation

Potential sources of negative environmental impact during construction and operational phases are listed in the following sub-sections.

5.2.1 Hydrodynamic Modelling-Model Setup, Calibration and Baseline Conditions

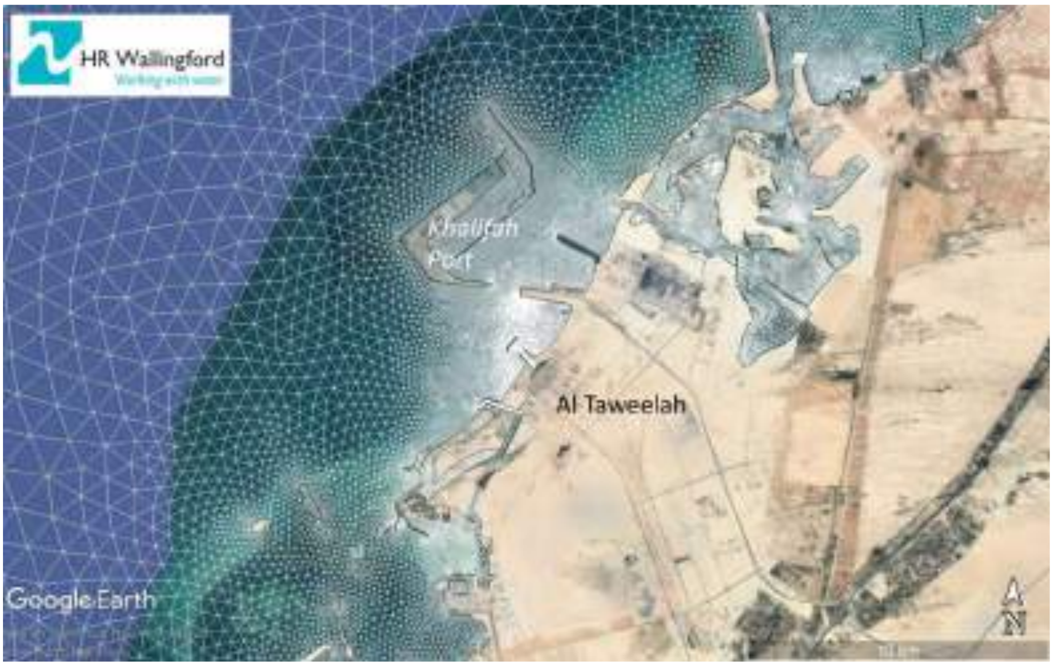
Hydrodynamic dispersion modelling was conducted by HR Wallingford pre-bid in October 2018 and more recently in April and May 2019. Modelling was conducted using the HR Wallingford TELEMAC model. The local model was nested in HR Wallingford's Arabian Gulf regional model, with the TELEMAC regional being utilised to set the local model's boundary conditions.

The Taweelah local model was built using TELEMAC-3D, which solves the 3D equations of motion and transport, and includes the important effects of buoyant spreading, inhibition of vertical mixing associated with sharp density gradients, and shear of wind-driven currents. Each of these processes is vital for the accurate simulation of brine discharge dispersion and recirculation.

Hydrodynamic Model Setup

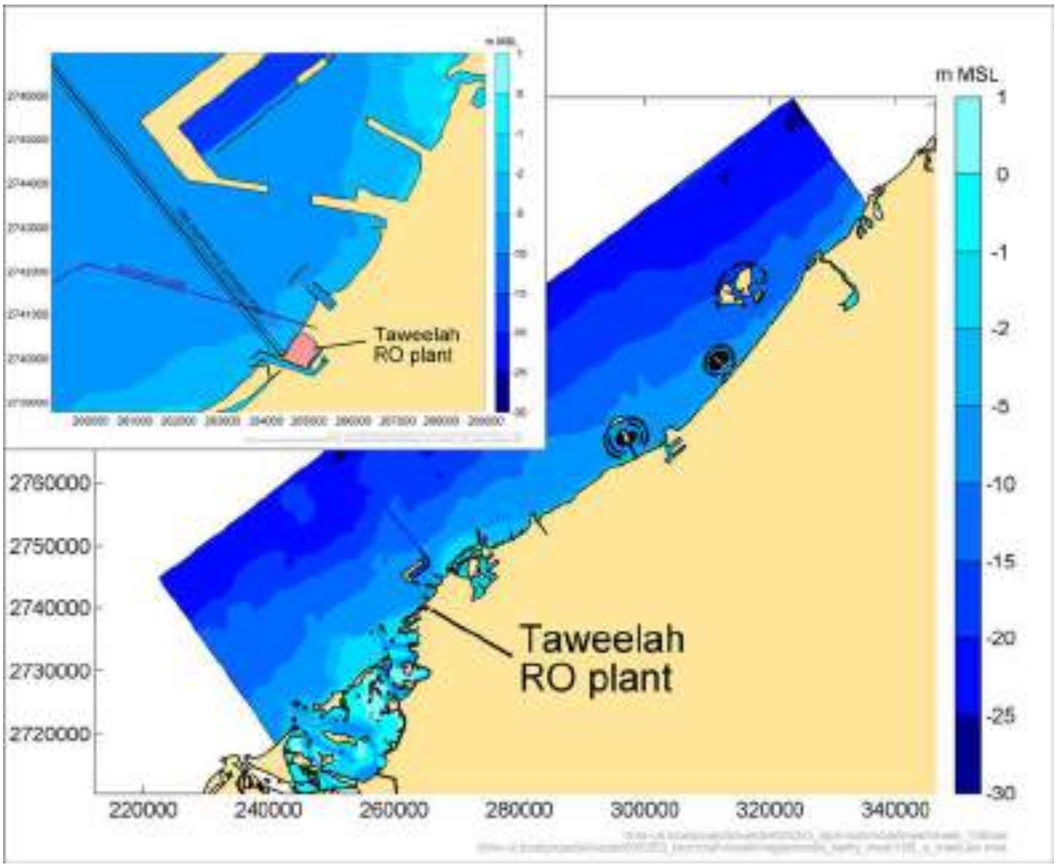
A close-up image of the baseline local model mesh is shown in the figure below. The model mesh resolution varies between about 50 m near the outfalls and intakes, rising gradually to around 2 km at the offshore boundaries.

Figure 5-67 HR Wallingford Local Model Mesh



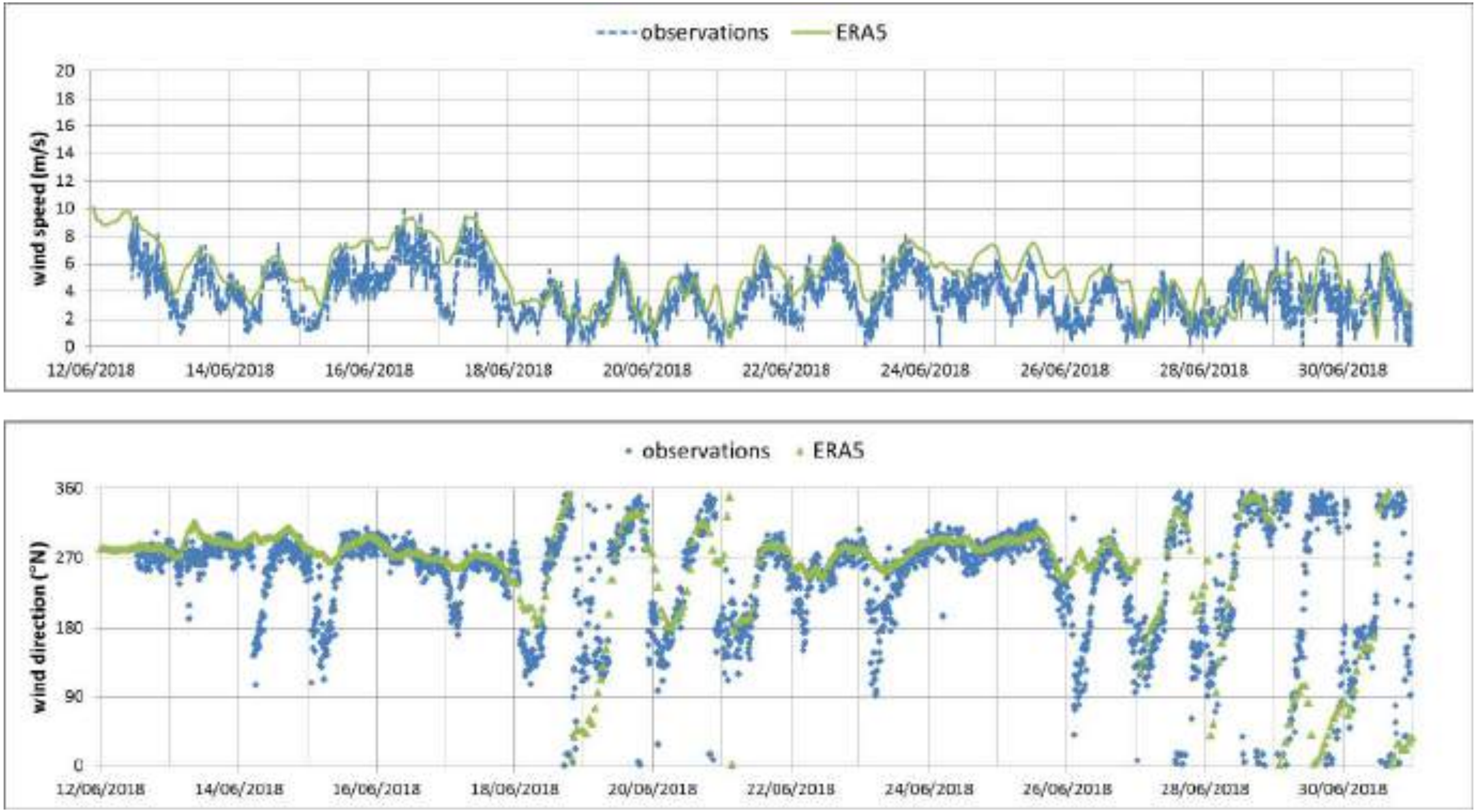
The model bathymetry was defined using information from international hydrographic offices, supplemented with data from a local survey provided by ACWA Power. The survey area extended 2 km offshore and 500 m alongshore. The detailed local data were merged with sparser hydrographic office data, which means that bed levels beyond the edges of the survey are estimated using interpolation and extrapolation. The resulting bathymetry used in the model is shown in the figure below.

Figure 5-68 HR Wallingford Modelled Bathymetry



Wind conditions at the site were simulated using data from the European Centre for Medium-range Weather Forecasting (ECMWF) ERA5 hindcast dataset. ERA5 is a climate reanalysis dataset, generated using Copernicus Climate Change Service information. Wind measurements were collected by HDR at the Taweelah project site as part of the original baseline ambient air quality monitoring survey between 12th June 2018 and 19th July 2018. Comparisons of measured and ERA5 modelled data are presented in figure 5-67. The ERA5 model reproduces the general trends of the winds, including the periods of stronger Shamal (northerly) winds that occurred during the first and third quarters of the measurement period, as well as the periods of lighter sea breezes that occurred during the second quarter. ERA5 gives hourly predictions, which means that some higher frequency variations are not resolved. However, this is to be expected and is unlikely to significantly affect local or regional hydrodynamics. On this basis, the ERA5 model dataset was deemed suitable for the purposes of the present assessment.

Figure 5-69 Comparison of Measured and Predicted Wind Speeds and Directions at Taweelah (June – July 2018)

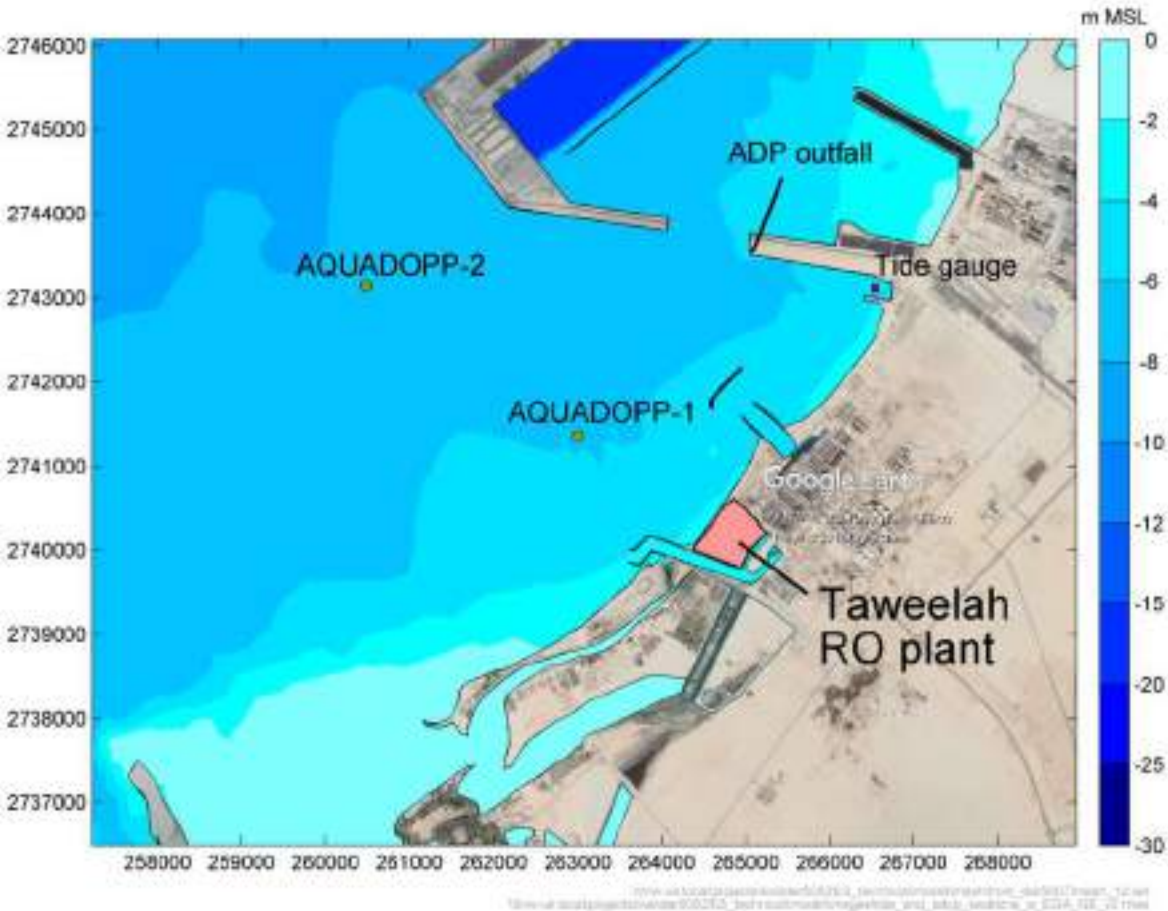


To ensure that the hydrodynamic model predictions (water levels, current speed and direction) were suitable for use in the dispersion assessment, the local 3D model was validated using local current meter and tide gauge data, collected by HDR as part of the original modelling study, conducted in 2018 (refer to Technical Appendices).

Two current profiler (Aquadopp) instruments were deployed approximately 2 km and 5 km offshore from the project site, over the period May to June 2018. In addition, one tide gauge was deployed in the marina, south-east of the ADP Khalifa Port causeway, to record variations in water levels. The locations of the instruments are shown in figure 5-70.

The model was run for the survey period, with ERA5 data applied as described above. The ambient seawater temperature was set to 30°C with a view to reflecting ambient conditions outside of the Taweelah Complex zone of influence. Parameters such as bed friction, turbulence formulations, boundary conditions and wind drag parametrisation were varied (within physically realistic ranges) to give as close a match as possible with the observed currents and water levels.

Figure 5-70 Location of 2018 Aquadopp and Tide Gauge Data Collection



Time-series of observed and predicted water levels at the tide gauge are shown in figure 5-71. The model predicts the tidal ranges to within a few percent of those observed. Predicted water level variations are therefore well within the accuracy required for this type of assessment. Time-series of observed and predicted depth-averaged current speeds and directions are shown in figure 5-71 (Aquadopp-1, inshore) and figure 5-72 (Aquadopp-2, further offshore). Current directions (including the rotations through the tide) are generally well reproduced by the model.

Daily peak current speeds are generally reproduced to within a few centimetres per second of those observed, although during the first half of the measurement period, the second daily peak current is under-predicted by the model. This is likely due to small changes in the position of the eddy that forms next to the Khalifa Port reclamation, and was considered unlikely to affect the overall study conclusions. Predicted current speeds match those observed much more closely during the second half of the survey period.

Figure 5-71 Comparison of Predicted and Observed Water Levels (upper panel) and Currents (Aquadopp-1)

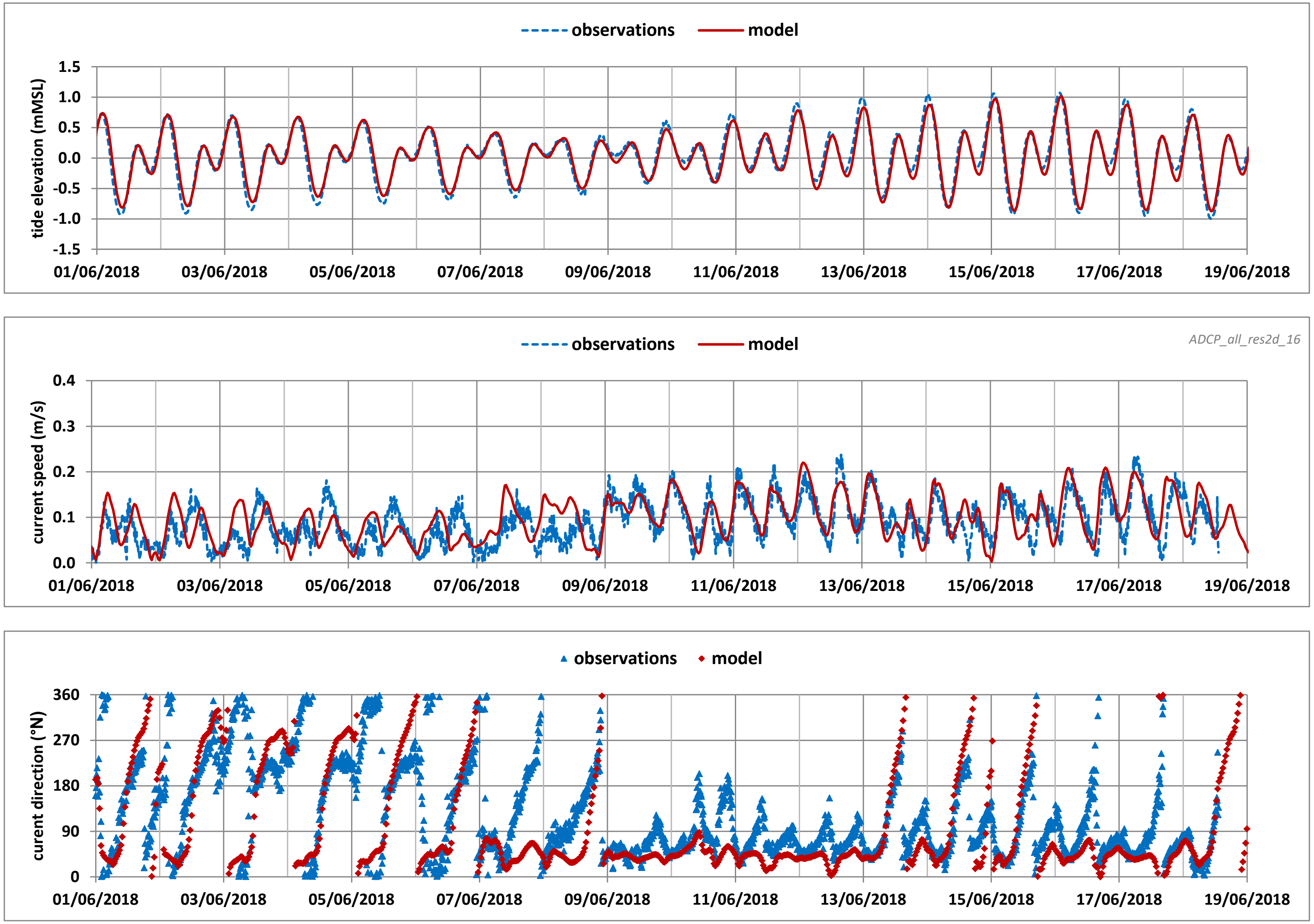
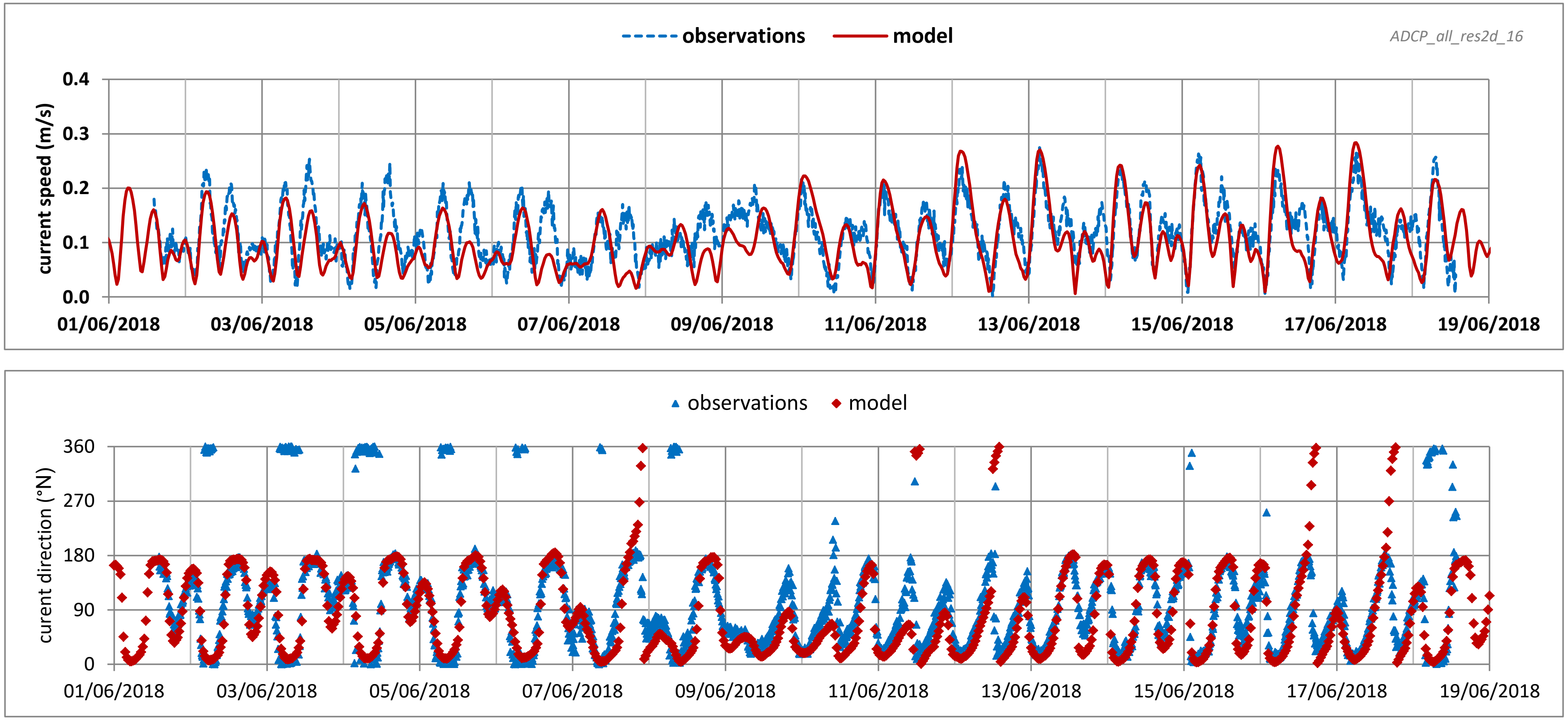


Figure 5-72 Comparison of Predicted and Observed Water Levels Currents (Aquadopp-2)



Additional ADCP Deployment and Model Calibration

After the submission of the EIA to EAD on 05/29/2019, comments were received on 07/07/2019 (Ref: EMS/16/ESRF/11095). As part of the comments, EAD requested additional data collection and model calibration to give further confidence to the existing model prediction. Following discussions and meetings with EAD (22nd May and 18th June 2019), three ADCP devices were deployed between 17th August and 6th August 2019 at the following locations and as shown in the figure below:

- SGS-ADCP1: in the centre of the opening between the port and causeway;
- SGS-ADCP2: near the centre point of the proposed IWP outfall diffuser; and
- SGS-ADCP3: a few hundred metres offshore of the north-east corner of the port reclamation.

Figure 5-73 Location of the Additional ADCPs and the Original Aquadopps

Comparison with the model reinforced the original conclusions that the model is aligned with observed data and that the model is well suited for use in the dispersion assessments at the site (Reference Appendix H for the Addendum report-further data collection and model analysis report). In addition the addendum report has also underpinned the rationale for the selection of the 3km outfall configuration compared with the concept design.

Test Conditions

Winter conditions were assumed for the modelled simulations, with a seawater temperature of 19°C, and an ambient salinity of 40.5 PSU. Sensitivity tests were also carried out using representative summer seawater temperatures. The warmer temperatures generally give higher rates of evaporative cooling, which results in a denser plume that spreads slightly further at the seabed. The overall changes to the plume were found to be small compared with the overall size of the area affected. However, we recommend that a wider range of conditions are tested during subsequent project phases, when more time is available.

Tests were carried out for full spring-neap cycles to include the effects of both spring tides (which give faster ambient current speeds and a wider range of water depths) and neap tides (which give slower current speeds and a narrower range of water depths).

Wind conditions were simulated using data from the European Centre for Medium-range Weather Forecasting (ECMWF) ERA5 hindcast dataset.

Each dispersion simulation was carried out for 30 days, with all analysis carried out on the last 20 days. The objective of this was to allow for the model to "spin-up" (i.e. for the predicted dispersion patterns to develop and reach an approximate dynamic equilibrium). Quality assurance checks were carried out on the predicted dispersion patterns to confirm whether the plume is still building up near the outfall site, and over the wider area, by the end of the simulations. Plume concentrations near the outfalls and intakes reach a dynamic equilibrium over the simulation (concentrations are not still increasing by the end of the simulation). At the plume edges, the plume was found to be still growing, although at typically low concentrations.

Study Limitations

Whilst the calibration of the model shows good correlation with respect to hydrodynamic conditions (i.e. currents and water elevation), there remain some limitations to the assessment that must be considered when interpreting the results. The absence of temperature and salinity calibration combined with the relatively short model run time (30 days) limits the validation of the model. Nonetheless, the hydrodynamic calibration provides a reliable base for the dispersion modelling.

Intake Outfall Parameters

The IWP will produce 200 MIGD. The operational parameters provided by ACWA for Taweelah IWP and neighbouring plants are given in Table 5-14.

Table 5-14 Operational Parameters

UNIT	Intake flows Flow (m³/s)	Intake flows temp. (°C)	Intake flows TDS (g/kg)	Discharge to culvert Flow (m³/s)	Discharge to culvert temp. (°C)	Discharge to culvert TDS (g/kg)
Taweelah A+A1	34.1	32.0	45.0	32.5	42.9	47.1
Taweelah A2	27.4	32.0	45.0	24.7	40.4	49.8
Taweelah Initial B	35.0	32.0	45.0	31.3	41.0	50.4
	40.0	32.0	45.0	40.0	44.0	45.0
Taweelah B Ext.	17.6	32.0	45.0	16.4	39.3	48.2
Taweelah B New Ext.	24.8	32.0	45.0	21.1	44.3	52.8
	2.7	32.0	45.0	2.7	42.3	45.0
	1.0	32.0	45.0	1.0	44.0	45.0
Auxiliaries	1.7	32.0	45.0	1.7	44.0	45.0
Taweelah IWP	27.8	32.0	45.0	17.3	34.0	72.4

The discharge from the nearby EGA plant was also included in the model. The EGA plant is understood to include both desalination (5 MIGD) and cooling water processes. Information on discharge flow rates and constituents were taken from email correspondence with EGA (April 2019):

- Flow rate: 9.3 m^3/s
- Excess temperature (ΔT): +3.6°C
- Excess salinity (ΔS): +3.9 ppt.

Environmental Regulation

Site-specific environmental regulations are not applicable for the study. Therefore, we have assumed that Federal standards will apply: the salinity should fall within 5% background at the edge of a mixing zone. It is assumed that "background" in this case corresponds to the undisturbed ambient salinity, away from the existing plumes. Based on the data analysis, this threshold corresponds to an excess salinity of about 2 ppt (relative to the undisturbed ambient salinity of 40.5 ppt). The Federal standards do not set a target mixing zone size, and therefore we have presented the results as:

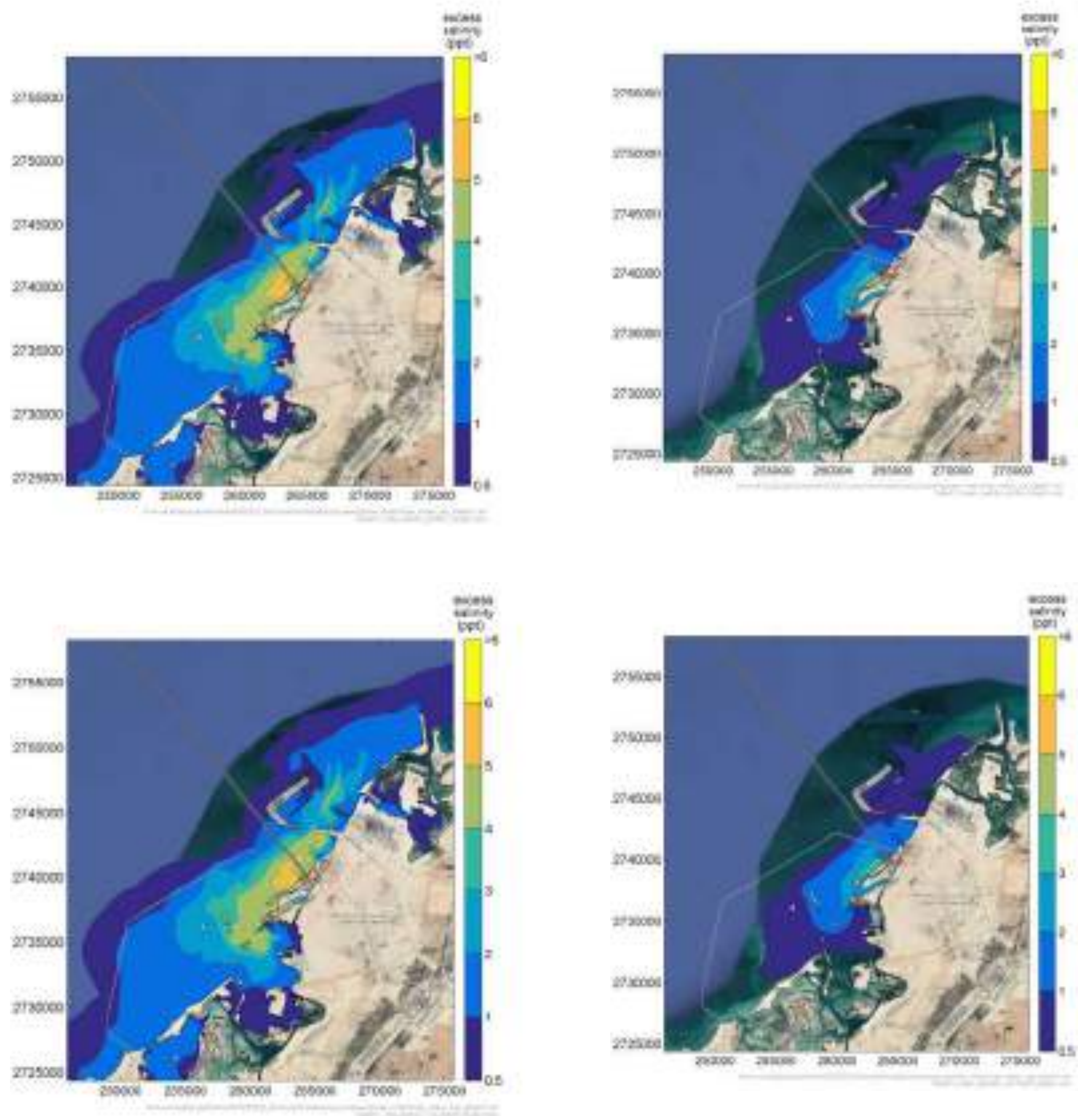
- Maximum and average extents of the plume, showing the size of the areas > +2 ppt;
- Predicted brine plume extents and concentrations at sensitive sites; and,
- Excess salinities at the edge of a nominal 500 m mixing zone around the IWP outfall.

It is not possible to configure a diffuser for the IWP that meets the environmental standards, as the local ambient seawater entrained into the plume for dilution is already at a higher salinity.

Baseline Discharge Assessment

Predicted excess salinity patterns under current operating conditions, as output by the TELEMAC 3D model, are shown as contour plots in Figure 5-74 and 5-75. Baseline Predictions are shown at the sea surface, mid-depth, and at the seabed.

Figure 5-74 Baseline Maximum and Average Excess Salinities Under Typical Wind Conditions



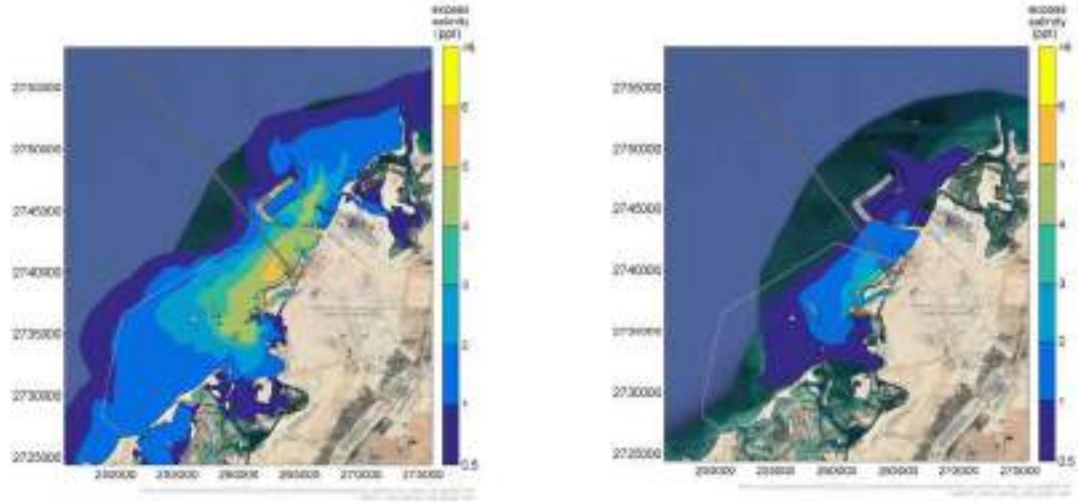
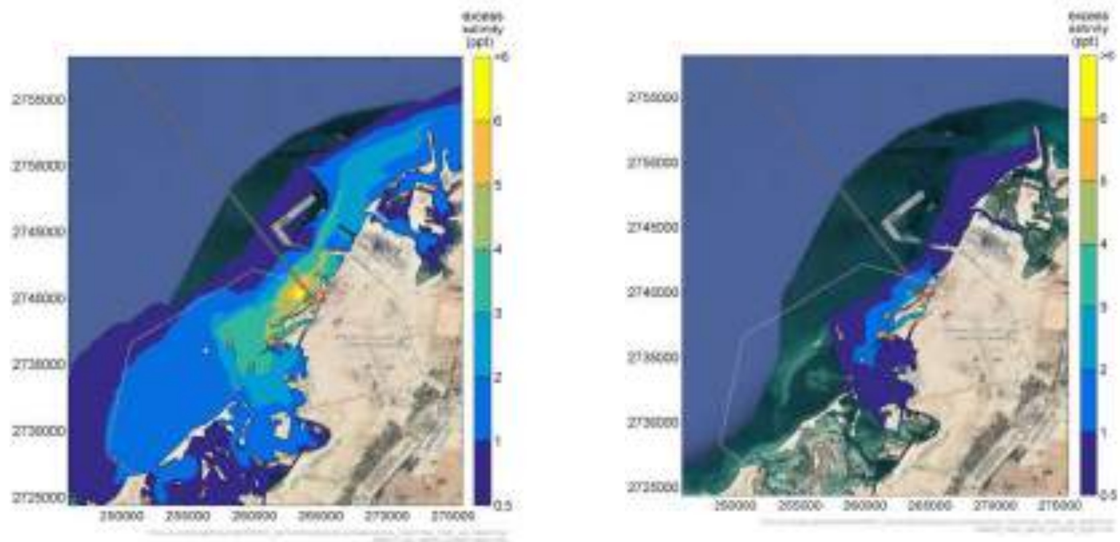
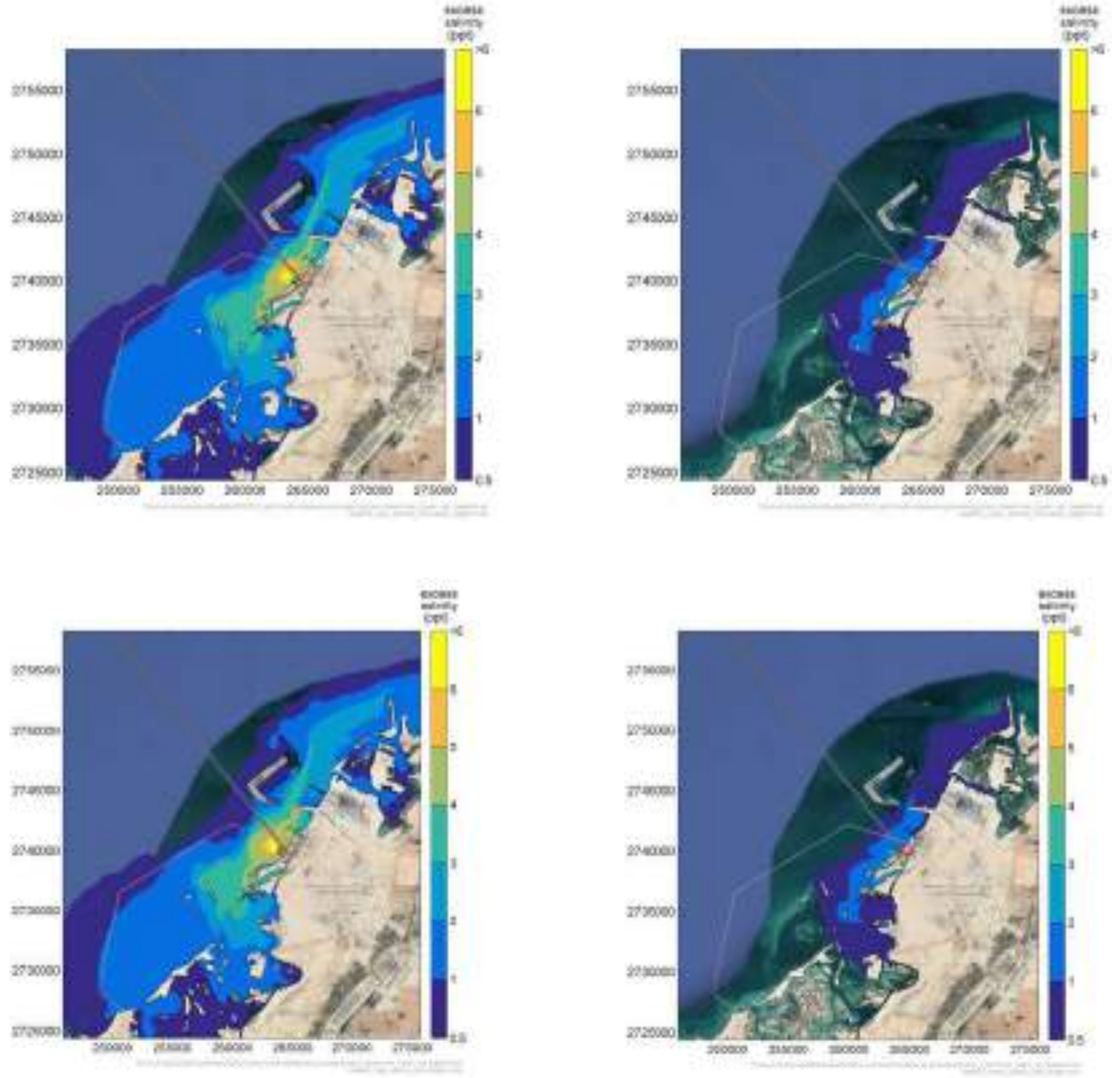


Figure 5-75 Baseline Maximum and Average Excess Salinities Under Strong Wind Condition





The modelled results indicate that the current Taweelah plant operations exert a footprint, characterized by elevated salinities and temperature, many kilometres beyond the point of discharge from the Taweelah Complex. The patterns of dispersion are intricate and are generated by the interaction of the tidal- and wind-driven currents with eddies that form along the complex coastline shape. The maximum excursion of the plume towards the west is not just driven by the flooding tide (which causes advection towards the west); it can also be caused by:

- Longer periods of weak winds with an easterly or north-easterly component;
- Shorter periods of stronger winds with an easterly or north-easterly component.

Similarly, the maximum excursion of the plume towards the east is not just driven by the eastward ebbing tide; it can also be caused by periods of wind with a westerly or north-westerly component. These winds generate coastal drifts which act over several days to cause a net movement of the plume alongshore. Maximum concentrations of the Taweelah

Complex discharge are higher during the strong wind conditions, due to increases in recirculation, and the confinement of the plume to the shallower nearshore region.

The (existing) combined discharges result in an area exceeding +2 PSU that extends more than 10 km east, contributing to small increases in both salinity and temperature at ecologically sensitive receptors within Khalifa Port (seagrass beds) and Ras Ghanada MPA (fringing coral reef and seagrass beds). The plume exerts a greater influence to the southwest of the site during the typical wind simulation, with increases in temperature and salinity at the bed level that will likely generate chronic impacts on marine ecology on the intertidal mudflats that provide valuable feeding grounds for migratory and resident bird species. It should be noted that these maximum eastward and westward extents do not occur at the same time; this is simply an indication of the maximum footprint of the plume at any time during the simulation. The area above +2 ppt extends more than 15 km east of the site during the stronger wind simulation (due to the additional coastal drift current). On average, excess salinities generally fall below +2 ppt within 5 km of the site.

As observed in the 2018 and 2019 water quality surveys , the existing thermal-saline discharges spread over the area proposed for the Taweelah IWP outfall. The model predicts excess salinities at the proposed outfall site of up to about 4.5 ppt above the undisturbed ambient salinity for the typical wind test, which is in good agreement with the observations.

The results of the HR Wallingford baseline scenarios broadly mirror those of the baseline scenarios modelled by HDR using the ECOM model in 2018.

5.2.2 Construction Phase Impacts

Potential impacts on marine water and sediment quality, will also generate negative impacts on marine ecological receptors. It is anticipated that, if left unmitigated, the impacts could be generated as result of the following construction phase activities.

The construction activities will take place over an estimated time period of 41 months. Based on current information, the marine components of the marine construction will include the following:

- Dredging marine sediments for footing trench along the length of the proposed outfall alignment;
- Dumping of excavated sediments parallel to excavation footprint;
- Placement and levelling of bedding material in base of footing trench
- Installation of the GRP outfall pipeline;
- Backfilling footing trench and placement of armour rip rap layers;

- Dredging of the open intake channel and associated breakwater toe trench; and
- Construction of the rock revetment protecting the open intake channel.

Figure 5-76 Proposed Alignment of the ACWA Power IWP Outfall

The following sub-sections identify potential impacts the above activities may have on the marine environment within the footprint of the construction footprint and in the surrounding marine environment.

Direct Habitat Loss and Modification

Habitat Characterization and Presence of Local Habitats of High Ecological Value

The alignment of the SWRO effluent outfall channel with a total length of 3 km would be located to the west of the existing seawater intake channel running parallel to the Dolphin Energy Gas Pipeline and the Khalifa Port breakwater (Figure 3-3). Surveys conducted by HDR in 2018 and 2019 identified predominantly unconsolidated sandy sediments and low profile exposed caprock along the majority of the 3 km outfall alignment. Though there were no areas of high ecological sensitivity within the immediate footprint of the proposed alignment, mixed beds of low to medium density seagrass were identified to the east of the proposed alignment. Seagrass beds were dominated by *Halophilia uninervis*, with sparser densities of *Halodule ovalis* also recorded. These areas of seagrass are designated as being of high ecological importance by EAD. The proposed footprints of both the SWRO open intake channel and outfall trench do not directly impact on the seagrass, with the exception of a small portion of the open intake channel breakwater (Figure 5-75). A small portion of seagrass can be expected to be lost during placement of breakwater rocks, however as a proportion of the total seagrass present in the study area, the area directly impacted by construction activities is expected to be negligible.

Figure 5-77 Indicative Seagrass Coverage In Relation To Proposed Intake and Outfall Footprints

The 3 km pipeline alignment was surveyed by HDR in April 2019 using drop-down camera deployed from the survey vessel. The survey effort was intended to refine the resolution of benthic habitat classification along the 3 km outfall route. Similar to the findings of HDR's 2018 marine baseline survey, the results indicate that the dominant bedform along the alignment is unconsolidated sandy sediments. These mobile wave-driven sediments support sparse macroalgal growth and overlay calcarenite caprock that is exposed in some areas along the alignment. None of the areas along the proposed surveyed identified the presence of high value sessile macrofaunal communities supporting assemblages of scleractinian (stony) corals, dense stands of macroalgae, sponges or ascidians (sea squirts). Based on the current design information available, development of this pipeline orientation (2.5 km and 3 km lines) would require a corridor of approximately 15 metres width, with a footing trench of 2 metres depth along the entire alignment. The removal of the upper layers of the substrate will result in direct mortality of flora and sessile faunal assemblages present within the corridor. All ecological receptors with limited motility (i.e. benthic infauna and macro algal growth) would likely be lost as a result of the dredging and dumping of excavated material.

Though the total volumes of dredged sediments are only broad estimates at this point, the excavation of the 3 km footing trench and the open intake channel will generate significant volumes of dredge spoil. Material excavated for the intake channel is expected to be removed for re-use or disposal on the land-side. Side casting of dredge spoil from operations facilitating marine construction access and excavating the footing trench will be stockpiled on the seabed pending transfer back into the footing trench as backfill. This will result in an increase in the marine impact footprint, with further direct habitat loss as benthic habitats are smothered by spoil dumping. Given there is already provision for stockpiling of some excavated material on land, it would seem to be preferential to stockpile all excavated material on land pending re-use as backfill material. This would have the benefit if reducing the impacted footprint of the marine works and would also reduce the volume of suspended sediments mobilized into the water column during dumping and re-excavation works.

Impacts Associated with Dredging Sediment Plume Dispersion

If unmitigated, dredging operations wouldl generate sediment plumes that will disperse and settle beyond the immediate footprint of the construction works. Elevated sediment loads in the water column leads to reduced light penetration. As plumes disperse and sediments settle out of the water column without the implementation of environment mitigation measures, this can result in benthic habitats in the vicinity of construction works and further afield being smothered by the settlement of fine-grained sediment particles. In order to assess the extent to which sediment plume dispersion might impact surrounding ecological receptors and alter seafloor bathymetry, ACWA Power commissioned a sediment dispersion modelling study.

The sediment dispersion modelling study was conducted by HR Wallingford on behalf of ACWA Power, utilizing the same TELEMAC 3D model that was setup and calibrated for the hydrodynamic dispersion modelling assessment (Appendix H) coupled with SEDPLUME-RW. Additional detail on SEDPLUME-RW is provided in the modelling report provided for reference. Two simulations were undertaken:

- Simulation 1 - dredging and placement of the diffuser trench at the offshore end of the outfall trench;
- Simulation 2 - dredging of the outfall trench inshore of the diffuser trench.

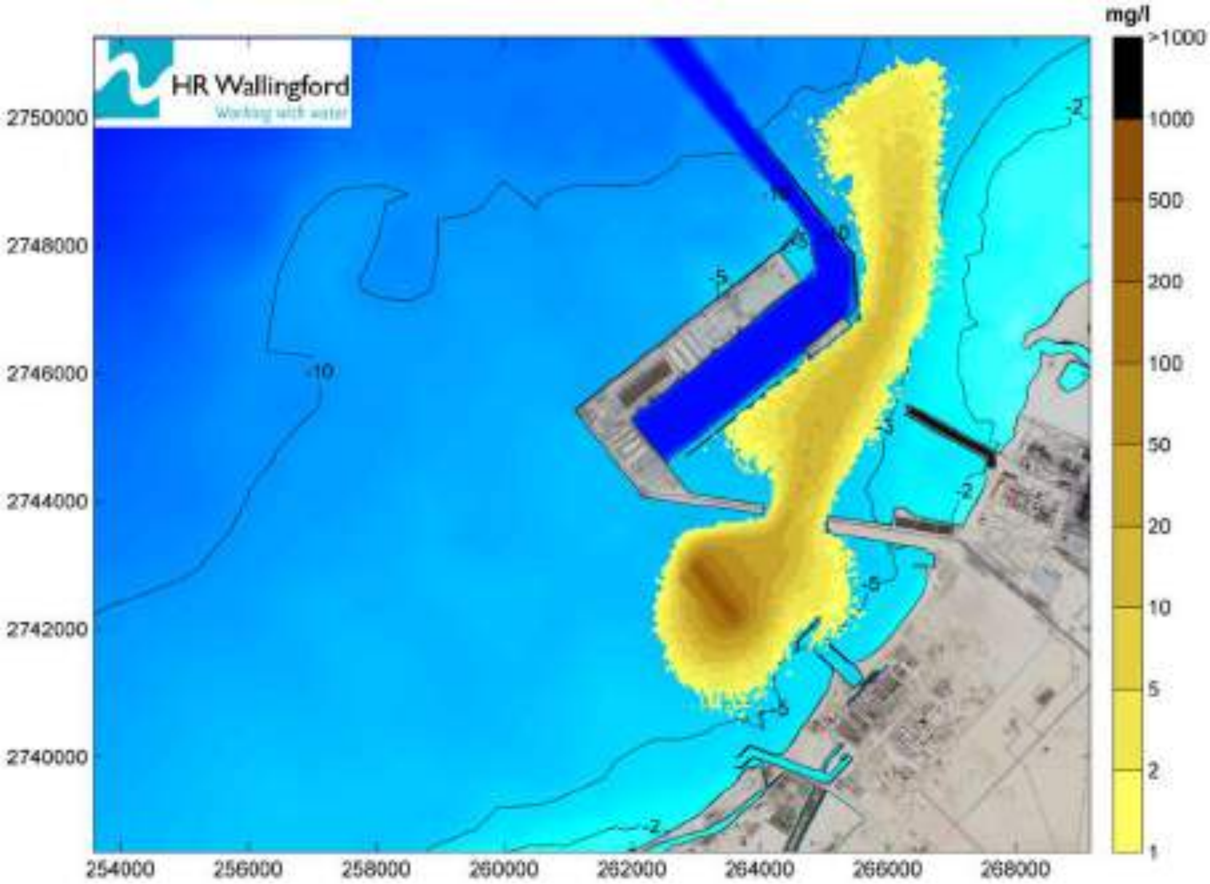
The locations of the different dredging and placement activities for the two simulations are presented in figure 5-78.

Figure 5-78 Alignment of Dredging and Excavated Material Placement Zones

The diffuser trench simulation was undertaken for a period of 14 days (a spring-neap cycle) while the inshore trench simulation was undertaken for a period of 29 days (two spring-neap cycles). The representation of dredging in the plume dispersion simulations assumed continuous dredging and was represented as an average dredging rate over this period. In reality it can be expected that there will be dredging down time due to mechanical failure, weather and/or movement of the dredger.

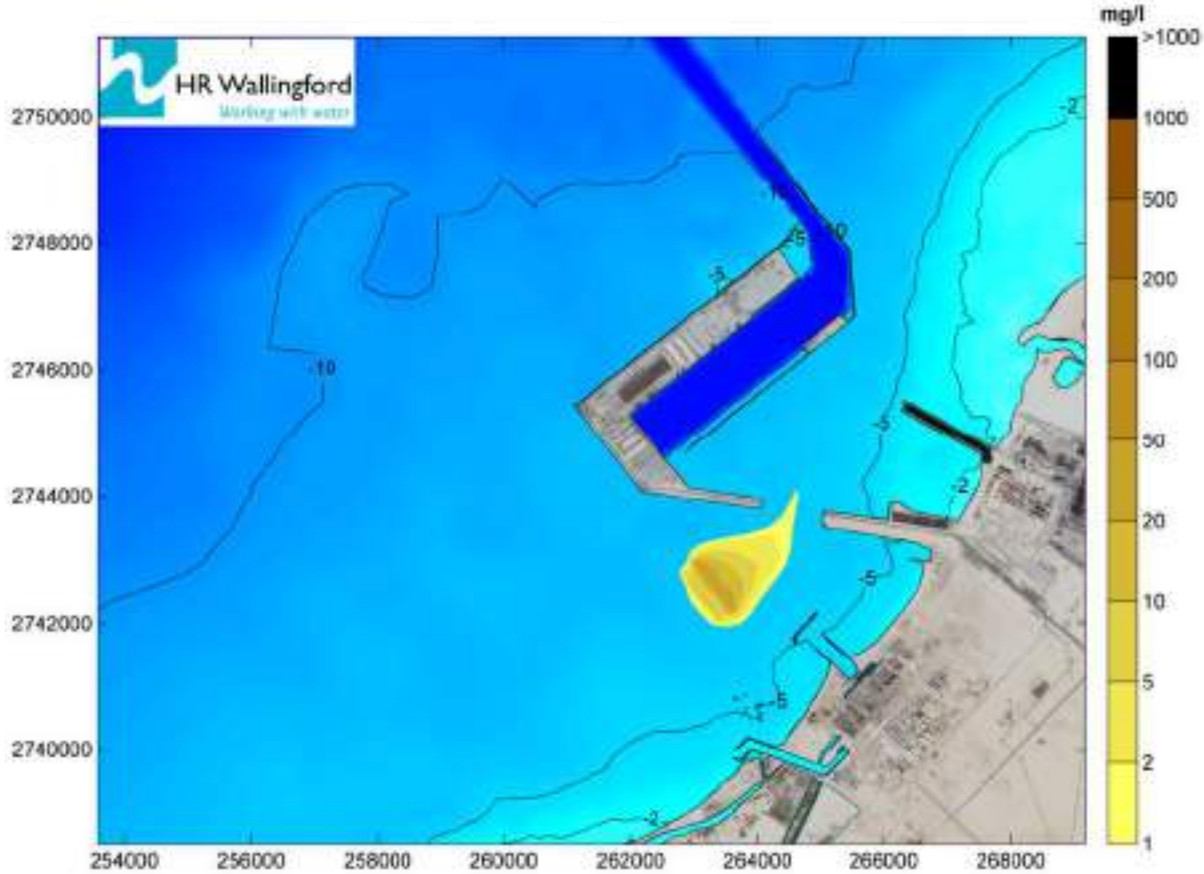
The predicted peak increase in depth-averaged suspended sediment concentration resulting from Simulation 1 (dredging of the diffuser trench and placement to the north-west of the trench with no environmental mitigation such as silt curtains) is shown in Figure 5-79. Suspended sediment concentrations predicted to increase by more than 10 mg/l would be carried through the port to Ras Ghanada MPA to the north of the proposed works, with predicted peak increases in depth-averaged sediment concentration of up to 5 mg/l within the MPA. This worse case will not occur in reality due to the mitigation measures including silt curtains preventing wide dispersion of silts. In the vicinity of the dredging/placement, concentrations are predicted to increase by up to 500 mg/l (though in the immediate near-field of the dredger and/or placement higher concentration increases would be expected).

Figure 5-79 Predicted Maximum increases in depth-averaged TSS above background



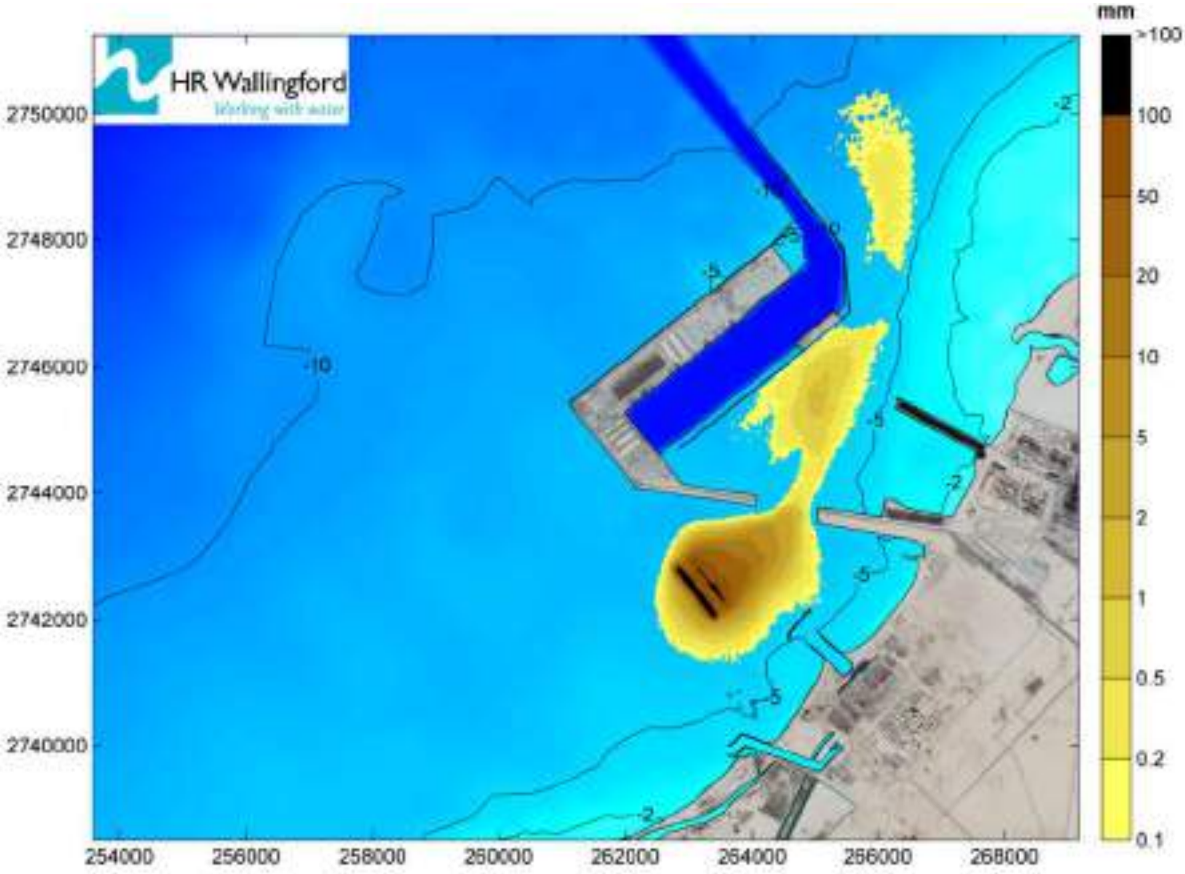
The predicted mean increases in depth-averaged suspended sediment concentration resulting from Simulation 1 is shown in Figure 5-80. The figure indicates that mean suspended sediment concentration increases of more than 10 mg/l above background extend up to 2 km to the NW in the absence of the any environmental mitigation measures to control the dispersion of sediment plumes. In the vicinity of the dredging/placement, mean concentration increases are predicted of up to 50 mg/l (though in the immediate near-field of the dredger and/or placement higher mean concentration increases would be expected).

Figure 5-80 Predicted Mean increases In depth-averaged TSS above background – Scenario 1



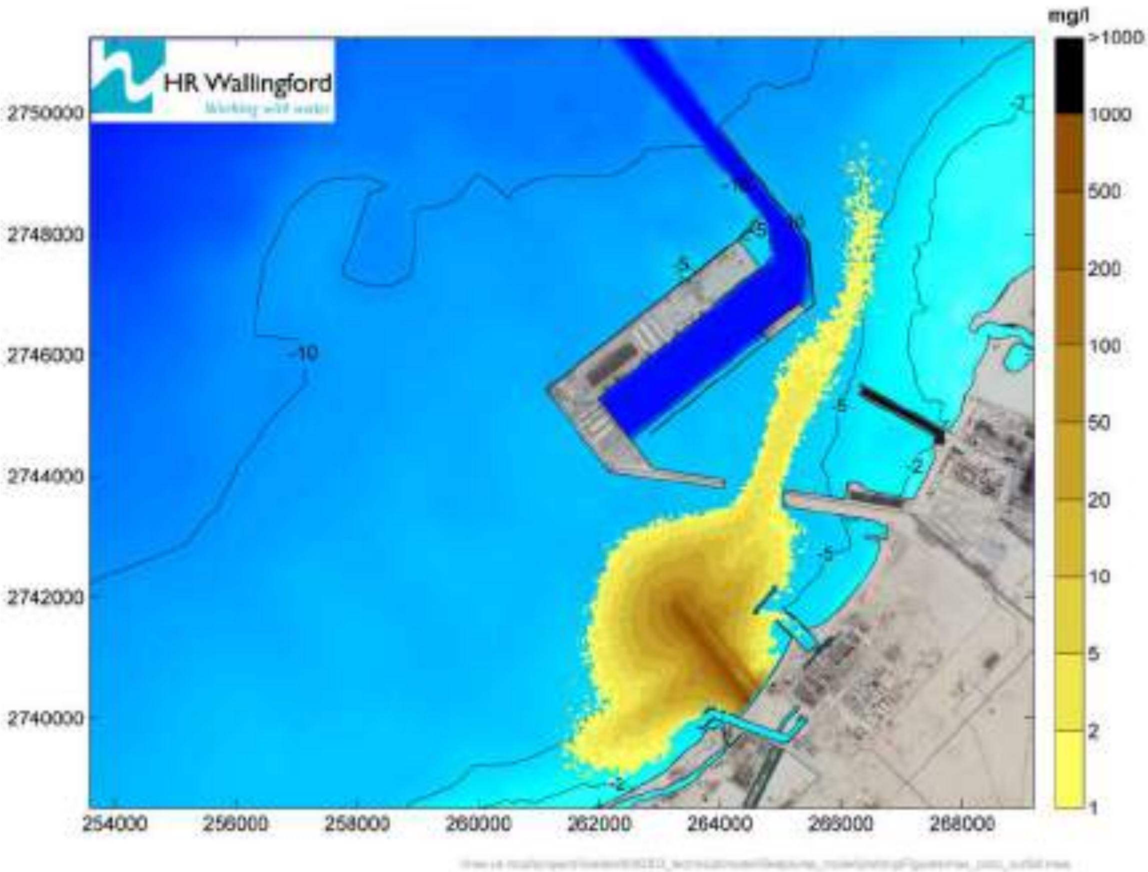
The predicted unmitigated fine sediment deposition resulting from the 14 days of dredging and placement represented by Simulation 1 is shown in figure 5-81. The Figure shows that the footprint of deposition extends to within and north of the port. Within the port the predicted thickness of deposition is less than 1 mm further north the predicted thickness of deposition is very low (a fraction of a millimetre). Deposition of more than 1 mm is predicted up to 2 km NW of the placement and up to a few hundred metres SE of the dredging. In the vicinity of the dredging and placement fine sediment deposition of more than 100 mm is predicted.

Figure 5-81 Predicted Fine Sediment Deposition after 14 days of continuous dredging and deposition along the diffuser alignment – Scenario 1



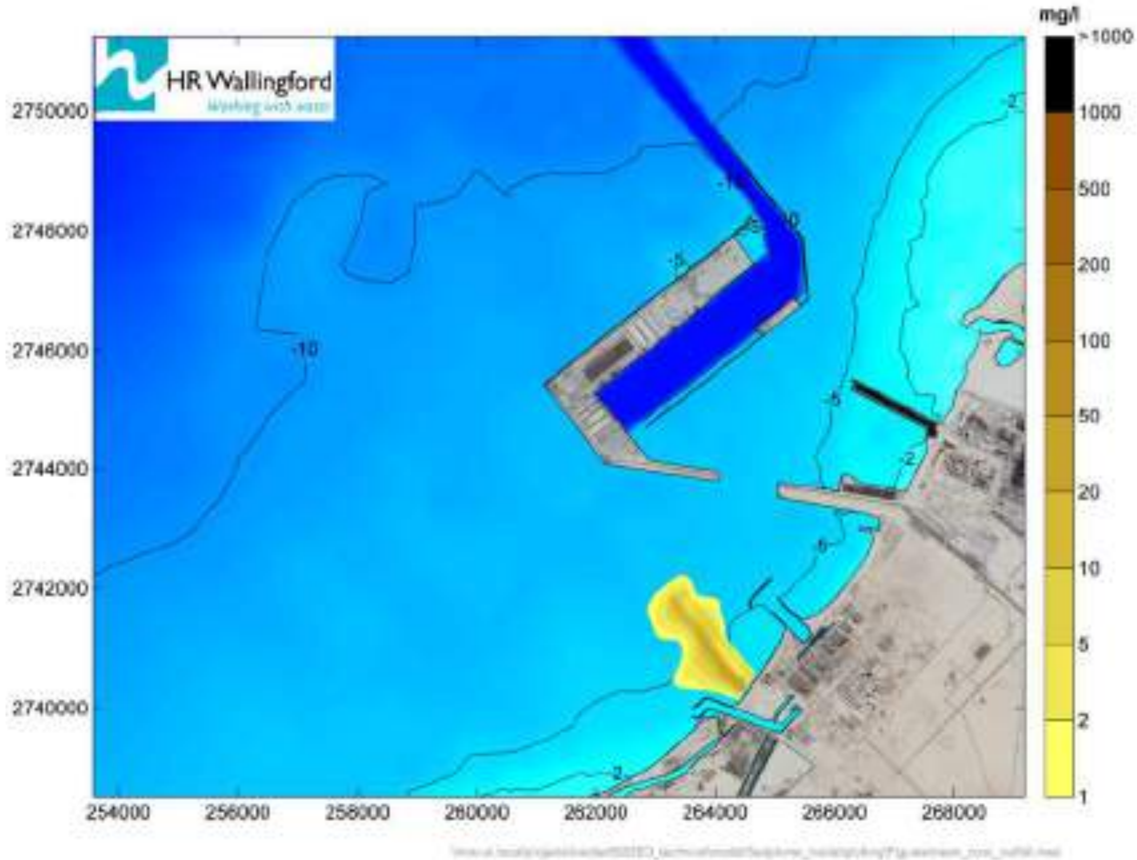
The predicted peak increase in depth-averaged suspended sediment concentration resulting from Simulation 2 (dredging of the outfall trench and placement to the south-east of the trench) Figure 5-82. Suspended sediment concentration increases of more than 10 mg/l are limited to within 750 m of the dredging/placement with plumes and predicted peak increases in depth-averaged sediment concentration over the coral itself are less than 2 mg/l. In the vicinity of the dredging/placement concentrations are predicted to increase by up to 500 mg/l (though in the immediate near-field of the dredger and/or placement higher concentration increases would be expected).

Figure 5-82 Predicted Maximum Increases In Depth-averaged TSS Above Background – Scenario 2



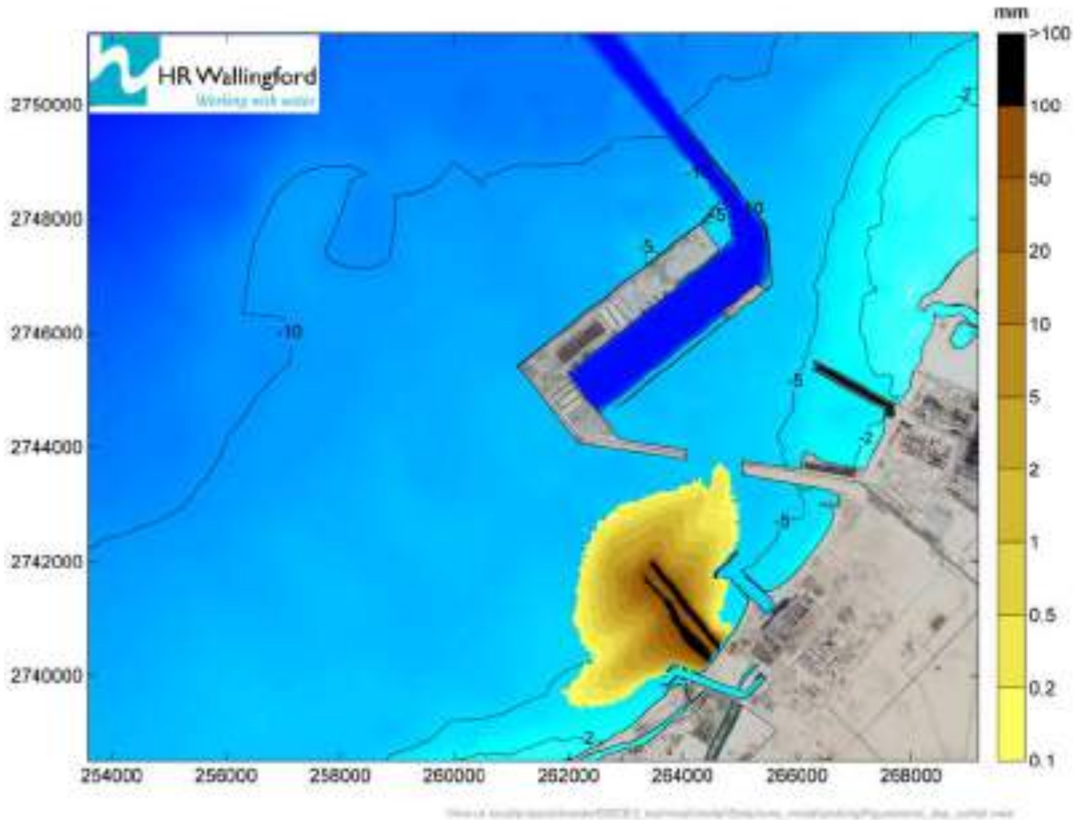
The predicted mean increases in depth-averaged suspended sediment concentration resulting from Simulation 2 is shown in Figure 5-83. The figure shows that mean suspended sediment concentration increases of more than 1 mg/l above background extend less than 500 m from the dredging/placement. In the vicinity of the dredging/placement, mean concentration increases are predicted of up to 50 mg/l (though in the immediate near-field of the dredger and/or placement higher mean concentration increases would be expected).

Figure 5-83 Predicted Fine Sediment Deposition After 14 Days of Continuous Dredging and Deposition Along the Outfall Alignment – Scenario 2



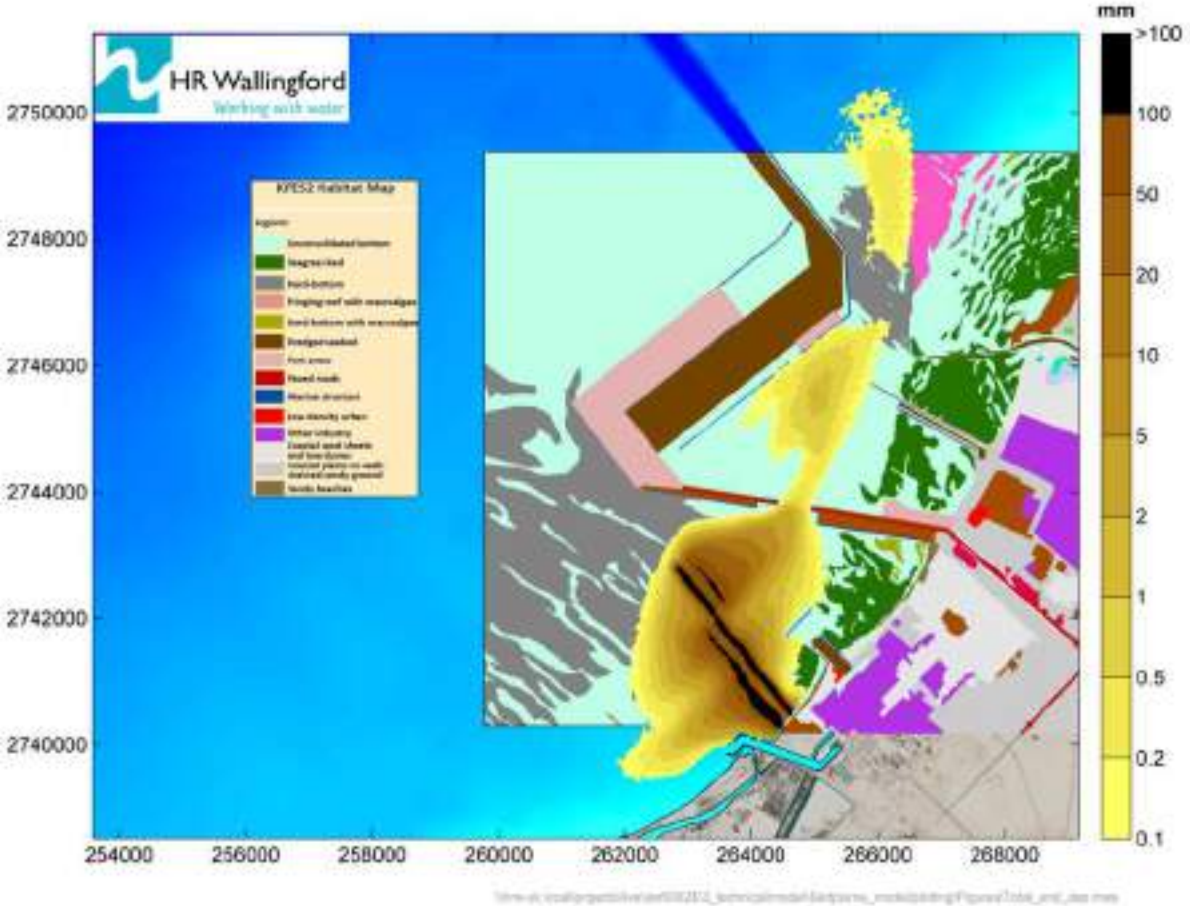
The predicted fine sediment deposition resulting from the 14 days of dredging and placement represented by Simulation 1 is shown in Figure 5-84. The figure shows that deposition of more than 1 mm is predicted up to 750 from dredging/placement. In the vicinity of the dredging and placement fine sediment deposition of more than 100 mm is predicted.

Figure 5-84 Predicted Mean Increases In Depth-averaged TSS Above Background – Scenario 2



The results of the study also estimated the unmitigated deposition of fine sediments anticipated from the works as a whole. Given the nature of the works, with excavation of marine sediments a prerequisite for laying the GRP pipelines, mobilization and dispersion of marine sediments cannot be avoided. Figure 5-85 presents the total unmitigated settlement of fines with the EAD habitat classification also included for reference. The predictions indicate that, in the absence of any measures to limit the dispersion of sediment plumes during marine excavation works, that there will be small amounts of deposition on the fringing coral reef in the Ras Ghanada MPA, as well as some local deposition, in the order of 0.1 – 0.5 mm, on the seagrass bed immediately north of the inshore works. The fine sediment predicted to be deposited can be expected to be slowly re-worked by waves and currents so that it spreads to and along the shoreline. As discussed in the previous section, by favouring landside stockpiling of all excavated material, this would remove the need for marine dumping of excavated material thereby reducing the sediment load suspended into the water column and also reducing the area of the site where environmental management controls would need to be implemented by the construction contractor. This would likely allow for greater control of the areas where larger volumes of fine sediments would settle out, limiting the zone of impact as far as is feasible given the nature of the construction works.

Figure 5-85 Predicted unmitigated Fine Sediment Deposition as a result of All Works



The smothering of benthic communities will result in reduced primary productivity and, in areas of heavy sediment settlement, direct mortality of benthic flora and fauna. Seagrasses and other filter feeders have varying levels of tolerance to deposition. For example, large seagrass species such as *H. decipiens*, can maintain substantial photosynthetic surface even after large-scale burial. Small species, such as the *Halodule* sp. or *Halophila* sp. present at the site, are often completely removed after very small sedimentation events. However, these species tend to grow very quickly and recover to pre-event abundances in a short period of time (Duarte et al. 1997[9]). In a study undertaken by Sheridan (2004[10]), the impact of

9 Duarte, C.M., Terrados, J., Agawin, N.S.R., Fortes, M.D., Bach, S and Kenworthy, W.J. (1997). Response of a mixed Philippine seagrass meadow to experimental burial, Marine Ecology Progress Series, Vol. 147, pp. 285-294.

10 Sheridan, P. (2004). Recovery and faunal communities after placement of dredged material on

seagrasses in Laguna Madre, Texas, Estuarine and Coastal Shelf science, Vol. 59, pp. 441-458 sediment disposal from maintenance dredging on adjacent benthic habitats was measured. The study showed that seagrass populations in the area of disturbance were well established three years after dredging. It is noted that no published studies that are directly applicable to the Emirate of Abu Dhabi are currently available to draw direct comparisons and, given each site is subject to unique conditions and pressures, the referenced studies only show that there is the possibility of recovery after cessation of construction works. The results of the modelling study suggest that the impacts to seagrass beds associated with smothering are likely to be negligible, with only the fringes of beds covered in 0.1 – 0.5 mm of sediment.

The implementation of construction controls aimed at limiting the dispersion of sediment plumes and the sediment load entering the water column will greatly reduce the spatial extent of smothering impacts on seagrass receptors. The EAD conditional 3-month Marine Permit requires the EPC to prepare a detailed Dredging Management Plan as part of the CESMP and this will be submitted for approval prior to any dredging works being undertaken. In addition two continuous Ambient Water Quality monitoring stations that will record turbidity in real-time will be installed prior to dredging works and linked to the EPC, Consultants and EAD. While the locations of the monitoring stations are yet to be agreed with EAD, it is possible that one location could be the seagrass bed close to the Taweelah Complex intake which will also ensure that suspended solids do not impact the existing Taweelah operations.

Summary of Direct Impacts to Subtidal Habitat as a result of Dredging Works

The results of the 2018 and 2019 surveys, modelling studies and impact assessment suggest that the marine construction works will result in localised impacts to sessile invertebrate communities in the intertidal and subtidal sediments within the immediate footprint of the construction works. A small portion of seagrass is also expected to be lost during construction of the new open intake channel Figure 5-86, though as a proportion of total seagrass coverage across the study area, the area that will be directly lost is considered negligible.

Figure 5-86 Indicative Footprints of Existing Seagrass Bed And New Open Intake Channels

Beyond the immediate footprint of the works, sediment plume dispersion may potentially result in the direct mortality of sessile benthic communities. Infaunal communities are, however, expected to eventually recolonize disturbed habitats, any minor impacts to seagrass beds will likely be ephemeral and areas of sandy substrate may be recolonized. The extent of seagrass recolonisation and the rate at which this takes place is largely dependent on the influence of the effluent plumes from the existing Taweelah Complex and the new SWRO plant. Retaining areas of seagrass on the western side of the existing intake channel will aid recovery. *Halodule* species have negatively buoyant seeds that will not disperse long distances (Kaiser et al. 2011), so ensuring that healthy seagrass beds are retained in close proximity to the intake will increase the recovery in that portion of the study area.

The loss and modification of habitat and, by association, the sessile communities' resident within these habitats maybe considered permanent, irreversible and cumulative. However, this will very much depend on whether the mitigation measures such as dredging management techniques including silt curtains can prevent dispersion of silt onto the seagrass beds at a rate that would cause significant damage. Moderate consequences are anticipated to soft sediment and fisheries assemblages as these can be expected to recover and recolonise disturbed areas over varying timescales. Though the pipeline alignment is not thought to harbour significant breeding, nursery or feeding grounds that would be lost as a result of construction, the area will be utilised by pelagic fish species for feeding and as a transit route between other areas. Similarly turtle and marine mammal species are known to utilize the area. More mobile species will be displaced during construction with the return of mobile fauna anticipated following the completion of construction. The timeframe for return of these species will be significantly quicker than the recovery of benthic infaunal communities, which could take years to return to current levels. The extent of recovery will be heavily influenced by the impact of effluent discharge plumes from the existing Taweelah facility and the new SWRO Plant. As has been discussed herein seagrass provides critical habitat to marine biodiversity, such that EAD classify seagrass beds with greater than 10% coverage as being of high ecological importance with protection and management measures required. The implementation of suitable management and monitoring measures will help limit the impact and aid future recovery. Consideration, therefore, needs to be given to offsetting or reducing impacts on these receptors and monitoring the seagrass habitat during and post-construction to ensure management measures that are implemented are effective. Proposed management measures are provided in this ESIA.

Direct Habitat Loss – Intertidal and Foreshore Zones

As detailed herein, two Hawksbill turtle (*Eretmochelys imbricata*) nesting sites were recorded by HDR during visits to the sandy beach site in May 2019. The Hawksbill turtle is widely acknowledged to be the only species of marine turtle to nest in the UAE, and is listed by the IUCN as being critically endangered, with global populations decreasing as a result of industrial and military discharges, direct impacts associated with fisheries, habitat loss, climate change and severe weather, and the impacts associated with the increased proliferation of anthropogenic marine wastes, particularly plastic materials. The identification and protection of turtle nesting grounds is considered a key component of species protection, both globally and in the United Arab Emirates. The proposed open intake channel will result in the loss of approximately 140 metres of the 1.5 km beach nesting beach and subtidal habitat approaching the beach. The construction of the intake channel and associated rock revetments will fragment the habitat, but will not result in a significant proportion of the beach being lost. More significant impacts could be associated with the noise and lighting impacts during construction and the operation of associated infrastructure (i.e. pumping stations and physical screening) (see following sub-sections and Operational Impacts). The rationale for favouring an open intake is linked predominantly with the fact that the volume of water required by facility on a daily basis means that an offshore intake will require significant dredging operations with numerous pipes of two (2) metres diameter required to meet plant operating capacity.

Disturbance Linked to Water Quality Impacts

Increased Turbidity

Sediments surveyed during the marine baseline survey found that sediments across the study consisted predominantly of medium to fine grained sand with a low proportion of very fine particles. Nonetheless, as detailed above, during dredging operations the excavations will mobilise sediments into the water column, increasing turbidity within the footprint of the excavation works and in the surrounding areas. Increased turbidity limits the amount of light that is able to penetrate the water column, subsequently limiting primary productivity. The extent of sediment plume dispersion can be simulated using mathematical modelling, the results of which can be used to inform targeted management measures to reduce impacts during marine excavations. Limiting the spread of sediment plumes will subsequently reduce the spatial extent of the impacts associated with elevated sediment load in the water column, as well as reducing the extent of impact when sediment particles settle out of the water column.

Mobilisation of Contaminants

The water quality in transitional, coastal and marine regions can be adversely affected by land-based and water-based anthropogenic activities. The path preparation and excavation of the seabed will result in the re-suspension of marine sediments in to the water column, as well as the mobilization of nutrients and sediment bound contaminants. Sediments analysed as part of the environmental baseline study of this Project did not reveal any significant metal or hydrocarbon contamination. As such, impacts to the site water quality conditions caused by dredging and construction works are expected to be limited to elevated levels of turbidity and, potentially, localised increases in the availability of nutrients present in the marine sediments.

Algal Blooms

The re-suspension of sediment particles and decomposing organic matter in the upper layers of sediment during dredging operations provides a stimulus for the rapid release of nutrients into the water column (Zhang et al., 2010[11]). This combined with the potential presence of dormant dinoflagellate cysts means that mobilizing sediments during dredging may create conditions that allows the cysts to release new motile stages with the potential to form plankton blooms. The state of knowledge of phytoplankton ecology in general, and particularly, the seeding of blooms from cysts, is still in its infancy. As such, we cannot unequivocally predict the expected impact of an engineering project of this nature. It is only relatively recently that the presence of dinoflagellate cysts in marine sediments has been

11 Zhang, S., Zhou, Q., Xu, D., Lin, J., Cheng, S. and Wu, Z. (2010) Effects of sediment dredging on water quality and zooplankton community structure in a shallow eutrophic lake. Journal of Environmental Science. 22 (2): 218-224

considered as a potential environmental hazard associated with coastal development in the Arabian Gulf (Dale, 2001[12]). By disturbing bottom sediments, the number of cysts that may potentially excyst and bloom in the favourable conditions subsequently increases. It is, however, important to acknowledge that whilst even relatively few cysts released by dredging could initiate a threatening bloom, in many cases the normal factors of competition and predation and influence of meteorological and water quality conditions would reduce the likelihood of triggering a significant event during the marine construction works.

As noted above, the chances of triggering a bloom of sufficient magnitude to generate impacts on a regional scale or impact production at the Taweelah Complex is considered relatively low. Should an event be triggered and a bloom form, the potential bloom levels and the associated impacts differ intrinsically between species. Different species can generate impacts on ecological receptors through the clogging of fish gills, cellular damage caused by reactive oxygen species, localized anoxia and through predation (Bauman et al. 201013). In addition, certain species of dinoflagelletae produce neurotoxic substances such as saxitoxin and brevetoxin. Mortality of marine fauna can result as a consequence of direct ingestion, upon exposure to secreted toxins or from toxin vectoring through the food chain (Yasumoto and Murata, 199314). It is noted that the mere presence of a toxic species does not necessarily lead to the generation of serious negative impacts. Instead the population must typically pass a threshold population density level, above which the effects become inimical. This threshold level varies widely from species to species.

Excessive phytoplankton growth, whether harmful or not, can generate eutrophic conditions. As the abundant phytoplankton age and senesce, they sink toward the seabed, producing a high flux of organic detritus into the deeper waters. The decomposition of this detritus frequently results in hypoxic and anoxic conditions in bottom waters and can lead to mortality of benthic and pelagic faunal communities. In addition, the blooming phytoplankton reduce light penetration, deposits at the bottom of the water column and can smother benthic communities.

12 Dale, B. (2001) The sedimentary record of dinoflagellate cysts: looking back into the future of phytoplankton blooms. Scientia Marina. 65(2): 257-272

13 Bauman, A.G., Burt, J.A., Feary, D.A., Marquis, E. and Usseglio, P. (2010) Tropical harmful algal blooms: An emerging threat to coral reef communities? Marine Pollution Bulletin. 60:11: 2117-2122

14 Yasumoto, T. and Murata, M. (1993) Marine toxins. Chemical Reviews, 93

A proportion of the airborne dust mobilized during the construction works will likely be deposited in the nearby marine environment. The volume deposited is likely to be dependent upon the direction of the wind and extent of dust generation during construction. Dust deposited into the marine environment may lead to increased nutrient loading and increased turbidity in the marine environment. It is noted that dust mobilization will be greatest during the initial phases of construction. Given the prevailing wind direction is from the northwest, blowing in towards the site off the sea, the volume of dust deposited into the marine environment is not expected to be significant. This is especially true when considered in the context of ambient conditions where high background airborne dust levels, particularly during the summer months, would be expected to deposit significantly higher volumes over an extended period of time into the marine environment. The cumulative impact of construction dust is also not anticipated to be significant.

Accidental Spills / Leaks

Oil or chemical spills from marine vessels have the potential to introduce contaminants into the marine environment and the Taweelah Complex seawater intakes. With the implementation of good site housekeeping, appropriate storage of oils and chemicals, provision of spill kits and booms on all marine vessels and rapid response to any leaks or spills the contamination risk faced by the proposed construction activities to the marine environment can be markedly reduced.

Existing Taweelah Complex Seawater Intakes

A degradation in water quality as a result of construction operations has the potential to negatively impact the quality of feedwater drawn in by the Taweelah complex seawater intakes. The impacts detailed above all have the potential to negatively impact on production efficiency if water quality is affected in close proximity to existing intake structure. The sediment plume dispersion modelling study conducted by HR Wallingford suggest that impacts of sediment dispersion at the existing open intake are likely to be negligible, even without the implementation of environmental mitigation measures (HR Wallingford, 2019b). The implementation of control measures and close monitoring of conditions during the construction phase is still of critical importance to ensure there is no loss of operational capacity as a result of the marine construction works.

Introduction of Invasive or Exotic Species

Proposed construction works have potential to introduce marine pest species if they are carried in ballast or as biofouling associated with the dredger or other vessels. These species can threaten biodiversity as some exotic species can become invasive, spreading rapidly and out-competing native species through competition for resources (Gardner and Howarth, 2009[15]). The introduction of invasive or exotic species is considered permanent, irreversible and cumulative and could impact marine ecology. Use of vessels that have not visited locations where marine pest outbreaks are present, which have appropriate antifouling solutions in place and which practice appropriate ballast water exchange will, however, manage the risk of introduction.

Disturbance to Local Marine Fauna

Noise

Underwater radiated noise will generate marine noise pollution which is expected to have a negative impact on local marine fauna. Though not recorded during this survey, previous studies in the Taweelah area have reported the presence of dolphins, turtles and dugongs in the area (Wijsman and Riegl 2001, Dome and Marubeni 2005). The construction works will likely impede the ability of marine ecological receptors to hear biologically relevant sounds that might interfere with critical functions such as acoustic communication, predator avoidance and prey detection (Slabbekoorn et al. 2010). Cetaceans and other marine species that have a high dependence on acoustics for navigation, breeding and other life history traits. Fishes that could be affected by underwater noise are predicted to move out of the construction area to avoid impacts from water quality and other disturbances. The construction noise is expected to lead to displacement of marine fauna and avoidance of the site by more transitory species, such as dolphins and turtles. Construction noise will be temporary and reversible once construction has ceased.

Light

While turtles tend to prefer dark beaches, they do also nest in lit areas. When they do, however, the survival of their hatchlings is jeopardized (Witherington and Martin, 2000). As

15 Gardner AS, and Howarth B (2009). Urbanisation in the United Arab Emirates: the challenges for ecological mitigation in a rapidly developing country. In: Krupp F, Musselman LJ, Kotb MMA, Weidig I (Eds) Environment, Biodiversity and Conservation in the Middle East. Proceedings of the First Middle Eastern Biodiversity Congress, Aqaba, Jordan, 20–23 October 2008. BioRisk 3: 27–38

hatchlings emerge from nests they can be disoriented or mis-oriented by artificial lights. Artificial lighting may also deter mature turtles from emerging from the water to nest (Mortimer, 1982; Raymond, 1984; Witherington, 1992; Mattison et al, 1993). In particular, a female laying eggs for the first time in her life is more likely to avoid beaches affected by light. Witherington (1992) showed in field experiments that turtles displayed a significant tendency to avoid brightly illuminated stretches of beach. In areas where glow from artificial lights is present behind the dunes, turtles have been shown to prefer to nest in the darker area shaded by tall buildings or dune vegetation (Salmon et al., 1995). Avoidance of lighted beaches may lead to a gradual decline in the number of turtles using a beach, with changes not evident for decades because of the long-life cycles involved.

Hatchling turtles primarily rely on vision to find the sea by orienting towards the brightest direction (Salmon et al, 1992). Sea finding occurs when hatchlings orient away from dark, elevated horizons (Limpus, 1971; Salmon et al, 1992) towards the low, light horizon over the sea and make a frenzied dash for the water en masse once they emerge from the nest. Under natural conditions, the brightest direction is almost always away from elevated horizons (e.g. dunes, vegetation) towards the horizon over the sea due to the reflection of celestial light off the water. Artificial lighting can disrupt this pattern (Tuxbury and Salmon, 2005).

Turtles which are disoriented or mis-oriented by artificial lights often do not find the sea promptly and may die due to dehydration, predation or exhaustion (Witherington and Martin, 2000). Two hours of crawling towards a landward light source temporarily impairs the subsequent ability of loggerhead hatchlings to crawl seaward, by interfering with their ability to respond appropriately to the cues normally used to locate the ocean (Lorne and Salmon, 2007). Hatchlings may also waste part of the limited energy stored in the egg yolk, reducing their capacity to swim offshore away from coastal predators (see Lorne and Salmon, 2007). Reports also exist of turtle hatchlings perishing by walking into an abandoned fire (Mortimer, 1979).

The wavelength a light emits influences its colour and its impact on turtles. Human perceptions of light and means of measuring it are not necessarily relevant to the way turtles perceive the colour and brightness of light. The term ‘brightness’ is often used to describe the combination of wavelength and intensity that affects turtle behaviour (Witherington and Martin, 2000). Turtles are most sensitive to short wavelengths of light, probably because they live in a marine environment that filters out long wavelengths. Green and loggerhead turtles are least attracted to longer wavelength light in the yellow-orange to red end of the spectrum (630 to 700 nm) (Witherinton and Martin, 2000; Ecological Associates, 2002). Hatchling loggerhead and leatherback turtle eyes have been shown to be more sensitive to shorter (including ultraviolet) than longer light wavelengths (Horch et al, 2008). In the absence of other light sources, however, turtles may still be attracted to long wavelength light.

<u>Waste</u>

Female turtles are known to be disturbed by beach litter on emergence and will often return to the water and make successive emergences in search of suitable nesting sites. This adds unnecessary stress on the animal and the expenditure of valuable energy reserves required for the labour-intensive nesting process whereby if a nesting female is obstructed by large waste items on her way up the beach she will turn around and will have to locate a waste-free area to nest which can expend a lot of unnecessary energy and can cause complications for the turtle.

Injury / Death to Local Fauna

The presence of construction waste could result in injury or death to local marine fauna through entanglement or ingestion of potentially lethal waste material. Although generated construction waste will be temporary, impacts to local marine fauna will be permanent, irreversible and cumulative and can effect fauna within and beyond the Project footprint. Minor adverse impacts are anticipated on local marine fauna given most are mobile and will move out of the construction area during works. Nonetheless, in the absence of stringent waste management measures on marine vessels, the introduction of waste into the marine environment presents a viable risk to marine ecological receptors.

5.2.3 Operational Phase-Hydrodynamic Modelling

This section details the assumptions that were implemented as part of the operational phase hydrodynamic modelling study undertaken by HR Wallingford and the model predictions to demonstrate the cumulative impacts of the exiting Taweelah Complex and the Taweelah IWP.

Background to Operational Modelling Approaches Employed on Project

Federal standards, stipulate excess salinity to be below 5% of the background salinity at the edge of a mixing zone. This correlates to a ΔS of approximately 2 PSU. Since the background salinity from the existing Taweelah Complex is already 2ppt above ambient, HR Wallingford has modelled the excess salinity and determined the cumulative impacts (concentrations) at specified sensitive receptor locations (see Figure 5-87) (Ref HR Wallingford, 2019).

As detailed in the HR Wallingford report (Appendix H), the methodology employed to re-calibrate the site of effluent discharge carried out a qualitative site assessment whereby certain conditions imposed by the EWEC (i.e. outfall line to be to the east of the existing submarine cable and Dolphin gas pipeline) and baseline plume dispersion patterns were considered, and established formulae and the latest research on brine jets were then used to determine length of diffuser, ports number, minimum required port separation, distances to impact with the seabed, impact dilution rates and near-field extents.

HR Wallingford relatively basic coupling representation for the near- and far-field models is presented in the report and attribute this to the tight timeframe in which the work was undertaken. The report indicates that the preference would be to apply a more complex time-varying coupling between the two modelled regions, with a more direct exchange between the near-field and far-field. As such the results of the modelling may present and outcome where the level of dilution in the immediate vicinity of the outfall may be slightly over-predicted, whilst at other tidal conditions the results may be under-predicted.

To demonstrate the importance of the initial dilution representation, equivalent "worst-case" simulations were also carried out, where explicit treatment of near-field dilution was removed. In reality, the salinity fields that develop will not be as concentrated as these worst-case simulations; they simply provide a highly conservative upper boundary for comparison with the other tests. HR Wallingford point to the sensitivity testing showing that the mid-field behaviour of the plume is particularly sensitive to this representation in the model, and that additional validation of the model may be warranted.

The modelling runs provide an overarching view of the nature and scale of the impacts associated with discharging the reject brine through diffusers between 2 km and 3 km from the shoreline. The following discussion builds on the findings of the modelling studies and the anticipated impacts associated with discharging 1.5 million m^3/day of brine with a salinity of typically of between 70 to 80 PSU in to the marine environment.

Outfall Configuration

The reject brine from the proposed plant will be denser than the receiving seawater, which means it will tend to sink following release, forming a dense layer or gravity current at the seabed. Rates of dilution in gravity currents can be relatively slow, and so outfalls for reject brines must be designed to ensure high levels of dilution and mixing with the ambient seawater before the plume reaches the seabed.

Brine is therefore usually discharged as a series of individual jets from diffuser ports spread along a pipe. The ports are normally angled upwards so that the jets initially rise before sinking back to the seabed under their negative buoyancy. This increases the trajectories of the individual jets before they reach the seabed, maximizes the potential for entrainment of ambient seawater, and reduces near-bed concentrations. The actual rates of dilution for the proposed outfall will be limited at times, as the reject brine will mix with the thermal-saline plumes from the existing facilities as it rises from the diffuser ports and then sinks back to the seabed.

The rise of the jets from the outfall ports, their subsequent sinking to the seabed and their formation of an initially turbulent gravity current at the seabed are controlled by the initial momentum and negative buoyancy of the discharge, as well as the outfall configuration. The region over which these factors dominate mixing and dilution of the reject brine is known as the "near-field". As rapid near-field mixing processes dissipate the brine's initial momentum and buoyancy, the gravity current forms a relatively stable structure near the seabed, and ambient turbulence begins to dominate mixing and dispersion processes. This region is known as the "far-field". The area of transition between the two regions is known as the mid-field. Typically, rates of dilution in the far-field are much slower than those in the near-field.

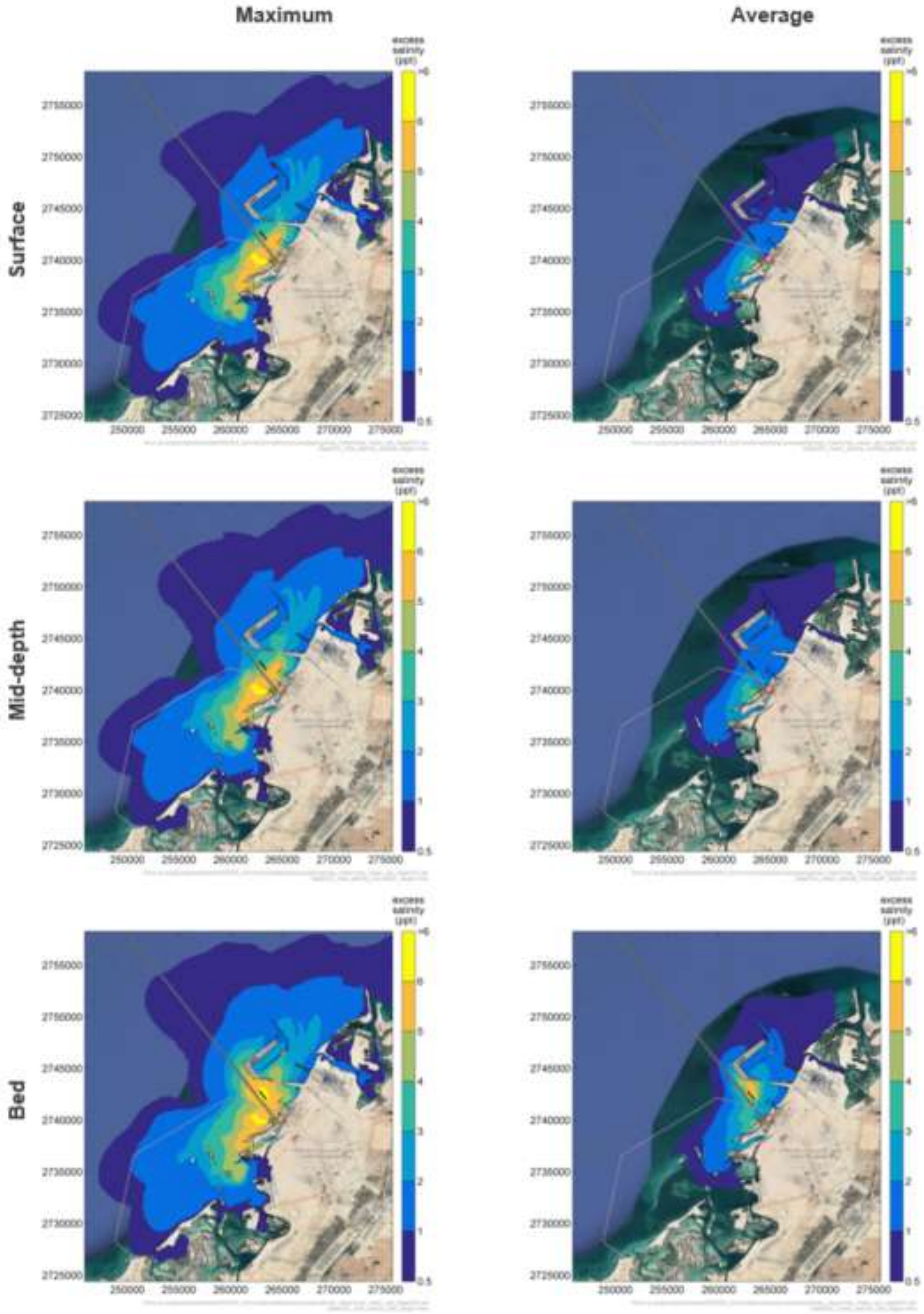
The outfall alignment will consist of 2 outfall lines, with the first pipe 2.5 km in length, with a diffuser section over the final 500 m (Figure 5-87). The second pipe will be 3 km long, with a diffuser section over the final 500 m section. As the two pipes are close together, this essentially makes a single diffuser section, approximately 1 km long. The first pipe will have with 30 single-port risers, equally spaced along the diffuser section, and the second will have 31 ports (that is, 61 ports for the combined outfall). Port diameters are about 0.35 m, which gives exit velocities of around 2.9 m/s. For this stage of modelling, we have assumed that the centre point of each diffuser port is located around 1 m above the seabed. This aimed at increasing the trajectory lengths of the jets, and to minimise their interaction with both the sea surface and seabed. The ports should make an angle of about 30° with the seabed. For the modelling, HR Wallingford assumed that the port on each riser were orientated normal to the diffuser pipe axis, and neighbouring risers discharge in opposite directions.

Figure 5-87 Proposed Outfall Alignment

Operational Phase Impacts

Model simulations were carried out for the same conditions tested for the baseline. Predicted excess salinity patterns following the completion of the 30-day scenario runtime are shown in Figure 5-88.

Figure 5-88 Predicted Maximum And Average Excess Salinities – Typical Wind Conditions



The HR Wallingford modelling show maximum footprints of the combined plume with several differences when compared with the equivalent plots for the baseline simulations. Under typical wind conditions, as would be expected, salinity concentrations in the immediate vicinity of the proposed discharge are higher, and the proposed RO discharge increases salinity concentrations to the north-east (in the vicinity of Khalifa Port).

The addition of the Taweelah Complex discharge appears to cause an increase in the overall density of the combined plume (that is the combination of the existing and Taweelah Complex brine plume). The combined plume tends to flow further offshore down the seabed gradient, which partially reduces the westernmost extents of the plume, compared with baseline, for the typical wind conditions. As a result, the maximum offshore extent of the area above +2 PSU is several kilometres further offshore compared with baseline.

For the stronger wind condition test, the maximum alongshore extents of the areas above +2 PSU are increased by several kilometres with the addition of the Taweelah Complex. On average, the area extends a few hundred metres east of the Taweelah Complex outfall, and merges with the existing Taweelah Complex discharge to form a combined area above +2 PSU that extends several kilometres west of the site.

These show significantly higher maximum concentrations, with larger areas of the seabed experiencing salinities well above the mixing zone threshold. Accurate representation of the near-field is therefore important in order to correctly represent the entrainment of the nearby discharges into the Taweelah Complex plume. This emphasizes the importance of applying a more complex time-varying coupling between the two modelled regions (HR Wallingford, 2019).

The principal marine impacts associated with the construction and operation of the proposed SWRO facility are likely to be associated with changes in water quality during the operational phase. The following sub-sections outline the potential unmitigated marine impacts that might be anticipated as a result of introducing the new effluent stream to the marine environment at Taweelah.

Given the greater density of brine effluent than receiving waters, the extent of brine effluent plumes tends to extend further on the seabed than the surface, with benthic communities affected over a wider spatial extent than pelagic and planktonic communities (Roberts et al. 2010). Seagrass are highly sensitive to elevated salinity (Sanchez-Lzazo et al, 2008, cited by Scott Jenkins et al, 2012). Whilst some laboratory experiments indicate that some

Mediterranean seagrass species mass mortality in salinities above 40 PSU (Sanchez-Lizaso et al, 2008), growth and leaf production of seagrasses collected from Shark Bay, Western Australia were greatest at salinities of 42.5 PSU (Roberts et al. 2010[16]). The baseline data collected shows that the seagrass beds at Taweelah are currently tolerating salinities in the region of 40-43 PSU. The modelling output provided by HR Wallingford suggests that the seagrass beds in the nearshore waters of Taweelah (300m from the Project site) will be subjected to an average increase between 2 and 3 PSU under normal operating conditions, with maximum increases up to 5 PSU. It has been reported that salinity increases should be less than an increment of 2 PSU for not more than 5% of the time to protect seagrass from the effects of desalination effluent plumes (Sanchez-Lizazo et al, 2008)[17]. However, the seagrass beds that are found either side of of the existing Taweelah Complex intake have established during the time that Taweelah Complex has been operating during the past 10 years. This suggests that tolerance to fluctuating salinity levels from the thermal desalination plants has been built up over some years. The marine modelling demonstrates that the cumulative increase from the IWP will fluctuate on extreme spring tides but will only be marginally higher on average conditions. It is proposed that a Seagrass Management Plan is prepared for approval and implementation within the first 3 months to monitor the health of this community under all conditions.

The HR Wallingford modelling of cumulative impacts from both the Baseline discharges and the IWP predicts an increase of no more than 0.2ppt at the sensitive designated habitats to the north east of the Port including fringing coral reef, seagrass, mangrove and intertidal mudflat habitats which form the Marine Protected Area. This very small increase in salinity is shown in the Time Series plots (Figures 5-88 and 5-89). Similar small incremental changes at sensitive habitats to the south west are also evident under both typical wind and strong wind conditions. These plots show Baseline conditions (blue line) and Baseline +IWP (green line) in close alignment indicting a minimal change in salinity compared with the existing Taweelah Complex.

[16] Roberts, D.A., Johnston, E.L. and Knott, N.A., 2010. Impacts of desalination plant discharges on the marine environment: A critical review of published studies. *Water research*, *44*(18), pp.5117-5128.

[17] Sanchez-Lizazo, J.L., Romero J., Ruiz, J., Gracia, E., Buseta, J.L., Invers, O., Torqemada, Y. F., Mas, J., Ruiz-Mateo, A., M, Manzanara (2008). Salinity Tolerance of the Mediterranean Seagrass Posidonia oceanica: Recommendations to Minimize the Impact of Brine Discharges from Desalination Plants. Desalination Vol 21 (1-3): 602 – 607.

Though laboratory experiments found no effects of salinities below 50 PSU, behavioural avoidance has been recorded in sea bream at salinities of 45 PSU (Iso et al 1994[18]). Desalination brines have been shown to be acutely toxic to developing cuttlefish embryos, which is attributable to both elevated salinities and the presence of elevated copper concentrations (Dupavillon and Gillanders, 2009[19]). It is considered likely that the shorter outfall alignment will result in greater impacts on nearshore seagrass beds than the extended outfall alignment as a result of increased seabed salinities.

Studies conducted in the vicinity of an SWRO outfall in Alicante, Spain found that benthic infaunal communities reduced abundance and diversity of polychaete assemblages directly adjacent to the point of outfall and infaunal communities close the point of brine outfall were dominated by nematodes with polychaetes, molluscs and crustaceans becoming more abundant with increasing distance from the point of outfall (Ruso et al, 200720, Ruso et al. 200821). In light of this, it is considered likely that the elevated salinities within the 500-meter mixing zone will negatively impact benthic infaunal community recolonization and development. This will be the case under all options considered as seabed salinities will exert an influence on infaunal communities within the dispersion zone. Effects will be more acute within closer proximity to the outfall with impacts lessening as the effluent plume dilutes with distance away from the outfall. The modelling output also suggest that the Khalifa Port breakwaters will also be subject to an increase in salinity in the region of 1.5 PSU above summer conditions.

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[18] Iso, S., Suizu, S. and Maejima, A., 1994. The lethal effect of hypertonic solutions and avoidance of marine organisms in relation to discharged brine from a destination plant. *Desalination*, *97*(1-3), pp.389-399.

[19] Dupavillon, J.L. and Gillanders, B.M., 2009. Impacts of seawater desalination on the giant Australian cuttlefish Sepia apama in the upper Spencer Gulf, South Australia. *Marine Environmental Research*, *67*(4-5), pp.207-218.

[20] Ruso, Y.D.P., De la Ossa Carretero, J.A., Casalduero, F.G. and Lizaso, J.S., 2007. Spatial and temporal changes in infaunal communities inhabiting soft-bottoms affected by brine discharge. *Marine environmental research*, *64*(4), pp.492-503.

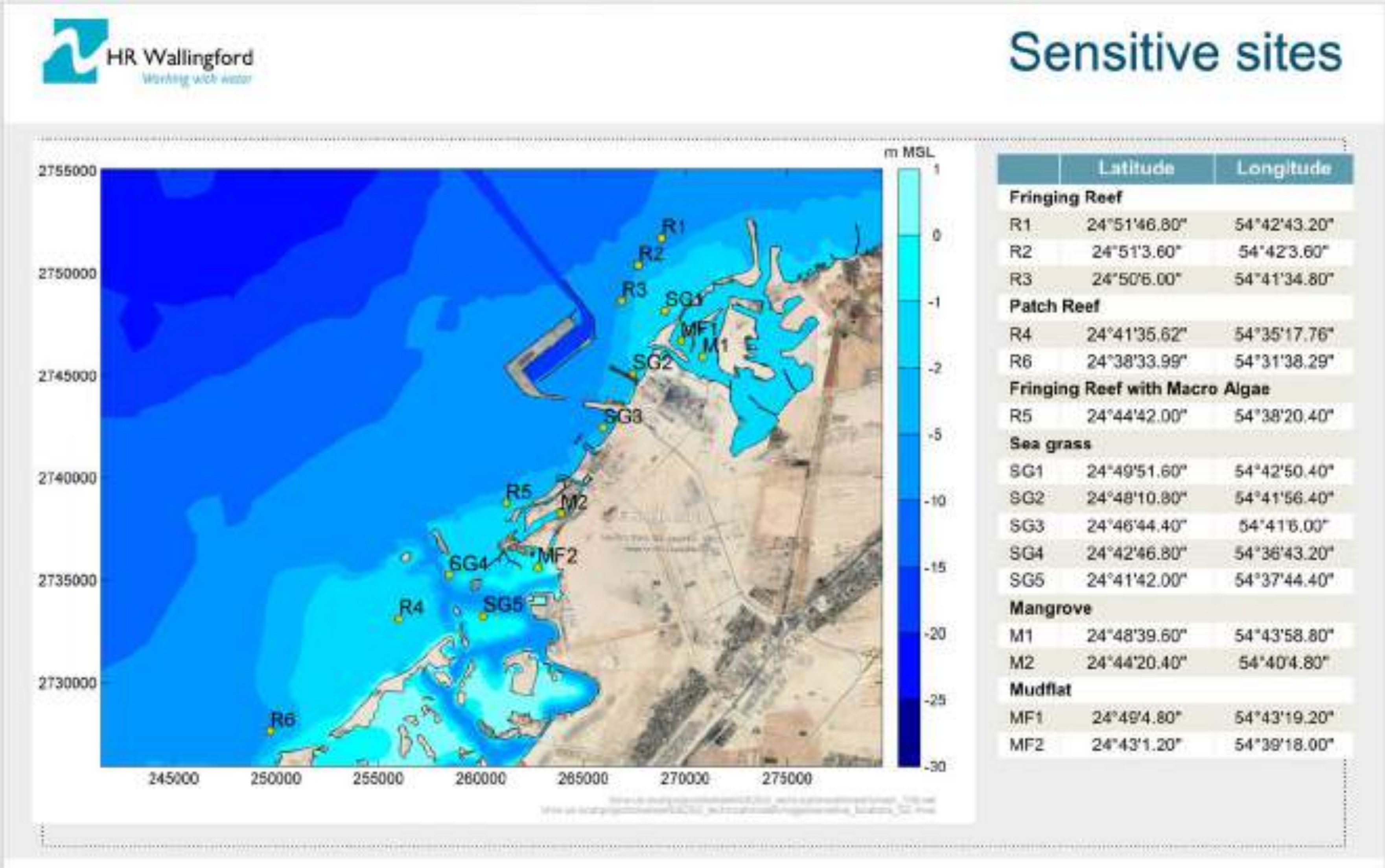
[21] Del-Pilar-Ruso, Y., De-la-Ossa-Carretero, J.A., Giménez-Casalduero, F. and Sánchez-Lizaso, J.L., 2008. Effects of a brine discharge over soft bottom Polychaeta assemblage. *Environmental Pollution*, *156*(2), pp.240-250.

Further afield, beyond the immediate footprint of Taweelah, the ecologically sensitive receptors at Ras Ghanada to the north and at the intertidal mudflats to the southwest, the new configuration is likely to result in a negligible increase in salinities at bed level (figures 5-88 and 5-89). The extent and duration of increases will depend on wind and tidal conditions, however the model outputs provided in the HR Wallingford report suggest average increases in salinity of 0.2 PSU. The baseline model runs show that both sites are already influenced by the existing outfalls from the Taweelah Complex. Adding increased loads of 0.2 PSU to these sites may not generate acute impacts, but may potentially increase chronic stress on ecologically sensitive sites that are at the edge of their tolerance thresholds. However, this will differ for different species within the community.

The summer of 2017 was notable for a mass coral bleaching event that resulted in the loss of approximately 73% of total coral cover in the Abu Dhabi Emirate (Burt et al, 2019). Sites such as Ras Ghanada experienced some of the most significant losses in coral coverage, although in contrast similar coral bleaching was observed at other sites in the UAE that have no thermal or brine discharges and globally the period 2014 to 2017 has seen unprecedented coral bleaching due to elevated sea temperatures. The outlook for natural recovery of the Ras Ghanada coral communities is considered bleak, with increasing prevalence of positive sea surface temperature anomalies, although it is not known to what extent the existing Taweelah Complex discharge has contributed to these recent events. Introducing additional chronic stress at the site by increasing ambient salinity has the potential to further reduce species diversity, as well as negatively impacting growth rates and natural larval settlement, although the increase is restricted to on average 0.2 PSU at the designated sites to the northwest and sensitive habitats to the south east. The notable exceptions are seagrass site (SG4) and Fringing Reef with macroalgae (R5) which are already impacted by the Taweelah Complex shoreline discharge. As such, the impact of effluent plume from the SWRO facility has the potential to further reduce the likelihood of coral recovery in the MPA, although based on the predicted increases of 0.2PSU, this seems unlikely. Though the intertidal mudflats to the southwest were not surveyed for infaunal abundance and diversity, the site is considered of importance of as feeding site for both residential and migratory bird species. These sensitive habitats are also predicted to have Increased salinity of 0.2PSU and in some cases less, so there is no reason to suggest that the effects of the existing Taweelah Complex on the mudflats infaunal communities will be significant.

The key to the 15 selected sensitive sites assessed by the HR Wallingford model, including the location coordinates are shown in Figure 5-89. In addition to the protection of sensitive ecological sites, the potential for recirculation at the Taweelah Complex intake and the IWP intake is also important to avoid operational impacts to the existing thermal desalination plants and the new IWP. A summary of the changes in salinity at the intakes is shown in Figure 5-92 and demonstrate a small increase in salinity compared with the existing baseline conditions. It is concluded that the increase in recirculation can be managed within the normal operating modes for the Taweelah Complex and the SWRO technology equipment for the new IWP.

Figure 5-89 Representative Sensitive Habitats to the north-west and south-east of Taweelah



	Latitude	Longitude
Fringing Reef		
R1	24°51'46.80"	54°42'43.20"
R2	24°51'3.60"	54°42'3.60"
R3	24°50'6.00"	54°41'34.80"
Patch Reef		
R4	24°41'35.62"	54°35'17.76"
R6	24°38'33.99"	54°31'38.29"
Fringing Reef with Macro Algae		
R5	24°44'42.00"	54°38'20.40"
Sea grass		
SG1	24°49'51.60"	54°42'50.40"
SG2	24°48'10.80"	54°41'56.40"
SG3	24°46'44.40"	54°41'6.00"
SG4	24°42'46.80"	54°36'43.20"
SG5	24°41'42.00"	54°37'44.40"
Mangrove		
M1	24°48'39.60"	54°43'58.80"
M2	24°44'20.40"	54°40'4.80"
Mudflat		
MF1	24°49'4.80"	54°43'19.20"
MF2	24°43'1.20"	54°39'18.00"

Figure 5-90 Time Series Plots at Sensitive Ecological sites (blue =Baseline); (green = Baseline +IWP) Typical Winds

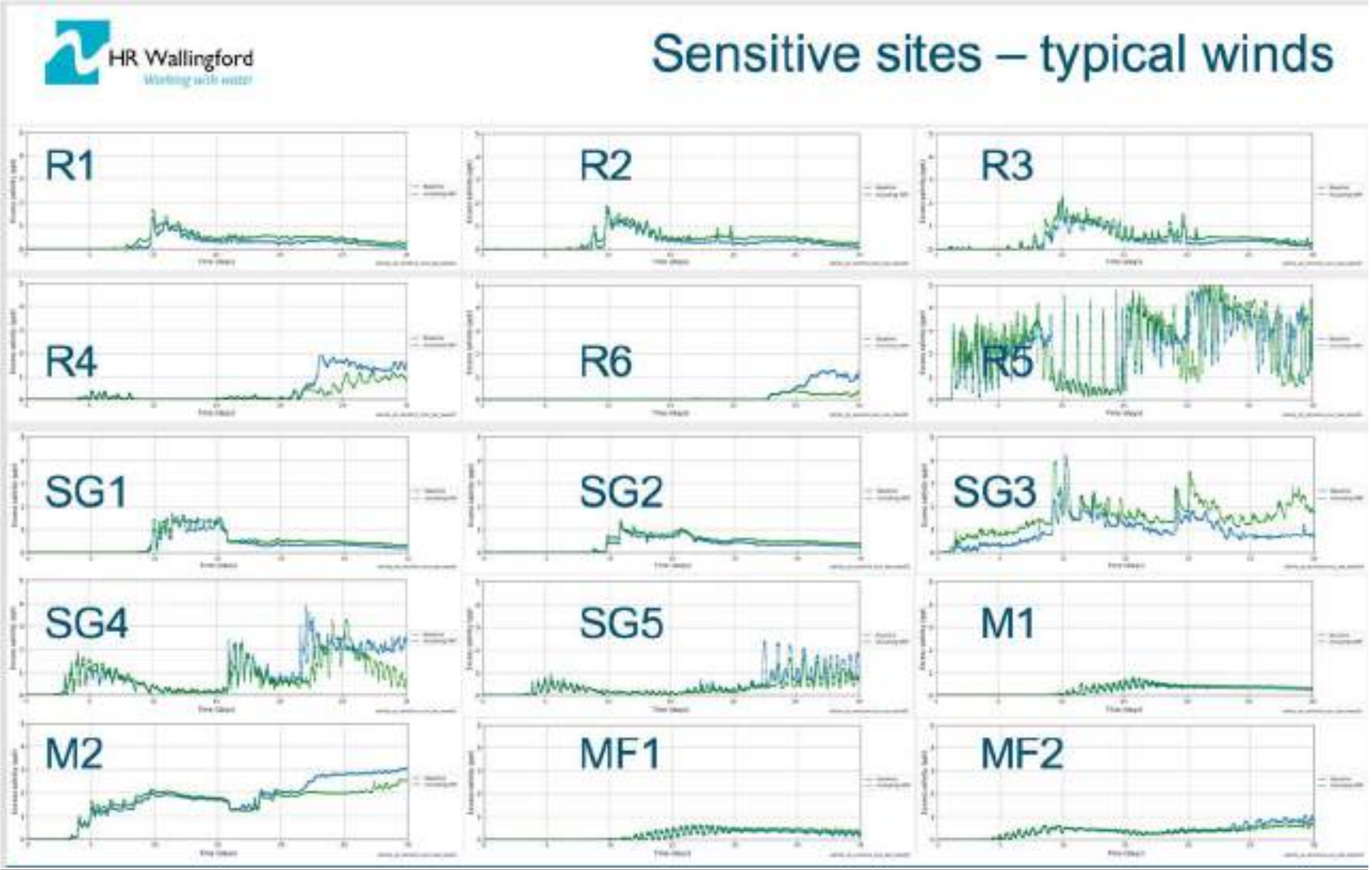


Figure 5-91 Time Series Plots at Sensitive Ecological sites (blue =Baseline); (green = Baseline +IWP) Stronger Winds

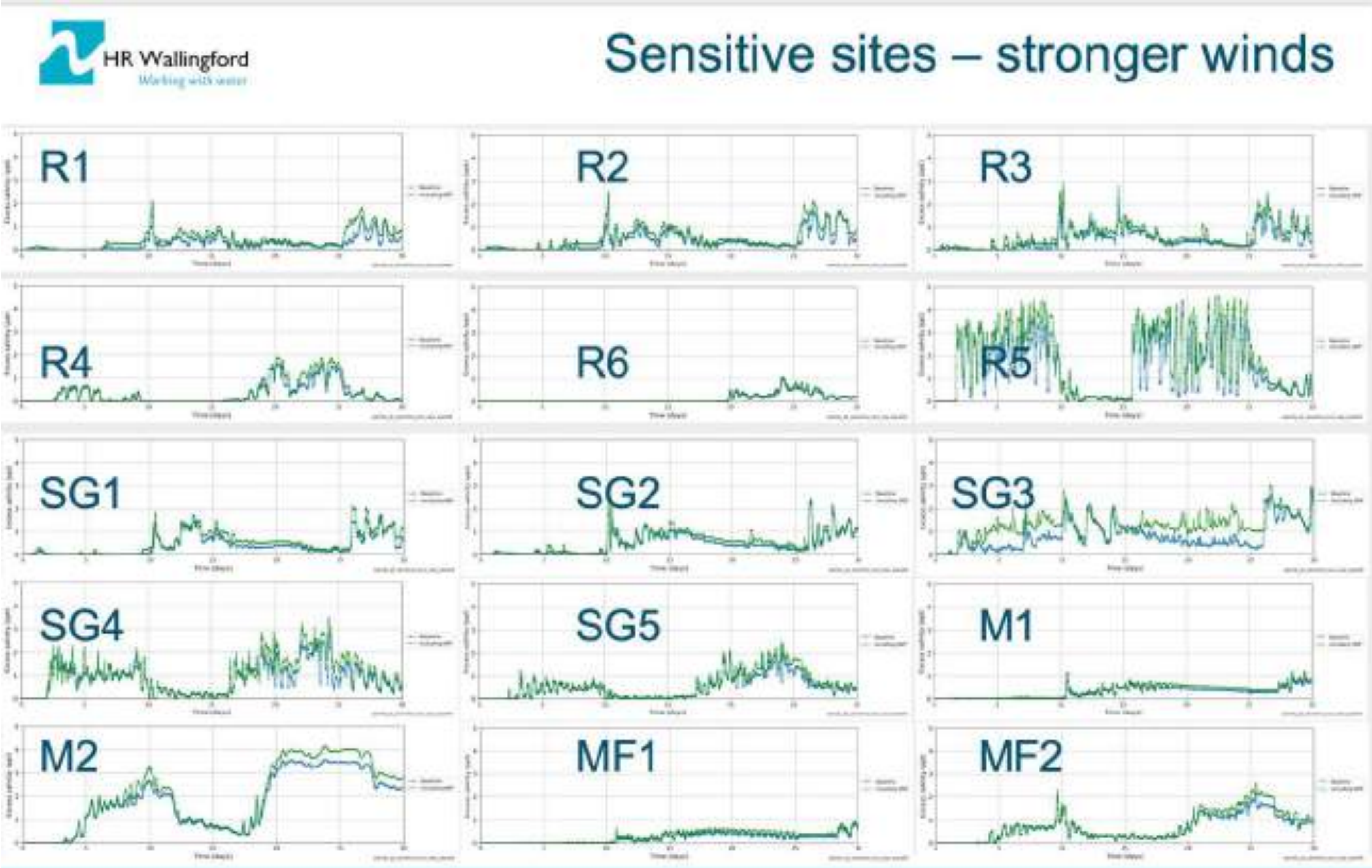


Figure 5-92 Summary of Predicted Recirculation at Intakes for Taweelah Complex and IWP

HR Wallingford
Working with water

Recirculation summary

At existing Taweelah Complex intake

wind condition	ΔS (ppt), red is including IWP outfall average	95th-percentile	maximum
typical	1.2 (1.8)	2.5 (2.8)	3.7 (4.0)
stronger	1.2 (1.6)	3.1 (3.2)	3.9 (4.1)

At proposed IWP intake

wind condition	ΔS (ppt), red is including IWP outfall average	95th-percentile	maximum
typical	1.4 (2.1)	3.1 (4.0)	3.6 (4.9)
stronger	1.4 (2.0)	3.8 (4.1)	4.5 (5.0)

Chemicals in RO Effluent

Besides high salinity, the brine contains other chemicals used for removing impurities from raw seawater in addition to biocides applied on the RO membranes for cleaning purposes. The latter are important chemicals for the RO operation as the membrane rejects more than 99% of dissolved salts in the feed water, producing a concentrate containing up to 7-fold increased concentration of dissolved and suspended constituents (Jenkins et al., 2012). Table 5-14 provides some details on chemicals that may be used and the respective phases of the production of the process where they might be required. Figure 5-93 shows conceptually the locations where those chemicals will be applied. The chemicals are classified according to their use in the plant:

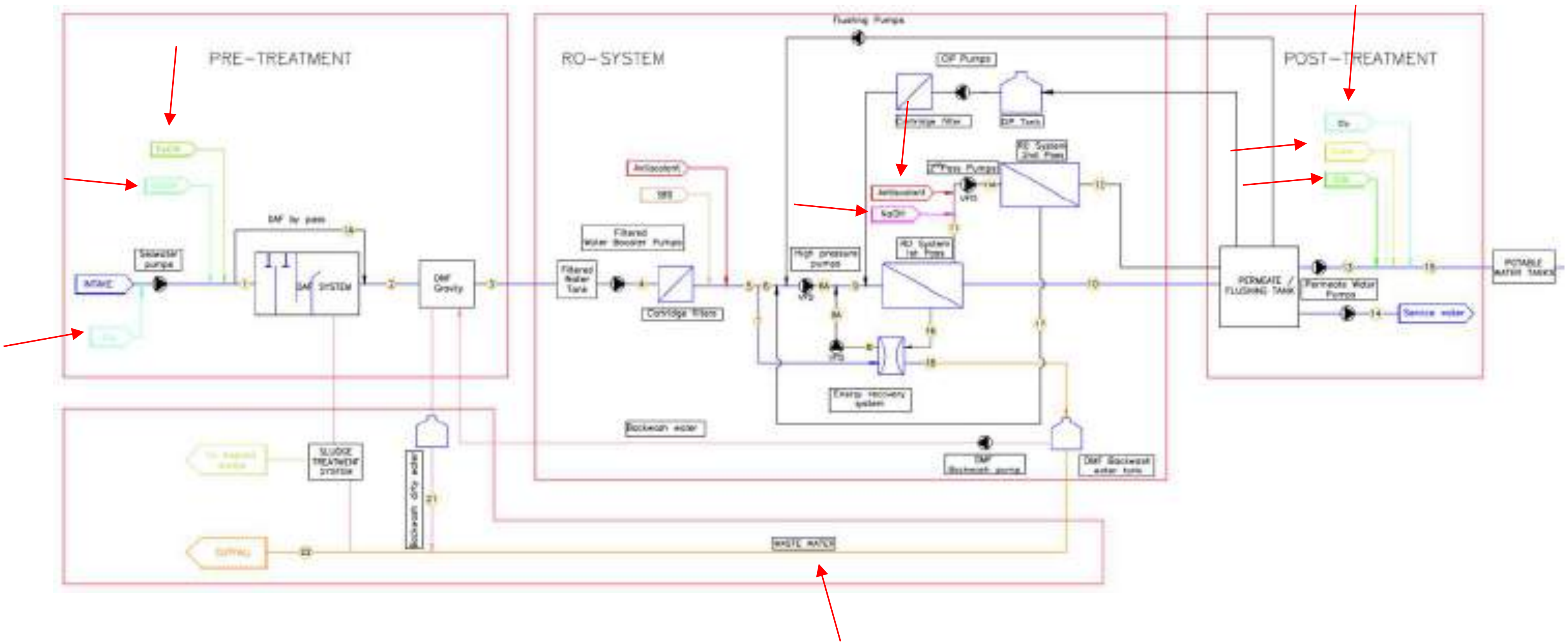
- Pre-treatment:
  - Coagulants: mostly ferric chloride ($FeCl_3$)
  - Neutralization solutions: mostly sulfuric acid (H_2SO_4)
  - Disinfectants chemicals: mostly chlorine dioxide (ClO_2)
  - Neutralization solutions: sodium hydroxide (NaOH)
- RO System:
  - Anti-scalants: mostly polycarboxylates, polyacrylates and polymeric acids. The total active ingredients in antiscalant products for the proposed facility is 100% and the expected dosing rate will reach a maximum of 1.3 mg/L in the brine.
  - Dechlorination agents: mostly sodium bisulphite (SBS) ($NaHSO_3$)
  - Cleaning chemicals: mostly oxidizing biocides such as sodium hypochlorite (NaOCl)
- Post-treatment
  - Disinfectants chemicals: mostly chlorine (Cl_2)
  - Buffering and re-mineralization agents: mostly lime and CO_2.

Table 5-15 Key Chemical Dosing Requirements and Flow Rates

CHEMICAL	DOSING RATE (MG/L) CONCENTRATION (%)	DOSING RATE (MG/L) CONCENTRATION (%)
Pre-treatment	**Expected**	**Max**
NaOCl	Not Available	Not Available
H_2SO_4	-	135 (98%)
$FeCl_3$	2.5 (40%)	20 (40%)
$FeCl_3$	-	3 (40%)
1st Pass RO		
Antiscalant	1 (100%)	1.3 (100%)

CHEMICAL	DOSING RATE (MG/L) CONCENTRATION (%)	DOSING RATE (MG/L) CONCENTRATION (%)
SBS	3 (98%)	6 (98%)
2^{nd} Pass RO		
Antiscalant	1 (100%)	1.3 (100%)
NaOH	9.5 (25%)	30 (25%)
RO CIP		
H_2SO_4	Not Available	Not Available
NaOH	Not Available	Not Available
Sludge Treatment		
Polyelectrolyte	4 (99%) Powder	6 (99%) Powder
Potabilization		
Carbon Dioxide	45 (99.9%)	55 (99.9%)
Lime stone	40 100%)	50 (100%)
NaOH	9.5 (48 to 50%)	30 (48 to 50%)
ClO_2	0.5 (31%)	1 (31%)
Neutralisation Pit		
H_2SO_4	Not Available	Not Available
NaOH	(48 to 50%)	(48 to 50%)

Figure 5-93 Concept Process Showing Points of Injection of Chemicals (red arrows)



Residuals from the chemicals will be co-discharged with the brine after treatment including pH adjustment and sludge removal, before discharge. In addition, the backwash water generated at different stages of the process will contain suspended solids averaging approximately 500 mg/L. The volume of wash-water produced will be relatively small and only be generated over a period of about 10 minutes after each wash cycle. This backwash-water with the excess clarified and filtered water will be treated in the wastewater treatment plant before the treated effluent is mixed with the brine for sea disposal which will also be significantly diluted. All treated wastewaters will comply with Federal and EAD discharge standards (and IFC) prior to mixing with the brine effluent.

The DAF system will also will produce sludge containing significant quantities of suspended solids. However, the sludge will be treated in a sludge treatment area using additional polyelectrolyte and proper system (centrifuge, thickener) to reduce the content of water and reach a dryness value of 20%. The dewatered sludge – non-hazardous - will not be mixed with the brine, but will rather be stored in silos and disposed off-site as per EAD environmental regulations. Finally, the sludge coming from backwash of limestone filters will be a small quantity; composed of particulates from limestone residues mixed with permeate water and calcium bicarbonate. It will initially be treated via the backwash recovery system, and then sent to sludge treatment system. It will not be discharged through the outfall. Note that the potabilisation of the product water prior to distribution to the public distribution network will produce very small amount of sludge notwithstanding the absence of any chemicals with any toxic effects, as these chemicals are added to the water for human consumption. Although no-toxic, no sludge will be discharged through the outfall.

The brine is predominately the concentrated salts from seawater. The chemical additives are largely non-toxic and typically require pH adjustment for acids and alkalis used either sporadically or continuously. However, the guidelines or target values for some of the chemicals listed in table 5-14 are not always available. In addition, it is ultimately the contractor's responsibility to provide the finalized list of chemicals and dosage rates that will be used once the plant is built. The IWP will be operated by NOMAC who have considerable experience of operating ACWA Power's IWP, IWPP and IPP plants globally .

To overcome these limitations, the approach adopted here to assess the potential impacts of those chemicals is to use:

- Generic dosage rates provided by the project proponent or cited in the literature for similar facilities
- Calculated dilution rates obtained from the modeling study
- Conservative dilution threshold as a conservative target value for modeling exceedances.

Each chemical category will be assessed on the basis of the above approach

<u>Chemicals</u>

Chlorinated disinfectants (ClO_2 and NaOCl): Although Chlorine is very reactive in water and does not persist, its by-products, i.e., chloramines, halogenated compounds and bromanines, are more stable and may be harmful to aquatic life. Because seawater contains relatively high levels of bromides, the later compounds are typically present in the reaction products between chlorine and bromides. In addition, sodium hypochlorite is harmful to fish, invertebrates, amphibians and plants. The ecotoxicological data shows that LC50 after 96 hours for Bluegill sunfish is 2.90 mg/L, and 140 mg/L for Fathead minnow and only 0.90 mg/L for Rainbow trout22. Because it is an inorganic material, it is not subject to biodegradation and does not persist in the environment.

Yet, the maximum total residual chlorine in the brine is expected to be low as a dechlorination agent, i.e., sodium bisulphite as discussed below, will reduce the presence of residual chlorine that is co-discharged with the brine. A residual chlorine of less than 0.5 mg/L must be maintained throughout the pre-treatment line upstream of the RO membranes. The sodium bisulphite is then applied to dechlorinate, i.e., remove the chlorine from the water in order to protect the membranes. The expected chlorine residual that is co-discharged with the brine is almost inexistent at that stage. In addition, chlorine will be applied under a "shocking regime" that involves using high chlorine levels for few seconds rather than continuous release; 2 ppm for 20 minutes every six hours of ClO_2. The residual chlorine concentration in the brine would have to be 29 mg/L to reach the threshold value of 0.9mg/L, i.e., 96hr LC50 for the Fathead minnow. Even when added at a concentration of 0.31 mg/L (1 mg/L at 31% active ingredient) during the potabilisation process, the residual chlorine needs to be diluted by a factor of 31 to achieve a target value of 0.01 mg/L in the receiving waters as per EAD guidelines. Note that 1 mg/L is a very conservative value since some of the dosed chlorine will be consumed upon injection and the expected operational dosing rate is 0.5mg/L, which would require a dilution rate of only 15 in order to comply with the guidelines.

The application of the minimum dilution factor of 40 will yield an in situ concentration in the receiving water of 0.007 mg/L when dosing is maximal and 0.003 mg/L when dosing is applied at the expected operational conditions.

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22 Material Safety Data Sheet – Sodium Hypochlorite, Kuehne Company, May 2015 http://www.kuehnecompany.com/pdf/Sodium%20Hypochlorite%20Rev%20C.pdf

Ferric Chloride ($FeCl_3$): While $FeCl_3$ is not listed as hazardous compound in any of the literature consulted [WHO Acute Hazard, U.S. EPA Toxics Release Inventory List or the U.S. National Toxicology Program (NTP)], it does enhance coagulation and generates flocculated materials that need to be removed when backwashing the RO filters. This process produces a sludge that is blended with the brine stream. An expected continuous maximal dosing rate of 9.2 mg/L 23 is anticipated in the intake water flowing at 5.5 m3/sec. This translates into a maximum load of 4,371 kg/day, most of which is directed towards a sludge treatment system. Most of the solids are then removed and disposed of on inland facilities. However, even in the worst case where such solids loads are blended with the brine stream, the nominal flocculant concentration in the final brine discharge with be about 5.3 mg/L 24. No acute effect of this sludge is expected, apart from a possible increase in turbidity and suspended solids at the discharge point. Note that the more realistic continuous dosing rate of FeCl3 is close to 1 mg/L, which will produce a nominal concentration of 1.6 mg/L that is 9.2 times less than at the maximal dosing rate.

In addition, the ecotoxicity of $FeCl_3$ varies between an LC50 of 4mg/L for striped bass and 15 mg/L for water flea Daphnia25. Therefore, even in the unlikely worst case condition, the final concentration in the receiving waters will reach a transient value of 0.13 mg/L which is 30 times lower than the LC50 of striped bass. Yet, there is still some uncertainty as to the long term toxicity of the degradation products.

Sodium Bisulphate (NaHSO4) (SBS): Because of its low log Pow (Octanol/water partition coefficient), the risk of bioaccumulation of sodium bisulphate in aquatic species is low. Although there are no available discharge standards for SBS, it is not listed as a hazardous substance by US EPA (40 CFR 261), or by CERCLA (40 CFR 302.4) and is only regulated when

23 Value based on maximal dosing rate of 23mg/L at 40% active ingredient which translates into 9.2 mg/L.

24 Value based on intake flow of 5.5 m3/sec receiving 9.2mg/L of FeCl3 thus producing a maximum flocculant mass of 4,371 kg/d that is assumed to be discharged together with the brine. As a result, this mass loading into a brine stream of 3.3m3/sec translates into a nominal concentration of 15.3 mg/L.

25 Material Safety Data Sheet – Ferric Chloride. Fisher Scientific, July 2009 and Cleartech 2011. http://dept.harpercollege.edu/chemistry/msds/Iron%20(III)%20Chloride%20Anhydrous%20Fisher.pdf

http://www.cleartech.ca/msds/ferricchloride.pdf used as a food preservative26. Unlike sodium metabisulphite, sodium bisulphite is inherently non-toxic unless present at concentrations exceeding 200 mg/L; yet, it can exert an oxygen demand and reduce dissolved oxygen levels in the receiving waters if present at concentrations of 39 mg/L or more (Basu and Dorner, 2010). Such high levels are not expected to occur in the receiving waters since the highest dosing rate is 6 mg/L which will be diluted to a maximal concentration of 0.15 mg/L upon mixing in the receiving waters. However, sodium bisulphate is still considered as an oxygen scavenger compound and its use and application operationally at the plant must be controlled to avoid the need to aerate the effluent prior to co-discharge with the brine.

Antiscalants: Antiscalants are a family of chemicals designed to inhibit the formation and precipitation of crystallized mineral salts that form scale. Although the type of the antiscalants to be used in the proposed SWRO facility is not defined, the expectation is that only polymeric antiscalants such as polycarboxylic and polymlaeic acids will be used, as opposed to polyphosphates which could be a major macronutrients contributors to the receiving waters. The dosing rate at the proposed SWRO is expected to reach a maximum of 1.3 mg/L. While non-toxic at low concentrations, acrylic polymers have an EC50 (algae) of 72.4 mg/L and a 72 hours EC50 (Daphnia magna) > 1040 mg/L and 48 hours LC50 (Salmo gairdneri) > 1100 mg/L/ 96 hours27. Polycarboxilic acids have a 96hr-LC50 on fish of more than 2500 mg/L28. These concentrations are orders of magnitude higher than typical dosage levels. The residual concentrations that is likely to be co-discharged in the brine may conservatively reach a maximum of 2 mg/L before reaching the Gulf waters where it will be diluted by a factor of 40, leaving under the worst conditions a residual of 0.05 mg/L in the receiving waters. Yet, their degradability in the environment is relatively slow and little is known about their long term fate.

Cleaning agent Sodium Hydroxide (NaOH): Cleaning the RO membranes is as critical as the membrane itself. It is essential that the membranes are maintained in a good, clean condition. While NaOH is used to increase the RO feed pH, it is also used to periodically clean

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26 Material Safety Data Sheet – Sodium Bisulfate. Calabrian, May 2015 (http://www.calabriancorp.com/sites/default/files/documents/sbs_2015_sds_rev5.pdf)

27 Material Safety Data Sheet – VITEC 4000. Avista TEchnologies, August 2012. http://meras.com/pdf/Vitec_4000_MSDS.pdf

28 Material Safety Data Sheet – Sodium salt of polycarboxylic acid, BWA, January 2011 http://www.houghton.com/wp-content/uploads/FLOCON-PLUS-N-United-States.pdf

the RO membranes to remove residual deposits. However, the concentrations likely to be discharged with the brine are difficult to estimate at this stage. Yet, if undiluted or not neutralized, the hydroxyl ion (pH effect) of NaOH can be harmful to the aquatic organisms in the receiving waters. For this reason the effect of NaOH on the organisms depends on the buffer capacity of the aquatic ecosystem. In the case of the SWRO plant, the spent cleaning solutions will be co-discharged with the brine into the sea without treatment. Given the large volumes of brine, this mixing allows a significant dilution of the cleaning agents before discharging in the receiving waters. When used for cleaning the RO membranes, the NaOH is used as a 0.1% solution by weight at pH 1229.

Sodium hydroxide is not expected to readily biodegrade and, as such, it may cause harmful effects to aquatic organisms. Its EC50 is 34.59 mg/l 48 h for Water flea (*Ceriodaphnia dubia*), 125 mg/l 96 for western mosquitofish (*Gambusia affinis*) 30 and 45.4 mg/l for *Salmo gairdneri*31. Also, the variation in acute toxicity for aquatic organisms can be explained by the variation in buffer capacity of the test medium. LC50 values of acute toxicity tests with aquatic organisms ranged between 33 and 189 mg/l32.

However, its expected concentration once co-discharged in the brine is likely to be minimal and will be orders of magnitude lower than any of the cited thresholds. The application of the 40-dilution factor further provides a safety net that the residual concentration of sodium hydroxide will be negligible in the receiving waters.

A summary values of expected concentrations of the above chemicals is given in the table below.

29 Dow Filmtec Membranes Tech Fact – Dow Chemicals, form N0 609-23010-0211. http://msdssearch.dow.com/PublishedLiteratureDOWCOM/dh_060a/0901b8038060a66f.pdf?filepath=liquidseps/pdfs/noreg/609-23010.pdf&fromPage=GetDoc

30 Material Safety Data Sheet – Sodium Hydroxide, Puritan Products, January 2016 https://www.puritanproducts.com/wp-content/uploads/2016/02/SODIUM-HYDROXIDE-PELLETS-SDS.pdf

31 Material Safety Data Sheet – Sodium Hydroxide 50%, Lab Chem, October 2013. http://www.labchem.com/tools/msds/msds/LC24150.pdf

32 UNEP (2002). Sodium Hydroxide, CASNo: 1310-73-2 http://www.inchem.org/documents/sids/sids/NAHYDROX.pdf

Table 5-16 Summary of expected chemicals concentrations in the receiving waters versus threshold values

COMPOUND	DOSING RATE (MG/L)	THRESHOLD (MG/L)	EXPECTED CONCENTRATION IN RECEIVING WATERS AFTER DISCHARGE (MG/L)
ClO2	0.31	0.01	0.0075
NaOH	30 at 25%	33	0.18
	30 at 48%	33	0.36
FeCl3	20 at 40%		0.38
Sodium Bisulphate (SBS)	6	39	0.15
Antiscalant	1.3	72.4	0.05

<u>Entrainment and Impingement</u>

The open intake structure might cause negative impacts by entraining and impinging (E&I) organisms into the feed water system. Impingement will cause marine organisms to be pinned against the screen mesh while entrainment will allow the passage of smaller organisms to pass through the screen with no ability to exit the system. The impacts of E&I cannot be underestimated and while often very difficult to be eliminated, they can be minimized. Yet, the adoption of an open channel intake presents its own challenges relative to E&I:

- Unlike intake pipes that can be placed away from the near-shoreline biologically productive area, the extraction points within the open channel intake are located immediately at that shoreline.
- The deeper an intake is situated, the less the risk for young fish to be entrained or impinged. The open channel configuration being located at the shallowest part of the nearshore where bottom dwelling young fish are vulnerable to E&I.
- In an open channel, the total height of the intake is equal to the total depth of the intake site, and fish can be entrained at all depths
- The ambient hydraulics are characterized by low current velocities posing a greater risk of than one located in an area with relatively stronger currents that can sweep non-motile organisms away.

Mitigating those risks requires a careful selection of the intake screening technology that minimize flow velocity through the screen surface – typically 0.15m/sec which is the maximum velocity at which a juvenile fish can turn around, swim away and not be impinged onto a screen. In addition, a tightly spaced screen, e.g., 5 mm, will minimize entrainment of fish and other marine organisms. A mitigating factor that will likely reduce the risk of I&E is the absence of a biologically active area at the proposed intake location.

The E&I ecological trawl sampling completed as part of this study points to the presence of a high number of fish eggs and larvae within the immediate proximity of the intake. This is likely to be attributable to the close proximity of a seagrass bed to the north of the intake, which is a habitat known to be significant for fish spawning. March-April is a known spawning season for fish within the waters of Abu Dhabi so the high levels of eggs and larvae is expected.

The projected requirement of seawater to enter the designed intake for the Taweelah SWRO plant is 2,482,944 m^3 of seawater per day, where the required velocity of this source water is 0.2 m/s maximum with the aim of achieving 0.15 m/s. Typically, 0.15 m/s is the maximum velocity at which a juvenile fish are able to turn around and swim away while not being impinged onto an intake screen.

The projected mesh size for the intake filter is 5 mm which in general is known to minimize entrainment of fish and other marine organisms.

5.2.4 Cumulative Impacts

The existing open channel outfall from the Taweelah Complex was considered as an integral part of the impact study. Data was collected in close proximity to the existing EGA outfall to ensure that the impact assessment covers all industrial discharges into the study area. Therefore the established baseline reflects all current operations in the Taweelah area. In addition, the model baseline considers the effluent currently discharged by the existing facilities. All simulations therefore take into account the existing operations and the impacts associated with the planned SWRO operation are inherently cumulative based on information that is currently available.

Cumulative impacts are anticipated as the effluent from the proposed IWP will contribute to incremental changes in salinity, but not temperature increase, beyond the footprint of the Project site. These have been shown in the preceding Figures and Tables in this Section.

5.3 Mitigation Measures

5.3.1 Potential Mitigation Measures

The potential mitigation measures are shown in table 5-17 below.

Table 5-17 Potential Mitigation Measures for Marine Water, Sediment and Ecology

Impact Description	Mitigation Measures	Regulation / Standards
Construction Phase		
Marine Water and Sediment Quality Impacts	• Install heavy duty, low permeability silt screens to minimize the dispersion of marine sediments during trenching • Continuous visual observations of the silt screens to monitor for damage and dispersion of the sediment plume in the marine environment. • Turbidity must be continuously monitored using a real-time measurement system prior to and during dredging and/or trenching operations. (at 2 locations including seagrass habitat) • No dumping of dredged spoil in to the marine environment will permitted. • All vessels to reduce speed below 5 knots within nearshore environments to minimize turbidity generation caused by propeller wash • On-site refuelling of marine vessels is prohibited • All wastes to be collected and disposed off-site • Use of environmentally degradable greases • All vessels will be equipped with a spill response kit, including booms that can be deployed from the vessel. • The contractor will designate a marine fauna observer (MFO) on each vessel.	Recommended Ambient Marine Water Quality Standards for Abu Dhabi Emirate (AWQOs) and IFC standards, whichever is the most stringent
Marine Ecology	• Minimise construction footprint in the intertidal zone to limit the loss of suitable turtle nesting habitat as far as is feasible. • Marine construction to be prohibited during turtle nesting season (mid-March to mid-June). • Access to beach to be restricted to all but selected authorised personnel during turtle nesting season. • Any night lighting in the vicinity of the turtle nesting beach to utilise red lights and take into account direction of major light sources during turtle nesting season. • Seagrass Management and Monitoring Plan to be implemented prior to marine dredging works • The anticipated 5% loss of seagrass under the footprint of the intake structure will be mitigated by new habitat creation/ and discussion of compensation/offsetting with EAD.	Federal Law No. 23 of 1999 and IFC Guidelines
Operational Phase		

Impact Description	Mitigation Measures	Regulation / Standards
Marine Water Quality	• Discharge at location(s) defined to meet regulatory ΔS in absence of existing discharge(s) • Chemicals to be mixed with brine after neutralization when needed • Backwash water to be treated prior to mixing with brine effluent. • No sludge shall be discharged down the outfall	Cabinet decree no 37 - 2001 (Annex no 8) Recommended Ambient Marine Water Quality Standards for Abu Dhabi Emirate (AWQOs) and IFC standards, whichever is the most stringent
Marine ecology – Impingement and Entrainment	• Incorporation of a velocity-cap intake system to minimise entrainment of icthyofauna • Use of barrier nets at the mouth of the intake channel to prevent fish and large marine fauna entering the intake channel • Use of bar screens with a distance between the exclusion bars of no greater than 20 cm is recommended for preventing large organisms from entering the seawater intake • Consideration of reduction in seawater intake velocities on a seasonal basis, most notably during coral and fish spawning season • Consideration of fish diversion systems and behavioural deterrents with site specific solutions to be implemented • Ongoing fish egg and larvae survey to be conducted for a duration of three years as per the EAD TGD requirements. The results of this survey will inform a full E&I report to be submitted to EAD	Federal Law No. 23 of 1999 and IFC Guidelines
Marine Ecology	• Access to beach to be restricted to all but selected authorised personnel during turtle nesting season (mid-March to mid-June). • Any night lighting in the vicinity of the turtle nesting beach to utilise red lights and take into account direction of major light sources during turtle nesting season. • Implementation of lighting management plan aimed at reducing light impacts at the nesting beach. • Implementation of noise abatement management measures at all facility components (particularly pumping stations etc. in close proximity to the turtle nesting beach). • Development of a Biodiversity Action Plan for critically endangered Hawksbill Turtles in line with IFC PS6	Federal Law No. 23 of 1999 and IFC Guidelines

5.3.2 Selected Mitigation Measures

Construction Phase

Impacts to the marine environment during the construction works are inevitable. However, the extent of the impacts can be managed with the implementation of the following appropriate mitigation measures:

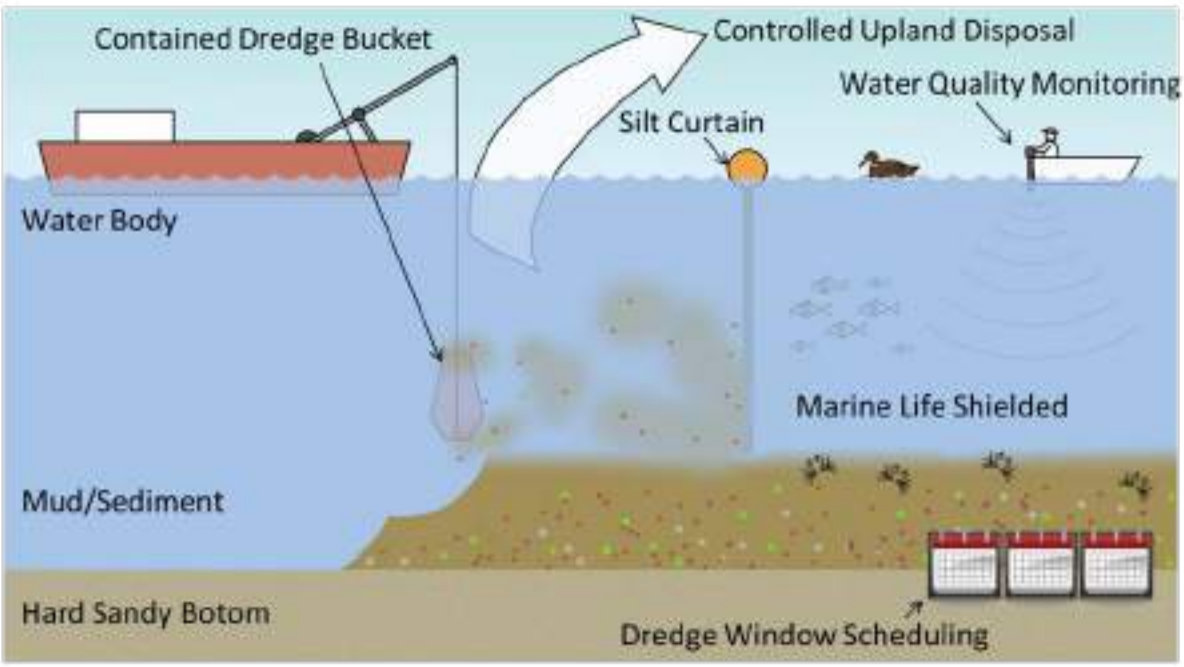
- Prior to starting any construction works in the marine environment, the contractor will install heavy duty, low permeability silt screens to minimize the dispersion of marine sediments during trenching;
- Continuous visual observations of the silt screens to monitor for damage and dispersion of the sediment plume in the receiving environment. If damage is observed, construction works will be put on hold until the damage is repaired or new silt curtains have been installed;
- Turbidity will be continuously monitored using a real-time measurement system prior to and during dredging and/or trenching operations. The collected data will be compared with EAD AWQOs. In this regard it is important that baseline conditions established prior to trenching or dredging operation serve as the basis for interpreting the real–time data. Should the EAD objectives be exceeded due to marine construction activity, the contractor will be required to suspend work until additional mitigation measures are put in place and/or sea conditions improve if the increase in turbidity is weather related. The adoption of an adaptive management process that could include the implementation of "environmental dredging" methodologies may be needed in case of repeated exceedances. Yet, the expected minimum disturbance of the seabed during the trenching operation may preclude the need to adopt environmental dredging methods.
- No dumping of dredged spoil in to the marine environment will permitted. All excavated material will be collected for off-site disposal by a Tadweer licensed waste disposal contractor.
- All vessels to reduce speed below 5 knots within nearshore environments to minimize turbidity generation caused by propeller wash;
- On-site refuelling of marine vessels is to be prohibited;
- All wastes to be collected and disposed off-site;
- Use of environmentally degradable greases wherever feasible;
- All vessels will be equipped with a spill response kit, including booms that can be deployed from the vessel. All vessel employees will receive training in the appropriate spill response measures; and
- The contractor will appoint a marine fauna observer (MFO) on each vessel. The MFO will check for marine megafauna within a 300 meter radius of the vessel. Dredging activities are to be ceased until 20 minutes after the last observation of marine fauna in the monitoring zone.

An overview of an Environmental Dredging Plan is presented herein, starting with the classification of the sediments depending on its chemical composition. Requirements for each class of sediments are listed below and include both operational, i.e., reduce release rate or slow down production, etc. and engineering controls such as the use of the appropriate equipment (Table 5-17), i.e., environmental buckets, silt curtain etc while a schematic view of the dredging requirements is shown in Figure 5-94.

Table 5-18 Engineering Controls for Environmental Dredging Operations

	Mitigation Measures	Regulation / Standards	Site Containment
Mechanical Dredging or Hydraulic Dredge	• Environmental bucket • Real-time positioning • Bucket size/type	• Use experienced operator • Slow down production • Slow bucket at bottom and at water surface (less than 0.5 m/s) • Reduce impeller rotation speed • Eliminate multiple bites • Avoid sweeping • Schedule judiciously • No barge overflow	• Silt curtain • Gunderboom

Figure 5-94 Schematic view of "environmental dredging" through operational and engineering control



The implementation of a management plan would require a series of steps that are detailed below:

- **Sediment analysis prior to actual dredging** – must be carried out by contractor.
- **Submission of dredge design**: draft design plan, specifications, water quality monitoring plan (TSS, turbidity, nickel, copper, zinc, chlorophyll "a" immediately outside the confines of the silt curtain), sampling frequency and triggers to increase or decrease sampling frequency

- **Submittal of Final Dredge Design Plan:** design drawing, schedule, equipment specifications, dewatering methodology and treatment of effluent, selected disposal site and methodology.
- **Pre-dredging bathymetric survey** of the area to be dredged and immediate surroundings
- **Implementation of dredging operations:** use of environmental bucket or controlled hydraulic dredger (sealed gaskets or overlapping sealed design at the jaws, or flaps to minimize loss of material during transport)
- **Floating Booms and Silt Curtains:** must be positioned to enclose the entire dredge area prior to commencement of dredging activity, and must remain in place during actual operations and at least two hours after dredging is completed. Water quality background concentrations should not be exceeded by more than 30% outside the immediate vicinity of the curtains.
- **Protection of exposed sediments**: use clean sand for capping if needed
- **Return water discharge limitations and monitoring requirements:** overlying water in a decant barge or on land can be returned to the channel after 24 hours of settling (avoiding re-suspension or previously settled sediments)
- **Post dredging bathymetric survey** at same scale and datum
- **Post dredge monitoring:** benthic/chemical evaluation of sediment and water column
- **Reporting requirements:** all analytical results must be submitted within 48 hours in addition to on-site real-time monitoring

Operational Phase

The following mitigation measures will be adopted:

- Wastewater streams and chemical wastewater including backwash water generated from the DAF and DMF stages of sea water filtration will be neutralized in the on-site facilities to comply with UAE Federal and IFC discharge standards prior to mixing/dilution with the brine effluent;
- No sludge will be added to brine effluent or discharged through the outfall at anytime;
- No wastewater will be discharged to the marine environment without prior consent by EAD;
- A Biodiversity Action Plan for critically endangered Hawksbill Turtles will be developed in line with IFC PS6; and
- Measures to minimise entrainment of fauna at the intake will be detailed within the OESMP and operating procedures.

5.4 Monitoring Program

5.4.1 Monitoring Program for Compliance with Selected Mitigation Measures

The following monitoring program (Table 5-18) has been developed to ensure that the proposed mitigation measures are consistently implemented in order that any adverse impacts on the local marine environment are prevented, where possible, or reduced to acceptable levels.

Water quality monitoring will be conducted with samples of brine generated by the SWRO plant collected prior to discharge into the outfall. Samples will be taken and be analysed for the suite of parameters detailed in EAD Effluent Discharge guideline, as provided in Table 5-19. The number of samples will be analysed once for physico-chemical in addition to biological parameters (described below) before construction commences.

During construction, in situ parameters will be monitored on a frequency to be agreed with EAD at the marine construction site. During commissioning, salinity will be monitored in the outfall and at the edge of the 500 m mixing zone. Process chemicals or indicators will be analyzed until a representative profile is established. Once this is completed, these analyses will be repeated twice a year. During the operation phase, continuous measurements will be conducted on pH, salinity and turbidity and samples taken twice daily for residual chlorine at the outfall.

Table 5-19 Proposed Brine Monitoring Parameters

PARAMETER	UNITS
Physico-Chemical	
Biochemical Oxygen Demand	mg/l
Chemical Oxygen Demand	mg/l
Chlorides	mg/l
Chlorine – residual	mg/l
Cyanide as CN	mg/l
Detergents	mg/l
Dissolved Oxygen	mg/l and % saturation
Fluorides	mg/l
Nitrogen, ammoniacal	mg/l
Nitrogen, nitrate	mg/l
Nitrogen, organic (Kjedahl)	mg/l
Nitrogen, total	mg/l
Oil & Grease, emulsified	mg/l
Oil & Grease, Free oil	mg/l
pH	units
Pesticides, non-chlorinated	mg/l

PARAMETER	UNITS
Petroleum hydrocarbons	mg/l
Phenols	mg/l
Phosphate-Phosphorus	mg/l
Sulphates, total	mg/l
Sulphides as S	mg/l
Surfactants	mg/l
Total Suspended Solids (TSS)	mg/l
Temperature	°C
Total Dissolved Solids (TDS)	mg/l
Turbidity	NTU
Antiscalant	mg/L
Sodium Bisulphate	mg/L

The biological parameters to be measured include the abundance of dominant zooplankton and phytoplankton species as well as benthic macrofauna and macroflora as per the procedure to be detailed in the Biodiversity Action Plan.

A proposed monitoring plan is included in the table below.

Table 5-20 Marine Water and Sediment Monitoring Program

MONITORING ACTIVITY	PARAMETERS	MONITORING SCHEDULE
Pre-Construction		
Establishment of a baseline of intertidal and sub-tidal invertebrate macro faunal communities before construction commences (already undertaken in 2019)	Benthic infauna counts.	Once
Establishment of a baseline of water quality and sediment quality baseline before construction commences (already undertaken in 2019)	**Water quality** TDS TSS Bicarbonate Carbonate Total Alkalinity Calcium Hardness Total Hardness Free Oil Nutrients (total phosphorous, sulphides, sulphate, nitrate, nitrite, ammonium) Metals (aluminium, arsenic, cadmium, chromium, copper, nickel, lead, mercury, zinc, vanadium) Anions (chlorine, fluorine, bromide, boron) Cations (calcium, magnesium, sodium, potassium, strontium, barium)	Once

Monitoring Activity	Parameters	Monitoring Schedule
	Total cyanide Silicon TOC DOC **Sediment** Particle Size Distribution Metals (aluminium, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, zinc) Nitrate Nitrite Ammonium Ammonia Total Nitrogen Phosphate TOC Sulfate Sulfide Phenols TPH PAH Total Bacterial Count	
Construction		
Measurements of in situ parameters during the construction phase at marine construction site	Turbidity Chlorophyll-a Dissolved Oxygen	Daily
Ichthyofaunal surveys including sampling for fish eggs and larvae and adult fish assemblages at sensitive receptors in close proximity to the construction footprint	Ichthyofauna UVC, fish eggs and larval zooplankton tows	Monthly
Seagrass monitoring surveys immediately prior to, during and following marine construction works	Seagrass species composition, percentage cover and health on fixed monitoring transects.	Monthly
Regular monitoring of turtle nesting beach during the nesting season	Tracks, nests, waste and timing and frequency of hatchling emergence	Daily during nesting season (early morning)
Commissioning		
Monitoring of the RO effluent after commissioning for process chemicals used in the plant and at the edge of the 500m mixing zones	Biochemical Oxygen Demand Chemical Oxygen Demand Chlorides Cyanide Detergents Dissolved Oxygen Fluorides	At inception and until a representative profile of the discharge is established. Every 6 months

MONITORING ACTIVITY	PARAMETERS	MONITORING SCHEDULE
	Ammoniacal Nitrogen Nitrate Organic Nitrogen Total Nitrogen Emulsified Oil & Grease Free Oil pH Non-chlorinated Pesticides Petroleum Hydrocarbons Phenols Phosphate-Phosphorous Total Sulfates Sulfides as S Surfactants TSS TDS Temperature Turbidity Antiscalant Sodium Bisulfate	thereafter.
Operation		
Monitoring of the RO effluent	pH Salinity Turbidity	Continuous
Measurements of biological indicators at the edge of the mixing zone and at 2,000m from the shoreline	Phytoplankton Zooplankton Benthic Infauna	Bi-monthly
Measurement of temperature and salinity profiles at the edge of the mixing zone and at 2000m from the shoreline	Temperature and salinity	Monthly
Seagrass monitoring surveys.	Seagrass species composition, percentage cover and health on fixed monitoring transects in areas likely to be impacted by effluent plume.	Quarterly
Ichthyofaunal surveys including sampling for fish eggs and larvae and adult fish assemblages at sensitive receptors likely to be impacted by the effluent plume	Ichthyofauna UVC, fish eggs and larval zooplankton tows	Monthly
Regular monitoring of turtle nesting beach during the nesting season	Tracks, nests, waste and timing and frequency of hatchling emergence	Daily during nesting season (early morning)

5.4.2 Monitoring Programme for the first Three (3) Months (Construction)

The construction activities during the three (3) months from August to October 2019 will include the following:

- Construction of temporary construction jetty if required (September);
- Pushing fill material from the beach out into the marine environment to create a construction platform from which the open intake channel can be excavated (October);
- Dredging of the open intake channel and associated breakwater toe trench (October); and
- Start of construction of the rock revetment protecting the open intake channel (i.e. placement of quarry run core material placed using dumper trucks and excavators).

The marine contractor will be required to fully comply with all mitigation measures set out during the initial three (3) months of works, and environmental monitoring will be required to commence in advance of the start of any works in the marine environment. The monitoring works are to be conducted by an EAD-licensed environmental consultant, with monthly reporting to EAD proposed in advance of the approval of the Marine CEMP to provide reassurance that all necessary measures are being implemented. 5Capitals will provide additional oversight on behalf of ACWA Power and the international lenders. The detailed environmental monitoring plan and reporting requirements are detailed in the below table.

It should be noted that dredging works are not anticipated during the first two (2) months of the construction works and until the dredging management plan has been approved by EAD.

Table 5-211 Monitoring Plan during First Three (3) Months of Offshore Construction

Key Performance Indicator	Monitoring Activity/Methodology	Trigger for Corrective Actions	Corrective Actions
No elevated turbidity outside of the protective high-density silt screens	Discrete daily in situ monitoring at five (5) locations in the vicinity of the construction works. Measurements to include the following parameters, as minimum: • Turbidity • Chlorophyll-a • Dissolved Oxygen Continuous real-time monitoring of turbidity downstream of dredging and excavation works. Water quality monitoring buoy to be situated between the dredging works and the nearest sensitive receptor (i.e. seagrass beds, Taweelah Complex seawater intake channel)	Exceedance of EAD Ambient Water Quality Objectives outside of the protective silt screens.	In the event that monitoring identifies an exceedance of the relevant water quality objectives, works are to cease until readings reduce to background and protective silt screens are replaced / repaired
No unauthorised mortality of critical fauna and flora will occur as a result of the construction activities	• Monthly sampling for fish eggs and larval zooplankton at four (4) locations • Quarterly monitoring of benthic infauna at four (4) fixed monitoring locations	• Evidence of negative impacts on sensitive flora and fauna as a consequence of the construction works (i.e. smothering of benthic communities)	• Activities carried out on the construction site and in the vicinity of the monitoring location during monitoring shall be reviewed to determine if exceedances are associated with the Project construction

Key Performance Indicator	Monitoring Activity/Methodology	Trigger for Corrective Actions	Corrective Actions
	• Seagrass monitoring surveys at five (5) fixed monitoring transects prior to the start of construction and monthly during the construction phase • Benthic monitoring surveys at two (2) fixed transects at the boundary of the Ras Ghanada Marine Protected Area prior to the start of construction and monthly during the construction phase • Daily visual inspections of turtle nesting beach to be conducted during early mornings during the turtle nesting season (March to end of June)	• Evidence of disturbance to nesting Hawksbill turtles	activities on-site • If necessary, cease the construction activity causing the disturbance, and identify and implement appropriate corrective actions • All necessary corrective actions are to be fully implemented and approved by the Project consultant prior to works re-starting
No contaminated dewatered water is discharged to the marine environment. Dewatering activities do not elevate turbidity in the receiving waters	Monthly monitoring (sampling and analysis) of: • pH; • Electrical Conductivity; • Total Dissolved Solids; • Total Suspended Solids; • Nitrate	Exceedance of RSB Trade Effluent Control Regulations (2010)	• Contaminated dewatered water is appropriately managed without causing any unacceptable impacts to environmental and human receptors. • Groundwater discharged at high velocity that is generating high turbidity in receiving

Key Performance Indicator	Monitoring Activity/Methodology	Trigger for Corrective Actions	Corrective Actions
above EAD AWQO threshold.	• Nitrite • Phosphorous • Metals • TPH		waters is to be discharged at a lower rate and redirected in to deeper receiving waters, as necessary
No disturbance to nesting Hawksbill turtles or other sensitive ecological receptors as a consequence of excessive light spill.	Spot measurements at the boundary between the construction site and the turtle nesting beach on a weekly basis during the turtle nesting season	Exceedance of 50 LUX at the monitoring location	• Identify source of excessive light spill and remove or redirect lighting • Additional monitoring to be conducted to confirm excessive light spill has been remediated. Exceedance and remediation to be documented.
No unnecessary waste is generated. Adequate waste management facilities are provided onsite. No waste is indiscriminately dumped.	• Visual inspection of waste management facilities. • Keep records of the following data: o Types and volume of wastes generated; o Date and time for transport to either materials recovery facility or landfill disposal; and o Chain of custody/manifests for waste transport and disposal. Monthly Waste Management Report	• Observation of inadequate waste management measures / poor housekeeping / nuisance odour during daily site inspections. • Damaged / leaking / overflowing septic tank. • Expired NOC / licence of the ESPs. • Inadequate maintenance of waste transport and disposal	Upgrade waste management facilities, where necessary.

Key Performance Indicator	Monitoring Activity/Methodology	Trigger for Corrective Actions	Corrective Actions
Wastes generated are accounted for (i.e. whether reused, recycled, or disposed to landfill) as evidenced by waste transport and disposal manifests. No nuisance odour is generated from waste stockpile/storage. CWM accredited ESPs are commissioned for waste transport, disposal and treatment requirements. No liquid waste is indiscriminately discharged onsite or offsite. All regulatory NOCs are obtained for waste	submission, in line with the CWM requirements.	manifests. • Receipt of complaint.	

Key Performance Indicator	Monitoring Activity/Methodology	Trigger for Corrective Actions	Corrective Actions
management.			
No chemical or hazardous waste is indiscriminately dumped on-site or off site. Hazardous wastes generated are accounted for as evidenced by waste transport and disposal manifests. Asbestos containing waste materials are appropriately identified and managed. No significant chemical or hazardous materials spills occur on-site.	◗ Daily inspection of storage and handling areas. • Inventory of hazardous substances stored on-site.	◗ Accidental spill or leakage. ◗ Expired NOC. ◗ Inadequate maintenance of waste transport and disposal manifests. • Receipt of complaint.	• Upgrade chemical and hazardous materials storage facilities, where necessary.

5.4.3 Monitoring Program for Cumulative and Residual Impacts

The monitoring program provided in Table 520 includes the evaluation of cumulative and residual impacts associated with the Project.

6 Waste Management

6.1 Description of the Environment

6.1.1 Waste Generation

Figures released by the EAD in the State of Environment Report (2017), reports that approximately 8.48 Mt of waste was generated during the year of 2015 in the Emirate from the estimated 2.67 million residents currently inhabiting the area (EAD, 2016). Of the total waste generated, it is estimated that 99% (i.e. 8.44 Mt) was categorized as non-hazardous and 1% (i.e. 84 thousand tonnes) was classed as hazardous. Of the waste received for disposal or treatment in 2015, 66% was disposed of in landfills, 28% was recycled and 6% was composted. The per capita generation rate within the Emirate is reported to be 1.65 kg per day.

The 8.44 Mt non-hazardous waste generated in 2015 within the Emirate of Abu Dhabi was comprised of:

- Construction and demolition waste: 34%;
- Industrial and commercial waste: 39%;
- Agriculture waste: 6%;
- Municipal waste: 20%; and
- Others (including sludge and oil and gas sector waste): 1%.

An ongoing survey with Bayanat (EAD, 2017) shows that illegal dumping within Abu Dhabi is a very prevalent issue where there has been a 32% increase in the number of illegal dumping sites since the previous EAD State of the Environment Report (2016).

6.1.2 Waste Management in the Emirate of Abu Dhabi

The three government entities responsible for waste management in the Emirate are the EAD, CWM and DMA. Their roles and responsibilities are outlined in the table below.

Table 6-1 Roles and Responsibilities of Government Entities in the Waste Management Sector.

Entity	Responsibility
EAD	• As the competent Authority • Developing government and targets • Regulating the waste management sector and enforcing the waste laws and regulations
CWM	• Operating the waste management sector together with private sector contractors. • Developing the infrastructure, setting prices and managing the overall

ENTITY	RESPONSIBILITY
	operational budget and public investment programmes. • Identifying and adopting the appropriate technologies for integrated waste management.
DMA	• Setting standards that contribute to better practice in waste generation. • Monitoring and inspecting illegal waste dumping.

In 2015, EAD, Tadweer (Centre of Waste Management – Abu Dhabi – CWM), the Federal Authority for Nuclear Regulation (FANR) and the Abu Dhabi Sewerage Services Company (ADSSC) developed a high-level strategy for Abu Dhabi waste management. This strategy aims to upgrade the Emirate' s waste management infrastructure, operations, monitoring and funding mechanisms in the course of the next 5-10 years.

In line with this newly developed strategy, EAD and Tadweer established a set of policies and guidelines aiming to reinforce sustainable waste management in the Emirate of Abu Dhabi. The new policies include the initiatives listed below and will serve as a framework for the waste sector. It is also planned that these policies will assist EAD in their mission to create a complete integrated system that encourages recycling and reuse, reducing the waste sent to landfills.

- Waste planning;
- Waste classification, licensing and enforcement (including a newly created technical guideline for classification);
- Waste collection, segregation, transfer and tracking;
- Waste reuse and recycling; and
- Resource recovery, treatment and disposal.

Waste generation in Abu Dhabi Emirate is expected to increase due to the growth of the population and economy. It is projected that increases in the following sectoral quantities of waste will be recorded in the upcoming years:

- Municipal solid waste – 6%;
- Construction and demolition waste – 2%; and
- Industrial waste – 7%.

In order to establish a world-class sustainable waste management system which diverts polluting waste away from landfill disposal and maximises resource recovery properly, the UAE have set two strategic targets to be achieved by all emirates by 2021 (1.5 kg MSW capita/day and 75 % of MSW generated to be treated). Also, Abu Dhabi Emirate, through the Abu Dhabi Plan, set a national target that should be achieved by 2020 whereby a total of 60 % of total waste generated is to be treated using environmentally and economically sustainable methods.

The latest Waste and Environment Annual Report for Abu Dhabi (2016) shows that the following waste facilities are in place and operational within the Emirate:

- 10 controlled dumpsites (i.e. Al Dhafra, Al Ain, Ruwais, Madinat Zayed, Al Mirfa. Al Jabanna, Al Sila'a, Al Gurban and ADNOC);
- 10 transfer stations (i.e. Al Mafraq, Remah, Al Wagan, Al Hiyar and Sweihan);
- One (1) sanitary landfill site in Al Ain;
- Two (2) sorting plants located in Al Ain and Al Dhafra;
- Four (4) compost plants in Al Ain, Al Mafraq, Liwa and Al Khatim;
- Two (2) recycling plants for construction and demolition crushing plants in Al Ain and Al Dhafra;
- One (1) recycling plant for engine oil in Musaffah;
- One (1) waste tyre plant in the Western Region; and
- Two (2) medical and animal waste incinerators in Al Ain.

6.1.3 Waste Management and Disposal for Project

Site walkovers conducted at the Project site by the EIA and ESIA teams in 2018 and 2019 found that the site did not contain any significant formal or informal waste or waste storage areas. Small amounts of wind-blown plastic and causally disposed general waste were identified, however, there was no record of significant waste issues or potential contamination.

Tadweer is the regulator of the waste management sector in Abu Dhabi. The majority of waste generated in Abu Dhabi is disposed of to landfill. The closest landfill to the project site is the Al Dhafra landfill, which is located approximately 100 km from the project site. The majority of waste generated during the construction phase of the project is likely to be diverted to this landfill.

The site of disposal for operational waste, in particular waste sludge generated by the water treatment facilities, will be detailed within the OESMP prepared 3 months prior to operations.

6.2 Environmental Impact Prediction and Evaluation

6.2.1 Construction Phase Impacts

The types of solid waste materials likely to be generated during the construction phase of the Project include:

- Spoil from earthmoving activities and excavation works;
- Concrete waste;

- Plastic waste (e.g. packaging materials, pipes);
- Metal (e.g. reinforcement bars, aluminium window panels, electrical and telecommunication wires);
- Wood (e.g. packaging materials);
- Glass (e.g. scrap glazing);
- Ceramics (e.g. finishing materials);
- Paper (e.g. office supplies, cardboard, packaging materials);
- Food wastes; and
- General refuse.

These types of waste are generally easy to manage, with a large component that is either reusable on-site (e.g. excavated materials to be used for backfilling, where applicable) or recyclable via an off-site facility. Food waste and other domestic garbage on the other hand would require regular collection for disposal to an appropriate landfill.

The following are the key components of liquid waste anticipated during the Project construction:

- Domestic sewage from toilets;
- Concrete truck washing;
- Equipment washing; and
- Dewatered groundwater from excavation works (if required).

Sewage will be generated from washing and toilet facilities on-site. Sewage will be collected for off-site disposal by a CWM-accredited ESP.

Typical construction hazardous wastes will also be generated and these include:

- Paint;
- Oil, fuel and grease;
- Batteries;
- Light bulbs;
- Electrical equipment (i.e. from relocation of services);
- Adhesives;
- Solvent; and
- Containers of hazardous materials.

Spill clean-up and contaminated materials will also be considered and managed as hazardous waste.

Hazardous wastes require segregation from the non-hazardous waste and suitable storage facilities on-site prior to collection for off-site disposal. While hazardous waste is commonly generated in much smaller quantity than non-hazardous waste, the environmental risk associated with its storage and disposal is considered to be significantly greater.

Though the volumes of waste generated at the site are not anticipated to be high, given the comparatively small scale of the development, inadequate waste management can still generate adverse environmental impacts, including the following:

- Risk of soil and groundwater contamination. The risk is primarily associated with the temporary storage of sewage, diesel and hazardous waste on-site which could result in spill / leaks contaminating the soil. If soil contamination is not mitigated, contaminants have the potential to migrate towards the groundwater.
- Risk of stormwater and marine pollution. Litter and other contaminants (e.g. oil, grease) associated with the construction works could enter the marine environment via wind dispersion or stormwater discharge. Although an impact may not be readily apparent at the time of the discharge, some contaminants (e.g. oil, trace metals from waste paints) tend to be bioavailable to the flora and fauna in the marine environment, accumulate in the sediment and released in water under favourable redox conditions with further impact on water quality in the marine environment.
- Risk of injury or death to marine flora and fauna. When deposited into the marine environment, construction debris could potentially result in injury / harm or death of marine species such as fish (e.g. clogging of fish gills, entanglement). Deposition of fine waste materials (e.g. erosion of excavated materials) into the marine environment negatively impacts marine flora as it reduces light availability for photosynthesis.
- Nuisance odour due to inadequate storage of putrescible wastes and leakage from portable toilets and temporary septic tanks. Such an issue is typically localised, and the sensitive receptors likely to be affected are construction workers. Odour may also be a potential indication of contamination (e.g. leak / spill of sewage, chemical waste or oil waste).
- Vermin infestation (e.g. rats, flies and mosquitoes). This is mainly related to food waste, which, when left uncontrolled or not routinely collected, has the potential to encourage vermin infestation on-site.

Adverse impacts associated with waste management can generally be avoided via the implementation of suitable management measures. Where impacts cannot be avoided (e.g. soil contamination), the extent is typically localised and reversible if cleaned-up immediately.

Construction wastes from the Project will eventually generate additional strain on the existing waste management infrastructure and services in the Emirate of Abu Dhabi. It is noted that construction waste already accounts for a large proportion (43%; EAD 2017) of the total waste generated in the Emirate.

Cumulative Impacts

Construction waste from the Project will add to the waste loads to existing waste management infrastructure and services in Al Ain as well as the Abu Dhabi Emirate (e.g. Al Dhafra landfill site, waste transfer facilities, recycling facilities and treatment plants).

6.2.2 Operational Phase Impacts

The primary waste streams generated during the operational phase are likely to be the brine discharge and sludge generated from the seawater filtration process.

During the generation of potable water, the extracted seawater will constantly be filtered prior to entering the RO process. This will constantly generate sludge from the DAF process (Section 5), as well as brine from the RO process which will need to also be discarded of in an appropriate fashion. The sludge will be treated in the sludge treatment plant, located on site. The brine will be discharged directly in to the sea. It is anticipated that the brine will be discharged at a rate of 15.932 m^3/s from the SWRO plant in to the marine environment. This discharge will not be high in nutrients due to the water filtration process prior to the RO process. However, the brine will be very high in salinity (approx. 80 PSU). In order to mitigate the impacts of high salinity HDR has carried out a modelling exercise to identify the most compliant discharge structure in to the marine environment (Section 5).

A by-product of the wastewater treatment process is the generation of sludge. Sludge will be dry compressed to remove as much liquid as is feasible. Waste sludge will be regularly removed off-site and disposed of in a suitable matter at an EAD approved and certified landfill site.

Employees and visitors will generate relatively small volumes of sewage and domestic wastewater. This will be transferred to an on-site septic tank for temporary storage prior to disposal off-site by a CWM-accredited ESP to the closest STP. The day-to day operation will also generate small volumes of packaging, office waste and domestic organic waste.

It is almost certain that the brine generated from the Project as discussed in section 5 will have negative environmental impacts on the marine environment. If not managed appropriately, the other Project operational wastes are likely to generate negative environmental impacts. If not managed properly, other waste streams could lead to generation of odour, vermin infestation, hazard to Project employees and visitors as well as the terrestrial flora and fauna.

Waste from the Project's operation, though relatively small scale, will contribute to placing additional strain on the Emirate of Abu Dhabi's municipal waste collection, disposal and treatment infrastructure.

Cumulative Impacts

The main cumulative impact for this Project with regards to waste management will be additional brine effluent (concentrated seawater) discharged into the marine environment. However the modelling undertaken by HR Wallingford predicts no more than 0.2 PSU increase at the Marine Protected Area of Ras Ghanada. The outfall design has been optimized through multiple modeling activities as detailed in the marine section.

As only minimal amount of waste will be generated from the operation of the infrastructure components, the cumulate impact of this aspect of the Project is considered negligible.

6.3 Mitigation Measures

6.3.1 Potential Mitigation Measures

Impact Description	Potential Mitigation Measures	Regulation/Standard
	Construction Phase	
Generation of waste (non-hazardous; solid and liquid), with potential risk of pollution (stormwater, soil & groundwater) onsite, and the nearby desert environment.	Implement waste minimisation program / measures: • Efficient design, procurement and materials management; and • Procurement policies. • Reuse and recycle waste, where possible. • Segregate waste at source (where possible) and allocate suitable waste containers. • Provide waste management facilities onsite, including suitable waste containers / bins. Food waste bins to be provided with lids. • Label waste bins / containers and storage areas, in Arabic, English and Urdu (as a minimum). • Locate waste bins / containers strategically (e.g. work areas, rest areas, canteen). Waste containers / stockpiles to be located away from sensitive areas. • Restrict access to waste storage areas / facilities, with warning signs put in place.	Federal Law No. 24 of 1999 AD Law No. 21 of 2005 AD EHSMS RF CoP 54.0 - Waste Management IFC General EHS Guidelines
	Reuse of waste: • Preference of materials with minimum packaging. • Arrangements with the suppliers for the return or buy-back of containers and packing materials. • Preference for pre-fabricated / pre-casted structure or materials. • Preference for environmentally friendly materials, such as those that are wholly or partly recycled. • Re-use of excavated materials for fill purposes during site development or foundation works, ensuring that materials are geotechnically	As above

Impact Description	Potential Mitigation Measures	Regulation/Standard
	suitable for purpose, • Use of scrap materials such as wood and metals for temporary structures on-site. Drip trays could also be made from scrap metal sheets. • Recycling of concrete waste and washings. An arrangement where such waste can be sent back to the supplier / concrete batching plant for recycling will be considered. • Recycling through EAD/ADM approved service providers. Where possible, paper, wood, metal and plastic wastes will be sent to suitable recycling facilities.	
Generation of hazardous waste	• Maintain a log / inventory of hazardous wastes and where possible look to substitute / minimize the product or process producing the waste. • Provide bunded storage area or drip trays for hazardous waste. The bunded area will have a capacity to contain at least 110% of the total volume of the largest container. • Drip trays to be provided for petrol-operated equipment and during handling of chemicals (e.g. at workshops). • Provide spill kits and fire extinguishers where there is risk of spill and fire, respectively. • Arrange for regular collection of hazardous waste for offsite disposal by suitably licensed ESPs.	Federal Law No. 24 of 1999 AD Law No. 21 of 2005 AD EHSMS RF CoP 1.0 - Hazardous Materials CWM Technical Guideline on Requirements and Procedures for the Disposal of Hazardous Waste IFC General EHS Guidelines
Generation of sewage.	• Provide a suitable temporary sewage holding tank onsite. • Arrange for regular collection of sewage for offsite disposal (i.e. sewage to be collected when tank is at 80 % of capacity) by ESPs. • Locate sewage storage tanks away from sensitive areas (e.g. site offices).	Federal Law No. 24 of 1999 Uniform Plumbing Code of Abu Dhabi AD Law No. 21 of 2005 AD EHSMS RF CoP 54.0 - Waste Management IFC General EHS Guidelines
Generation of dewatering water.	• Reuse treated effluent where possible (e.g. dust suppression).	ADM Circular No. 8
Generation of equipment / truck	• Truck washing (e.g. concrete / cement trucks) to be undertaken at designed bunded area. • Reuse / recycle equipment washings, for the	Federal Law No. 24

Impact Description	Potential Mitigation Measures	Regulation/Standard
washings.	same purpose as much as possible. • Consider undertaking washing / cleaning of equipment off-site.	of 1999 IFC General EHS Guidelines
Waste management requirements	• Provide appropriate training and PPEs to relevant staff. • Regular beach cleans to remove marine debris before and during turtle nesting season (mid-March to mid-June)	AD EHSMS RF CoP 54.0 - Waste Management
Operation Phase		
Organic waste from landscaping	• Organic waste from landscaping to be stored in designated areas. • Ensure regular collection of organic waste for disposal to appropriate disposal facility.	Federal Law No. 24 of 1999 AD Law No. 21 of 2005 AD EHSMS RF CoP 54.0 - Waste Management IFC General EHS Guidelines
Sludge and effluent production	• Rigorous sludge treatment process • All effluent treated to a level where the waste stream leaving the site is compliant with EAD guidelines	IFC General EHS Guidelines
Waste management requirements	• Regular beach cleans to remove marine debris before and during turtle nesting season (mid-March to mid-June)	AD EHSMS RF CoP 54.0 - Waste Management IFC General EHS Guidelines

6.3.2 Selected Mitigation Measures

Construction Phase Impacts

Consistent with the hierarchy of waste management, the following measures will be implemented during construction. Contractor(s) (including sub-contractors) as well as other relevant entities (e.g. site visitors) will be required to adhere to these measures at all times:

- Contractors and sub-contractors will be required to identify the types of waste generated from their activities. Waste registers will be maintained and kept updated on a regular basis (i.e. minimum of monthly) depending on waste generation rates;
- Waste minimisation through efficient design, procurement and material management practices. Construction Work Methods will be developed and

corresponding site instruction issued to facilitate the efficient use of construction materials and minimise waste generation. Other waste minimisation measures will include:

- Adopting policies such as double sided printing at administration offices to reduce paper wastage; and
- Use of high-pressure water spray for equipment / plant washing / cleaning;

• Implementation of procurement policies. Standard procedures for procurement of construction materials, consumables and equipment / plant will include, where possible:

- Specifying the actual quantity of materials required for construction;
- Ordering of materials in bulk to minimise packaging waste;
- Preference of materials with minimum packaging;
- Arrangements with the suppliers for the return or buy-back of containers and packing materials; and
- Preference for environmentally friendly materials, such as those that are wholly or partly recycled;

• Waste reuse and recycling. Reuse of scrap materials for onsite works should be considered a priority. Specific measures to be undertaken include:

- Establishment of waste segregation areas on construction sites. The minimum requirement is to segregate the hazardous waste from the non-hazardous stream. Further segregation (e.g. paper, wood, metal, plastic) will facilitate recycling both onsite and offsite (i.e. ESPs);
- Re-use of excavated materials for fill purposes during site development or foundation works. This would be subject to a geotechnical study to ascertain the suitability of the materials for fill purposes;
- Use of scrap materials such as wood and metals for formworks and other temporary structures onsite. Drip trays could also be made from scrap metal sheets;
- Reuse of dewatered effluent (i.e. ensuring that it is of suitable quality / after settling of solids) for dust suppression;
- Recycling of concrete waste and washings. An arrangement where such waste can be sent to the concrete batching plant for possible recycling will be considered; and
- Recycling through CWM-approved ESPs. Where possible, paper, wood, metal and plastic wastes will be sent to suitable recycling facilities;

• Provision of appropriate waste bins. Different waste types require different bins. For example, food wastes require bins with lids to avoid vermin infestation, and sharp waste materials will require sturdy waste bins. Skips and bins will also be covered to prevent littering by light-weight materials, particularly during periods of strong wind which could disperse litter offsite (e.g. to the protected sand dunes area);

• Labelling of waste bins / containers and collection areas. The labels will be written in English and other languages understood by the workers, and will include the name of the waste and safety risks and precautions (i.e. for hazardous waste). This will assist workers in segregating waste properly thereby minimising the risk of cross contamination;

- Strategic location of waste bins / containers. Areas where waste is produced (e.g. work areas, canteen) will be provided with suitable waste bins / containers. Waste stockpiles will be located away from stormwater flow paths;
- Provision of a suitable temporary sewage holding tank onsite. The tank will be leak proof to prevent soil contamination or health issues. A contractor will be used to ensure that the volume of sewage will not exceed 80% of tank capacity, and regular collection of sewage for offsite disposal will be arranged. Sewage tanks will be located away from sensitive receptors (e.g. site office);
- Designate bunded areas for equipment and vehicle washing; the wastewater will be collected in tanks for offsite disposal or reuse on site if safe to do so;
- Provision of bunded storage area and drip trays for hazardous waste. The bunded area will have a capacity to contain at least 110% of the total volume of the largest container. Containers will be clearly labelled with the name of the waste, as well as safety warnings / signage. Where practical, bunded areas will be provided with a roof to prevent them from being filled with water during heavy rains. Drip trays will also be provided for petrol-operated equipment and during handling of chemicals (e.g. at workshops). Spill kits and fire extinguishers will be available where there is a risk of spill and fire, respectively;
- Provision of training and PPE. Staff designated to handle or manage construction waste will be provided with training on the proper handling, storage and disposal of waste as well as the proper use of PPE. Access to waste storage areas, particularly hazardous waste, will be restricted and signs will be posted at these areas; and
- Use of CWM-approved ESPs. Only CWM-approved ESPs will be engaged for the disposal of construction waste. A waste collection log will be maintained, and copies of waste manifests / chain of custody will be compiled to ensure that wastes were disposed of to a licensed facility.

With consistent implementation of the above mitigation measures, waste and other associated impacts from the construction are not anticipated to adversely affect the Project site.

Operational Phase Impacts

The WMP integrates the following key measures:

- Waste minimization: Implement a waste minimization program tailored to the Facility's day-to-day activities / operations. Induction training for all employees to ensure they are fully aware of waste management procedures and rationale behind implementation of waste management procedures;
- Waste segregation: Waste segregation should be implemented. Suitable and dedicated waste storage bins will be allocated to facilitate waste segregation at-source and reduce risk of cross contamination issues.

- Provision of suitable waste management facility: Appropriate waste collection bins / skips and storage facilities will be provided and strategically located such that they are at adequate distance from the marine environment. The design of the principal waste management facility (the wastewater treatment plant) will ensure all wastewater from the facility is sufficiently treated prior to discharge to the marine environment. Adequate ventilation and housekeeping should be maintained at the facility.
- Sewerage waste should be discharged into the dedicated septic tank. The septic tank will be constructed and installed in accordance with DM requirements for hazard liquid storage tanks. Discharge of liquid waste into marine water or connecting the discharge network to the stormwater drains will be prohibited.
- Dedicated, sealed storage receptacles for sludge generated by the wastewater treatment plant.
- Use of CWM approved service providers: The collection of waste on a regular basis will be arranged through CWM approved service providers.

Additionally, a rigorous sludge treatment process will be implemented. All effluent will be treated to a level where the waste stream leaving the site is compliant with EAD guidelines.

6.3.3 Mitigation Measures to Address Cumulative Impacts

In general, the consistent implementation of waste minimisation and management measures specified above will reduce the potential for odour emissions, marine contamination, soil contamination, safety hazards and the risk of stormwater pollution or clogging of stormwater drainage. Opportunities for waste reuse and recycling will be identified and optimised where possible to reduce the quantity of waste requiring disposal at landfill.

6.3.4 Residual Impact

Generation of waste cannot be wholly avoided, and nor will waste be entirely recycled or reused. Food and other biodegradable waste and non-recyclable waste will be disposed of at an appropriate landfill site while hazardous waste will be treated prior to final disposal.

6.4 Monitoring Program

6.4.1 Monitoring Program for Compliance with Selected Mitigation Measures

The table below presents the proposed monitoring program to ensure that mitigation measures for waste impacts are effectively implemented.

Table 6-2 Monitoring Requirements

IMPACT	MITIGATION MEASURES	MONITORING REQUIREMENTS	MONITORING SCHEDULE

IMPACT	MITIGATION MEASURES	MONITORING REQUIREMENTS	MONITORING SCHEDULE
Construction Phase			
Generation of construction waste (non-hazardous and hazardous; solid and liquid), with potential risk of pollution (stormwater, soil & groundwater) onsite and the nearby desert environment.	Waste minimisation program / measures: Efficient design, procurement and materials management. Procurement policies.	Keeping records of actual materials consumed against Bill of Quantities. This will assist in determining whether there was unnecessary wastage. Maintaining waste inventory.	Monthly
	Waste reuse and recycling program / measures.	Maintaining logs for waste collected and sent to recycling facilities. Keeping records / copies of waste transfer notes / manifest.	As per collection schedule
	Waste segregation at source (where possible) and allocation of waste containers.	Visual inspection of waste storage areas to ensure waste is segregated properly and that there is no cross contamination.	Daily
	Provision of waste management facilities including waste containers / bins. Food waste bins will be provided with lids.	Visual inspection to check general site housekeeping.	Daily
	Labelling of waste bins / containers and collection areas in Arabic, Urdu and English and language understood by the staff members / contractors who have to manage the waste.	Visual inspection of waste storage facilities / areas.	Daily
	Strategic location of waste bins / containers (e.g. work areas, rest areas and canteen). Waste containers / stockpiles will be located away from stormwater flow paths.	Visual inspection to check general site condition.	Daily
	Waste storage areas / facilities will be restricted, with warning signs put in place.	Visual inspection of waste storage facilities / areas.	Daily

Impact	Mitigation Measures	Monitoring Requirements	Monitoring Schedule
Generation of sewage.	Provision of temporary sewage holding tank (i.e. double skinned and leak-proof) onsite. Regular collection of sewage for offsite disposal (i.e. sewage to be collected when tank is at 80 % of capacity) by ESPs. Sewage tanks to be located away from sensitive receptor areas (e.g. marine environment and site offices).	Visual inspection to check for any signs of leak / spill and ensure that sewage tanks are in good condition.	Daily
Generation of equipment washings.	Reuse / recycle of equipment washings for same purpose.	Visual inspection of washings, to check if they can be reused or need disposal.	Daily
	Use of high-pressure spray for cleaning to minimise water consumption as well as the resulting wastewater.	Keeping records of water consumption.	Daily or as necessary
	Regular collection by ESPs for offsite disposal.	Keeping waste collection logs. Keeping records / copies of waste transfer notes / manifest.	As per collection schedule
Generation of hazardous waste	Provision of bunded storage area and drip trays for hazardous waste. Bunded areas will have a capacity to contain at least 110% of the total volume of the largest container. Drip trays provided for petrol-operated equipment and during handling of chemicals (e.g. at workshops).	Visual inspection of storage areas / facilities.	Daily
	Provision of spill kits and fire extinguishers where there is risk of spill and fire, respectively.	Visual inspection of spills kits.	Weekly
		Visual inspection of fire extinguishers.	Monthly
	Regular collection for offsite disposal by ESPs.	Keeping waste collection logs. Keeping records /	As per collection schedule

Impact	Mitigation Measures	Monitoring Requirements	Monitoring Schedule
		copies of waste transfer notes / manifest.	
Waste management requirements.	Provision of appropriate training and PPEs to relevant staff.	Waste training records.	As per training schedule.
Waste collection and disposal requirements.	Use of CWM-approved ESPs.	Keeping copies of ESP's licenses from CWM.	Prior to engaging ESPs
		Keeping records / copies of waste transfer notes / manifest.	As per collection schedule
Operational Phase			
Generation of organic waste from landscaping	Use of designated waste storage areas. Use of CWM-approved ESPs.	Keeping records / copies of waste transfer notes / manifest.	Monthly

6.4.2 Monitoring Program to Address Cumulative Impacts

The risk of waste resulting in further environmental issues (e.g. soil and stormwater contamination, injury hazards and nuisance odour) will be monitored via visual site inspections to be undertaken during the construction phase of the Project.

6.4.3 Monitoring Program for Residual Impacts

Waste materials requiring treatment and / or disposal offsite will be managed and monitored in line with the CWM Nadafa waste tracking system. Waste records and manifests will be maintained or kept on file as required in the relevant regulations (e.g. AD EHSMS RF).

7 GEOLOGY, SEISMICITY, SOIL AND GROUNDWATER

7.1 Description of the Environment

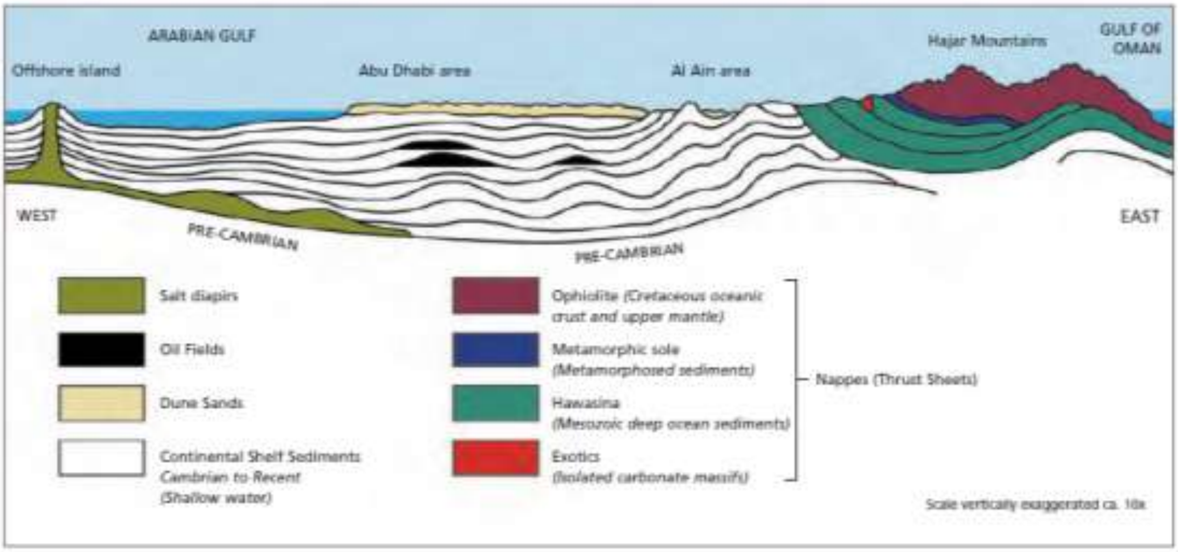
7.1.1 Regional Context

A review of the EAD EnviroPortal shows that the project site is classified as urban, but sits within an area made up of torripsamments, which are dominated by wind-borne sands on dunes and sand sheets. A few of the soils are alluvial sands with little or no gravel. Torripsamments are the most extensive soils in the UAE, covering an estimated 75% of the UAE's surface area (Emirates Soil Museum, 2018). The natural soil profile at the site is likely to have been disturbed during stockpiling and removal of soil at the site in the last 10 years.

Given the proximity of the site to the Arabian Gulf, it is considered likely that groundwater levels at the site are shallow and influenced by marine waters. Salinity is likely to be elevated and levels may shows variation with the tides. The EAD EnviroPortal indicates that the project site sits within the band of maximum salinity, with salinity potentially as high as 125,000 – 165,000 ppm. As such, groundwater at the site is not a potable water resource or considered suitable for irrigation. The site also does not contain any groundwater extraction wells.

The UAE occupies a corner of the Arabian Platform, a body of continental rock that has remained relatively stable since the Cambrian Period more than 500 million years ago. The Arabian Gulf is a shallow tectonic depression formed in the Tertiary period in front of the rising Zagros Mountains. The asymmetry of the depression results in steep coastal slopes and deeper water on the Iranian side, and the low-lying Arabian coastline with adjacent shallow sea floor on the other. This geological structure has resulted in the UAE incorporating an extensive low lying plain on the west side which gradually climbs to the Hajar Mountains in the east.

Figure 7-1 Geology of the UAE



Seismicity

The Arabian Peninsula lies on the Arabian Plate. The Arabian Plate is bordered to the south by the African Plate, to the east by the Indian Plate, and to the west both by a lateral fault known as the Dead Sea Transform Fault and a divergent boundary known as the Red Sea Rift, which runs the length of the Red Sea. To the north lies the Eurasian Plate. The Arabian, African and Indian plates are all moving northward, colliding with the massive Eurasian Plate and causing the uplift of mountain ranges, including the Zagros Mountains of Iran. The forces and energy that occur as a result of tectonic activity in the region will continue to shape the landscape of the Arabian Peninsula into the future (EAD, 2011).

The Zagros Fold and Thrust Belt and Makran Subduction Zone are the only fault systems that have direct effect on the seismicity of the UAE (Abdalla and Al-Homoud, 2004).

Figure 7-2 Tectonic Plates and Faults on Arabian Peninsula

There are two fault lines that run through the UAE namely, the Western Coastal Fault Line and the Dibba Fault Line. The Western Coastal Fault Line runs through the coastal cities of the UAE including Abu Dhabi. It is not known whether the Western Coastal Fault Line is active.

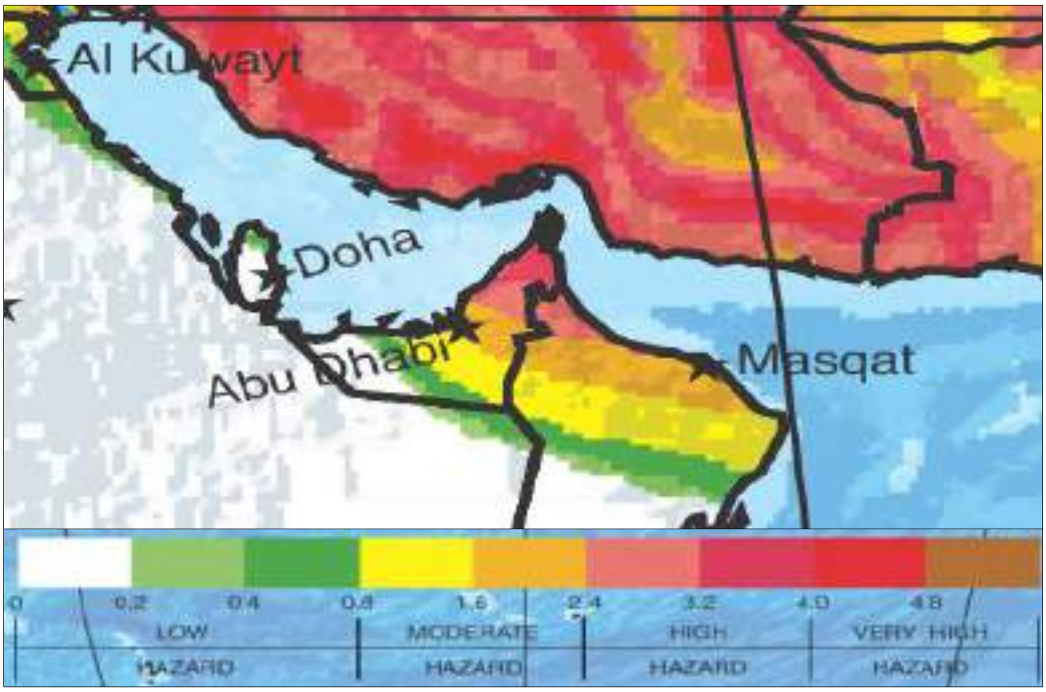
The Arabian Peninsula (including the UAE) has traditionally been considered as a seismically quiet and geologically stable region, with almost all regional earthquakes located on the northern side of the Persian Gulf, within the Straits of Hormuz and Gulf of Oman and in southern Iran. However, recent (2002, 2003) earthquakes have affected the Masafi area located on the edge of the Hajar Mountains between Ras Al Khaimah and Fujairah to the north of the UAE, indicating that the seismic risk in the UAE is potentially greater than originally thought.

The Abu Dhabi Municipality, Town Planning Sector publish seismic hazard assessment maps (Abu Dhabi Municipality, 2012) identifying the area of interest to fall within a low seismic area with a Peak Ground Acceleration (PGA) of between 0.07g and 0.08g (0.7 to 0.8m/s^2) for a 475 year return period event (typically used for design). Similarly even for a 1 in 2475 year extreme event PGA values are below 0.2g.

Figure 7-3 One in 2475 Return Period Peak Ground Acceleration Seismic Hazard Map

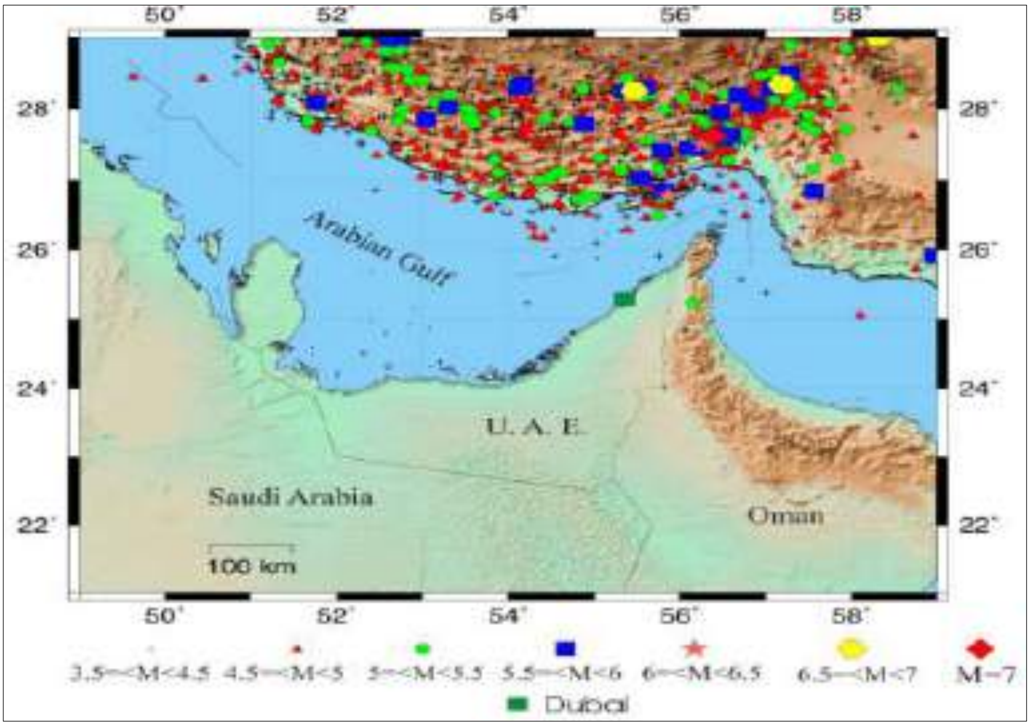
Based on the world scale seismic hazard map produced by the Global Seismic Hazard Assessment Programme (GSHAP), Abu Dhabi is shown as an area of "low to moderate hazard" as seen in the figure below.

Figure 7-4 Global Seismic Hazard Map



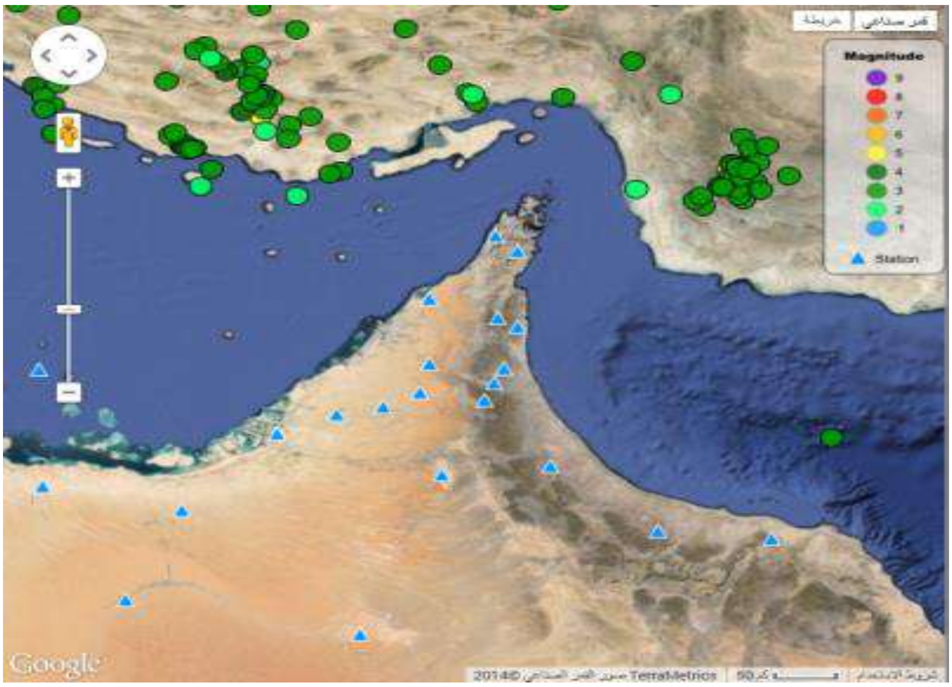
The available maps of recent seismic activity for 1976 to 2006 and December 2013 until March 2014 supports the premise that the seismicity of Abu Dhabi is considered low to moderate.

Figure 7-5 Seismic Activity In and Around the UAE (1973-2006)



Source: http://www.seismo.geodesy.ae/images.aspx?img=figureS3.gif&wid=526

Figure 7-6 Seismic Activity In and Around the UAE (Dec 2013 to Current)



Source: http://seismology.ncms.ae/earthquakes

Geology

Abu Dhabi is situated along the southern part of the Arabian Gulf, at the northeast edge of the Arabian Plate. The present land surface of Abu Dhabi Emirate is predominantly desert sands overlain by sedimentary rock deposited more than 950 million years ago.

The Arabian Gulf is a shallow tectonic depression formed in the Tertiary period in front of the rising Zagros Mountains. The asymmetry of the depression results in steep coastal slopes and deeper water on the Iranian side, and the low-lying Arabian coastline with adjacent shallow sea floor on the other. This geological structure has resulted in the UAE incorporating an extensive low lying plain on the west side which gradually climbs to the Oman Mountains in the east.

The flanks of the Oman Mountains are overlain by the superficial Quaternary deposits consisting of gravels, sands, silt and sabkha. The majority of the Abu Dhabi region is low-lying and covered by these Quaternary sediments.

Soil

Aeolian deposits, which are soil deposits formed through transportation of soil material via wind, dominant in the UAE desert environment. Soils formed through aeolian processes are the least developed young soils without any horizon development and are very widely distributed in the Emirate in the form of loose sandy, hummocky dune soils.

Generally, the soils of Abu Dhabi Emirate are sandy in nature and the texture ranges between sand and sa ndy loam. A typical composition of soil texture of the upper 40 cm (Shahid *et al*., 2004) in the desert soil "Typical Torripsamments" is shown in the table below. The overall textural classification of these desert soils can be summarised as fine sand.

Table 7-1 Particle Size Distribution

Names of Soil Separate	Diameter Range (mm)	Percentage Distribution
Very coarse sand	2.0 - 1.0	1.0
Coarse sand	1.0 - 0.5	3.5
Medium sand	0.5 - 0.25	14.5
Fine sand	0.25 - 0.10	46.0
Very fine sand	0.10 - 0.05	30.0
Coarse silt	0.05 - 0.02	1.0
Fine silt	0.02 - 0.002	0.0
Clay	< 0.002	4.0
Summary		
Total sand	2.0 - 0.05	95.0
Total silt	0.05 - 0.002	1.0
Total clay	<0.002	4.0

Sandy soils have a high infiltration rate (more than 250 mm/h), very high drainage capacity, moderate to rapid permeability, low runoff, and are highly prone to wind erosion.

The Soil Maps of Abu Dhabi indicates the following with regard to the site:

- The areas surrounding the site, including sections of the study area, are flat coastal sandy areas classified as a mix of:

- Typic Torripsamments
- Haplosalids - strongly or very strongly saline soil. Haplosalids have a concentration of salts within 1 meter of the soil surface (salic horizon).

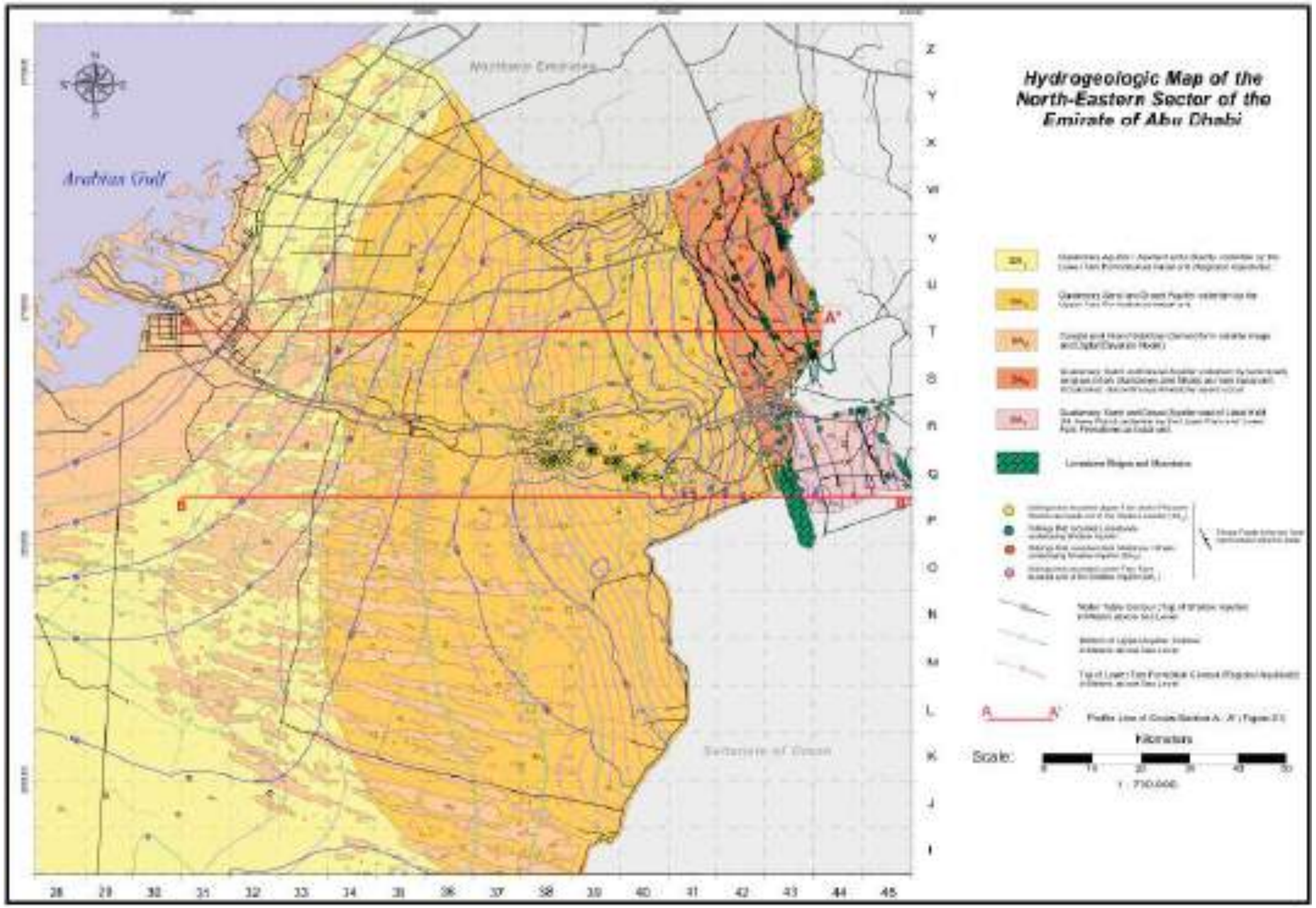
Groundwater

In the UAE, groundwater movement is generally from east to west. Flow times from recharge zones in the east to the sabkha discharge zones along the Gulf coastline can take up to 15,000 years. The slow groundwater movement allows for considerable dissolution of salts in the groundwater (EAD, 2008b).

The main aquifers in the eastern region are Quaternary sands and gravels underlain by the Upper Fars Formation, which continues eastwards into neighbouring Oman, the Lower Fars Formation in the south eastern, Umm Az Zamoul area, limestone bedrock units (Dammam and Simsima) and discontinuous carbonates as part of the tectonically-affected hydrogeology north of Al Ain.

Coastal Abu Dhabi, where the Taweelah site is located, is dominated by sabkha environment and so the groundwater discharging here is hyper-saline, and unsuitable for potable or irrigation use.

Figure 7-7 Hydrogeological Map Showing Groundwater Contours



7.1.2 Baseline Sampling Methodology

Geology and Soils

Four (4) boreholes within the Project site were drilled on the 24 – 27 May 2018, at the locations specified in the table and figure below. In addition, five (5) surface soil samples were collected from across the Project site on the 28th of April 2019. The Sampling methodologies and analytical analysis were as per the EAD-approved TOR (refer to Appendix B).

Table 7-2 Borehole Details

STATION NAME	EASTING	NORTHING	DEPTH	JUSTIFICATION
SGW_01	265,203	2,740,227	5.0	This location is in an irrigated and vegetated area, and is likely the only location at site where prior human activity has been carried out.
SGW_02	264,891	2,740,477	5.0	This location is the most inland and closest to existing industrialised areas.
SGW_03	264,854	2,740,184	5.0	This location is in the centre of the site, and undeveloped.
SGW_04	264,448	2,740,051	5.0	This location is closest to the coast and existing outfall channel.
2019 Surface Sediment Survey				
T1	264748.07	2740055.17	Surface	This area is towards the centre of the project site and is characterized by lighter coloured loose sand.
T2	264942.10	2740456.36	Surface	This site is located in an area that seems to have had some human activity in the past where a foundation for a building has been laid close by.
T3	264853.09	2740399.14	Surface	This area is in a vegetated area close to a small hut building, indicating prior human activity.
T4	264929.12	2740049.88	Surface	This area is located amidst small bushy vegetation near to the centre of the project plot.
T5	264629.92	2740069.38	Surface	This area is located on an existing road access area near to the centre of the project plot.

Figure 7-8 Drilled Borehole Locations

7.1.3 Result of Soil and Groundwater Baseline Survey

This section presents the results of the soils and groundwater baseline survey at the Project site. The technical report for these surveys has been provided in Appendix I.

Soil Analysis Result

The analytical laboratory results of the detected parameters in the soil samples are presented in Appendix I and indicate that barium, chromium, copper, manganese and zinc were the only parameters detected in all four (4) soil samples. However, none of the metal concentrations exceeded the screening level values provided by the 2017 Abu Dhabi Specification Environmental Specification for Soil Contamination and the Dutch soil target values.

The table below presents a summary of the soil analysis results for those parameters with concentrations recorded above the Limit of Detection (LOD) as compared with the Abu Dhabi Specification Environmental Specification for Soil Contamination and Dutch Soil Standards.

Table 7-3 Laboratory Analysis Results for the Detected Parameters in the Soil Samples (2018)

Parameters	LOD	SGW_01 (mg/kg)	SGW_02 (mg/kg)	SGW_03 (mg/kg)	SGW_04 (mg/kg)	ADS Standards	Dutch Soil Intervention Values (mg/kg)
Barium	0.05	29.71	26.05	28.16	19.63	-	**625**
Chromium	0.05	44.82	9.52	29.17	24.16	**63**	**380**
Manganese	0.05	127.91	59.12	240.93	77.53	-	-
Zinc	0.05	66.97	25.55	30.68	16.62	-	**720**
Copper	0.05	7.05	3.51	2.01	1.51	-	**190**

Concentrations of Polyaromatic Hydrocarbons (PAH), BTEX, Phenols and Polychlorinated Biphenyls (PCBs) were below the respective laboratory detection limits in all of the samples collected. As part of the total petroleum hydrocarbon suite, EPH was detected at a concentration of 68mg/kg at SGW_01.

Soils 2019

The analytical laboratory results of the detected parameters in the soil samples are provided in Appendix I. Barium, cadmium, chromium, copper, manganese and zinc were the only metals parameters detected in the five (5) soil samples. However, none of these metal concentrations exceeded the screening level values provided by the 2017 Abu Dhabi Specification Environmental Specification for Soil Contamination.

Concentrations of EPH (C10-C40) were exceeded substantially only in one (1) sample collected from T3 which is located within the flora dense northerly corner of the project site.

EPH levels were 3,150 mg/kg at this station where the PAH's chrysene, fluroanthene and pyrene were also present at the following levels, respectively: 0.02 mg/kg, 0.03 mg/kg and 0.05 mg/kg. This sampling station was located immediately next to a man-made hut structure, where the field team also noted that the specific patch from where soil was collected was discoloured and darker than other areas when the soil was turned over as shown in the images below. It is therefore assumed, due to the very localized nature of the high EPH and PAH values, that the soil sample was likely collected from a small patch of contaminated soil left by anthropogenic activity associated with the hut structure.

Plates 7-1 Man-made Hut Structure at Soli Sampling site T3

Plates 7-2 Discoloured Soil at Site T3

Concentrations of Polyaromatic Hydrocarbons (PAH), BTEX, Phenols and Polychlorinated Biphenyls (PCBs) were below the respective laboratory detection limits in all of the other four (4) samples collected.

Table 7-4 Laboratory Analysis Results for the Detected Parameters in the Soil Samples (2019)

Parameters	Detection Limit	T1	T2	T3	T4	T5	ADS Standards	Dutch Soil Intervention Values (mg/kg)
		Reporting Unit mg/kg						
Barium	0.10	8.87	13.80	14.85	20.14	27.78	**-**	**625**
Cadmium	0.10	3.23	2.92	3.16	3.15	4.52	**980**	**12**
Chromium	0.10	11.90	11.18	6.42	7.42	49.95	**63**	**380**
Copper	0.10	-	-	3.52	-	-	**-**	**190**
Manganese	0.10	92.43	72.45	33.60	97.10	172.90	**-**	**-**
Zinc	0.10	11.28	16.52	43.19	13.12	12.86	**-**	**720**

Groundwater Analysis Result

At the time the piezometers were installed in the boreholes (25th May 2018), the groundwater table ranged between 3.0 – 3.2 meters below existing ground level. During the sampling (13th June 2018) the groundwater table had stabilized at 2.22 – 3.33 m below ground level. However, the level of the groundwater table is dependent on the tidal and seasonal variations. The measured ground water depth at each borehole is presented in the table below.

Table 7-5 Groundwater Table Readings

ID	Groundwater Depth Below Existing Ground Level (m)	
	25th May 2018	13th June 2018
SGW_01	3.15	3.33
SGW_02	3.00	2.22
SGW_03	3.00	2.94
SGW_04	3.20	3.09

<u>In-situ Results</u>

In-situ water quality measurements for groundwater extracted from each borehole were taken on 13th June 2018. The results are presented in the table below. All of the measured parameters except salinity (and related specific conductivity) are within expected ranges for the groundwater on-site. However, considering the close proximity of the boreholes to the marine environment (100-200meters), higher salinity values closer to 35 – 40 PSU would be expected – as encountered at SGW_04. The extremely low salinity values (less than 1 PSU) at SGW_02 can potentially be accredited to potential network leakage from the surrounding industrial infrastructure. SGW_01 and SGW_03 likely reflect normal groundwater conditions.

Table 7-6 Groundwater in-situ Water Quality Measurements

ID	Temp (°C)	Salinity (PSU)	pH	Sp. Cond (uS/cm)	DO (%)	DO (mg/L)
SGW_01	41.9	3.16	7.56	5,977	7.9	0.47
SGW_02	34.0	0.18	8.23	381	7.9	0.5
SGW_03	29.8	4.34	7.45	7,904	6.8	0.5
SGW_04	30.7	42.31	7.13	63,013	52.2	3.09

The results of sample analysis that recorded concentrations above the respective detection limits are provided in the table below, which includes the relevant target and intervention values of the selected chemicals in groundwater. The full set of results are provided in Appendix J for reference.

All concentrations of the measured parameters were compared Dutch Groundwater target values and noted to be below the established target values.

Table 7-7 Analytical Results of Detected Parameters in the Groundwater Samples

Parameter	Reporting Units	Method Detection Limit	Dutch Groundwater Target Value (mg/L)	SGW_01	SGW_02	SGW_03	SGW_04
Arsenic as As	mg/L	0.01	**0.01**	ND	0.019	ND	ND
Barium as Ba	mg/L	0.05	**0.05**	0.045	0.059	ND	ND
Total Dissolved Solids	mg/L	10	-	3757	160.67	3,485.33	42,680.33
Phenols							
Naphathalene	µg/L	0.02	-	0.08	0.12	0.15	0.07
Phenanthrene	µg/L	0.02	-	ND	0.02	0.02	ND
TPH							
VPH C5-C10	µg/L	10	-	ND	ND	ND	ND
EPH C10-C40	µg/L	120	-	362	ND	ND	ND

Note: ND = Not Detected

7.2 Environmental Impact Prediction and Evaluation

7.2.1 Construction Phase Impacts

Soil

Infrastructure construction works at the site will involve extensive earthworks including cut and fill activities, compaction, grading and excavation. Construction is anticipated to result in the following impacts and / or issues, which are typically associated with construction works:

- Land alteration: Construction requires a range of site development works including earthmoving, clearing, excavation, fill placement, grading and other ground preparation works that will directly impact on landform and condition, structure and composition of the site soils. These activities will unavoidably result in changes in the site's existing soil composition.
- There will be major irreversible change to the Project site associated with fill and grading of the area. Whilst impacts within the site boundary will be significant and irreversible, the overall impact of fill activities are considered necessary to develop a stable platform for future development at the site.
- Clearing and excavation works for infrastructure will generate spoil. Spoil may require offsite disposal particularly when its quality is not suitable for fill purposes. Cut and fill activities will be planned to minimise the generation of spoil material that cannot be used at the site.

The enabling works and infrastructure construction have the potential to contaminate site soils in one of the following ways:

- Contaminated fill is imported to site;
- There is an accidental spill or leak of fuel, lubricants, paint, solvent and/or other hazardous chemicals resulting from inadequate storage and handling of these items;
- There is a leak or spill from temporary sewage facilities on site;
- Inadequate storage and management of solid and liquid wastes occurs; and
- Contaminated water (from water tankers) is used for dust suppression and wash down of vehicles, equipment and machinery on site.

If contaminated material is not promptly contained, further contamination may occur in other areas of the site via cut and fill operations, spoil disposal, and surface water transport. Contaminated soil can pose a human health risk to site workers who come into contact with the soil.

- The risk of soil erosion is generally low but would increase as a result of the following:

- There is a lack of appropriate control measures at excavation sites and soil stockpile;
- Heavy stormwater run-off;
- Strong wind;
- Movement of heavy equipment over unsealed tracks and unconsolidated soils; and
- Excessive runoff from dust suppression water and equipment wash-down water.

With regard to soil erosion the potential for significant soil erosion to occur is considered unlikely given that heavy prolonged rainfall rarely occurs in the Eastern Region of Abu Dhabi. It is also expected that standard engineering control measures, such as progressive compaction, will be implemented during construction works.

Groundwater

Construction of the facility may involve foundation excavation below the water table (although invert levels are not yet known). This will generate a temporary discharge from the project, which poses a potential impact, both by

- Removing groundwater from the aquifer and
- Discharging, likely to the marine environment.

The proximity to the coast means that these impacts are typically not significant, if best practice dewatering operation is performed. Rather than abstraction from an aquifer, seawater is essentially recirculated through porous beach deposits, settled in dewatering break tanks before being returned to the marine environment.

Impacts to groundwater quality, through pollution, are generally indirect or secondary to soil quality issues. Typically, groundwater contamination occurs where there is sufficient percolation of contaminated water through the vadose zone and into the aquifer.

The earthworks will require significant volumes of water to be used during mixing of sand with aggregate. At this stage the precise source of the water is not yet confirmed. However, given the water quality requirements (i.e. limits to salinity of water) it is thought that potable water will be imported via tanker. This eliminates the need to extract large volumes of groundwater at the Project site, but also introduces the chance of contamination if contaminated water is used.

However, the overall risk associated with groundwater contamination is considered to be low, due to the following:

- The types of activities to be undertaken during the construction phase do not require or generate large volumes of hazardous materials / wastes;

- Robust controls in place to ensure adequate water quality, spill prevention measures and waste management measures are in place throughout the construction phase;
- The recorded groundwater level on-site is at significant depth of 18.8 to 26.7m from ground surface. Borehole BH110, located at one of the lowest points of the site at the western boundary of the site, was drilled to 35mbgl and groundwater was not encountered;
- The arid climate condition on-site, wherein there is no significant surface/stormwater flow that will infiltrate any contaminants into the groundwater.

Summary of Construction Impacts

The risk for construction activities to generate significant soil and groundwater contamination is generally considered to be minimal, provided that mitigation measures are adopted and consistently implemented on-site.

7.2.2 Operational Phase Impacts

Soil

If appropriately managed, the operation of the infrastructure at the Project site is not generally considered to generate significant adverse impacts on the soil condition. However, activities that have the potential to cause soil contamination include:

- Leak or overflow from potable water transmission infrastructure (albeit that this is a freshening impact);
- Leak or overflow from sewage pipes;
- Accidental spill or leakage from on-site bulk storage (i.e. USTs, ASTs);
- The long-term use of the road by a range of vehicles has the following associated environmental issues:
  - Risk of contamination (i.e. chromium, lead and zinc) resulting from the vehicles' fuel combustion process, lubrication system losses, tyre and brake wear, transportation load losses, and paint; and
  - Risk of contamination particularly in the event of an accidental spill associated with the transport of hazardous substance (i.e. oil and chemicals).

Contaminant deposits on the road have the potential to reach the surrounding soils through storm water run-off or when blown by strong winds, thereby expanding the impact area. Typically, the impacts of the above road contaminants are not immediately evident and would accumulate over time. It is expected that most open space associated with the infrastructure at the Project site will be paved with concrete (i.e. roads) or hardstand which will function as a cap for potential surface contamination sources.

Salinization of the surface soils may occur should there be excessive irrigation of landscaped areas and corresponding accumulation of salts in the surface soils.

Groundwater

If robust spill prevention / waste management practices are implemented at the site, the potential for the operation of infrastructure at the Project site to pose a contamination risk to groundwater is considered limited.

Potential sources of groundwater contamination during the operational phase of the Project are similar to that of soil contamination. Soil would typically be the first point of contamination, during which contingency measures will need to be implemented to prevent groundwater contamination.

Summary of Operational Impacts

The impact of operational activities on soil and groundwater quality is considered minimal. The most significant environmental risk is associated with overflow or leaks from the pipe networks installed for potable water, sewage transfer and landscaping. It is anticipated that the installed infrastructure will incorporate provisions to monitor the networks so that any leaks or overflows will be identified and immediately with impacts to soil and groundwater subsequently minimised.

7.2.3 Cumulative Impacts

Construction Phase

If contaminated material is not promptly and adequately contained, further contamination may occur in other areas of the site via cut and fill operations, spoil disposal, surface water transport (albeit unlikely), and wind deposition. Contaminated soil can also pose a human health risk to site workers who come into contact with the soil.

The soil condition (i.e. loose sand) on-site will also have a potential cumulative impact to the construction dust emissions particularly during windy weather conditions such as those anticipated during the summer months when the Shamal winds blow from the north-west.

Operational Phase

The introduction of sub-surface infrastructure such as a water transport and sewage transfer network does have the potential to affect soil and groundwater quality over time. Installation of infrastructure with leaking pipes that is subject to consistent blockages and overflow is not anticipated and cumulative impacts associated with the operational infrastructure are expected to be minimal.

7.3 Mitigation Measures

7.3.1 Potential Mitigation Measures

The following are potential mitigation measures for soil and groundwater impacts

Impact Description	Potential Mitigation Measures	Regulation/Standards
Construction Phase		
Land alteration.	• Where possible re-use excavated material from the sand dune area at the north of the site (rather than off-site disposal to landfill). • Where importation of soil/aggregate is required implement clean fill importation monitoring and checking measures to confirm no contaminated material is imported to site.	Federal Law No. 24 of 1999 and its Executive Order issued by Council of Ministers Decree No. 37 of 2001 Dutch Ministry of Housing, Soil and Groundwater Intervention Values Guidelines
Potential soil contamination (existing).	• Removal of ACM and hydrocarbon contaminated soil in accordance with Remedial Action Plan set out in the Phase 1 Contamination Assessment.	As above.
Potential soil contamination (future).	• Ensure that water used for dust suppression is of a suitable quality. • Implement the construction waste management measures • Provide a purpose built bunded area for potentially hazardous substances such as fuel, grease, oil, adhesives and other chemicals. • Use dedicated vehicle re-fuelling points / stations. Re-fuelling points to include impermeable hardstand surface, bunding (designed to the volume of fuel stored), fuel bowser / filling gun and signage. • Develop spill or leakage prevention and contingency measures.	As above.
Potential soil erosion.	• Stage construction works and progressively compact or stabilise ground surfaces. • Provide drainage within the site so that loose soil will not be scoured off in the event of high surface	-

Impact Description	Potential Mitigation Measures	Regulation/Standards
	run-off. • Locate soil stockpile away from storm water flow paths.	
Potential for groundwater contamination.	• Effective implementation of the measures proposed to mitigate soil contamination.	As above
Groundwater discharge.	• In the event that groundwater extraction is required, ensure that groundwater is not contaminated (i.e. with oil) and is suitable for discharge to the AAM storm water discharge network.	As above.
Operational Phase		
Potential soil and groundwater contamination from leaking sewage system	• Incorporate system monitoring technology top alert operator to leaks / damage to pipes and / or lifting stations.	As above
Potential leakage of newly-generated potable water	• Quality control of construction standards.	As above

7.3.2 Selected Mitigation Measures

Construction Phase

Soil Contamination Control

The risk of future soil contamination occurring can be mitigated through the following management measures:

- Ensure that imported fill material is of a suitable quality via development and implementation of control measures through the site-wide CEMP. In line with this, the Project Contractor will be required to coordinate with relevant authorities (e.g. EAD and Center of Waste Management) to identify:
- Suitable sites from which clean fill can be sourced;
- Use of water that is of suitable quality for dust suppression and washing of equipment. The source of water will be carefully identified and then monitored throughout the project. Application of water will be controlled in order to prevent increased salinity impacts and alteration of the sub-surface environment;
- Implementation of construction waste management measures;
- Provision of a dedicated bunded area for storage and handling of hazardous substances such as fuel, grease, oil, adhesives and other chemicals. The compatibility of materials to be stored in the area will be also considered in the management of this dedicated area; and
- Development and implementation of spill preventive and contingency measures.

<u>Fuel and Chemical Storage Management</u>

The risk of soil contamination resulting from the fuel and chemicals storage, handling and use will be greatly reduced through the following measures:

- Storage of chemicals on concrete or hard surface base in order to prevent soil and groundwater contamination. The storage capacity of containment is 110% of the total volume of stored materials;
- Locating chemical, fuel and other hazardous materials storage facilities away from sensitive receptors or general public;
- Use of double walled tanks for the storage of fuel or alternatively, single wall tanks mounted on concrete base and bunded with storage capacity of 110% of the total volume of fuel to be stored;
- Pressure testing of fuel storage vessels to ensure the integrity before use;
- Immediate clean-up of spillage or leakage;
- Keeping the amount of chemicals and fuel stored onsite to the minimum;
- Maintaining of a register and updated inventory of chemical and hazardous materials stored/ used onsite;
- Keeping records or copies of Material Safety Data Sheets (MSDS) for all chemicals and hazardous materials;
- Provision of labels and warning signs according to the type of the stored chemical. Labels will be in languages understood by all workers (e.g. but not limited to Arabic, English, Urdu);
- Implementation of control procedures, where feasible, when refilling from oil/fuel storage tanks on-site:

- Maintenance and checking for worn or faulty "O" rings in hose and connector couplings, to reduce accidental oil spills during tank loading;
- Complete drainage of fuel from loading hoses to reduce accidental oil spills during tank loading. An automatic control valve and filling gun can be installed to ensure accurate fuel loading without any spill or leakage;
- Accurate tank level readings and loader attention to avoid negligence, helping to reduce accidental oil spills during loading;
- Installation of spill guards, which capture nuisance spills and overfills when delivering fuels and chemicals by tanker trucks; and
- Undertaking refuelling, repair and maintenance of machine, equipment, vessels and vehicles at designated hardstand areas made of impervious materials and use of collection tanks for any wastewater generated.

- Restriction of access to chemical and hazardous material storage areas to allow access to only qualified and trained personnel;
- Provision of adequate training and Personal Protective Equipment (PPE) (e.g. gloves, mask and protective clothing) to staff designated to handle and use chemical and hazardous materials;

- Provision of precautionary devices such as fire extinguishers particularly in areas where flammable materials are stored or used; and
- Maintenance of chemical spill containment or control kits at storage facilities in order to facilitate immediate clean up during spill incidents.

Equipment Management

The risk of contamination associated with the operation and maintenance of various equipment, plant and vehicles onsite will be reduced through implementation of the following measures:

- Placement of drip trays beneath stationary diesel and petrol operated equipment;
- Regular inspection and maintenance of plant, equipment and vehicles in order to prevent leakage or spill during the course of operation or movement across the construction site; and
- Undertake re-fuelling activities at designated areas in accordance with appropriate procedures.

Soil Erosion Control

Though rainfall is limited in Abu Dhabi there will be significant earthworks undertaken as part of the works. Visual inspection of excavation sites as well as embankments will be carried out as part of the overall monitoring process. This would ensure that any erosion related hazard can be identified and promptly addressed.

Where a risk of soil erosion is identified, the following measures will be implemented:

- Staging of construction works and progressive compaction or stabilization of ground surfaces;
- Efficient drainage within the Project site such that loose soil will not be scoured off in the event of heavy surface run-off (albeit unlikely given the arid climate condition);
- Locating the soil stockpile(s) away from the stormwater flow path; and
- Installation of erosion control structures, where necessary

Operation Phase

The potential for increased soil salinity on landscape areas will be controlled by developing and implementing an irrigation management plan. The form and content of the management plan will depend mainly on the landscape design (i.e. trees and plant species selected). The irrigation management plan will include:

- Schedule and frequency of irrigation;
- Volume and quality of the water to be applied; and

- Method of application (based on the design of irrigation network.

To minimize the risk of increased soil salinity, resulting from excessive water application, the Client will consider drip irrigation or other sustainable irrigation systems rather than the conventional spray system.

Landscape design will also consider the use of native flora species that will not require significant water and other water conservation techniques such as hydra-zoning. The intention of the proposed measures is to reduce the risk of soil contamination and increased salinity associated with TSE irrigation.

In the event of accidental spill from transportation of oil, chemical and other hazardous materials on the road, the party responsible for the spill will be required to immediately undertake spill clean-up and remediation, where necessary. Soil monitoring may also be required depending on the result of the spill investigation and assessment.

7.3.3 Mitigation Measures to Address Cumulative Impacts

Construction Phase

The potential for soil condition (i.e. loose sand, stockpiles) to generate increased volumes of airborne particulates (dust) will be controlled through application of water, progressive compaction of the Project site, and provision of cover to stockpiles of fill materials.

Operation Phase

In general, the proposed irrigation management plan will reduce the risk of increased soil salinity over time. A sustainable type of irrigation system (i.e. drip system vs. spray) will also reduce the risk of increased soil salinity associated with excessive water application.

7.3.4 Residual Impact

The change in soil composition resulting from the cut and fill operations during Project construction will be permanent and irreversible.

With the implementation of the proposed control measures the risks associated with soil and groundwater can be managed and therefore only minor potential groundwater and soil contamination impacts associated with accidental spills are anticipated.

7.4 Monitoring Program

7.4.1 Monitoring Program for Compliance with Selected Mitigation Measures

The following monitoring program in the table below will be undertaken to ensure that the selected measures are consistently implemented and to determine whether these measures are sufficient to reduce soil and groundwater impacts to acceptable level.

Table 7-8 Monitoring Program for Selected Mitigation Measures- Soil and Groundwater

IMPACT	MITIGATION MEASURE	MONITORING METHODOLOGY	MONITORING SCHEDULE
Construction Phase			
Land alteration	Monitoring and checking of fill material imported to confirm that no contaminated material is imported to site.	Analyse representative sample for metals, TPH and asbestos. Sampling frequency to be commensurate with the volume of material imported and the number of fill source sites.	Prior to the importation of clean fill material.
Soil contamination (existing)	Further assess and remediate areas of potential contamination, namely asbestos in the surface soils, and localized hydrocarbon contamination.	Resample existing groundwater wells prior to start of construction to determine presence of possible hydrocarbon contamination.	Prior to completion of the detailed EIA update.
Spoil from clearing and excavation activities.	Reuse materials for fill purposes, where applicable.	Record volume of excavated and cleared materials. Monitor the volume of materials reused onsite.	During excavation works.
	Dispose of excess materials to an appropriate landfill site.	Record volume of materials disposed offsite. Keep record of chain of custody or manifests of such disposal.	Once prior to filling operations.
Potential soil contamination	Ensure that water used for dust suppression is of a suitable quality.	Supplier to provide analytical report on water quality.	Every 6 months.
	Implement construction waste management measures		
	Provide dedicated areas for storage and handling of hazardous substances (e.g. fuel, grease, oil, adhesives).	Visual inspection of bunded area(s).	Daily and immediately after bulk delivery.
	Use of dedicated vehicle re-fuelling points / stations. Re-fuelling points	Visual inspections of refuelling area to ensure the mitigation measures	Daily and immediately after bulk delivery.

Impact	Mitigation Measure	Monitoring Methodology	Monitoring Schedule
	to include impermeable hardstand surface, bunding (designed to the volume of fuel stored), fuel bowser / filling gun and signage.	are implemented.	
	Develop spill or leakage prevention and contingency measures. Use fuel filling gun to enable accurate dispensing of fuel.	Visual inspection of storage facilities for any signs of spill or leakage. Record incidence of spill and leakage including actions undertaken.	Daily and immediately after bulk delivery.
Potential soil erosion	Stage construction works and progressively compact or stabilise ground surfaces.	Visual inspection of ground condition. Monitor compliance with work programme.	Daily.
	Provide efficient drainage so that loose soil will not be scoured off in the event of heavy surface run-off.	Visual inspection of work sites and drainage.	Daily. During rainy/winter season, inspection will be conducted before, during and after a storm event, where possible.
	Locate soil stockpiles away from storm water flow-paths.	Visual inspection of stockpiles, drainage, and general site condition.	Daily. During rainy/winter season, inspection will be conducted before, during and after a storm event, where possible.
	Install erosion control structures, where necessary.	Visual inspection of work sites and control structures.	Daily.
Potential for groundwater contamination.	The proposed measures for soil contamination will reduce potential for groundwater contamination.	Refer to above soil monitoring methodology.	Refer to above soil monitoring methodology.
Operational Phase			
Soil contamination resulting from use of poor-quality TSE for irrigation.	Ensure that TSE to be used is of suitable quality for landscape irrigation.	Testing of a TSE grab sample for parameters including pH, BOD_5, COD, total phosphorus, total nitrogen, oil & grease, TSS, chlorine residual, total coliform, faecal coliform, dissolved oxygen and metals[5].	Quarterly
	Coordinate with RSB to ensure that the TSE requirements of the Project will be available.	Regular coordination / meeting.	Design and construction phases, and during securing of NOCs.

IMPACT	MITIGATION MEASURE	MONITORING METHODOLOGY	MONITORING SCHEDULE
Soil contamination from accidental spill / leak of sewage.	Prepare an emergency spill response plan in event of a spill of raw sewage.	Review of feedback from sewage infrastructure monitoring system.	Daily.

7.4.2 Monitoring Program for Cumulative Impacts

Construction Phase

Dust emissions associated with the soil condition (i.e. loose sand) onsite will be monitored as part of the air quality monitoring program.

Operation Phase

The potential impacts of increased soil salinity can be monitored through visual observation of soil on landscape areas in addition to inspection of flora species for any signs of withering, which can be an indication of highly saline soil condition.

7.4.3 Monitoring Program for Residual Impacts

The change in soil composition resulting from the introduction of fill materials will not require any monitoring, particularly where measures (i.e. ensuring that the fill materials are not contaminated) have been adequately implemented.

8 TERRESTRIAL ECOLOGY

8.1 Description of the Environment

8.1.1 Regional Context

The distribution of vegetation assemblages is dependent upon a range of key drivers including climatic conditions (low precipitation, high temperatures), physical conditions (soils, geology and hydrology) and anthropogenic disturbance regimes (grazing pressure from livestock and off-road driving). Climate (specifically annual rainfall) and substrate are considered to be the major influencing factors in determining the distribution of botanical and zoological communities throughout the UAE and the broader Arabian Peninsula (Abulfatih et al, 2001; Loughland & Cunningham, 2002).

The UAE's aridity is due to a combination of regional and global climatic processes. The Emirate of Abu Dhabi is located within the Gulf region between latitudes 22° 40' and 25° 00' (Perry, 2008) and coincides with the North Temperate margin that occurs between latitudes 24-30° N, a region that encompasses most of the Earth's deserts. These latitudes mark a region between the tropical trade-wind circulation and the synoptic weather systems of mid-latitudes, where sinking dry air produces the clear skies and arid conditions of the Middle East. This is a key driver, which largely influences the distribution of the earth's subtropical 'hot deserts' both north and south of the Equator (Abulfatih et al, 2001). Annual temperatures range from a minimum of 10°C in the winter to summer highs of up to 50°C. Rainfall is infrequent and irregular, averaging approximately 120mm per year or less (Reynolds, 2002). Humidity is high, particularly in the coastal zone, and can be very oppressive in the summer months. The little cloud cover that exists is more prevalent in winter and thunderstorms and fog are rare. Dust storms or haze occur frequently in summer (Reynolds, 2002).

Despite the prevailing climate and increasing level of agricultural activity, natural terrestrial habitats are prevalent throughout the Emirate of Abu Dhabi and can generally be classified as one of the following:

- Tidal flats;
- Beaches and coastal cliffs;
- Mangroves;
- Coastal plains;
- Coastal sand sheets;
- Coastal and inland sabkha;
- Inland plains (alluvial and inter-dunal);

- Mountains;
- Rocky exposures; and
- Wadis.

In addition, anthropogenic habitats within Abu Dhabi can broadly be characterised as follows:

- Oases;
- Farmland;
- Forestry plantations; and
- Urban areas.

Faunal diversity is dominated by avifauna, which dominates the overall biodiversity (Loughland & Cunningham, 2002). Birds constitute nearly 81% of the overall higher vertebrate biodiversity in the UAE. Over 400 species of birds are known to occur in the Abu Dhabi Emirate. A large proportion of these are migrants travelling along either the Afro-Eurasian Flyway or Central Asian Flyway migration routes that pass over the UAE. This rich diversity of bird life is important for conservation due to the large number of species that occur in Abu Dhabi, but also because of the presence of regionally and internationally important breeding and wintering bird species. Other species of fauna known to occur in the Emirate comprises of 54 varieties of reptile, 2 amphibians and 31 mammals (Perry, 2008).

It is estimated that there are approximately 678 species of plants in the UAE and approximately 380 of these have been recorded within the Emirate of Abu Dhabi (Perry, 2008). Many species of vegetation occurring in the UAE also occur in other arid locations of the Arabian Peninsula and North Africa given the similarities in environmental conditions (Abulfatih et al, 2001).

Historical studies of the Taweelah area report that the site consisted of coastal sabkha with windblown corraline sandsheets of varying thickness. Floral communities were typically halophytic and largely dominated by Chenopods and related succulent species. *Zygophyllum qatarense*, *Anabasis setifera*, *Suaeda aegyptica* and *Salsola* sp. Were reported as typical, often co-ocuuring (Dome, 2004[33]). Though development pressure contributed to significant habitat fragmentation, areas of Taweelah supported areas of coastal white sands with a relative profusion of perennial plant species and dense vegetation cover (up to ca

[33] Dome (2004) Marubeni Taweelah Power Extension IWPP Ecological Survey Report, 2004. Abu Dhabi

15%) prior to the development of KIZAD Area A. The development of KIZAD Area A entailed an extensive cut-and-fill operation and the majority of the area is now heavily impacted by anthropogenic development (URS 2004, Dome 2004).

Terrestrial vertebrate populations in the Taweelah area supported breeding populations of Chestnut-bellied Sandgrouse (*Pterocles exustus*) and Lesser Short-toed Lark (*Caladrella rufescens*) (Dome, 2004). A dedicated ornithological survey conducted by Simon Aspinall within a four (4) km radius of the Taweelah complex in 2005 and 2006 confirmed the area of Ras Hanjurah to the west of the project site, to be of national importance for species of migratory waterfowl. The population of no one species exceeded the requisite level for international importance, although the wintering flock of Mallard constituted the largest single congregation of this species in the UAE (Aspinall, 2006)[34]. Cream-coloured Courser (*Cursorius cursor*) and Chestnut-bellied Sandgrouse (*Pterocles exustus*) were again confirmed to breed in areas around the site, but Lesser Short-toed Lark (*Caladrella rufescens*) was notably absent. This was attributed to increased development pressure (Aspinall, 2006).

Within the footprint of the Taweelah Industrial Complex habitat, and by association avifaunal diversity was low. Species were species of low conservation importance that are typically synonomous with areas of human habitation, such as Feral Rock Dove (*Columba livia*), Eurasian Collared Dove (*Streptopelia decaocto decaocto*), House Sparrow (*Passer domesticus*) and Crested Lark (*Galerida cristata*). Western Osprey (*Pandion haliaetus*) and a variety of gulls were noted along the coastal zone, with no evidence of breeding in the area.

8.1.2 Baseline Sampling Methodology

A single season Phase 1 terrestrial ecology survey of the site was undertaken by HDR on 29th June 2018. The site investigation was undertaken in accordance with the methodology set out in the EAD ToR Report (HDR, 2017). The objective of the survey was to assess the following elements:

- Identify habitats within, and immediately adjacent to, the proposed Project development footprint;
- Identify the presence of species of flora and fauna present; and

[34] Aspinall, S. (2006) Taweelah Ornithology Monitoring Study. Report to Taweelah Asia Power Company, TAPCO. June 2006. Abu Dhabi, UAE.

- Identify the presence of any protected, rare or endangered species of flora or fauna that may be of local, regional or international conservation interest.

The site was surveyed on foot with all observed species of flora and fauna recorded. No cameras were permitted within the Taweelah Complex by CICPA security protocols in June 2018, however, necessary camera passes were obtained from CICPA in the second survey undertaken in April and May 2019.

Habitats recorded during the survey were classified in accordance with the "*Interpretation Manual of the Major Terrestrial Natural and Semi-Natural Habitat Types of Abu Dhabi Emirate*" (Brown & Boer, 2004). Species of flora recorded during the site survey were classified in accordance with "*The Comprehensive Guide to Wild Flowers of the United Arab Emirates*" (Jongbloed, 2003).

Fauna within the survey area were recorded either by visual sightings or by identifiable indications of presence such as tracks, bird calls, burrows and nests.

The site was re-visited in April and May 2019 with a view to addressing EAD review comments provided on the original EIA (HDR, 2018). The principal objectives of the site inspection was to confirm that the site is not utilized as a nesting site for Western Osprey (*Pandion haliaetus*). HDR's field team carried out a targeted survey at the site to check that there were no active or inactive nesting sites within the footprint of the Project Site that might be impacted by the proposed construction works. During visits to the site, HDR's field team also investigated whether there was the suitable habitat that might support significant numbers of bat roosts at the site. Finally, the 2019 site investigations were aimed at confirming the initial findings reported in 2018 with regards to both floral and faunal abundance and diversity at the Project site.

In addition to targeted Osprey nesting surveys, the site investigations were intended to characterize the dominant habitats, identify areas of potential ecological sensitivity at the site.

Habitats and Flora

The project site is situated within the Gulf (coastal) Region of the Emirate of Abu Dhabi, as defined by Boer and Gliddon (1997[35]). The site consists of made ground with the original soil

35 Böer, B. and Gliddon, D., 1998. Mapping of coastal ecosystems and halophytes (case study of Abu Dhabi, United Arab Emirates). Marine and Freshwater research, 49(4), pp.297-301.

profile, floral community and elevation of the site altered during site clearance and placement of excavated marine material. The site was originally utilized as a storage site for dredged material with the material excavated from the current Taweelah outfall channel (URS, 2004[36]). As such, the site is classified as 9000: Urban Habitat types in accordance with the classifications set out in Brown and Boer (2004).

The site is generally of a low profile with no significant elevations within the site boundary. Whilst the majority of the site is flat, there are minor undulations and depressions as a result of historical earthworks and cut and fill operations. The site was previously used a stockpile storage area with marine dredge spoil from the neighbouring outfall channel stored on the site. A portion of the material is still stored at the site, and this provides an area of higher elevation in the centre of the Project site.

Figure 8-1 View across the site showing Dredge Material Stockpile in the background with *Zygophyllum qatarense* in the foreground

36 URS (2004) Environmental Impact Assessment Taweelah Gas Receiving Facility and Onshore Export Pipeline Section. For Dolphin Energy Limited. October 2004. JN 51398-007-057. UAE

Much of the site consists of saline, sandy soils with high drainage capacity. Much of the disturbed ground has been re-colonized by halophytic perennial shrubs that commonly colonise saline, sandy soils. The site was found to support 16 different species of flora, none of which are considered to be of particular conservation importance. Though coverage across the majority of the site is generally sparse, the perennial halophytic species *Zygophyllum qatarense* dominates. A full species list is provided in table 8-1. with *Zygophyllum qatarense* the dominant shrub species across the majority of the site. The site also supports *Cyperus* sp. grass growth with localised abundance of *Heliotropium kotschyii*, particularly in the northern corner of the site.

The northern corner of the site differs markedly from the remainder of the site with comparatively high species diversity compared to the remainder of the site. It is considered likely that potable water seepages from the existing Taweelah Complex to the north of the site provide sufficient subsoil water that supports growth of mature *Tamarix nilotica*. In low lying depressions, stands of the reed *Phragmites australis* are present.

Of the plant species recorded at the site all are locally or regionally common in coastal areas of the UAE or in areas of disturbed ground in close proximity to irrigated areas. The majority of species are commonly associated with sandy soils of high salinity in areas where water supply is limited. The notable exception is *Prosopis juliflora* which was originally introduced to the UAE and is now well established throughout the northern areas of the country. It is drought resistant and can tolerate conditions of high salinity. It has the ability to spread aggressively and out-competes indigenous and non-native species utilized in landscaping and, as such, requires careful management (Jongbloed, 2003).

Table 8-1 Species of Flora Recorded on the Site

FAMILY	SPECIES	ANNUAL/PERENNIAL	HABITAT
Mimosaceae	*Prosopis juliflora*	Perennial	Introduced but now well established. Common along coasts and in urban areas. Invasive species and requires careful management.
Tamaricaceae	*Tamarix nilotica*	Perennial	Saline sand. Common along Arabian Gulf coast with brackish groundwater or on moist ground.
Poaceae	*Phragmites australis*	Perennial	In or near water. Tolerates saline conditions. Locally common.
Cyperaceae	*Cyperus sp.*	Perennial	Sand, quickly colonizes disturbed ground. Common and widespread throughout the UAE.
Fabaceae	*Lotus garcinii*	Perennial	Sand. Tolerates saline conditions. Locally common in coastal areas.
Zygophyllaceae	*Zygophyllum qatarense*	Perennial	Sandy plains. Common and widespread along the Arabian Gulf coastline and into the Northern Emirates.
Fabaceae	*Acacia sp.*	Perennial	Sand. Common in the UAE
Boraginaceae	*Heliotropium kotschyi*	Perennial	Stands on bare sand and is common in the UAE
Chenopodiaceae	*Salsola imbricata*	Annual or Perennial	Grows in desert sand and is common in the UAE
	Suaeda Vermiculata	Perennial	Grows in desert sand and is common in the UAE
	Arthrocnemum macrostachyum	Perennial	Coastal habitat and saline soils
Cynomoriaceae	*Cynomorium coccineum*	perennial	Sandy soils and saline habitats close to the coastline
Poaceae	*Sporobolus ioclados*	perennial	Common along the Arabian Gulf and its found in sandy soils and tolerates high salinity
Poaceae	*Centropodia forsskaolii*	perennial	Sandy dunes and it is common and widespread in the UAE
Combretaceae	*Conocarpus lancifolius*	Tree	Exotic species used extensively in landscaping throughout the UAE.
	Phoenix dactylifera	Tree	Mostly on cultivated farms or in areas of landscaping. Commonly recorded throughout the UAE in areas of urban development.

Table 8-2 Floral Species Encountered in the project Site

SCIENTIFIC NAME	PHOTO

SCIENTIFIC NAME	PHOTO
Phragmites australis	
Acacia sp.	
Tamarix nilotica	

Scientific Name	Photo
Species indet,	
Sporobolus ioclados	
Tetraena qatarense	

Scientific Name	Photo
Heliotropium kotschyi	
Conocarpus lancifolius	 

<table>
<tr><th>Scientific Name</th><th>Photo</th></tr>
<tr><td><u>Cynomorium coccineum</u></td><td></td></tr>
<tr><td rowspan="2"><u>Suaeda vermiculata</u></td><td></td></tr>
<tr><td></td></tr>
</table>

Scientific Name	Photo
Arthrocnemum macrostachyum	
Prosopis juliflora	 

Avifauna

The survey recorded a total of thirteen (13) bird species on the Project site and in the surrounding areas. All of the species are commonly recorded in the Emirate of Abu Dhabi. The table below provides details on the species identified, in addition to the respective status of each of the species as per the Emirates Bird Record Committee and BirdLife International.

Table 8-3 Species of Avifauna Recorded at the Site

Common Name	Scientific Name	EBRC Status	BirdLife International
Black-winged Stilt	*Himantopus himantopus*	Common migrant and breeding resident	Least Concern
Egyptian Goose	*Alopochen aegyptiaca*	Introduced	Least Concern
Eurasian Collared Dove	*Streptopelia decaocto*	Very Common Breeding Resident	Least Concern
Feral Pigeon	*Spilopelia senegalensis*	Very Common Breeding Resident	Least Concern
Grey Heron	*Ardea cinerea*	Very Common Migrant and Winter Visitor	Least Concern
Pallid Swift	*Apus pallidus*	Very Common Migrant and Breeding Visitor	Least Concern
House Sparrow	*Passer domesticus*	Very Common Breeding Resident	Least Concern
Crested Lark	*Galerida cristata*	Very Common to Abundant Resident	Least Concern
Western Osprey	*Pandion haliaetus haliaetus*	Common Resident, Migrant and Winter Visitor	Least Concern
Purple Sunbird	*Cinnyris asiaticus*	Common breeding resident	Least Concern
Laughing Dove	*Spilopelia senegalensis*	Abundant and widespread resident	Least Concern
Grey Francolin	*Francolinus pondicerianus*	Very common and widely released; doubtfully native	Least Concern
Red-vented Bulbul	*Pycnonotus cafer*	Released. Common – range expanding	Least Concern

The majority of the bird species recorded at the site are commonly recorded in the UAE. Breeding populations of species such as the Eurasian Collared Dove (*Streptopelia decaocto*) and House Sparrow (*Passer domesticus*) have increased significantly with the expansion of urban landscaping, agriculture and farming areas throughout the UAE. As of 2010, it was thought that the UAE contained approximately 35,000-50,000+ and 100,000+ breeding pairs of Eurasian Collared Dove and House Sparrow, respectively (Aspinall, 2010).

Western Osprey (*Pandion haliaetus haliaetus*) was recorded in the northern portion of the site. Ospreys were recorded transiting over the site and utilizing the boundary fence for perches. It is noted that targeted ornithological surveys conducted in 2005 and 2006 recorded Osprey regularly but did not record any sign of breeding in the area around Taweelah. Single birds were seen on occasion, typically being immature birds or unpaired adults (Aspinall, 2006). There was no evidence of nesting recorded during either of the surveys and no suitable habitat was recorded during the investigations in April and May, 2019.

Table 8-4 Some of the Avifauna Species Encountered in the project Site

SCIENTIFIC NAME	PHOTO
Pandion haliaetus haliaetus	 

Black-winged Stilt and a flock of eight (8) Egyptian Geese (*Alopochen aegyptiaca*) were recorded in the channel that borders the southern boundary of the site. No evidence for nesting or breeding of either species were recorded during the site investigation.

Mammals

There were no direct observations of any species of mammal on the Project site. Tracks of both feral cat (*Felis catus*) and Arabian Red Fox (*Vulpes vulpes arabicus*) were recorded across the site. A common species of fox throughout the UAE and the Middle East, populations of Red Fox are expanding due to the increase in suitable habitat and expansion of urban areas (Hellyer & Aspinall, 2005). There were no indicators of rodent populations on the site, such as tracks or burrows during any of the visits to the site in 2018 or 2019. It is also noted that there are no suitable structures on the site that might be utilized as bat roosts. The number of trees at the site are not sufficient to support significant bat roosting and no visual evidence of bats were recorded around the trees on the site.

Plates 8-1 Animal paw prints as observed during the site walkover

Reptiles

Two (2) species of reptile was recorded during the initial site walkover in 2018. Three (3) Fringe-toed Sand Lizards (*Acanthodactylus gongrorhynchatus*) were observed in the northern portion of the site. The Fringe-toed Sand lizard, endemic to the Arabian Peninsula, has elongated scales on each toe that form a "fringe", increasing the surface areas of each toe. These fringes, combined with and a long, fragile tail, enables the lizard to move easily across the soft, unconsolidated surface of sandy deserts. This small to medium sized reptile is recorded frequently in the UAE and is primarily associated with sandy habitats. This species was listed as Least Concern in the most recent regional IUCN conservation category (Burriel-Carranza et al., 2019[37]). Whilst it is locally common in the UAE, populations are facing

[37] Burriel-Carranza, B., Tarroso, P., Els, J., Gardner, A., Soorae, P., Mohammed, A.A., Tubati, S.R.K., Eltayeb, M.M., Shah, J.N., Tejero-Cicuéndez, H. and Simó-Riudalbas, M., 2019. An integrative assessment of the diversity, phylogeny, distribution, and conservation of the terrestrial reptiles (*Sauropsida, Squamata*) of the United Arab Emirates. *PloS one*, 14(5)

increased pressure in some areas of its range as a result of habitat loss associated with urban expansion in the UAE (IUCN, 2017).

The Hadramaut Sand Lizard (*Mesalina adramitana*), also endemic to the Arabian Peninsula, was recorded in sandy areas of the site with perennial shrub vegetation. A diurnal lizard, it is an active hunter that moves in short dashes and sometimes climbs the lower branches of shrubs. It is common on sandy plains around coastal areas as well as further inland. It occasionally digs its own burrows and hides around the base of shrubs. It is listed as Least Concern in the most recent regional IUCN conservation category (Burriel-Carranza et al., 2019).

A single Slevin's Sand Gecko (*Stenodactylus slevini*) was recorded in May 2019 in the northeast portion of the site below a piece of scrap metal. The Slevin's Sand Gecko is an active hunter and occurs in open sandy desert to the west of Ras Ghanada. This species is listed as Least Concern in the most recent regional IUCN conservation category (Burriel-Carranza et al., 2019).

Plates 8-2 Sighting location of the Slevin's Sand Gecko at the project site

8.2 Environmental Impact Prediction and Evaluation

8.2.1 Construction Phase Impacts

During the construction phase the principal impacts to ecological resources at the site and in the immediate vicinity are likely to be generated by habitat loss and modification, disturbance to terrestrial fauna as a result of increased dust, noise and light emissions and increased likelihood of injury or mortality as a result of direct vehicle strike or pest control programmes.

During site enabling works, all vegetation will be stripped from the site. Earthworks will grade the site, imported fill material may be used to level the site and construction of the facility will require that a large proportion of the site will be surfaced or occupied by buildings and infrastructure. As such, the existing vegetation is expected to be removed entirely. Habitat loss will also result in the displacement and / or mortality of resident species. Though the site is relatively small and the terrestrial ecology walkover of the site did not encounter any species of local or regional conservation importance, it is recognized that the site does support an ecological community. The impact of the Project construction is such that all natural habitat and vegetation at the site will be permanently lost and there is likely to be displacement of more mobile fauna, with a high chance that less mobile fauna, such as reptiles, will suffer higher mortality rates as a result.

The construction works are likely to generate increased dust emissions and increased noise levels the result of which will increase disturbance on the bird species recorded on the site. The presence of possible osprey nesting in the north of the site may warrant checks prior to the start of the construction to confirm absence. (A survey in May 2019 confirmed no suitable sites for osprey nesting). Increased noise levels may potentially increase disturbance or result in negative health and behavioural effects to local terrestrial fauna including acoustic masking, hearing loss, and changes in foraging and anti-predator behaviour. Dust emissions are likely to be localised and intermittent and, as such, increased noise levels will have a greater impact on terrestrial fauna within and adjacent to the Project site. Increased levels of airborne particulates and ambient noise will be temporary and generally reversible once construction has ceased.

Exposure to Noise Pollution

Growth in transportation networks, resource extraction, motorised recreation and urban development is responsible for chronic noise exposure in most terrestrial areas (Barber *et al*, 2010). Previous studies have shown that increased noise levels reduce the distance and area over which acoustic signals can be perceived by animals, which can cause hearing loss, elevated stress hormone levels and hypertension (Barber *et al*, 2010; Jarup *et al*., 2008; Dooling and Popper, 2007). This can lead to substantial changes in foraging, anti-predator behaviour, reproductive success and community structure (Dooling and Popper, 2007;

Babisch, 2003). These responses begin to appear at exposure levels of 55–60 dB(A), which are generally restricted to relatively small areas close to noise sources (Barber et al, 2010).

Artificial Lighting

Artificial illumination causes disruption to the biological rhythm of flora and fauna and also interferes with the behaviour of animals, particularly nocturnal species. Previous studies have shown that artificial lighting can affect prey detection, predator avoidance, reproduction, foraging and social interactions in various fauna species (Buchanan, 2002). Artificial lighting can particularly affect bird populations, as nocturnal birds use the moon and stars for navigation during their bi-annual migrations and can become disorientated when flying through brightly lit areas (Buchanan, 2002).

Artificial lighting used during construction for vehicles, roads and work areas is likely to impact terrestrial ecology within the study site and the areas immediately outside. The presence of existing lighting from the existing Taweelah Complex already generates light pollution in the immediate vicinity of the site. In general, the most common adverse impacts of artificial lighting include:

- Disruption of foraging behaviour and increased risk of predation;
- Disruption of biological clocks; and
- Disruption of dispersal movements and corridor use.

8.2.2 Operational Phase Impacts

Impacts to the terrestrial ecology on site during the operational phase are expected to be minimal. The Project is likely to generate increased levels of light and sound. This has the potential to disturb or result in negative health and behavioural effects to local terrestrial fauna including disruption to biological clock, changes in foraging, prey detection, anti-predator behaviour and navigational disorientation. Artificial lighting has the potential to impact terrestrial fauna within and adjacent to the Project site. However, due to the industrial setting of the site and the high background levels, the increased light and noise are unlikely to generate significant impacts on terrestrial ecological receptors. Terrestrial ecological receptors within the Taweelah Complex are considered to be conditioned to the anticipated noise and lighting levels given that the area around the site is already given over to industrial developments. As such, the potential of the operational phase to have significant, long-term and irreversible impacts on terrestrial ecological receptors is considered negligible.

The presence of operational waste may potentially result in injury or death to local terrestrial fauna through entanglement or ingestion of potentially hazardous waste material. Without adequate waste management controls in place there may be minor negative impacts generated on local and transient fauna.

8.2.3 Cumulative Impacts

Construction Phase

The Project development and the proposed future developments at the Project site and in the vicinity of the site will irreversibly and permanently change the current terrestrial conditions of the project site. The contribution to the wider negative impacts on biodiversity in the Emirate of Abu Dhabi are anticipate to be negligible.

Operational Phase

Redevelopment of the site, though small and heavily disturbed, will contribute to the overall loss of habitat to development in the UAE. Though the contribution is likely to be negligible, it will make a small contribution to displacement / mortality of species of both flora and fauna.

8.3 Mitigation Measures

8.3.1 Potential Mitigation Measures

Potential mitigation measures to address potential issues and impacts on terrestrial ecology as a result of construction and operational activities are provided in the table below.

Table 8-5 Potential Mitigation Measures for Terrestrial Ecology Impacts

Impact Description	Potential Mitigation Measures	Regulations/Standards
Construction Phase		
Habitat fragmentation and loss	• Minimise the construction footprint wherever possible. • Implement pre-construction and construction monitoring of avifauna. • Implement a catch and release plan for non-mobile fauna species (reptiles) with relocation to a similar habitat.	Federal Law No. 24 of 1999
Loss of vegetation	• Re-establish landscape using native flora as compensation for vegetation loss, where feasible.	Federal Law No. 24 of 1999
Introduction of invasive / pest species	• Ensure only native species are utilised in landscaping. • Removal of all *Prosopis juliflora* (Mesquite) to ensure it does not spread throughout the development area. Planting of species to be prohibited.	Federal Law No. 24 of 1999
Disturbance to animals from construction dust and noise	• Implement construction dust and noise control measures outlined in the air quality and noise section respectively.	Federal Law No. 24 of 1999
Disturbance to animals from artificial lighting	• All outdoor lighting, other than signs, will be limited to those required for	Federal Law No. 24 of 1999

Impact Description	Potential Mitigation Measures	Regulations/Standards
	safety and security • Design a lighting system to minimise light spill. • Minimise work undertaken at night to reduce the need for artificial lighting, hence reducing the impact on nocturnal species	
Injury or death of animals from vehicle strike	• Provide dedicated HSE training to all personnel working on site detailing importance of ecological protection and site speed limits. • Vehicular traffic to remain on established roads and traffic to maintain low speed limits to minimise chance of vehicle strike.	Federal Law No. 24 of 1999
Risk of injury or death to animals (e.g. ingestion of litter) from construction waste	• Implement waste management measures outlined in the Waste Management Section herein.	Federal Law No. 24 of 1999
Influx of workers whose activities may pose a danger to animals	• Educate workers on the sensitivity of the nearby desert environment (e.g. through EHS site induction and regular refresher toolbox talks). • Issue official site instructions banning any form of hunting or activity that will result in injury or harm to animals.	Federal Law No. 24 of 1999
Operational Phase		
Disturbance to animals from operational noise	• Implement operational noise control measures as detailed in the Noise section of this report.	Federal Law No. 24 of 1999
Disturbance to animals from artificial lighting	• Design a lighting system to minimise light spill. • All outdoor lighting, other than signs, will be limited to those required for safety, security, highlighting and landscaping.	Federal Law No. 24 of 1999
Injury or death of animals from operational activities	• Educate workers on the sensitivity of the nearby desert environment (e.g. through EHS induction and regular toolbox talks). • Establish a policy banning any form of hunting or harming animals.	Federal Law No. 24 of 1999
Introduction of invasive or non-native species	• Appropriate removal techniques to be employed for removal of Prosopis juliflora (Mesquite) to ensure it does not spread throughout the development area	Federal Law No. 24 of 1999

8.3.2 Selected Mitigation Measures

Construction Phase

Mitigation measures that will be implemented to mitigate construction impacts on terrestrial ecology are discussed below:

- Implement a catch and release plan (translocation) for non-mobile fauna species (reptiles) with relocation to a similar habitat. Agree with EAD on suitable receptor locations nearby (e.g. Hanjura) that will not be impacted by new development.
- Appropriate removal techniques to be employed for removal of *Prosopis juliflora* (Mesquite) to ensure it does not spread throughout the development area;
- Ensuring that site works are undertaken only where necessary in order to minimise the impact area;
- Dust and noise mitigation measures. Consistent implementation of dust control and noise mitigation measures outlined in the air quality and noise sections respectively to minimise disturbance to fauna;
- Appropriate lighting system: Artificial lighting utilised during construction will be directed down and inwards onto the site to reduce the impact of glare and unnecessary lighting on flora and fauna. Lighting will also be restricted to that required for safety and security reasons only and working at night will be minimised. This will be a cost-effective measure to reduce the impact incurred by flora and fauna, particularly nocturnal species by restricting the impact area to only within the project site;
- Lighting will be directed away from the coastal areas due to the presence of turtle tracks within the site.
- Waste management measures. Construction waste will be managed so that litter (which could be mistaken for food by fauna) is avoided, where possible. This requires consistent implementation of waste management measures outlined in the Waste Management Section herein.
- Training / education of site workers. Workers will be provided with environmental awareness training, e.g. through site inductions, regular tool-box talks and posters. Training will include, as a minimum:

- Photos and a short brief describing species of conservation significance that could be present on site either as resident or migratory species, will be included to raise worker awareness;
- An alert system which will be developed as a response to any suspected sightings of species of conservation significance;
- Suitable treatment of flora and fauna on-site.

- An "alert system" will be established whereby any suspected sightings of species of conservation significance will be reported immediately and work is ceased in that area until confirmation by an experienced ecologist. Once confirmed, each individual will be dealt with on a case by case basis upon inspection and recommendation of an experienced ecologist.
- Any sighting of fauna within, or in close proximity to the construction site will be reported to management so that appropriate action (e.g. trapping for

relocation) can be undertaken. As necessary, such sighting will also be reported and coordinated with the EAD. In addition, site workers and visitors will be trained to capture and relocate potentially hazardous fauna (snakes or scorpions) to suitable areas outside of the construction boundary; and

- Ban on hunting: Hunting will be banned on-site. Relevant site instructions or policy will be issued and communicated to all workers and visitors.

Operational Phase

The following measures will be undertaken to mitigate potential impacts on any remaining terrestrial species during the operation of the Project site:

- Consistent implementation of dust and noise measures as discussed in the Air Quality and Noise Section respectively;
- Appropriate lighting system;
- Effective waste management measures as detailed in the Waste Management Section
- Training / education of workers; and
- Ban on hunting / killing fauna.

8.3.3 Mitigation Measures to Address Cumulative Impact

The selected mitigation measures will minimise the Project's contribution to cumulative terrestrial ecological impacts associated with construction and operation.

Control of construction and operational noise and air emissions, as well as management of waste at source will also address cumulative impacts on terrestrial ecology.

8.3.4 Residual Impacts

The implementation of mitigation measures has the potential to significantly reduce expected environmental impacts caused by the construction and operation of the Project. However, mitigation measures cannot always be implemented and as such there will be residual impacts. Residual impacts likely to occur include:

- Loss of coastal sand dune and interdunal plain (modified previously by dredge materials);
- Loss of vegetation resulting from site clearance during construction. It is not cost-effective, practical or ecologically necessary to translocate all species;
- Exposure to residual levels of noise, air and light pollution following implementation of mitigation measures; and
- Impact of human presence on-site.

8.4 Monitoring Program

8.4.1 Monitoring Program for Compliance with Selected Mitigation Measures

The table below presents the proposed monitoring program to ensure that mitigation measures for terrestrial ecological impacts are effectively implemented.

Table 8-6 Monitoring Program for Selected Mitigation Measures – Terrestrial Ecology

Impact Description	Mitigation Measures	Monitoring Methodology	Monitoring Schedule
Construction Phase			
Habitat fragmentation and loss	Minimise the construction footprint.	Visual inspection of construction site.	Daily
Loss of vegetation	Minimise clearing operations where possible.	Visual inspection of construction site.	Daily
	Vehicular traffic to remain on established roads where possible	Ensure management practices of the site are in place.	Daily
Disturbance to animals from construction dust and noise	Implement construction dust and noise control measures.	Refer to monitoring program for dust control) and noise mitigation in air quality and noise section respectively.	Refer to monitoring program for dust and noise mitigation in air quality and noise section respectively.
Disturbance to animals from artificial lighting	Use a lighting system that minimises light spill.	Visual inspection of lighting system at night time.	Weekly
	Minimise work undertaken at night to reduce the need for artificial lighting, hence reducing the impact on nocturnal species	Site inspection.	Daily
Risk of injury or death to animals from construction traffic movement	Provide dedicated HSE training to all personnel working on site detailing importance of ecological protection and site speed limits.	Review of HSE training material and toolbox talk records.	Monthly
	Vehicular traffic to remain on established roads and traffic to maintain low speed limits to minimise chance of vehicle strike	Site inspection.	Daily
Waste Management	Implement waste management	Refer to monitoring program for waste	Refer to monitoring program for waste

IMPACT DESCRIPTION	MITIGATION MEASURES	MONITORING METHODOLOGY	MONITORING SCHEDULE
	measures outlined in the waste management section	management	management
Operational Phase			
Disturbance to animals from operational noise	Implement suitable noise mitigation measures.	Refer to monitoring program for noise mitigation in the noise section y.	Refer to monitoring program for noise mitigation
Introduction of invasive or non-native species	Ensure only UPC approved species of flora utilised in landscaping.	Visual site inspection.	Monthly
Risk of injury or death to animals from operational activities	Educate workers on the sensitivity of the ecological resources and importance of protection and reporting of unusual observations (e.g. through EHS inductions and toolbox talks).	Visual site inspection (particularly at the vicinity of active disposal areas) to check for any species onsite.	Monthly
	Establish a policy banning any form of hunting or harming animals.	EHS induction records.	

8.4.2 Monitoring Program for Cumulative Impacts

The proposed monitoring program is considered to cover the cumulative impacts.

8.4.3 Monitoring Program for Residual Impacts

Similarly, the proposed monitoring programme also covers residual impacts.

9 NOISE

9.1 Description of the Environment

9.1.1 Regional Context

A review of existing ambient noise levels and noise sources is necessary to determine the likely significance of impacts on potential Noise Sensitive Receptors (NSRs) at the Project site and in the areas surrounding the development footprint. An assessment of ambient conditions prior to development and the potential changes to the baseline condition generated by the proposed construction and operational activities subsequently determines appropriate mitigating measures proposed with a view to avoiding, reducing or offsetting potential impacts.

This section provides a description of land use, noise sensitive receptors, local noise levels (undertaken as both a desktop exercise and on-site measurement), the impacts of noise associated with construction equipment and traffic during the construction phase and the operation phases, respectively, and proposes a series of mitigation measures.

Noise Sensitive Receptors (NSR)

The site is located within the existing Taweelah complex, a heavy industrial development that stretches for approximately 7 kilometres along the coastline of Abu Dhabi to the North West of the KIZAD development. As such, there are few noise sensitive receptors located within close proximity to the Project site. The principal NSRs identified within a radius of three (3) kilometres from the Project site include the following:

- Employees in the Taweelah complex;
- Residents and workers at the Sheikhs property/farm land to the south-west of the Project site within the Al Hanjura area (inaccessible restricted area);
- Bird and other species at the inland mangrove habitat patch within the Hanjura area to the south of the Project site (inaccessible restricted area);
- Terrestrial and marine fauna (e.g. turtles); and
- Visitors and workers at the Emirates Heritage Club to the north of the Taweelah facility.

Ambient Noise Environment

Site investigations were undertaken by HDR during both daytime and night-time hours on a weekday and weekend. The existing ambient noise conditions within the area proximal to the Project site were found to be influenced mainly by the following:

- Generator/turbine noises from the existing power and aluminium plant stations adjacent to the Project site;
- The ambient noise environment is predominantly influenced by its proximity to the operational Taweelah Complex.

9.1.2 Baseline Sampling Methodology

HDR identified 5 baseline noise monitoring sites which were strategically selected to provide an indication of ambient conditions at the Project site, within the ADWEA complex and at the closest residential NSR. The coordinates and details for each of the locations are presented in the table below.

Table 9-1 Baseline Ambient Noise Monitoring Sites

Station Name	Latitude	Longitude	Justification for Selection
NOI_N1	24.760573°	54.676299°	These monitoring stations are placed on the boundaries of the Project development site with a view to characterising ambient conditions at the perimeter of the site.
NOI_N2	24.756248°	54.671465°	
NOI_N3	24.754734°	54.676751°	
NOI_N4	24.754669°	54.679275°	This station is located on the opposite side of the outfall channel approximately 300 m away from the Project boundary at the south-east so as to understand the ambient noise conditions within the relatively near field area of the site.
NOI_N5	24.785286°	54.694682°	This station is located at the Emirates Heritage Club approximately 3 km north along the coastline from the Project site. This is the closest accessible NSR to the Taweelah facility and will give a good indication of the level to which not only the potential development works will impact the users and visitors, but also the existing Taweelah facility and Khalifa Port.

Figure 9-1 Baseline Noise Monitoring Locations

9.1.3 Baseline Site Conditions

The noise monitoring results from all 5 sites are presented in Table 9-4 where the LA_{eq} values that exceed the respective UAE Federal Allowable Noise Standards & WHO Ambient Noise Level Guidelines are highlighted in red. The UAE Federal Allowable Noise Standards & WHO Ambient Noise Level Guidelines are shown in the tables below.

Table 9-2 UAE Federal Noise Level Limits

Area	Allowable Limits (dBA) for Daytime (7AM to 8PM)	Allowable Limits (dBA) for Night time (8PM to 7AM)
Residential areas with light traffic	**40 – 50**	**30 – 40**
Residential areas in downtown	45 – 55	35 – 45
Residential areas which include some workshops and commercial business or residential areas near the highways	50 – 60	40 – 50
Commercial areas & downtown	55 – 65	45 – 55
Industrial areas (heavy industry)	**60 – 70**	**50 – 60**

Table 9-3 World Health Organisation Ambient Noise Level Guidelines

Receptor	One Hour LAeq (dBA)	
	Daytime (7am-10pm)	Night (10pm-7am)
Residential, Institutional, Educational	55	45
Industrial, Commercial	70	70
Guideline values are for noise levels measured out of doors.		

Source: World Bank EHS General Guidelines, 2007 & Guidelines for Community Noise, WHO, 1999.

Table 9-4 Noise Daytime Measurement Values for the Baseline Noise Monitoring

Monitoring Location	Date	Measurement Period		Results (dB (A))				
		Start Time	End Time	LEQ	LMAX	LMIN	L90	L10
N1	Weekday (01/07/2018)	19:42	20:12	62.8	82.0	60.2	61.6	63.5
	Weekend (30/06/2018)	15:27	15:57	64.6	81.4	61.7	63.2	65.5
N2	Weekday (01/07/2018)	18:59	19:29	50.1	75.7	47.1	48.4	51.3
	Weekend (29/06/2018)	19:40	20:10	56.9	71.1	52.5	55.1	58.1
N3	Weekday (01/07/2018)	18:18	18:48	55.3	72.1	52.1	53.8	56.2
	Weekend (29/06/2018)	18:58	18:28	60.4	72.9	56.3	58.5	61.8
N4	Weekday (01/07/2018)	17:38	18:08	66.9	80.1	64.9	66.1	67.5
	Weekend (29/06/2018)	18:07	18:37	58.5	73.3	55.5	57.3	59.4
Federal Allowable Noise Limit for Daytime, dB (A)				**70**				
WHO Ambient Noise Level Guidelines				**70**				
N5	Weekday (01/07/2018)	16:19	16:49	**51.4**	64.2	41.5	44.4	57.4
	Weekend (29/06/2018)	15:54	16:24	**54.0**	74.6	46.9	50.2	55.1
Federal Allowable Noise Limit for Daytime, dB (A)				**50**				
WHO Ambient Noise Level Guidelines				**55**				

Table 9-5 Noise Nightime Measurement Values for the Baseline Noise Monitoring

Monitoring Location	Date	Measurement Period		Results (dB (A))				
		Start Time	End Time	Leq	Lmax	Lmin	L90	L10
N1	Weekday (01/07/2018)	20:13	20:43	**62.6**	69.7	60.3	61.6	63.4
	Weekend (29/06/2018)	20:28	20:58	**67.3**	74.3	64.1	65.8	68.4
N2	Weekday (01/07/2018)	20:57	21:27	52.0	80.1	46.8	49.0	51.3
	Weekend (29/06/2018)	21:27	21:47	58.3	64.0	53.2	56.1	60.0
N3	Weekday (01/07/2018)	21:42	22:12	56.1	61.2	53.2	54.8	57.3
	Weekend (29/06/2018)	21:58	22:28	**61.2**	77.8	57.9	59.6	62.3
N4	Weekday (01/07/2018)	22:24	22:54	**67.3**	78.5	65.1	66.5	67.8
	Weekend (29/06/2018)	22:42	23:12	**67.3**	71.0	65.6	66.6	67.8
Federal Allowable Noise Limit for Daytime, dB(A)				**60**				
WHO Ambient Noise Level Guidelines				**70**				
N5	Weekday (01/07/2018)	23:41	0:11	54.0	64.8	45.9	48.1	56.7
	Weekend (29/06/2018)	23:58	0:28	51.3	61.0	48.1	49.6	52.3
Federal Allowable Noise Limit for Daytime, dB(A)				**40**				
WHO Ambient Noise Level Guidelines				**45**				

The federal and WHO limit of 70dbA for industrial areas (sites N1, N2, N3 and N4) was not exceeded during the daytime monitoring during the weekend and weekday. Similarly, at site N1, the federal & WHO limit was not exceeded during the daytime on the weekend and weekday.

The federal limit for site N5 is lower than the remaining sites, as it is located near the Emirates Heritage Club. The federal limit of 50dB(A) was exceeded during all sampling events at this site. Given the proximity of the site to a nearby industrial area the relatively high noise levels recorded at N5 during the week can be attributed to that nearby industrial sites located around 500m from the station. In addition, this site is adjacent to the marina club which is an active area for recreational boats. Although the result obtained during the week day & weekend at N5 exceeded Federal noise limits, when compared with WHO ambient noise levels of 55dB(A) for residential areas, the results obtained at N5 did not exceed the WHO limit.

The night-time guidance values of 60dbA for the industrial areas, and 40dbA for residential areas were exceeded at all of the sites during both week days and the weekend (See Figure 9-3 Below).

Figure 9-2 Day Time Average Noise Levels at Each Site on a Weekday and a Weekend Day

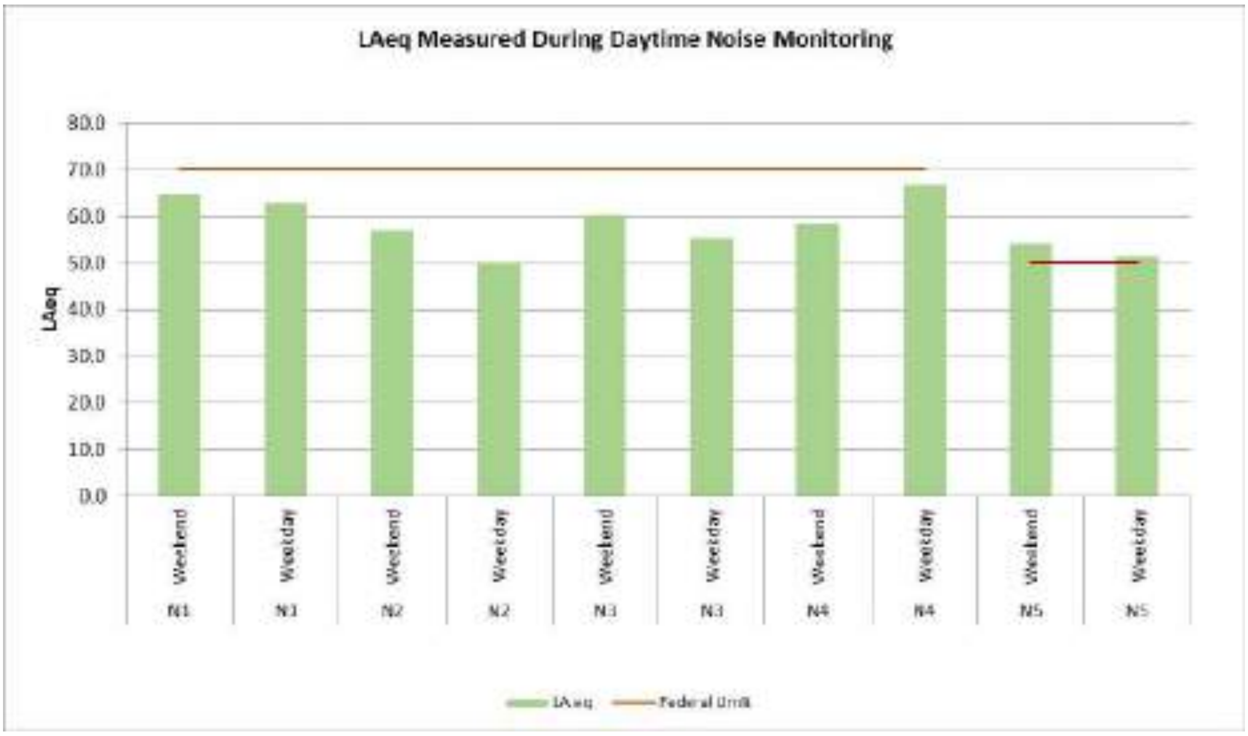


Figure 9-3 Night-Time Average Noise Levels at Each Site on a Weekday and a Weekend Day

The sound level meter calibration certificate and the complete noise monitoring results are provided in Appendix K and L respectively.

9.2 Environmental Impact Prediction and Evaluation

There are no significant noise sensitive receptors located within the direct footprint of the proposed Project site. As such, the noise impact assessment was focused on the potential effect of construction activities to the identified NSRs (as described in sub section 9.1). The nearest residential or public use areas to the Project site are the Hanjura buildings and farm land and the Emirates Heritage Club. The latter is approximately 3km away from the Project area. Within Hanjura there are some buildings and a small harbour which are located only 400-500m away from the Project boundary however the main residential building in this area is situated 1.4km away from the Project site. The Project site itself is bordered by a large industrial area to the North, as it is located within the existing Taweelah facility.

9.2.1 Construction Phase Impacts - Terrestrial

The construction activities on site will involve the operation of vehicles such as loaders, bulldozers, compactors and trucks to move, deposit and spread material on site. These activities will be the main source of noise during construction.

The prediction of construction noise at identified NSRs is based mainly on distance attenuation. Typical Sound Power Levels for the machinery that will be used during construction of the development are shown in the table below. The levels provided were sourced from BS5228 and AS2436. These sound power levels are maximum levels produced when machinery is operating under full load with no shielding or obstruction to minimize propagation of noise.

Table 9-6 Predicted Construction Noise Levels at Distance

Source	Sound Power dB(A)	Sound Pressure Levels at Distance dB(A)					
		15m	100m	200m	500m	1000m	2000m
Bulldozer	108	76	60	54	46	40	34
Compactor	113	81	65	59	51	45	39
Concrete pump truck	108	76	60	54	46	40	34
Concrete saw	117	85	69	63	55	49	43
Crane (mobile)	104	72	56	50	42	36	30
Excavator	107	75	59	53	45	39	33
Front end loader	113	81	65	59	51	45	39
Generator (diesel)	99	67	51	45	37	31	25
Grader	110	78	62	56	48	42	36
Piling (bored)	111	79	63	57	49	43	37
Roller (vibratory)	108	76	60	54	46	40	34
Truck (>20 tonne)	107	75	59	53	45	39	33
Vehicle (4WD)	106	74	58	52	44	38	32

The sound pressure levels generated by the construction equipment listed in the table above would not be expected to exceed 55db(A) at the first building units in Hanjura which are around 450m away from the Project site and would not exceed 49db(A) at the second building units in Hanjura which are 1.4 km away from the development area.

Sleep disturbance is considered to be a significant impact of noise on residential receptors. In this case it is unknown what the first building units are used for in Hanjura. If these are used as residential buildings, then there is a definite possibility that sleep disturbance may occur as a result of the construction noise produced at the Project site. There may also be potential disturbance caused in the second building units, whereas although these are located a significant distance from the Project site (1.4km) there are almost no additional screening or physical barriers (buildings or vegetation) or additional dampening ambient noise between both sites that might further reduce the attenuation of noise disturbance.

The construction works are likely to generate increased noise levels, the result of which, may increase disturbance local terrestrial fauna outside the project site, although this is unlikely as there will be no large mammals such as gazelles within the Complex and smaller animals will become acclimatised to background noise . Increased levels of ambient noise will be temporary and generally reversible once construction has ceased.

Noise impacts associated with construction will also be dependent upon a number of factors:

- The intensity of construction activities;
- The location of construction activities on-site;
- The type of equipment used;
- Existing background noise levels;
- Intervening terrain and structures; and
- The prevailing weather conditions.

Construction machinery will likely move about the Project area altering noise impacts with respect to individual receptors. During any given period, the machinery to be used in the project construction site will operate at maximum sound power levels for only brief stages. At other times, the machinery may produce lower sound levels while carrying out activities not requiring full power. It is highly unlikely that all construction equipment would be operating at their maximum sound power levels at any one time and certain types of construction machinery will be present in the project area for only brief periods during construction. Therefore, the predictions of sound pressure level at the potential NSRs should be considered as conservative estimates.

9.2.2 Construction Phase Impacts - Marine

Underwater radiated noise will generate marine noise pollution which may have a negative impact on local marine fauna. Biotic sound sources are produced by fish, invertebrates, marine mammals and other marine organisms, and are essential to communication, orientation, mate and prey detection, and echolocation. Noise generated by marine vessels (propeller / engine noise and sonar) have the potential to interfere with biological signals causing acoustic masking.

Anthropogenic noise can directly or indirectly affect many marine organisms, causing auditory masking, leading to cochlear damage, changing individual and/or social behaviour, altering body metabolism, and hampering embryogenesis. The fact that the construction phase does not currently propose to include pile driving, blasting or high intensity or high frequency noise generating activities means that the most extreme impacts associated with marine noise would be avoided. Marine excavations and construction of rock revetment will, however, result in increased noise generation for a relatively short period of time.

In general, free-swimming marine species may leave an unfavourably noisy environment resulting in a reduction in population density. Less mobile species of invertebrates may experience behaviour alterations, but may be unable to avoid noise generated by construction activities. The effects of anthropogenic noise on marine organisms are dependent on the species under consideration and both the levels of impulsive and stationary noise. Impacts are however anticipated in the short term during marine construction. The impacts are not, however, anticipated long-term, though there will be a cumulative impact during the construction works.

In view of the above, the construction phase is anticipated to generate increased noise levels at the site and in the areas adjacent to the Project site during the construction phase. The most significant impacts are likely to be generated on marine fauna. The impacts are expected to be comparatively short term in duration and will result in the avoidance of the study area by more mobile fauna during periods of peak construction.

Summary of Construction Impact

During the construction phase, the impact area will vary as construction progresses. The use of mobile machinery would alter the direction of the noise source and subsequently the receptor area. During any given period, the machinery items to be used on site will operate at maximum sound power levels for only brief periods. At other times, the machinery may produce lower sound levels while carrying out activities not requiring full power. It is highly unlikely that all construction equipment would be operating at their maximum sound power levels at any one time. Therefore, noise impacts will only be temporary and short term for the duration of construction.

9.2.3 Operational Phase Impacts

During the operational phase, the principal sources of noise generated by the facility are likely to be pumps, water treatment infrastructure and traffic travelling to and from the site.

Pumps are required to transfer water from the seawater intake to the filtering and RO systems, and to transfer sludge and wastewater to the relevant facilities and discharge lines. The level of noise generated and the locations of sensitive receptors is not likely to be significant as all the pumps, water treatment and filtration machinery will be located within dedicated, sealed structures. These structures may be dedicated concrete pumping stations or one of the buildings to be constructed on the Project site. The detailed design will be carried out with a view to ensuring that noise levels within the structure are compliant with regional health and safety requirements and that environmental noise levels outside of the buildings on the site do not exceed existing baseline conditions by more than 3dB(A) in accordance with UAE Federal noise guidance.

The additional traffic trips generated by the operational phase of the Project on the surrounding road transport network are not expected to be significant. Minor levels of additional traffic to the area will be generated by the site employees, sporadic visitors to the site, delivery of supplies and resources required to operate the SWRO plant and waste management contractors removing waste from the site. The ambient noise conditions in the area surrounding the site are already largely characterized by the existing operational industrial plant and machinery noise from the Taweelah facility and the traffic traveling to and from the site from the E11 Sheikh Zayed road. As such, the traffic travelling to and from the site during the operational phase is not expected to be generate significant detrimental effects on the ambient noise conditions in the area.

9.2.4 Cumulative Impacts

Construction Phase

The Project construction activities will contribute to the existing road traffic noise levels, not only through the introduction of various noise generating construction equipment onsite, but also through an increase in traffic travelling to and from the site. The accommodation facility within the Taweelah Complex for 2,700 workers will avoid the noise from buses coming to/from the site carrying the workers. This will reduce noise from potentially 100 bus movements/day.

As with the noise levels generated by construction activities, cumulative noise impacts are likely to be localised and short term in nature.

Operational Phase

The operation of the roads will generate noise impacts that will be cumulative with the existing carriageway traffic noise, particularly with the anticipated increase in road traffic flow over time.

9.3 Mitigation Measures

9.3.1 Potential Mitigation Measures

The potential mitigation measures are control-at-source, management procedures and are detailed in this section.

Table 9-7 Potential Noise Mitigation Measures

Impact Description	Mitigation Measures	Relevant Standard
Construction Phase Noise		

Impact Description	Mitigation Measures	Relevant Standard
Noise generated from construction activities across the site	• Layout the construction sites so that the primary noise sources are at a maximum distance from NSRs, and erect noise barriers at the noise sources, where applicable. • Plan and implement designated vehicle routes, parking locations, operating hours and on-site speed limit. • Deploy regularly maintained fit for purpose equipment. • Mufflers, silencers and acoustic enclosures fitted on plant. • Engine covers kept closed when equipment is operating. • Equipment maintained in good condition via regular service. • Plant emitting excessive noise removed from service and repaired. • Machines to be operated at low speed or power (where practical) and be switched off when not being used. • Broadband reversing alarm (audible movement alarms) kept to a minimum through improved route choice / layout / dimensions and proper manoeuvring procedures. • Optimise the number of deliveries by amalgamating loads and scheduling arrivals within designated hours.	Federal Law No. 24 of 1999 and its Executive Order issued by Council of Ministers Decree No. 37 of 2001. Council of Minister Decree No. 12 of 2006 under Federal Law No. 24 WHO Ambient Noise Level Guidelines
Exposure to occupational noise	• Providing personal protective equipment (PPE) to the staff exposed to excess noise.	AD EHSMS RF[38]
Nuisance to noise sensitive receptors	• Communicate with the community. • During turtle nesting season (March to June) there will be reduced activity in marine works. Daily Beach monitoring will be conducted during turtle nesting period.	--
Construction Phase Vibration		
Vibration	• Good planning of vibration intensive activities (timing, operating procedures,	

38 The allowable duration of exposure to workplace noise is provided in CoP 3.0 Occupational Noise, Version 2.0 (2012) issued under the AD EHSMS RF (http://www.oshad.ae/en/adehsms/Pages/codesofpractice.aspx)

Impact Description	Mitigation Measures	Relevant Standard
	locations).	
Operation Phase (Noise)		
Operation noise	• Enclose plant and equipment considered to be major noise sources and those are located close to the site's boundary. • Provide plant and equipment enclosure / structure interiors with absorptive treatment. • Selection of quiet equipment / system (at the design phase). • Maintain equipment via regular inspection and services.	Federal Law No. 24 of 1999 and its Executive Order issued by Council of Ministers Decree No. 37 of 2001. Council of Minister Decree No. 12 of 2006 under Federal Law No. 24. WHO Ambient Noise Level Guidelines
Exposure to occupational noise	• Absorptive treatment provided within the plant and equipment enclosure / structure interiors to reduce internal reverberation and minimise occupational noise. • Use of quiet equipment. • Personal protective equipment to staff exposed to excess noise.	AD EHSMS RF39
Operational Phase Vibration		
Vibration of buildings.	• Mounting of equipment on vibration mats, or increasing the mass weight of the equipment to reduce vibration and vibration related noise	-

39 The allowable duration of exposure to workplace noise is provided in CoP 3.0 Occupational Noise, Version 2.0 (2012) issued under the AD EHSMS RF (http://www.oshad.ae/en/adehsms/Pages/codesofpractice.aspx)

9.3.2 Selected Mitigation Measures

Construction Phase

Construction Noise

Impacts on ambient noise conditions during the construction activities can be controlled through the implementation of the following mitigation measures:

- Construction sites will be laid-out in such a way that the primary noise sources are at a maximum distance from residences/ noise sensitive receptors, with solid structures (sheds, containers, etc.) placed between residences and as close to the noise sources as is possible.
- Engines and exhausts are typically the dominant noise sources on mobile plants such as compactors, trucks, etc. Regularly maintained fit for purpose equipment will be deployed;
- Equipment will be selected to minimise noise emissions and maintained in good repair (properly serviced). Equipment such as generators will be fitted with appropriate silencers and acoustic enclosures (where practical). Machines found to produce excessive noise compared to normal industry expectations will be removed from the site or stood down until repairs or modifications can be made;
- Where practical, machines will be operated at low speed or power and will be switched off when not being used rather than left idling for prolonged periods;
- Reversing of equipment kept to a minimum through improved route choice / layout / dimensions, and operational procedures. Loader / dozer manoeuvring using the 'swivel technique' for turning may reduce the frequency of reversing beeper use for this piece of equipment. Satisfactory compliance with occupational health and safety requirements will need to be achieved and a safety risk assessment may need to be undertaken to determine that safety is not compromised;
- The number of deliveries to the site will be optimised by amalgamating loads where possible and scheduling arrivals within designated hours;
- All mechanical plant and equipment will be checked regularly to avoid any unnecessary noise caused by lack of maintenance;
- Truck drivers will be kept informed of designated vehicle routes, parking locations, operating hours and on-site speed limit; and
- All engine covers will be kept closed when equipment is being operated.

Construction Vibration

- Vibration intensive activities will be implemented during the least sensitive time periods; and
- Where possible, vibration intensive activities will be located as far from sensitive areas as possible.

Operational Phase

Operational Noise

- Buildings will be located close to the Project site's boundary as much as practicable to provide shielding effects of operational noise emanating from the site;
- Where practicable, absorptive treatment will be provided within the building interior to reduce internal reverberation and minimise occupational noise exposure;
- Selection of quiet equipment / system during the design phase will be considered. A 'buy quiet' purchasing policy will be established, with all equipment purchased to meet the sound power level standard. This policy will assist in minimising the off-site impact and help in preserving the hearing quality and reducing the Health and Safety risk for employees; and
- All equipment will be selected to minimise noise emissions and maintained in good repair (serviced). Equipment will be filled with appropriate silencers and be in good working order.

Operational Vibration

- Mounting of equipment on vibration mats, or increasing the mass weight of the equipment to reduce vibration and vibration related noise.

9.3.3 Mitigation Measures to Address Cumulative Impacts

In general, the consistent implementation of the noise minimization and management measures specified in Section 9.3 will reduce the potential for impacts on any noise sensitive receptors in the vicinity of the Project site. Opportunities minimization of noise and vibration both during and post construction will be identified and optimized where possible to reduce the impacts of noise in the surrounding environment.

9.3.4 Residual Impact

Noise is inherent in the construction industry and cannot be completely eliminated. There will be an increase expected in the ambient noise level within the Project site and noise impact is mainly on workers and visitor onsite. Due to current high noise levels at the Project site due to its proximity to the existing Taweelah facility, and with the consistent implementation of mitigation measures, noise is considered likely to be localized (within the Project site) and within acceptable levels.

9.4 Monitoring Program

9.4.1 Monitoring Program for Compliance with Selected Mitigation Measures

To ensure the implementation of the mitigation measures proposed in Section 9.3 and evaluate their effectiveness in reducing the noise impacts to acceptable levels, the following monitoring programme will be implemented.

Table 9-8 Monitoring Program for Selected Mitigation Measures – Ambient Noise

IMPACT	MITIGATION MEASURE	MONITORING METHODOLOGY	MONITORING SCHEDULE
Construction Phase			
Noise generated from construction activities.	Good layout of the construction site with solid structures close to the noise sources.	ISO 1996-1:2003 - Acoustics - Description, Measurement and Assessment of Environmental Noise -- Part 1: Basic quantities and assessment procedures. A Type 1 / Class 1 Sound Level Meter to be deployed for monitoring.	Noise monitoring undertaken at monthly intervals. Each measurement will last 30 minutes using Type 1 / Class 1 Sound Level Meter. The monitoring locations will include the site boundary and noise sensitive receivers within 1 km of the footprint. In the event of noise complaint (where applicable).
	Selection of quiet equipment, where possible.	Review the specifications of the equipment (e.g. sound power level) during procurement / contracting.	Daily
	Good maintenance of equipment.	Maintain equipment as per the manufacturer schedule and maintain maintenance records.	As per maintenance schedule.
	Operate equipment at low speed or power, engine covers to be closed when equipment is operating and switch off the equipment when not being used.	Visual inspection and maintain inspection records.	Daily
	Deploy swivel technique for turning the loaders / dozers	Visual inspection and maintain the inspection records.	Daily
	Scheduling material delivery.	Review the delivery schedule.	Bi-monthly
	Truck drivers to observe	Visual inspection.	Daily

IMPACT	MITIGATION MEASURE	MONITORING METHODOLOGY	MONITORING SCHEDULE
	the designated vehicle routes, parking locations, operating hours and on-site speed.		
	Good work ethics.	Visual inspection and record the inspection findings.	Daily
Vibration generated from construction activities.	Vibration intensive activities to be implemented during the least sensitive time periods.	Visual inspection.	Daily
	Perform the vibration intensive work remote from sensitive areas, where possible.	Visual inspection.	Daily
Occupational noise hazard.	Perform risk assessment.	Internal audit.	Quarterly
	Implementation of the mitigation measures provided in risk assessment and provision of PPE	Inspection. Occupational noise monitoring (by a Type 1 / Class 1 or Type 2 Sound Level Meter).	Inspection (daily) Occupational noise monitoring will be performed as per the site EHSMS (to be approved by the SRA).
Community relationships.	Maintain community relationship (via a Community Liaison Officer), proper handling of environmental complaints.	Internal audit.	Quarterly
Operational Phase			
Noise generated from operational activities.	Appropriate layout of the buildings (close to the site boundary, act as barriers to provide shielding effect).	Design review.	At the design stage
	Absorptive treatment provided within the building interior (where possible).	Design review.	At the design stage.

9.4.2 Monitoring Program for Cumulative Impact

The proposed noise monitoring undertaken at strategic locations (site boundary, noise sensitive receptors and work areas), outlined in the table above includes the evaluation of cumulative impacts.

9.4.3 Monitoring Program for Residual Impacts

The residual noise impacts during the operation of the proposed Project could be monitored by the noise monitoring programme (noise measurement at site boundary, noise sensitive receptors and work areas) outlined in the table above.

10 TRAFFIC

10.1 Description of the Environment

In the last few years Abu Dhabi has invested over AED 581 million towards improving traffic management systems in the last few years (Gulf news, September 2017). Abu Dhabi has been facing intensive problems with its road and internal transport system where reports in 2008 by the Abu Dhabi Department of Planning and Economy states that congested traffic condition in the city, which prevails throughout most of the day, was a direct threat to the economic growth of Abu Dhabi (UAE Interact News, June 2008).

Since this time significant investments have been made in a number of traffic optimisation initiatives including the installation of intelligent traffic control systems in the capital whereby traffic signals are monitored smartly though a computerised system that ensures a continuous a flow of traffic as possible. Another key enhancement has been the roll-out of the Darb smartphone application, which allows residents to book taxis, check on real-time bus schedules and stay informed of traffic incidents and developments.

These advancements led to Abu Dhabi being ranked as one of the best cities in the world at using infrastructure to manage its own traffic flow in 2016 by the TomTom traffic index. This award was given after 390 cities were ranked based on congestion using data collected from smartphone apps, GPS applications and from taxi and bus monitoring systems. Only one other city (Katowice in Poland) had similarly low levels of congestion (Gulf news, September 2017).

The main cause of the city's original traffic issues was said to be the steady increase in the population (consisting largely of foreign workers) as a result of the massive economic expansion in the Emirate and the UAE in general. Since the investments were made, peak hour travel takes only 14 minutes longer on average than during non-peak hours. There has been a 6 percent increase in travel time during peak hours during 2017 than during 2016 but this level is expected as a natural result of the current population growth rate.

In contrast to the traffic congestion being experienced in the central or business area of the city, traffic flow within the Project vicinity is considered very low. Currently, the Project site can only be accessed by private vehicles. The main access routes to the Project site are off of highway E11 through the KIZAD industrial area. Highway E11 provides the main link from Abu Dhabi City as well as from Dubai.

The planned Project development will not be directly affecting the existing road infrastructure within the Project vicinity at all, where no additional road development has been planned, and no amendments to the existing infrastructure will take place.

The location of the main arterial road links in comparison to AAIA and the Project footprint are provided below in the figure below.

Figure 10-1 Major Arterial Road Links Surrounding Taweelah

The majority of traffic travelling to and from the Project site and around the proximal area is largely generated by people working at the existing Taweelah industrial facility, Khalifa Port and associated industries located within the existing KIZAD area. The observations of the existing network indicate that the current road transfer network has significant available capacity and is able to support the increase in traffic associated with the development of the SWRO plant at Taweelah.

Traffic Estimates for Taweelah Project

A Traffic Management Plan (TMP) is under preparation by the EPC and will be included as a supplementary plan to the CESMP to be submitted to the Lenders by mid-September 2019. It is noted that the access to the Taweelah Complex is from major highways leading to a dedicated dual carriageway to the Taweelah Complex. The routing of lorries and buses carrying workers to the site will not be through any residential areas or town centres.

The estimated number of trips required by trucks to import and remove the fill material from the site is currently estimated to be 30,000 trips although this will be detailed/refined within the TMP. The current estimate of concrete trucks required for the construction of Project is 14, 500 trips. Around 15 to 20 buses per day are estimated to be required for the transportation of the workers to/from accommodation facilities.

10.2 Environmental Impact Prediction and Evaluation

10.2.1 Construction Phase

Increase in Traffic

The construction of the Project will generate additional traffic travelling to and from the site. Construction workers will be accommodated within the project site therefore reducing the traffic to and from the project site. When the peak number of workers are at site (2,700), this will reduce the number of bus movements/day on the main roads by 100/day. Vehicles and cars of staff and visitors will also travel to and from the site on a daily basis. These vehicle movements are likely to slightly increase the traffic utilizing the transport infrastructure around the Taweelah and KIZAD area.

Given the fact that the existing transport network has the capacity to support all vehicle movements associated with the construction and operation phase of the new SWRO plant, it seems unlikely that a minor increase in traffic as a result of the construction works will have a significant impact on traffic congestion within the area. The impact of traffic generated by employees and visitors working at the construction site on traffic systems is subsequently considered to be negligible.

For the earthworks and construction works, the following heavy equipment is expected to be used:

- Dozers;
- Excavators;
- Graders;
- Loaders;
- Six wheeler lorries; and
- Water tankers.

The precise number of vehicles required is not clear at this stage as the Project is still at the concept design phase. Given the scale of the Project and the available capacity of the existing road network, construction traffic is not anticipated to generate significant negative impacts on the road traffic in and around the Taweelah area.

Summary of Impacts

The construction phase, vehicles and equipment will be moving around and operating within the Project site for the majority of the time. The movement of staff and visitors, as well as the delivery of construction materials will slightly increase the traffic nearby the Project site, however the impacts to traffic systems within the vicinity of the Project site associated with the increased traffic volume are expected to be negligible.

10.2.2 Operational Phase

Workers on the SWRO plant travelling to and from site will generate the majority of traffic associated with the operational phase. The operational phase of the development will not, of itself, generate additional traffic to the area other than for deliveries, waste removals and maintenance of the various infrastructural components. As such, the impact of the operational phase on traffic at the site is considered negligible.

10.2.3 Cumulative Impacts

The construction, and to a lesser degree, operational traffic will have associated impacts on air emissions (Section 4) and noise generation (Section 9) In addition, the heavy equipment used during construction will have a negative impact on local ecology and biodiversity in and around the Project site.

10.3 Mitigation Measures

10.3.1 Potential Mitigation Measures

The table below outlines the traffic management measures considered for the Project.

Table 10-1 Potential Mitigation Measures

Impact Description	Mitigation Measures	Regulations/Standards
Construction Phase		
Increase in road traffic, and potential for traffic congestion.	• Avoiding materials delivery during traffic rush hours. • Arrangement for mass transport of workers to minimize trips and vehicles coming in and out of the site i.e. use of buses (where relevant). • Purchase of materials in bulk rather than in smaller batches that would require more frequent delivery or collection trips. • Where necessary, construction of temporary access roads to ensure the smooth flow of traffic. • A traffic Management Plan will be developed to confirm the designated access routes, site entrance points, waiting and parking areas etc. The plan will outline how construction traffic will be managed to limit impacts upon local communities, on-site personnel, and	N.A.

	other road users.	
Operational Phase		
Increase in road traffic resulting to air and noise emissions, as well as risk of accidents to nearby farm animals and desert species.	• Development of an effective traffic management plan to ensure the smooth and safe flow of traffic. • Wherever possible deliveries and waste removals will be scheduled outside of the traffic peak hours.	N.A.

10.3.2 Selected Mitigation Measures

Construction Phase

The following measures have been selected for controlling traffic and traffic-related issues expected during the construction of the Project:

- Avoiding materials delivery during traffic rush hours, particularly when materials will be coming from the city;
- Arrangement for mass transport of workers to minimize trips (in cases where workers are moving out of the project site or their accommodation areas);
- Purchase of materials in bulk rather than in smaller batches that would require more frequent delivery and collection trips. This may form part of the Contractor's purchasing policy, which will assist in reducing not only traffic load but also the associated noise and air emission, and which will also serve as an effective waste minimization measure; and
- Development of a construction traffic management plan to facilitate smooth traffic flow within the Project site and immediate vicinity. Details of the traffic management scheme will form part of the Project's Final Design. The traffic management plan may include the following measures among many others, where necessary:

- Traffic signs and traffic control signals to direct and control traffic flow;
- Signs that are reflective or adequately illuminated at night;
- Flagmen and signaling equipment; and
- Temporary diversion ways where works will interfere with the existing road.

Operational Phase

The following measures have been selected for controlling traffic and traffic-related issues expected during the operational phase of the Project:

- Development of an effective traffic management plan to ensure the smooth and safe flow of traffic.
- Wherever possible deliveries and waste removals will be scheduled outside of the traffic peak hours.

10.3.3 Cumulative Impacts

The risk for traffic related cumulative impacts will be minimised primarily through the implementation of consistent and effective traffic management measures discussed above during the construction and operational phase of the project.

10.3.4 Residual Impacts

There will be minor increases in road traffic during both construction and operational phases. These increases are likely to be negligible and have limited impact on traffic systems in the area around the Project site.

10.4 Monitoring Programme

Monitoring Programme for Compliance with Selected Mitigation Measures

The monitoring programme in the table below will be undertaken to ensure that the selected measures are consistently implemented and to determine whether these measurements are sufficient to reduce the Project's traffic and traffic related impacts to an acceptable level.

Table 10-2 Monitoring Requirements

IMPACT	MITIGATION MEASURE	MONITORING REQUIREMENTS	MONITORING SCHEDULE
Construction Phase			
Increase in road traffic, and potential for traffic congestion	• Avoiding materials delivery during traffic rush hours.	Record deliveries including material delivered, time etc	Daily
	• Arrangement for mass transport of workers to minimize trips and vehicles coming in and out of the site.	Record the daily trips of vehicles.	Daily
	• Purchase of materials in bulk rather than in smaller batches that would require more frequent delivery or collection trips.	Materials inventory.	Weekly
	• Where necessary, construction of temporary access roads to ensure the smooth flow of traffic.	Visual monitoring of traffic condition.	Daily
	• Development and implementation of a construction traffic management plan to facilitate smooth traffic flow within the Project site.	Visual monitoring of traffic condition.	Daily

Monitoring Programme for cumulative impacts

The Project's cumulative impact (i.e. to the existing road traffic) will be monitored through visual observation of the general traffic flow and condition during construction. Any traffic accidents found to be related to the Project construction works will be recorded and investigated in coordination with relevant authorities.

Monitoring of traffic-related issues (i.e. air emissions, noise, soil contamination, safety risks) will be carried out in accordance with the monitoring programmes presented in respective sections. This applies to the construction and operational phases of the Project.

Monitoring Programme for Residual Impacts

The Project's residual impact (i.e. to the existing road traffic) will be monitored through visual observation of the general traffic flow and condition during construction. Any traffic accidents found to be related to the Project (e.g. construction works) will be recorded and investigated, where deemed necessary.

11 ARCHAEOLOGY AND CULTURAL HERITAGE

11.1 Observations and Baseline Conditions

11.1.1 Archaeological Sites in the UAE

An examination of existing literature on archeologically and historically relevant sites in the UAE shows a selection of significant sites, which include ancient forts, trading camps, fishing villages and more. Archaeological artefacts have also been found within these sites. According to the UAE Ministry of Culture and Knowledge Development this can be attributed to the geographical location of the UAE which positioned it as one of the major trade destinations and commercial passage linking the three old continents (Africa, Asia and Europe).

This attracted many civilisations to the area that in turn marked it with historical landmarks and remains that have shaped the history of the country. Archaeological excavations in the UAE began in the 1950's with the first archaeological discoveries made in the Emirate of Abu Dhabi. In 1958, a settlement from the second half of the 3rd millennium BC was discovered on Umm Al Nar, a small island offshore Abu Dhabi Island. Since then, many more archaeological discoveries from the Bronze Ages until the Islamic period have been made. These discoveries have extended human habitation and cultural heritage in the UAE back to 3,000 years or more.

11.1.2 International Cultural Heritage Sites in the UAE

Al Ain (Hafit, Hili, Bidaa Bint Saud and Oases Areas) is the only UNESCO World Heritage site in UAE since 2011. The Cultural Sites of Al Ain (Hafit, Hili, Bidaa Bint Saud and Oases Areas) testifies to sedentary human occupation of a desert region since the Neolithic period with vestiges of many prehistoric cultures. Remarkable vestiges in the site include circular stone tombs (ca 2500 B.C.), wells and a wide range of adobe constructions: residential buildings, towers, palaces and administrative buildings. This site features one of the oldest examples of the sophisticated aflaj irrigation system, which dates back to the Iron Age. The site provides important testimony to the transition of cultures in the region from hunting and gathering to sedentarisation.

11.1.3 Cultural Sites in Abu Dhabi

Al Hilli Archaeological Park

This is the largest Bronze Age complex in the UAE, dating from the 3rd millennium BC. It is located in Al Ain in the Emirate of Abu Dhabi. According to the United Arab Emirates Ministry of Culture & Knowledge Development, seven circular tombs divided into rooms were discovered at the site. Inside the rooms, archaeologists found a number of pottery jars, beads and copper arrowheads. This site is found approximately 124.87 km from the project site.

Jabel Hafit Tombs- Bronze Age (300-2700 B.C)

This unique location is found on the foot of Mount Hafeet in the city of Al Ain and goes back to the bronze age. Archaeologists have discovered over 200 tombs in this location with many copperplates, crockery and coloured beads. Jabel Hafit Tombs were included in the World Heritage List in 2011. This site is 139.2 km from the project site.

Umm Al Nar

The island, first excavated in 1959 by a Danish archaeology team, contains important buildings and tombs of the Umm an-Nar Culture. The cemetery comprises above-ground tombs, which are circular in shape and range in diameter from 6 to 12 metres. They are several metres high and are divided into chambers accessed through small entrances. Each chamber was designed to contain several bodies, but the precise number is difficult to tell because of disturbances by grave robbers and the passage of time. The tombs were constructed using dressed stones. Some of these original stones were used in the restoration of a number of tombs during the 1970s. The ring walls of the larger buildings were sometimes decorated with carvings of Oryx, oxen, snakes and camels. Several buildings made from rough-cut stone were also excavated on Umm an-Nar Island. These comprised houses and a warehouse. The latter was used to store and transport goods from the island to regions around the Arabian Gulf. This site is found 39km from the project site.

Bidaa Bint Saud

Located 25 kilometres north of Al Ain, Bidaa Bint Saud contains a wealth of archaeological finds, including 5,000-year-old burial tombs, Iron Age (1300 BCE-300 BCE) irrigation systems, a rare Iron Age building and other artefacts showing the area was an important stop on a possible caravan route extending from Al Ain to the north of the United Arab Emirates. The area is dominated by Garn bint Saud, a 40-metre-tall rock rising above the surrounding landscape. Burial sites and tombs were found along the top and eastern sides of the outcrop, while slightly further south were the irrigation systems and building.

Maqta Conservation Area

Built at the shallow low-tide crossing to Abu Dhabi island from the mainland, Al Maqta Tower is a significant historic building in Abu Dhabi city. Constructed in the late 18th century and contemporaneous with Qasr al Hosn. it represents one of the few examples of coastal defensive towers built of coral stone and beach rock. This site is located 42 km from the proposed project site.

11.1.4 Project Site

An examination of existing literature on archeologically and historically relevant sites within Abu Dhabi did not show specific sites or activities of relevance regarding the immediate terrestrial area of the project site. Site visits undertaken to date further confirm this with no surface features of potential archaeological importance identified within the project footprint which is found in an industrial area.

11.2 Potential Impacts

11.2.1 Construction Phase

There is a potential of encountering buried archaeological remains or artefacts. While the risk of this is low, this could lead to damage, destruction and loss of archaeological artefacts of conservation value. However, given that the project is found in an industrial area the presence of archaeological features within the project footprint is likely to be very low.

A "Chance Find Procedure" will however be prepared and incorporated in the project CESMP such that in the unlikely event any items of archaeological significance are discovered, there is a clear procedure on stopping work and reporting immediately to the Construction and Environmental Managers so that the appropriate specialists from EAD and Abu Dhabi Municipality can be contacted to come to site to confirm the finds and ensure they are formally recorded, protected and conserved.

11.2.2 Operational Phase

The operational phase will not result in further impacts to cultural heritage, as the site will be static and excavations will not be required

11.3 Mitigation Measures

Table 11-1 Archaeology & Cultural Heritage Mitigation & Management Measures

POTENTIAL IMPACT	MITIGATION AND MANAGEMENT MEASURES
Accidental damage to unknown archaeological resources buried within the project site	• An archaeological Chance Find Procedure will be developed prior to construction and the start of site earthworks, as part of the CESMP. This will include protocols and procedures to stop work and report any finds immediately to the Construction Manager and Environmental Manager who will alert the Authorities for specialists to come to site. • Where artefacts or archaeological remains are encountered, the site will be clearly signed/delineated with high visibility flagging to prevent further access which may damage the artefacts which have just been found. • Any finds must not be removed from the location or cleaned in anyway and must be left in situ until the specialists from Abu Dhabi Municipality come on site. • Toolbox talks will include a session on the procedure to be followed should any suspected archaeological finds be discovered on site. • Removal of any archaeological artefacts from the site by site workers will be strictly prohibited

11.4 Monitoring Programme

Table 11-2 Archaeology & Cultural Heritage – Monitoring Requirements

MONITORING	PARAMETER	FREQUENCY & DURATIONS	LOCATION
Construction			
Archaeological resources & artefacts	Undiscovered archaeological remains within the project site	Daily visual observations by site workers involved in excavations	The SWRO project area requiring excavations, earthworks or grading during construction and operation

12 SOCIO-ECONOMIC

12.1 Description of the Environment

The socioeconomic information of the UAE and specifically the Project area is presented in this section. The information on the social baseline of the Project area was sourced to inform the social impact and significance analysis in this section of this report.

The Abu Dhabi government is striving to provide world-class healthcare, education and other services that lead to a safe and secure society in addition to the preservation of cultural heritage of Abu Dhabi. Abu Dhabi aims to ensure a better quality of life for all citizens.

Economy

The economy of the Emirate of Abu Dhabi grew by 2.8% in 2016 (SCAD, 2017) with GDP reaching AED 728.5 million. The GDP per capita at current process amounted to AED 246.5 thousand. The main activities contributing to economic growth in 2016 were 'Information and communication', 'Transportation and storage' and 'Manufacturing' which rose by 6.9%, 5.8%and 3.6%, respectively.

Foreign trade in goods is of paramount importance to the economy of the Emirate of Abu Dhabi and contribute to a considerable proportion of the Emirate's GDP. In 2016, net trade in goods accounted for 10.2% of the GDP, reflection the contribution of foreign trade to the economy in general. Re-exports in 2016 were valued at AED 24.8 billion compared with AED 18.8 billion in 2015. The top category during 2016 was 'Machinery, sound recorders, reproducers and parts', which contributed 26.7% of the re-exports total.

Population

The Project area falls under the Abu Dhabi region, which had a population of 2,908,173 in 2016. Of the total Abu Dhabi Emirate population, 551,535 people (19.0%) are Emirati citizens; of those, 293,860 live in the Abu Dhabi Region (as opposed to Al Ain and Al Gharbia Regions).

The non-citizen population comprise 81.0% of the total resident population. Of the non-citizens 1,513,376 people (64.2%) live in the Abu Dhabi Region. More than 63.9% of the population of Abu Dhabi Emirate are male, mostly due to an influx of male migrant workers.

The area proximal to the Project area includes migrant workers at the industrial facilities in KIZAD Area A and B as well as at the farms located in KIZAD Area A. The Al Samha area in KIZAD Area B is predominantly occupied by Emirati citizens who reside in residences provided by the government.

Economic Environment

Provision of resources such as water, electricity and gas is one of the strategically important economic activities in the Emirate of Abu Dhabi. The long-term economic development plan places importance on the resources sector to contribute significantly to the development of the non-oil economy and ensure more stable economic growth in the Emirate.

Electricity, gas and water supply activities accounted for 4.5% of the GDP in 2016. The value added of the manufacturing activity increased since the previous year rising from AED 29.8 million in 2015 to AED 32.6 million in 2016. Electricity and water had a 6.2% share in non-oil GDP during 2016.

Realising the importance of electricity, gas and water supply as a promising sector in the diversification of the economy and achievement of sustainable development, the Emirate of Abu Dhabi seeks to expand investment in this activity over the coming years.

The new SWRO plant at Taweelah is one of the Emirate's main water resource developments, which will ensure adequate provision of water to the Emirate's population in the upcoming years in line with increase in demand from the growing population.

Financial intermediation is an important productive activity, which plays a vital role in the development of the Emirate of Abu Dhabi, and acts as the main financing vehicle for other economic activities. The total value of shares traded on the Abu Dhabi Securities Exchange during 2016 amounted to AED 49.0 billion. The market capitalization of shares in the Abu Dhabi stock market in 2016 rose by 8.1%compared with 2015 despite the total companies remaining at 68 companies over the same period.

Employment and Livelihoods

The estimated percentage of employed persons aged 15 years and above was 78% in 2016. According to estimates based on the labour force survey covering the fourth quarter of 2016, the labour force constitutes 68.1% as a percentage of the total population and 81.5% as a percentage of the population aged 15+. Females made up 23.5% of the total labour force. The economic dependency ratio was of 46.9%

Emirati citizens are predominantly employed by the government and government – owned entities. This has driven the government to introduce an emiratization policy where the private sectors are encouraged to hire Emirati nationals and are given incentives in return.

The Project is located within a dedicated industrial zone (KIZAD), where the government entities of Emirates Aluminium (EMAL) and Al Taweelah Power and Desalination Plant exist. Both of these government entities employ Emiratis.

Emiratis residing in the Al Samha area are mostly employed in the government sectors in the army, police, oil companies, hospitals or in schools. Some of the Emiratis are self-employed (entrepreneurs). Some of the Emiratis source their income from fishing and herding (Halcrow, 2008).

Agriculture and Farming

There are a number of farm plots in the wider KIZAD Area A and B which are proximal to the Project site. These are farm plots granted to Emiratis by the government. The farms produce fruit, vegetables and fodder for livestock. Produce is sold nationally and the income is given to the Emiratis. It should be noted that this is not a sole source of income for the Emiratis that own these farms. The workers in these farms are expatriates of Asian origin.

There is one large farm area located to the South of the Project site across the outfall channel which is designated as private land. The exact purpose of this farm could not be verified.

Health

Health services in Abu Dhabi have experienced remarkable expansion and transformation over past years. This is most evident in the significant rise in the number of hospitals and other health facilities over this period. The number of hospitals grew to 51 in 2015, including new private hospitals opened in the region of Abu Dhabi. In general, the Emirate has also witnessed a remarkable increase in the number of health centres and clinics.

The Emirate has high rates of chronic diseases such as obesity, diabetes and cardiovascular diseases that are related to lifestyle. Respiratory infections are the second most common non-life-threatening condition in the Emirate.

In the Emirate of Abu Dhabi there are were 51 hospitals that cater to residents in 2015. Near the Project area, the closest hospital is the Al Rahba Hospital. This is a government – owned hospital and caters to all residents in the area surrounding Al Rahba. There is also a small healthcare clinic in the Al Samha area, which also caters to residents in Al Samha.

Education

Abu Dhabi has made remarkable achievements in the education sector, and has spared no effort in its endeavour to ensure the availability of high-quality educational infrastructure of schools, colleges/institutes, adult education centres and universities and qualified teachers in the government and private sectors.

The total number of schools in 2016 in Abu Dhabi Emirate was 442 of which 255 were government schools and 187 were private schools, comprising 17,118 classrooms. In these schools there were 366,029 pupils, 23,745 teachers and 10,265 administrators. The number of pupils per teacher was 15.4 and the number of pupils per classroom was 21.4. The estimated rate of illiteracy among the population aged 10 years and above declined to 7.0% from 6.2%

in 2015. This declining trend in illiteracy applies to both citizens and non-citizens and to males and females.

Recreation

The Emirates Heritage Club (EHC) was established in 1993 through the directives of the late Sheikh Zayed bin Sultan Al Nahyan. The EHC was formed to preserve local identity and the country's heritage. The EHC undertakes this through a number of activities they organise from their centres located across Abu Dhabi. One of these centres is located in the port area next to the Al Taweelah Power Plant. The centre consists of a small building and a beach area for children's activities. Since the area has become incorporated within the Taweelah Power Plant and EMAL, it is not clear whether this centre is active or not.

12.2 Environmental Impact Prediction and Evaluation

12.2.1 Construction Phase

The construction phase of the Project will generate new jobs and increased economic activity. This represents a positive economic impact of the Project. The workforce to be engaged during the construction of the SWRO Plant is unknown at present, however, based on similar type and size of projects, it is expected that the work force will reach approximately 2,708 people during peak construction periods, which will likely be split in to two (2) or three (3) working shifts.

The demand for construction materials will likely be sourced from local suppliers. Additionally, the requirement for food and catering services for construction workers will provide business opportunities for local companies in this industry as an when they are required. However, these jobs created will be temporary, for the period of the construction, which is approximately 41 months.

The Project is located in a designated industrial area and there will be no change in the land use pattern.

12.2.2 Operational Phase

The operation phase of the Project will also generate new jobs and increased economic activity. This represents a positive economic impact of the Project. The team to be engaged for operation and maintenance of the SWRO plant is unknown at this stage, however, based on similar type and size of projects, it is expected that the operation and maintenance team will consist of approximately 60 people, which will likely be split in to two (2) or three (3) working shifts.

12.2.3 Cumulative Impacts

The new SWRO plant at Taweelah is being developed to assist in providing adequate water resources to the growing population of Abu Dhabi. The location of the Project is in KIZAD; a dedicated industrial zone. As such during construction, there may be a number of other industrial projects being developed over the same timeframe. The impacts on the local population, employment and community facilities as a result of construction and operation of this Project and any other development project are considered to be positive.

12.3 Mitigation Measures

12.3.1 Potential Mitigation Measures

Potential mitigation measures associated with the current Project are presented in the table below.

Table 12-1 Potential Mitigation Measures

IMPACT DESCRIPTION	MITIGATION MEASURES	REGULATIONS/STANDARDS
Construction Phase		
Social impact of working conditions employment on construction workers	• HR Policy (in line with IFC PS2) • Client's Corporate Social Responsibility Policy; • Client's Health, Safety and Environmental Policy; • Client's Human Right Policy; • Client's Whistle Blowing Policy; • Stakeholder and Community Engagement Policy; • Community Grievance Management Policy; and • Code of Business Conduct.	IFC Performance standards ILO & UN requirements
Generation of employment opportunities for construction workers.	• Provide prompt and just payment to workers. • Utilise the local labour force, where feasible.	UAE Labour Code IFC Performance standards ILO & UN requirements
Generation of business opportunities.	• Prioritise local companies when sourcing construction materials and services.	--
Potential nuisance to sensitive receptors as a result of excessive noise, smoke and wastes.	• Implement the selected control measures for air emissions, waste management and noise.	Refer to selected control measures for air emissions, noise and waste management as discussed in this ESIA
Operational Phase		
Additional load/strain on existing infrastructure and	• Sustainable design of infrastructure and utility components.	Estidama Sustainability.

utilities.		

12.3.2 Selected Mitigation Measures

The measures selected for the socio-economic impacts of the Project during construction and operation include the following:

Construction Phase

- Provide prompt and just payment to workers. In particular, the UAE Labour Code provisions for the minimum salary, working hours and working conditions must be adhered to by all parties involved in this Project, primarily the Contractor;
- The EPC Contractor and the sub-contractor HR Policy will be in line with local labour laws and international ILO and UN conventions. The EPC Contractor is to ensure that this is applied as an overarching policy for all sub-contractors
- Utilise the local labour force, where feasible. This will optimize benefit to the local economy and contribute to reducing the existing population gap between foreigners and locals;
- Prioritise local companies when sourcing out construction materials and services. This will also optimize economic benefits to the Emirate as well as to the UAE in general; and
- Implement the proposed control measures for noise, air emissions and waste, which are issues that typically cause nuisance to sensitive receptors. Any complaints received in regards to the Project will be logged through a Complaints Register and addressed as promptly as possible.
- All project workers will receive induction training at the project, as well as vocational specific training for on-site construction works.
- All workers will receive training in regard to health and safety, as well as environmental awareness
- Toolbox talks will be conducted before work on each day to ensure workers are reminded of key topics.
- Cultural awareness training will be conducted for all foreign workers.

Operational Phase

- Employment and training of UAE nationals, wherever possible.
- It is recommended that key supply chains are monitored periodically during operations to ensure that materials, goods and services providers comply with ILO and UN requirements for employment and ensuring the suppliers have a suitable occupational health and safety record.
- All project personnel will receive induction training at the project, as well as vocational specific training for their duties.

- All workers will receive training in regard to health and safety, as well as environmental awareness. Training will be updated on a yearly basis as a minimum.
- Workers will be encouraged to develop their careers and maybe provided with opportunities to attend training courses and other career development processes.
- The plant will be operated by an experienced O&M company to ensure the appropriate operation and maintenance of the SWRO desalination plant to enable a secure supply of potable water for Abu Dhabi.

12.3.3 Mitigation Measures to Address Cumulative Impacts

The selected control measures for air emissions noise and waste management discussed herein will serve to reduce the likelihood for nuisance or disturbance to nearby sensitive receptors.

12.3.4 Residual Impacts

Construction Phase

The benefits and adverse impacts of the Project construction on the local socio-economic condition will be for the duration of the construction only; no residual impact is anticipated.

Operation Phase

The positive socio-economic impacts of the Infrastructure Project will be continuous throughout the service life of the infrastructures.

With the implementation of appropriate management measures for air emission, noise and waste, social nuisance is considered an unlikely issue with the operation of the Infrastructure project.

12.4 Monitoring Programme

Monitoring Programme for Compliance with Selected Mitigation Measures

Monitoring of any socioeconomic impacts will be undertaken through the development of a grievance mechanism. This will be developed by the Project Proponents and included in the CESMP and OESMP. The grievance mechanism will be developed as a tool to manage any socioeconomic impact as a result of the Project that may affect any of the Project stakeholders. Through this mechanism the Project proponent will monitor concerns and be able to facilitate resolutions that are mutually acceptable by the parties, within a reasonable timeframe.

Monitoring Programme for Cumulative Impacts

The proposed monitoring for air emissions, noise and waste management discussed herein will serve to reduce the likelihood for nuisance or disturbance to nearby sensitive receptors.

Monitoring Programme for Residual Impact

Positive residual socio-economic impact is expected from the services to be provided by the different Project utilities. Therefore, no monitoring is required for the residual impacts.

12.5 Project Company Commitment

The Project Company confirms its commitment to comply with the social policies in line with IFC Performance Standards.

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22nd August 2019

Letter of Commitment

To whom it may concern;

We, International Company for Water and Power Projects, hereby ensure that Taweelah RO Desalination Company LLC ("Project Company"), duly organized and existing under the laws of the U.A.E. and the Emirate of Abu Dhabi, and established on 25th July 2018, shall prepare and implement below mentioned documents within 2 months of Financial Close. These will also be cross-referenced in the CESMP and the future OESMP and will apply to both construction and operational phases of the project.

- HR Policy (in line with IFC PS2)
- Client's Corporate Social Responsibility Policy;
- Client's Health, Safety and Environmental Policy;
- Client's Human Right Policy;
- Client's Whistle Blowing Policy;
- Stakeholder and Community Engagement Policy;
- Community Grievance Management Policy; and
- Code of Business Conduct.

Again, we will ensure the implementation of the above document.

Yours sincerely,

For and on behalf of
International Company for Water and Power Projects

Ishaq Al Hammadi
Country Managing Director

International Company for Water & Power Projects | Dubai Branch | P.O. Box [illegible] | United Arab Emirates
شركة أعمال المياه والطاقة الدولية | فرع دبي | ص.ب: [illegible] | الإمارات العربية المتحدة

13 LANDSCAPE AND VISUAL AMENITY

13.1 Observations and Baseline Conditions

13.1.1 Landscape

Landscape character could be defined as "a distinct, recognisable and consistent pattern of elements, be it natural (soil, landform) and/or human (for example settlement and development) in the landscape that makes one landscape different from another, rather than better or worse" (Natural England, 2014).

The project site is situated within the Gulf (coastal) Region of the Emirate of Abu Dhabi and consists of made ground with the original soil profile, floral community and elevation of the site altered during site clearance and placement of excavated marine material. The site was originally utilized as a storage site for dredged material with the material excavated from the current Taweelah outfall channel.

The profile of the site is undulating, as a result of historical earthworks that have moved the imported fill material around the site. The disturbed ground has been re-colonized by halophytic perennial shrubs that commonly colonise saline, sandy soils with *Zygophyllum qatarense* the shrub species across the majority of the site with *Cyperus* sp. also present.

In the northern corner of the site is an area of unique habitat that differs markedly from the remainder of the site. Water seepages from the existing facilities to the north of the site have created an area of moist ground that supports the shrub *Tamarix nilotica* and stands of the reed *Phragmites australis*. It is understood that the area was historically utilized to house a labour camp and site offices.

Due to the varied nature of developments undertaken in the local project area, several landscape character types have been established or are natural features. These include the following:

- The coastline;
- The desert;
- The open sea;
- Taweelah Complex;
- Emirates Heritage Club;
- Khalifa Port;
- Emirates Global Aluminium; and
- Al Hamjurah (which includes forest plantation and private residences).

Plates 13-1 View of the Project site

Plates 13-2 Stands of *Phragmites australis* pictured in north of the site

Plates 13-3 View of the Khalifa Port and the coastline from the project site

13.1.2 Visual Quality

When establishing the value of views and visual amenity, the inter-relations between individuals or groups of people and landscape will be considered such as the change of views that people have of the landscape and the effects of change on their visual amenity. The visual baseline has therefore been established by:

- Identifying views, viewpoints and extent of possible visibility;
- Identifying receptors that may be affected.

Besides views of the large superstructures of the industrial facilities in close proximity to the site; the Taweelah Complex and Khalifa harbour which have resulted in an amount of disturbance to the visual envelope of the landscape, the Project site is typical of the typology found in a desert environment.

Besides existing industrial receptors, the nearest residential and commercial use areas to the project site are the Hanjura buildings and farm land and the Emirates Heritage Club. The latter is approximately 3 km away from the Project area. Within Hanjura there are some buildings and a small harbour which are located only 400-500 m away from the Project boundary however the main residential building in this area is situated 1.4 km away from the Project site.

Other visual residential/commercial receptors are several kilometres away from the Project boundary and have no direct visibility of the Project site.

13.2 Environmental Impact Prediction and Evaluation

13.2.1 Construction Phase Impacts

Change in Landscape Character

The construction of a new development, particularly those on a large scale have the potential to result in changes to the landscape character of a locality through land use and topographical changes or other factors. In situations where the visual horizon is disturbed by a development, such impacts may include the anthropogenic intrusion of the landscape by buildings/structures where no intrusion previously existed; or the change in the landscape character of an area, which could arise from new/out of place development or from changes in the land use.

One of the first stages of construction activities will result in the levelling, grading and preparation of the site prior to the commencement of construction. However, given the existing nature of the site, grading and levelling activities are not expected to be extensive. Also, the development of the SWRO plant is not expected to result in significant changes to the landscape character of the area as the new structures to be installed and constructed for the Project will embed with the existing large superstructures of the industrial facilities in close proximity to the site.

Reduction in Visual Quality

The movement of heavy construction vehicles and earthworks on sandy surfaces can potentially result in dust generation and a resulting temporary haze causing disturbance to the current visual envelope of receptors.

Impacts to the visual envelope of surrounding receptors will also occur at night where the addition of lighting during construction will illuminate the proposed project area. The use of lighting across the site will result in a night time light haze likely to be visible for several kilometres from the project area. However, it is not anticipated to have a significant impact on receptors due to the existing lighting at industrial facilities within the Project area.

Any impacts from lighting are anticipated to be minimised by the implementation of a CESMP on-site.

13.2.2 Operational Phase Impacts

Following the impacts of construction and establishment of project features, the operational phase will not result in changes to the landscape character or visual envelope of receptors overlooking the Project site. Although lighting impacts will occur, this will be similar to the construction phase, and as such significance has not been re-assessed. The mitigation and management measures with regards to light pollution will be the same as construction phase. This will include the deployment of lighting for safety and security that seeks to avoid light spill, skyglow and glare and will utilise efficient low energy systems where appropriate.

13.3 Mitigation Measures

Construction Phase

Table 13-1 Landscape and Visual Quality Mitigation & Management Measures- Construction

Potential Impact	Mitigation and Management Measures
Changes in landscape character	• Land clearance to be limited within the boundaries of the Project site. • Construction works to be limited within the boundaries of the Project site.
Changes in landscape character and disturbance to visual envelope of receptors	• Where appropriate, construction laydowns and working areas of the site will be screened to reduce the visual intrusion to existing off site receptors. • When not in use, cranes and other construction plant will be lowered, so they are at their minimum height and do not protrude unnecessarily within the visual envelope of local receptors. • Mitigation and management measures relating to the generation of dust (as detailed in the Section 4 Air Quality) will be implemented to minimise

Potential Impact	Mitigation and Management Measures
	visual impacts during construction activities. • Minimise construction works at night-time to those strictly required. • Any flood lights required during night time construction activities will be directed onto the working areas, with a maximum position angle of 30° from vertical, and back spill shields, therefore minimising any unwanted light spill.

Operational Phase

Following the impacts of construction and establishment of project features, the operational phase will not result in changes to the landscape character or visual envelope of receptors overlooking the Project site. Although lighting impacts will occur, this will be similar to the construction phase, and as such significance has not been re-assessed. The mitigation and management measures with regards to light pollution will be the same as construction phase. This will include the deployment of lighting for safety and security that seeks to avoid light spill, skyglow and glare and will utilise efficient low energy systems where approriate.

14 Community Health, Safety & Security

This chapter has been specifically included to outline and assess the impacts relating to the safety and security of the local community who live and work in surrounding area and may be subject to project related impacts.

The majority of secondary impacts relating to community in terms of air quality, noise, wastewater, waste etc., have been addressed in previous chapters of this report. This chapter therefore concentrates more specifically on the potential emergency impacts that could relate to the project and the security of the project to avoid instances of trespass, malicious intrusions or other misdemeanours.

The primary purpose of this chapter is to therefore identify specific management measures in regard to community health, safety and security.

14.1 Observations & Baseline Conditions

14.1.1 Public Health and Safety

The project is located in an area with industrial facilities as well as some residential and commercial receptors.

The nearest residential and commercial use areas to the project site are the Hanjura buildings and farm land and the Emirates Heritage Club. The latter is approximately 3 km away from the Project area. Within Hanjura there are some buildings and a small harbour which are located only 400-500 m away from the Project boundary however the main residential building in this area is situated 1.4 km away from the Project site. The Project site itself is bordered by a large industrial area to the North, as it is located within the existing Taweelah facility.

Given the nature of the Project, associated construction and operation activities and distance from the Project site, the receptors over 1km from the Project site will not be directly affected by the Project and therefore are not considered ‘Affected Communities’. Impacts relating to the local community in terms of air quality, noise, wastewater, waste etc., have been addressed in specific chapters elsewhere in this ESIA.

Project related activities might result in the increase of risks associated with those who may visit areas in and around active project sites.

14.1.2 Occupational Health and Safety

Any construction project will introduce health and safety risks associated with the use of plant, machinery and construction processes. Risks can be severe depending on the type of activities required, materials used and site condition.

For projects where the local population/skill sets require influx of people from other regions/countries consideration will need to be given associated with accommodation, welfare, sanitary provision, health care, hygiene, food potable water etc.

14.2 Potential Impacts

14.2.1 Construction Phase

Community Health

The construction phase of the project will require suitable accommodation areas for this workforce. As confirmed, the worker accommodation will be located off-site. It is expected that the majority of site staff worker including sub-contractor workers will be accommodated in the local area, and therefore may come into contact with the local populations. This therefore poses a potential risk for the spread of diseases to the local communities.

Community Safety

All construction projects have potential risks relating to public safety that could arise, particularly in regard to the use of high-powered equipment, heavy construction equipment, excavations, transportation amongst others, including fire and pollution releases.

Public risks during construction have the potential to result in isolated incidents, which could be of a devastating magnitude to a person or group of people in the wrong place at the wrong time; however, this rarely occurs. Unlike the operations phase, there is a low probability of widespread risks that could potentially affect the public and the environment as a single event (e.g. large-scale pollution incidents, dust dispersion, explosions etc.).

Risks to the public will be appropriately addressed and prepared for in the construction phase 'Emergency Preparedness and Response Plan' and training regarding this plan. Construction personnel should be trained in emergency procedures and the potential affected receptors should be notified of procedures to follow by means via relevant communication channels.

Security

The construction phase of the project will require site-based security at the gates and on patrol around the site in order to prevent the public from trespassing to the construction site. This is so as to minimise the potential for construction site incidents from occurring. Project security will need to adhere to the security plan prepared by the EPC Contractor in line with UAE National Standards.

In addition to this, security personnel will receive internal training in regard to grievances, reporting such grievances and dialogue with any members of the local communities.

Table 14-1 Community Health, Safety and Security Mitigation & Management Measures- Construction

Potential Impact	Mitigation and Management Measures
Potential for community exposure to diseases as a result of worker influx in the local area	There are no local communities within the Project area. However, the following is recommended: • The Health and Safety Teams will provide training/inductions on exposure to diseases. • During construction, staff will have access to medical professionals and suitable medical facilities, which will aim to prevent the spread of diseases internally and externally. • Any reportable disease will be diagnosed by the authorised occupation and health centre doctor. Diagnosis will include identifying any new symptoms or any significant worsening of existing symptoms. • Any external or internal spreading of diseases will be diagnosed and precaution taken as per the instructions from the national/local medical authority. • The potential for exposure to water-borne, water based, vector borne disease and communicable diseases as a result of the project activities will be avoided or minimised.
Emergency situations in regard to the use of high-powered equipment, heavy construction equipment.	• Risk to public safety will be appropriately addressed and prepared for in the operational phase 'Emergency Preparedness and Response Plan' and training. • The plan will include the appropriate procedure to respond to any such incidents, as well as site specific contact details and details of external agencies who may be required. • All high-risk areas including fuel storage areas will be secured with internal fencing and patrolled by security throughout the day and night. • Appropriate mechanisms for emergency control (e.g. firefighting equipment) will be placed at accessible positions around the site.
Security	• The project will employ its own security staff who will provide 24/7 security control across the project site and dedicated security staff at the gate house. • All vehicles entering the site will require pre-approved clearance and will need to be registered. • The project's security will record all instances of incoming vehicles. • CCTV will be installed at key locations around the site and at the gatehouse. • Appropriate lighting will be provided at the gatehouses to allow proper screening of personnel at night. • Project personnel will only be provided access to the construction site with valid ID cards and permits to work in line with EHS requirements.
Grievance Mechanism	• The project will implement an appropriate system to allow external parties to raise grievances in regards to the project. The Grievance Mechanism will be designed to allow engagement of applicable project stakeholders. The mechanism will be Cleary defined, transparent and accessible to identify

POTENTIAL IMPACT	MITIGATION AND MANAGEMENT MEASURES
	stakeholders.

14.2.2 Operational Phase

Community Safety

The project will carry out various risks that could result in impacts to public safety where such impacts are transferred or received outside of the project site. Such impacts are unlikely to occur and may relate to fire, VOC fumes, explosions, spills of back up fuels and unwarranted/ accidental releases of wastewater.

The extent of such impacts may go beyond the projects boundaries and require the involvement of outside agencies to help manage and abate such impacts (e.g. Civil Defence, Police)

Although public risks during operation of the SWRO are expected to be limited, there may be significant risks to receptors if realised such as an unwarranted release of wastewater to the Arabian Gulf. Risks to the public safety will be appropriately addressed and prepared for in the operational phase 'Emergency Preparedness and Response Plan' and training. This will include monitoring provisions to ensure that outgoing product water is of suitable quality for potable use and consumption.

Security

The project constitutes a facility of high importance due to the generation of potable water for consumption. The project will include site-based security at the project site access road entrance and at the project gates, who will patrol the site in order to prevent the public from trespassing to the site and any malicious intrusion during operation of the SWRO plant.

Security arrangements will be in line with the UAE National standards. In addition to this, security personnel will receive internal training in regard to grievances, reporting such grievances and dialogue with any members of the local communities.

Transportation

Transportation impacts during operation are not expected to result into any changes, as the operation of the SWRO desalination plant may not require continuous delivery of materials, or other equipment in order to operate.

There will be occasional deliveries and waste removal from the site, which is not expected to result in a noticeable increase in the amount of traffic on the road. Staff movements may also contribute to minimal additional vehicle flows on local roads.

Table 14-2 Community Health, Safety and Security Mitigation & Management Measures- Operation

Potential Impact	Mitigation and Management Measures
Emergency situations with regards to spills, leaks, fire, VOC fumes, explosions etc.	• Risks to public safety will be appropriately addressed and prepared for in the operational phase 'Emergency Preparedness and Response Plan' and training. • The plan will include appropriate procedure to respond to any such incidents, as well as site specific contact details and details of external agencies who may be queried. • All high-risk areas including fuel storage areas will be secured with internal fencing and will be patrolled by security throughout the day. • Appropriate mechanisms for emergency control (e.g. fire fighting equipment) will be placed at suitable positions around the site. • The plant will have various mitigation controls to protect against spillage of hazardous liquids and materials, including fuels.
Security	• The project will employ its own security staff who will provide 24/7 security control across the project site and dedicated security staff at gatehouses. • All vehicles entering the site will require pre-approved clearance and will need to be registered. Project security will record all instances of incoming vehicles. • CCTV will be installed at key locations around the site and at gatehouses. • Appropriate lighting will be provided at gatehouses for security personnel to prevent unauthorised access. • Project personnel will only be provided access to the site with valid ID cards and permits to work in line with HSE requirements.

14.3 Monitoring

Monitoring of Community Health, Safety & Security will be undertaken as is required via the management measures outlined above. For instance, monitoring of the security plan will form part of the wider Environmental and Social Management System (ESMS) internal audits to be undertaken monthly during construction and quarterly during operations. Incoming grievances will be monitored as they come in and will be managed and recorded in accordance with the provisions to be established in the Stakeholder Engagement Plan (SEP) for the grievance mechanism.

15 Workers Condition & Occupational Health & Safety

There are health and safety risks associated with the use of plant, machinery and construction processes of any project. Risks can be severe depending on the type of activities required, materials used and site condition.

For projects in isolated locations or where the local population/skill sets require influx of people from other regions/countries consideration will need to be given associated with accommodation, welfare, sanitary provision, health care, hygiene, food and potable water etc.

15.1 Potential Impacts

15.1.1 Construction Phase

Occupational Health and Safety

Common activities undertaken during construction such as the movement of heavy machinery, excavation, handling of chemicals works undertaken at height etc. can all introduce risk to the health and safety for the associated workforce. In particular, risks are more likely to be apparent for those who are not familiar with the type of works undertaken and/or the associated hazards.

The type of hazards attributable to a construction site will vary significantly dependent on the construction methods employed and the degree of control implemented by the EPC Contractor and affiliated sub-contractor(s). It is therefore of the outmost importance that the EPC and affiliated sub-contractor(s) demonstrate consideration of health and safety risks as part of their chosen construction methods and that these risks are appropriately mitigated.

Note: *Due to occupational health and safety being a risk rather than a potentially defined impact, its significance is not assessed further in this ESIA. Health and safety risks to the site force will be managed through effective risk assessment, development of appropriate methods statements, emergency and disaster planning and the communication of specific health and safety requirements relative to specific work/access requirements.*

Workers Conditions

Labour exploitation on construction site unfortunately cannot be ruled out. An inequality in income, education and opportunities has led to opportunistic immoral practices with labourers and site staff suffering as a consequence.

To ensure the wellbeing of the staff associated with the project, the EPC and associated sub-contractor(s), will need to plan for necessary provisions relative to the requirement of the required workforce. This includes appropriate labour accommodation plans and mechanisms for inspection and corrective actions.

Note: *As worker conditions are defined aspect of site planning rather than a potentially environmental impact, its significance is not assessed further in this ESIA. Risks associated with worker welfare during construction will be managed through effective project planning, and the enforcement of fair and just treatment throughout the construction phase.*

Table 15-1 Workers Condition & Occupational Health & Safety Mitigation & Management Measures -Construction

POTENTIAL IMPACT	MITIGATION AND MANAGEMENT MEASURES
Occupational Health and Safety	• The EPC Contractor will provide the workers with a safe and healthy work environment, considering inherent risks and specific classes of hazards associated with the project. • The EPC Contractor will implement and maintain and OHS management system considering specific risks associated with the project, legal requirements and duty of care. • The EPC Contractor will be responsible for ensuring that all affiliated sub-contractors comply with the OHS management system. The OHS management system will be in-line with recognised international best practice and as a minimum, this plan will include; – Means of Identifying and minimising, so far as reasonably practicable, the cause of potential H&S hazards to workers. – Provisions of preventive and protective measures, including modification, substitution, or elimination of hazardous conditions or substances. – Provision of appropriate equipment to minimise risks, and requiring and enforcing its use. – Training of workers, and provision of appropriate incentives for them to use and comply with H&S procedures and protective equipment. – Documentation and reporting of occupational accidents, diseases and incidents. – Emergency prevention, preparedness and response arrangements.
Workers Conditions-Terms of Employment, Non-discrimination and equal opportunities, Working Relationships	• The EPC Contractor will provide a plan detailing how working conditions and terms of employment are compliant with national labour, social security and occupational health and safety laws. • Employment relationships will be on the principle of equal opportunity and fair treatment, and will not discriminate with respect to any aspects of the employment relationship including recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, access to training, promotion, termination of employment or retirement, and discipline. • The EPC Contractor will not make employment decisions on the basis of personal characteristics, such as gender, race, nationality, ethnic origin, religion or belief, disability, age or sexual orientation, unrelated to inherent job requirements. • The EPC Contractor will document and communicate to all workers their working conditions and terms of employment including their entitlement to wages, hours of work, overtime arrangements and overtime compensation, and any benefits (such as leave for illness,

Potential Impact	Mitigation and Management Measures
	maternity/paternity, or holiday). • The EPC Contractor will base the employment relationship on the principle of equal opportunity and fair treatment, and will not discriminate with respect to all aspects of employment relationship, including recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, accommodation, access to training, promotion, termination of employment or retirement, and discipline. *Special measures of protection or assistance to promote local employment opportunities or selection for a particular job based on the inherent requirements of the job, which are in accordance with national law, will not be deemed discriminatory*
Workers Conditions- Forced Labour	• The EPC Contractor will not employ forced labour, which consists of any work or service not voluntarily performed that is exacted from an individual under threat of force or penalty. This covers any kind of involuntary or compulsory labour, such as indentured labour, bonded labour or similar labour-contracting arrangements. • HR policies and procedures will be adapted appropriately to the size of the workforce required for the project. Policies and procedures must be prepared to demonstrate consistency with the requirements of national legislation and IFC PS 2.
Workers Conditions- Child Labour	• The EPC Contractor will comply with all relevant national laws' provisions related to the employment of minors. • In any event, the client will not employ children in a manner that is economically exploitative, or is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. • Young people below the age of 18 years will not be employed in hazardous work and all work of persons under the age of 18 will be subject to an appropriate risk assessment.
Workers Conditions- Wages, benefits, conditions of work and retrenchment	• Wages, benefits and conditions of work offered should, overall, be comparable to those offered by equivalent employers in the UAE or the sector concerned. • If the EPC Contractor anticipates collective dismissals associated with the proposed project, the EPC Contractor will develop a plan to mitigate the adverse impacts of retrenchment, in line with national law and good industry practice based on the principles of non-discrimination and consultation. Without prejudice to more stringent provisions in national law, such consultation will involve reasonable notice of employment changes to the workers' representatives and, where appropriate, relevant public authorities so that the retrenchment plan may be examined jointly in order to mitigate adverse effects of job losses on the workers concerned. The outcome of the consultations will be reflected in the final retrenchment plan.
Workers Conditions- Grievance Mechanism	• The EPC Contractor will provide a grievance mechanism for workers to raise reasonable workplace concerns. The client will inform the workers of the grievance mechanism at the time of hiring, and make it easily accessible to them. The mechanism will involve an appropriate level of management and address concerns promptly, using an understandable and transparent process that provides feedback to those concern without retribution. The mechanism should not impede access to other judicial or administrative remedies that might be available under law or through existing arbitration procedures, or substitute for grievance mechanisms provided through collective

Potential Impact	Mitigation and Management Measures
	agreements.
Workers Conditions- Supply Chain	• The EPC Contractor will devise a supply management system to ensure the measures above are implemented by all sub-contractors. • The EPC Contractor will take reasonable steps to inquire about the use of child labour and forced labour in its supply chain.

15.1.2 Operational Phase

Occupational Health and Safety

The risk associated with the operational phase of the project are anticipated to be less than during the construction phase due to reduced site activity and requirements for heavy plant and machinery.

However, there will be incoming electrical connections on-site and movement of large volumes of water by high powered pumps, all of which pose a significant risk to worker health and safety. Maintenance and inspection will also require the use of site vehicles and activities that pose risks to human and safety.

The severity and likelihood of risks during the operation phase will be dependent on the frequency and requirements for planned and unplanned maintenance. The operation and maintenance will need to ensure that a robust plan is in place to appropriately manage these risks.

Note: *due to occupational health and safety being a risk rather than a potentially defined impact, its significance is not assessed further in this ESIA. Health and safety risks to the site force will be managed through effective risk assessment, development of appropriate method statements, emergency and disaster planning and the communication of specific health and safety requirements relative to specific work/access requirements.*

Workers Conditions

No long-term accommodation requirements are anticipated for the project. However, as with construction, operational activities will need to plan for and enforce just and fair treatment of operational and maintenance staff (including any engaged sub-contractors). Allowance will also be need to be made for site staff welfare facilities.

Note: *As workers conditions are defined aspect of site planning rather than a potentially environmental impact, its significance is not assessed in this ESIA. Risks associated with worker welfare during operation will be managed through effective project planning, and the enforcement of fair and just treatment throughout the operational phase.*

Table 15-2 Workers Conditions & Occupational Health & Safety Mitigation & Management Measures – Operation

Potential Impact	Mitigation and Management Measures
Occupational Health and Safety	• The O& M Company will provide the workers with a safe and healthy work environment, considering inherent risks and specific classes of hazards associated with the project. • The O&M Company will implement and maintain an OHS management system considering specific risks associated with the project, legal requirements and duty of care. • The O&M Company will be responsible for ensuring all affiliated sub-contractors comply with the OHS management system. The OHS management system will be in-line with recognised international best practice and as a minimum, this plan will include; – Means of identifying and minimising, so far as reasonably practicable, the causes of potential H&S hazards to workers. – Provisions of preventive and protective measures, including modification, substitution, or elimination of hazardous conditions or substances. – Provision of appropriate equipment to minimise risks, and requiring and enforcing its use. – Training of workers, and provision of appropriate incentives for them to use and comply with H&S procedures and protective equipment.
Workers Conditions-Terms of Employment, Non-discrimination and equal opportunities, Working Relationships	• The O&M Company will provide a plan detailing how working conditions and terms of employment are compliant with national labour, social security and occupational health and safety laws. • Employment relationship will be on the principle of equal opportunity and fair treatment, and will not discriminate with respect to any aspects of the employment relationship, including recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, access to training, promotion, termination of employment or retirement, and discipline. • The O&M Company will document and communicate to all workers their working conditions and terms of employment including their entitlement to wages, hours of work, overtime arrangements and overtime compensation and any benefits such as sick leave for illness, maternity/paternity, or holiday). • The O&M Company will not make employment decisions on the basis of personal characteristics such as gender, race, nationality, ethnic origin, religion or belief, disability, age or sexual orientation, unrelated to inherent job requirements. *Special measures of protection or assistance to promote local employment opportunities or selection for a particular job based on the inherent requirements of the job, which are in accordance with national law, will not be deemed discriminatory*
Workers Conditions-Forced Labour	• The O&M Company will not employ forced labour, which consists of any work or service not voluntarily performed that is exacted from an individual under threat of force or penalty. This covers any kind of involuntary or compulsory labour, such as indentured labour, bonded labour or similar labour-contracting arrangements. • HR policies and procedures will be adopted appropriately to the size of the workforce required for the project. Policies and procedures must be prepared to demonstrate consistency with the requirements of national legislation and IFC PS 2.
Workers Conditions	• The O&M Company will comply with all relevant national laws'

Potential Impact	Mitigation and Management Measures
– Child Labour	provisions related to the employment of minors. • In any event, the client will not employ children in a manner that is economically exploitative, or is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. • Young people under the age of 18 years will not be employed in hazardous work and all work of persons under the age of 18 will be subject to an appropriate risk assessment.
Workers Conditions-Wages, benefits, conditions of work and retrenchment	• Wages, benefits and conditions of work offered will, overall, be comparable to those offered by equivalent employers in the UAE and the sector concerned. • If the O&M Company anticipates collective dismissals associated with the proposed project, the Company will develop a plan to mitigate the adverse impacts of retrenchment, in line with national laws and good industry practice and based on the principles of non-discrimination and consultation. Without prejudice to more stringent provisions in national law, such consultation will involve reasonable notice of employment changes to the workers 'representatives and, where appropriate, relevant public authorities so that the retrenchment plan may be examined jointly in order to mitigate adverse effects of job losses on the workers concerned. The outcome of the consultations will be reflected in the final retrenchment plan.
Workers Conditions-Grievance Mechanism	• The O&M Company will provide a grievance mechanism for workers to raise reasonable workplace concerns. The Company will inform the workers of the grievance mechanism at the time of hiring, and make it easily accessible to them. The mechanism should involve and appropriate level of management address concerns promptly, using an understandable and transparent process that provides feedback to those concerned, without any retribution. • The mechanism should not impede access to other judicial or administrative remedies that might be available under law or through existing arbitration procedures, or substitute for grievance mechanisms provided through collective agreements.
Workers Conditions-Supply Chain	• The O&M Company will device a supply management system to ensure the measures above are implemented by all sub-contractors. • The O&M Company will take reasonable steps to inquire about the use of child labour and forced labour in its supply chain.

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