Salalah Independent Water Project
Sultanate of Oman

Environmental and Social Impact Assessment

Volume 4 (Appendices)

Prepared for:

ACWA Power

January 2018

Document Information

Project	Salalah Independent Water Project
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1	Financial Capital
2	Social Capital
3	Natural Capital
4	Manufactured Capital
5	Human Capital

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Appendix A

Environmental Scoping Study

Salalah Independent Water Project
Sultanate of Oman

Environmental & Social Scoping Study

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1 INTRODUCTION

The Oman Power & Water Procurement Company (OPWP) has awarded the Salalah Independent Water Project (Salalah IWP) to the consortium of ACWA Power, Veolia and DIDIC (The Project Sponsors). The project is a 25 MIGD seawater reverse osmosis facility and will be located in Dhofar Governorate, Sultanate of Oman. OPWP will purchase water from the project under a Water Purchase Agreement with Dhofar Desalination Company SAOC (the Project Company).

This Environmental & Social Scoping (ESS) study has been prepared by 5 Capitals Environmental and Management Consulting (5 Capitals) a registered environmental consultant with the Ministry of Environment & Climate Affairs (MECA), the environmental regulator in Oman. It is the intention that 5 Capitals will prepare the project's Environmental & Social Impact Assessment (ESIA) subsequent to this ESS.

The project sponsors will seek project finance from International Financial Institutions (IFIs) who are likely to be signatories of the Equator Principles (EP), a voluntary set of principles established to manage environmental and social investment risks. As such, the required project ESIA process will need to be of a standard that can demonstrate alignment with both the Omani regulations and the requirements of the IFI's; expected to align with the EP's, IFC Performance Standards and IFC EHS Guidelines. This includes consideration of potential 'social' impacts attributable to the Project, and the on-going management of these impacts & risks.

This report outlines the anticipated environmental and social impacts/risks associated with the Project and identifies the scope of work required for the subsequent ESIA. This ESS Report will be submitted to the MECA in Oman, and the consortium of prospective international lenders who may provide project finance.

1.1 Objectives of the ESS

The main objectives of this ESS in relation to the 'Project' are as follows:

- Preliminary identification of baseline environmental and social conditions based on review of available information and an initial site visit to ensure baseline surveys are designed to enable the establishment of robust environmental conditions of the Project site and surroundings;
- Identification of key environmental and social issues relating to the construction and operational phases of the project at an early stage to ensure assessment techniques for the subsequent ESIA address these issues specifically; and
- Identification at an early stage of the structure and content of the ESIA and the provision of a Terms of Reference for MECA.

This Scoping report has been informed by:

- Analysis of the Project details and proposed works;
- Study of the relevant mapping and aerial photography;
- Experience and review of ESIA's for similar projects;
- Initial site visit undertaken in summer 2016; and

- Review of secondary information (e.g. available online databases and reports).

1.2 Structure of the ESS

This ESS includes the following elements:

- *Section 2* describes the key features of the proposed project facilities, a brief description of the parameters of design and process design considerations and the scope of construction and operational activities as well as the Project schedule;
- *Section 3 d*escribes the regulatory framework applicable to the Project;
- *Section 4* presents the environmental assessment and planning process including the scoping and ESIA methodology;
- *Section 5* to *Section 17* present the following information for the different environmental aspects under consideration:
- A brief description of the existing environmental conditions of the Project site and an evaluation of existing environmental information on the area and a gap analysis to determine the additional information that needs to be gathered;
- Potential environmental issues and constraints (and opportunities) associated with the construction and operation of the proposed project facilities based on the existing information; and
- Proposed assessment methodology and requirements during the environmental assessment process.

1.3 Key Project Information

Table 1-1 Key Project Information

Project Title	Salalah Independent Water Project
Project Sponsor (Primary Contact)	ACWA Power Business Gate Office Complex, Building 5, P.O. Box 22616 Riyadh, 11416 Kingdom of Saudi Arabia Tel: +966 11 2835555, Fax: +966 11 2835500
Point of Contact	Janaki Kannan: Manager - Business Development, ACWA Power
Project Company	Dhofar Desalination Company SAOC Commercial Registration No: 1292748
EPC Contractor	SIDEM
O&M Company	To Be Confirmed
MECA Registered 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
Point of Contact	Ken Wade: Director Environment Planning

2 PROJECT INFORMATION

2.1 Project Background & Rationale

Given the demand requirements for water in the Dhofar region, rising at 8% (source: OPWP 7 Year Statement, June 2016), OPWP has planned a water desalination project in on the outskirts of Salalah with a planned commercial operation date of early 2019.

The project is structured as an Independent Water Project (IWP) with OPWP purchasing the Potable Water produced by the operator under a Water Purchase Agreement with a term of 20 years.

The scope of the project includes the design, construction, ownership, financing, operation and maintenance of high efficiency desalination facilities based on seawater reverse osmosis technology with a capacity of 25 MIGD of Potable Water output (113,650 m^3 per day of Potable Water output in nominal conditions, and 120,000m^3 per day during Exigency periods).

The scope of the Project includes not only the development of the main Potable Water production facilities, but also the supply of all equipment and services necessary for the operation of each Plant including the Seawater Intake/Outfall Facilities and Access Road from the public highway.

Electricity supply to the project will be provided via an 11kV connection from the Dhofar Power Company.

2.2 Project Location

The project will occupy an area of approximately 5.83 hectares, located approximately 30km east of Salalah, as presented in Figure 2-1 below.

Figure 2-1 Project Location

The proposed Project site with co-ordinates for all project facilities, access road and temporary construction areas are presented in Appendix A.

The project site is approximately 50m from the shoreline and located adjacent to the existing Salalah Sembcorp IWPP facility. The proposed project will be accessible from the north-west via a new access road, to be constructed as part of the project and connecting with the existing Sembcorp IWPP access road, as shown in Figure 2-2 below.

Figure 2-2 Local Project Area

2.3 Land Use and Site Condition

2.3.1 Land Ownership

The land is owned by the Ministry of Housing. The project will use this land under a Land Lease Agreement to be arranged with Ministry of Housing for the duration of construction and operations.

The Krooki, for the projects land area (issued by the Ministry of Housing) is presented in Appendix B.

2.3.2 Land Use

The land is currently unused, but was previously used as the construction laydown, staging and administration area for the adjacent Sembcorp IWPP project, but has since been rehabilitated.

2.3.3 Site Condition

The project site is situated on an open plain free of any expansive vegetation. The adjacent Sembcorp IWPP, located to the west, is the most notable feature within the immediate landscape. To the south, the project area slopes severely towards the sea where there is a narrow beach area. To the north of the project site is a large wadi that dominates the local landscape.

The primary land mass of the proposed project was previously used by the Sembcorp IWPP as the construction laydown area. On the day of the initial site visit in summer 2016, bulldozers, excavators and tipper trucks were active, associated with the demobilisation of this pre-existing site compound at the project area.

Plate 2-1 View to the South and Project Shoreline

Plate 2-2 View to the North over the area for the Proposed Desalination Facilities

Plate 2-3 View of Sembcorp IWPP from Proposed Access Road

Plate 2-4 View of Wadi Channel to the North of the Project

2.3.4 Local Facilities and Receptors

Sembcorp - Salalah IWPP

Salalah Sembcorp IWPP is located adjacent to the western boundary of the proposed project area. This is a gas fired power plant with a total gross capacity of 490 megawatts and a seawater desalination plant with a total water production capacity of 15 million imperial gallons (69,000 cubic meters) per day.

Camel Shelters

Several small shelters utilised as temporary refuge for camels believed to be owned by Bedouin were noted along the access road to the Sembcorp IWPP, approximately 1-2km from the project site. People believed to be employed by Bedouin were seen tending to these camels.

2.4 Project Description

The project includes the following key facilities:

- Sea water intake system;
- Sea water discharge system;
- Pumping station, including screening equipment;
- Chlorination facilities (pre-chlorination and disinfection);
- Pre-treatment system;
- SWRO system;
- Post treatment system;
- Waste water treatment system;
- Instrument and service air system;

- Fire protection and detection system;
- Ventilation and air conditioning;
- General buildings;
- Access roads;

Figure 2-3 Salalah IWP Main Entrance View

Figure 2-4 Salalah IWP Overview

The historical sea water conditions and the particularities of the region have been considered in the design and dimensioning of the desalination plant, with the aim of complying with the technical and operational expectations and requirements of OPWP. Further, the design of the plant and the related buildings has been developed focusing on the combination of operational suitability and efficiency while ensuring minimization of the environmental and visual impact.

Figure 2-5 Salalah IWP Cultural Building Design

Figure 2-6 Salalah IWP General Layout

In summary, the design criterion aims to achieve the following objectives:

- Ensure the guaranteed water capacity, availability and quality as required by OPWP;
- Optimize the energy consumption;
- Design the plant in a comprehensive approach considering the operation and maintenance period and the whole life of the project;
- Optimize the quality of the installed equipment with the best and most reliable suppliers and technologies;
- Optimize the layout of the plant to ensure a proper accessibility to equipment for a correct operation and maintenance;
- Reduce noise and vibration;
- Ensure the maximum flexibility in operation by implementing optimal automation processes;
- Minimize the environmental and visual impact during plant execution and operation.

The Salalah SWRO desalination plant has been designed to provide full capacity with the required quality considering the specific conditions of sea water in the region, the algal bloom and red tide phenomena which are likely to occur periodically and the optimization of the 20-year operation and maintenance expected.

2.4.1 Capacity

The total production capacity of the seawater desalination plant is 113,650 m^3/day in nominal conditions. The plant is designed to produce the full plant capacity working with 5 trains or working with 4 RO trains with one train out of service for maintenance. A design capacity of 22,730 m3/day +0.5% of extra production for internal consumption has been considered. A maximum capacity of 28,413 m3/day per train can be produced when one RO train is in maintenance.

During the Exigency periods, the plant will be able to produce 120,000 m^3/day working with 5 trains, each one will produce 24,000 m^3/day.

The configuration will enable the Project Company to produce the maximum capacity, optimizing the scheduled outages in order to ensure the optimal operational conditions considering the operational and maintenance requirements to ensure the most efficient operation for the 20 years of the concession.

2.4.2 Intake & Outfall

The intake and outfall will consist of buried pipelines sub-surface of 500m and 800m in length respectively. They will be aligned in the same trench to reduce the construction works and disturbance to the benthos (sea bed).

The proposed intake and outfall alignment is shown in the following figure.

Figure 2-7 Proposed Intake & Outfall Alignment

The intake head will rise from the seabed at 10m depth and will take in water at approximately 7m depth. The intake velocity will be 0.15m/s (maximum) and will have a mesh screen of 100mm width (maximum), to minimise entrainment of marine fauna.

The outfall will consist of a series of diffusers rising from the seabed at an approximate 13m depth.

Indicative designs of the intake head and outfall diffusers are shown in the following figures.

Figure 2-8 Intake Head Design

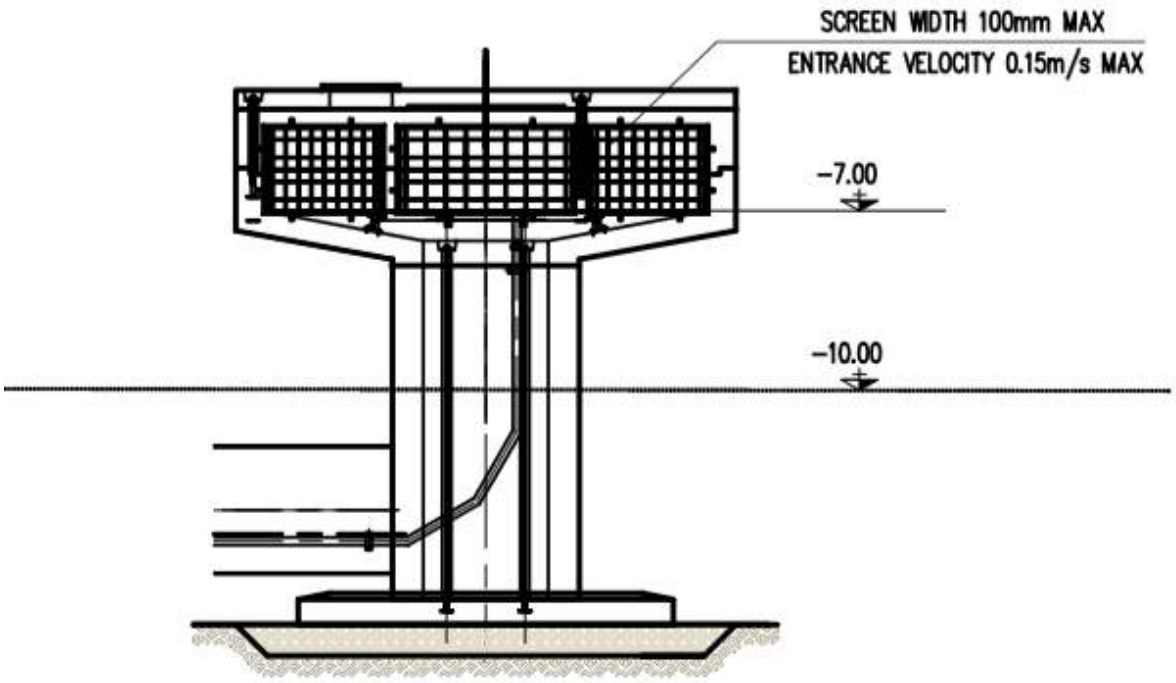
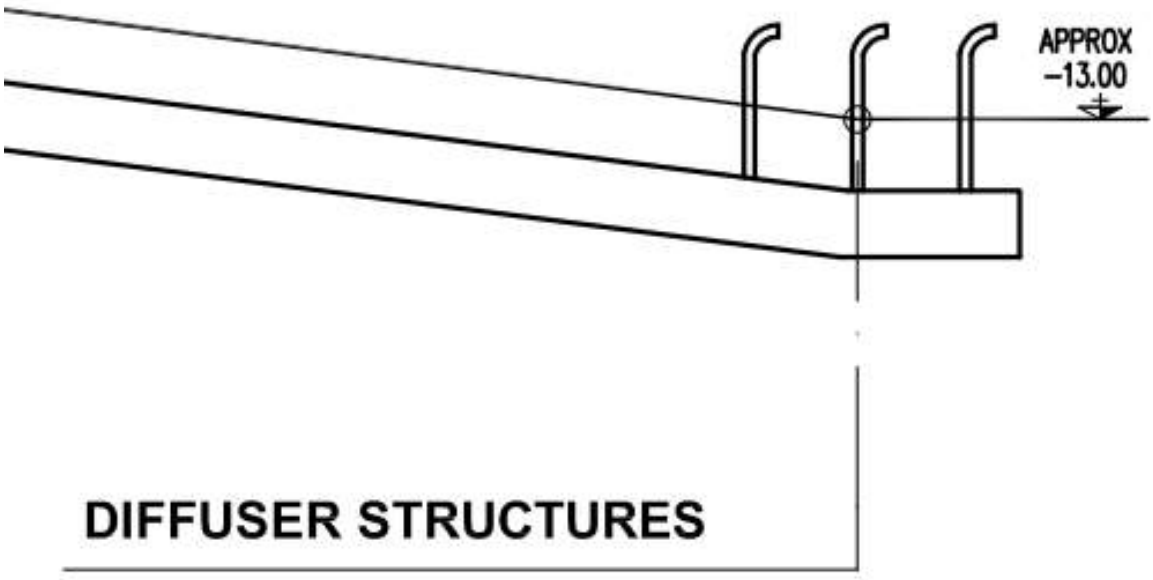


Figure 2-9 Outfall Diffuser Design



2.4.3 Pre-Treatment

The pre-treatment process, which includes a Dissolved Air Flotation (DAF) system, gravity filters, pressurized filters and cartridge filters, is designed to remove a large range of suspended solids, ensuring that the water quality entering the RO process complies with membrane requirements and, therefore, product water quality can be guaranteed without reducing the plant availability. The complete pre-treatment process consists on the following:

- Chemical dosing for coagulation and flocculation
  - Ferric chloride for coagulation: two (2) dosing tanks (with 50% of the required capacity each) and three (3) dosing pumps of 50% of capacity each (2 operating +1 in stand by unit) will be installed;
  - Sulphuric acid: two (2) dosing tanks (with 50% of the required capacity each) and three (3) dosing pumps of 50% of capacity each (2 operating +1 in stand by unit);
  - Flocculation system: two (2) automatic systems (with 100% of capacity each) and three (3) dosing pumps of 50% of capacity each (2 operating +1 in stand by unit) will be installed.

2.4.4 Dissolved air flotation system (DAF)

This system has also been designed complying with the energy efficiency and flexibility-in-the-operation philosophy of the whole plant. The DAF, which has been designed to treat the full plant capacity, will operate when it is required according to the sea water conditions and will be by passed if no flotation is needed. The system will be composed of 5 lines, and 4 can treat 100% of flow when one unit is out of service/maintenance.

2.4.5 Gravity multimedia filters

Fourteen (14) filtration cells will be installed. Designed for filtering velocities below 8.3$m^3/m^2/h$ in nominal conditions and 9$m^3/m^2/h$ with 1 unit in backwash. With anthracite and sand, gravity filters are expected to remove more than 85% of the TSS in the inlet water before RO. Filtered water will be conducted to the intermediate filtrate water tank, which is split in two tanks.

Intermediate pumping station to RO system. Consisting of 6 horizontal centrifugal pumps (5 operating +1 in stand by unit) which will pump filtered water to pressurized filters and RO process.

2.4.6 Pressurized multimedia filters

Eleven (11) filters will be installed. Designed for filtering velocities below 14.27 m3/m2/h in nominal conditions and 15.7 m3/m2/h with 1 unit in backwash. With anthracite and sand, pressurized filters are expected to remove more than 70% of the TSS in the inlet water.

2.4.7 Chemical storage and dosing

For each chemical compound used in the plant, two storage tanks (50% of required capacity) with filling and transfer pumps will be installed. The capacity of chemical storage tanks has been calculated to maintain a spare time of storage of fourteen (14) days. Redundancy has also been considered for both filling pumps (1operating +1 stand by unit) and transfer pumps (1operating+1 stand by unit).

2.4.8 SWRO system

The reverse osmosis is the core of the desalination process. The process, from the intake of sea water, has been engineered and designed to guarantee the product water quality. RO membranes are designed to operate under very specific conditions. The process prior to the RO shall ensure an adequate removal of suspended solids to avoid membrane damage.

Apart from the suspended solid removal, an adequate RO requires chemical balance (with sodium bisulphite and anti-scalant) and high pressure to induce the reverse osmosis process.

2.4.9 Chemical dosing

Dosing tanks and dosing pumps will be installed for each of the chemical compounds used in the RO process. The volume of dosing tanks has been calculated to ensure availability even in case of supply cuts. In particular:

- For sodium metabisulphite, two (2) dosing tanks (with 100% of the required capacity each) and three (3) dosing pumps (with 50% of capacity each (2 operating +1 in stand by unit)) will be installed;
- For the anti-scalant, two (2) dosing tanks (with 100% of the required capacity) and three (3) dosing pumps (with 50% of the required capacity each (2 operating +1 in stand by unit)) are designed for the RO system.

2.4.10 Cartridge filters

Used to retain and remove any remaining suspended solid in the inlet water and protect the RO membranes from damage. A total number of five (5) units will be installed (4 operating + 1 in stand by unit).

2.4.11 Reverse Osmosis Trains

The RO trains are the core of the desalination process. The size and number of trains have been chosen in order to be consistent with the overall philosophy of the desalination plant. Five (5) RO trains with 1,656 RO membranes each will be installed. The RO system has been designed to produce the full plant required capacity with five RO trains working or four working and one in standby. The RO process is designed to work with low flux (≈14lmh) with five RO trains

Low fluxes allow to work with lower pressures and head losses and, therefore, to optimize the energy consumption and life cycle and efficiency of RO membranes.

Each of the RO trains includes:

- 1 Energy Recovery Device (ERD) system;
- 1 ERD booster pump;
- 1High Pressure Pump (HPP);
- 1RO rack with 1,656 RO membranes;

2.4.12 Cleaning In place (CIP)

The Cleaning In Place (CIP) and waste water neutralization system for membrane chemical cleaning, consisting of:

- CIP tank with 100% of the required capacity required to clean 1 RO train;

- Two (2) CIP pumps (1 operating + 1 stand by unit) with 100% of required capacity each one to clean 1 RO train;
- One (1) cartridge filter for chemical cleaning;
- One chemical preparation (dissolving and mixing) tank with two loading pumps (1W+1S).
- One (1) permeated/flushing water tank, split into independent chambers, connected to the CIP pumps

2.4.13 Post treatment system

After reverse osmosis, permeated water requires a post-treatment and re-mineralization treatment which will provide the water with the adequate pH, chemical and mineral composition for final consumption. The post-treatment and re-mineralization process consists of:

- CO2 dosage system for pH regulation and preparation of water for re-mineralization. The system will include a storage and dosing system with two (2) units (1 operating + 1 in standby) and two (2) storage tanks of 50% capacity.
- Limestone filters for re-mineralization: for the guaranteed capacity, fourteen (14) units will be installed;
- Chemical dosing: final chemical tuning to the final product water parameters will be done with sodium hydroxide, sodium hypochlorite and sodium fluoride:
    - The sodium hydroxide dosing system will consist of two (2) dosing tanks (50% of the required capacity each) and three (3) dosing pumps (50% of capacity each);
    - The sodium hypochlorite dosing system, consisting of two (2) dosing tanks (50% of the required capacity each) and three (3) dosing pumps (50% of capacity each); and
    - The sodium fluoride dosing system, consisting of two (2) dosing tanks (50% of the required capacity each) and three (3) dosing pumps (50% of capacity each).

2.4.14 Potable Water Pump Station

A Potable Water Pump Station with three pumps (2 working + 1 in standby) and a potable water connection pipeline with a 100% of capacity until Connection Point at the Site boundary.

2.4.15 Wastewater Treatment

Waste water treatment systems: for the waste water outlet from the desalination process and with the aim of comply with environmental requirements and philosophy, waste water treatment process is included in the design of the desalination process. The process includes:

- A backwash waste water basin;
- Two (2) feeding pumps to coagulation chambers;
- Coagulation, flocculation and lamella settling tanks: two (2) lines installed;
- A sludge homogenization tank;

- Sludge dewatering line, consisting of two (2) sludge feeding pumps of 50% of the maximum required capacity, two (2) screw press of 50% of the maximum required capacity and two (2) dewatered sludge pumps to silos.
- Two silos for sludge storage until final removal;
- A clarified water tank;
- Four (4) clarified water pumps (3 operating units and 1 in stand-by);

2.4.16 Other Facilities

- Instrument and service air systems.
- Fire protection and detection systems.
- Ventilation and air conditioning.
- Administration and Operations Buildings
- Warehouse(s).
- Security Building.

2.4.17 Energy Efficiency and Energy Recovery

Apart from the robust-flexible design of the pre-treatment, the process has been adjusted to optimize the power consumption and maximize the efficiency. This optimization is achieved by developing a comprehensive plant design which includes, among others, the following equipment and systems:

- Installation of turbine in brine discharge line for effluent energy recovery.
- Isobaric chambers for energy recovery in each RO train.
- Variable frequency drives in all main pumps: sea water intake pumps, intermediate pumps, high pressure pumps and booster pumps, product water pumps, allowing controlling the system with optimal power consumption. Also VFD in others minor pumps such as DAF pumps recirculation, CIP pumps, have been included.
- Design of the DAF and gravity filters line to work by gravity with low head loss.
- Optimization of the pump operation and efficiency by reaching the duty point of each and all pump in the process.

2.4.18 Redundancy

The design of the plant has been developed taking into account the availability and reliability requirements and in order to achieve the expectations, the following spare systems will be installed:

- - One spare pump per each pumping system;
- - One spare unit of each treatment system as follows:
    - 1 DAF line (equivalent design);
    - 1 gravity filter unit (equivalent design);
    - 1 pressurized filter unit (equivalent design);
    - 1 spare cartridge filter prior to SWRO system;
    - 1 RO train with booster pump to HPP, HPP pump, booster and energy recovery system (equivalent design);

- 2 bulk storage tanks per each chemical product to be dosed (2 x 50% of capacity considering the whole plant);
- 2 dosing tanks where required (2 x 50% of capacity considering the whole plant) with 3x50% dosing pumps;

2.4.19 Associated Facilities

Access Road

The primary associated facility of the project is the access road that will be constructed by the EPC but owned and maintained by Dhofar Governorate.

Water Connection Facility

The Potable Water output from the Salalah IWP Project will be metered and sampled by the Project Company and delivered to a Connection Point at the Site boundary. The connection to the existing reservoir, is out of the scope of the bidders.

The downstream pipeline to transport the potable water from the Project Site to the Water Transmission Pipeline, will be constructed by PAEW.

Electrical Connection Facility

DCP will be building a new 33/11 kV substation next to the site. The IWP will be connected to the DPC substation with two redundant 11 kV feeders.

2.5 Construction of the Plant

2.5.1 Construction Facilities

Temporary Laydown Area

The construction phase will require temporary laydown areas to provide materials storage, & administration preparation areas for the EPC and sub-contractors works. The project is expected to require a 17,500m^2 area and will be located on land immediately east of the project site (also owned by the Ministry of Housing).

Manpower

Requirements for manpower are yet to be finalised and will be considered at eh ESIA stage, and used in the respective impacts assessment of construction waste, wastewater, as well as requirements for working conditions, community health, safety & security and worker accommodation.

Worker Accommodation

Requirements for worker accommodation have not been finalised, but will likely be provided on a contractor by contractor basis. These areas are unlikely to be at the project site, but may be situated locally.

It is expected that the Project Company will specify the necessary facilities and standards of facilities for worker accommodation in accordance with the IFC/EBRD Worker Accommodation Guidelines.

2.6 Project Alternatives

In accordance with good practice methodologies for ESIA, the evaluation of various project design and activity alternatives should be considered, in order to ensure that the objectives of the proposed project have accounted for social, environmental, economic and technological options.

Given that the project has been awarded under a very structured bidding process with defined technical requirements, there have been few opportunities to alternate the design. For instance, it has not been possible to consider other land areas for the project based on the stipulated use of this land in the bidding process.

As part of the ESIA an overview assessment of project alternatives will be considered for:

- No Project Alternative;
- Design Parameters.

2.6.1 No Project Alternative

The potable water generating capacity of the Project will be 22 MIGD. The 'no project' option is considered not viable given the requirement for additional potable water in Oman as per the project's rationale. The table below presents a basic comparison of the anticipated impacts from the development of the proposed project versus the option of 'no project'.

Table 2-1 Evaluation of the 'No Project' alternative vs Proposed Project

Environmental Issue	No Project	Construction Phase	Operational Phase
Air quality	No change=0	Negative = -1	0
Noise	0	-1	0
Soil & Groundwater	0	-1	0
Terrestrial Ecology	0	0	0
Marine Environment	0	0	-1
Transport	0	0	0
Resource & Utilities	-1	-1	+1
Socio-Economic	-1	Positive = +1	+1
Cultural Heritage	0	0	0
Landscape & Visual	0	0	0
Total	**-2**	**-3**	**+1**

Although the construction phase of the Project will likely result in an overall negative impact, the operational phase will likely result in a slight overall positive impact, particularly due to the development of utilities and socio-economic benefits.

2.6.2 Design Parameters

As part of the ESIA process, consultation with the projects engineers will outline any alternatives that have been considered with respect to the technology and design parameters of the project. These alternatives will be explained in the ESIA and the rationale behind the ultimate

design selections discussed; specifically, where environmental or social considerations have had an influence on the design.

3 REGULATORY FRAMEWORK

3.1 Requirements for EIA/ESIA

3.1.1 Environmental Regulator in Oman

The environmental regulator in Oman is the Ministry of Environment and Climate Affairs (MECA).

Royal Decree No. 90/2007 established the Ministry for Environment and Climate Affairs (MECA), where environment-related works, allocations and assets were transferred from the responsibility of the Ministry of Regional Municipalities, Environment and Water Resources. Omani legislation relating to the requirement for environmental assessment followed the issuance of Royal Decree No 10/82 (and its amendments No 114/2001) entitled 'Law on Conservation of the Environment and Prevention of Pollution'.

The bullet points below provide a select summary overview of the responsibilities of MECA:

- The environmental regulator is the designated competent agency to preside over and implement the laws in relation to the environment.
- The environmental regulator has the right to implement laws, fine violators and suspend or close facilities not complying to the applicable environmental laws.
- The environmental regulator has the authority to approve the environmental aspects related to projects and permit their construction and operational activities.
- The environmental regulator also has the authority to allow deviations from the standards, under agreed circumstances.

Prior to the issue of the request for proposal at the bidding stage, OPWP consulted with MECA regarding the development of IWPs at the proposed project site.

A preliminary in-principle application based on tentative conceptual plants and process designs had been submitted by OPWP to MECA as a basis for securing an initial "No Objection Letter" for development of the proposed project site.

In accordance with the "No Objection Letter" the successful bidder (i.e. the project sponsors) are required to undertake an EIA in accordance with the Omani Environmental requirements and regulations. As such, the projects sponsors are ultimately responsible for obtaining an environmental permit from MECA and complying with any conditions to such environmental permit for the applicable Project.

3.1.2 Omani Requirements

EIA Regulatory Considerations

Environmental requirements developed and implemented by MECA classify projects into eight groups according to the technical aspects of their construction and operation. Any project that falls into any of these MECA categorisations will require an Environmental Permit. It is anticipated that the proposed project will be classified under group 'C' Water Purification and Desalination Plants. The already issued "No Objection Certification" confirms that in order to permit the project, an EIA will be required.

The complete EIA document will form a principle component of the application package for an Environmental Permit. After the review is completed, MECA will either:

- Accept the conclusions of the EIA and issue an Environmental Permit,
- Request further study through clarifications, or
- Request re-application for an alternative proposal. Once the permit is issued, the submitted EIA document becomes a part of the permit and any changes to the EIA require amendment to the Permit.

3.1.3 Lender Requirements for EIA

It is understood that the project sponsors will seek project finance from international lenders who are likely to be signatories of the Equator Principles. As such there are a number of separate requirements for ESIA as set out below, particularly in regard to Equator Principle 2 (Environmental and Social Assessment).

A core difference between expected MECA and lender requirements is the extent of Social Assessment required by the lenders. Hence the impact assessments for international lenders is termed as ESIA (Environmental and Social Impact Assessment). This ESS considers the likely environmental and social requirements from MECA and the lenders.

The Equator Principles

The Equator Principles are considered the project finance industry standard for addressing environmental and social issues in project financing globally. The Equator Principles were updated in 2006 (EP II) to include projects with a capital cost of US$10 million or more across all industry sectors and these are the prevailing applicable conditions for this project. The Equator Principles Financial Institutions (EPFIs) reviewed the Equator Principles in 2011 and approved the latest version, EP III on April 26th 2013. These became effective from June 4th 2013 and should be fully implemented by December 31st 2013.

The EPs establish the minimum standards to be adopted by the EP Financial Institution (EPFI) as those from IFC Performance Standards/World Bank EHS Guidelines and/or the relevant host country laws, regulations and permits that pertain to environmental and social issues.

The Equator Principles consist of the following 10 Principles:

- Principle 1 - Review and Categorisation
- Principle 2 - Environmental and Social Assessment
- Principle 3 - Applicable Environmental and Social Standards
- Principle 4 - Environmental and Social Management System and Equator Principles Principle Action Plan
- Principle 5 - Stakeholder Engagement
- Principle 6 - Grievance Mechanism
- Principle 7 - Independent Review
- Principle 8 - Covenants
- Principle 9 - Independent Monitoring and Reporting
- Principle 10 - EPFIs Reporting

The Categorisation of the Project with regards to the Equator Principle 1 will be determined by the projects lenders, however based on the type of project and surrounding environment it is expected to be "*Category B*" as there is potential for '*significant adverse social or environmental risks and/or impacts that are diverse, irreversible or unprecedented.*'

The expectation of a Category B project is based on the extent of development already established by the adjacent Sembcorp IWPP. As the adjacent facility is an operational desalination plant, the impact is not considered unprecedented, and the diversity of impacts is generally low (i.e. primary operational environmental impacts relating to brine discharge). Further, the impacts are generally not expected to be irreversible (full assessment of impacts will be determined in the ESIA).

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, etc.

The following lists the IFC Performance Standards (2012):

- Performance Standard 1: assessment and Management of Environmental and Social Risks and Impacts
- Performance Standard 2: Labor and Working Conditions
- Performance Standard 3: Resource Efficiency and Pollution Prevention
- Performance Standard 4: Community Health, Safety, and Security
- Performance Standard 5: Land Acquisition and Involuntary Resettlement
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
- Performance Standard 7: Indigenous Peoples
- Performance Standard 8: Cultural Heritage

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

3.2 Applicable Environmental Legislation & Standards

3.2.1 International Treaties and Conventions

Oman is a signatory to, and has ratified, several international protocols and conventions. As such Oman is committed to the principles and policies therein. The proposed Project must therefore comply with the environmental requirements of the following international treaties and conventions to which Oman is a signatory:

Table 3-1 Applicable International Protocols and Conventions

Name of International Protocol/Convention
United Nations Framework Convention on Climate Change (UNFCCC) – Paris Agreement, 2016
Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), 1997 - Non-Annex I Country
Stockholm Convention on Persistent Organic Pollutants (POPs), 2001
United Nations Convention to Combat Desertification (UNCCD), 1994
United Nations Convention on Biological Diversity, 1992
United Nations Framework Convention on Climate Change (UNFCCC), 1992
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, 1989 and amendments in 1995
Montreal Protocol on Ozone Depleting Substances, 1987 and Montreal Amendments (London 1990, Copenhagen 1992, Vienna 1995, Montreal 1997, Beijing 1999)
Vienna Convention for the Protection of the Ozone Layer, 1985
International Convention for the Prevention of Pollution of the Sea by Oil (MARPOL), 1973 and Annexes
Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (LDC) (1972)
Kuwait Regional Agreement for Cooperation on Protection of Marine Environment from Pollution and the regional cooperation protocols for combating marine pollution by oil and other harmful substances in emergencies (24 April 1978);
The Convention of Conservation of Wildlife and its Natural Habitat in the GCC Countries;

3.3 Environmental Standards and Emission Limits

The applicable environmental standards for the Project as per the national regulations and lender guidelines are outlined below. Full reference of the applicable standards is provided in each relevant chapter herein.

Table 3-2 Applicable Standards & Guidelines

Environmental Parameter	Omani Standards	Lender Guidelines
Ambient Air Quality	MECA currently uses the US EPA National Ambient Air Quality Standards (NAAQS)	IFC EHS General Guidelines: Table 1.1.1 WHO Ambient Air Quality Guidelines
Wastewater	MD 159/2005 describes the requirements and maximum allowable limits for wastewater	IFC EHS General Guidelines: Table 1.3.1 Indicative Values for Treated Sanitary Sewage Discharges

Environmental Parameter	Omani Standards	Lender Guidelines
	discharge to the marine environment	
Soil	Omani standards do not exist for soil or groundwater quality. As such, the use of the Dutch standards is common practice for the analysis of soils and groundwater, and these are viewed as international best practice.	
Noise	M.D. 79/94 and the applicable limits of noise generated from industrial facilities	IFC EHS General Guidelines: Table 1.7.1 Noise Level Guidelines

All the above-mentioned standards require project compliance. Where there is contradiction in limits between Omani standards and lender guidelines, the most stringent will apply.

In accordance with lender requirements, where specific national standards do not exist, a best practice standard should be applied.

4 APPROACH TO ESIA

4.1 Delineation of Study Boundaries and Scope of Assessment

4.1.1 Project Area for Assessment

The proposed project will be located on land leased from the Ministry of Housing to the immediate east of the Sembcorp IWPP facility at Salalah.

The co-ordinates of the project boundary have been detailed in Table 2-1 of the Project Description, which also includes satellite images of the project area respective to the Sembcorp IWPP.

The primary study area therefore comprises the footprint of the project, and the access road.

Where project impacts extend to areas external to the study area, these will also be assessed (i.e. brine discharges and noise).

The ESIA will endeavour to assess impacts relating to ancillary facilities such as worker accommodation areas, however the location of such facilities may not be identified at this stage as the majority of staff are expected to be accommodated by sub-contractor companies, who may not be appointed until the construction phase. Where information is available these impacts will be assessed, however it is expected that the ESIA will include general management measures to ensure that the applicable standards can be met.

4.1.2 Associated Facilities for Assessment

Access Road

The primary associated facility of the project is the access road that will be constructed by the EPC but owned and maintained by Dhofar Governorate. The access road will be fully included in the ESIA scope.

Water Connection Facility

The downstream pipeline to transport the potable water from the Project Site to the Water Transmission Pipeline, will be constructed by PAEW.

It is expected that a separate environmental assessment will be undertaken by PAEW, with the necessary approvals obtained from MECA. Where information is available in regard to the water connection, this will be assessed in the ESIA as an associated facility.

Electrical Connection Facility

The Electrical Connection Facility to provide a power supply to the project will be built and operated by DPC. Where information is available in regard to the connection facility, this will be assessed in the ESIA as an associated facility.

4.1.3 Scope of Assessment

The ESIA will assess the potential impacts related to the proposed projects construction phase, commissioning and operation.

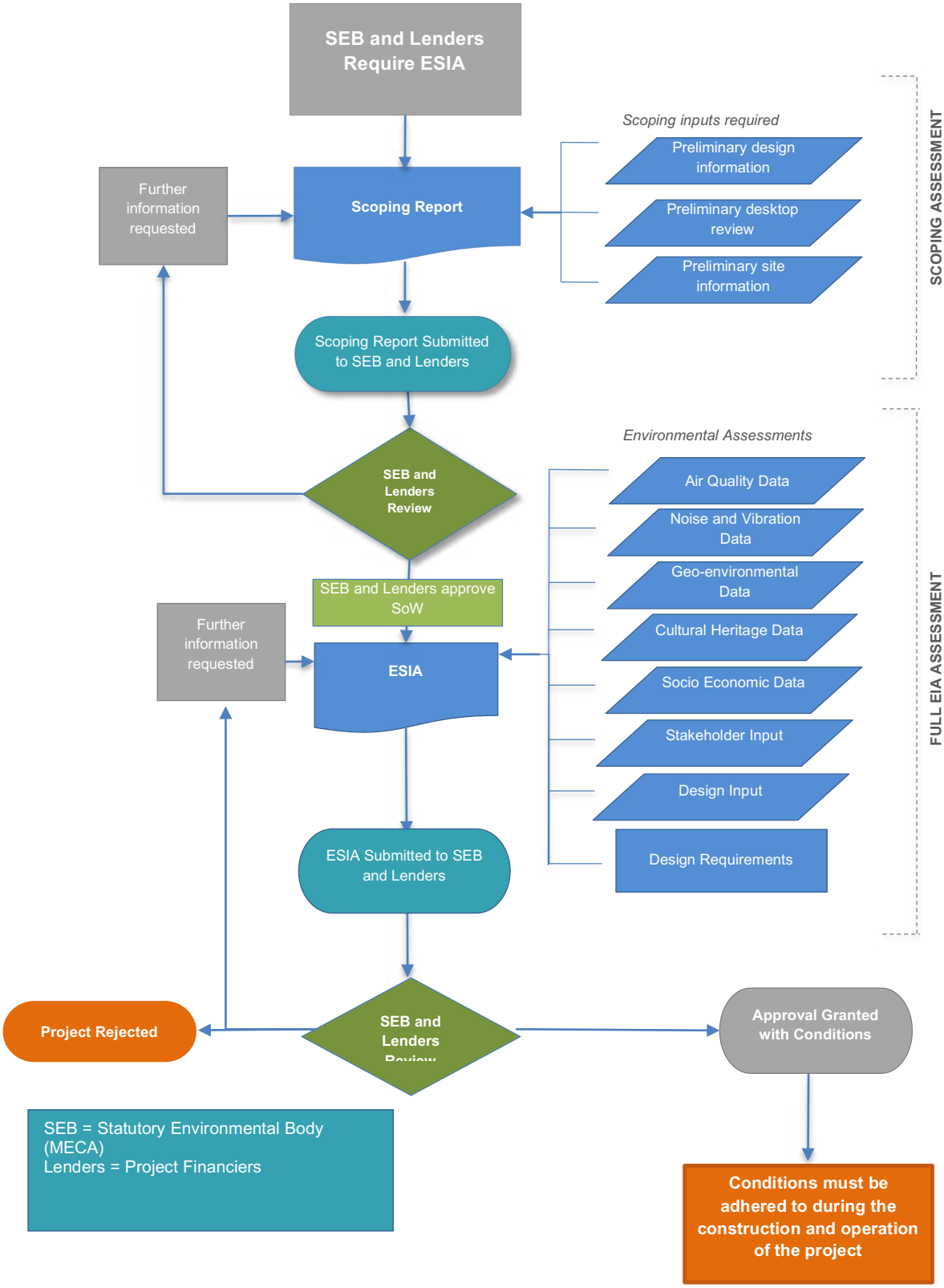
Potential impacts relating to decommissioning will be similar to those encountered during the construction phase. Given that the decommissioning phase is not expected for at least 20

years (in accordance with the term of the water supply agreement), it is not practical to speculate on future environmental & social conditions including the sensitivity of current or future receptors at this time. It is considered that impacts relating to decommissioning are best approached and mitigated via a specific decommissioning plan prepared closer to the time of decommissioning. A plan prepared at this time would be able to account for changes in regulation (e.g. requirements for specific decommissioning methodologies), improvements in technology (e.g. ability to re-use or recycle waste) and methods of demobilisation (e.g. improvements in plant).

4.2 ESIA Process

The illustration in the following Figure provides an outline of the scoping and ESIA process for the project. It should be noted that conditions are likely to be established by both the Statutory Environmental Body and the IFI's that must be adhered to during the project construction and operational phases.

Figure 4-1 Scoping/ESIA Process



4.3 Scoping

Scoping is a key stage in the ESIA process; it draws upon an understanding of the Project, available environmental baseline data and relevant regulations. With an understanding of these components, the aim of the scoping process is to identify potentially significant environmental impacts and evaluate whether they will be scoped in or out of the full assessment. This will ensure that only the impacts of potential significance will be assessed at the ESIA stage. This report includes the scoping assessment for each chapter herein.

Where potential project impacts are scoped out of further assessment in the ESIA, further data collection, quantitative analysis or detailed assessment will not be undertaken as part of the ESIA. Despite this, applicable mitigation and management measures will be included to the ESIA in an attempt to reduce any adverse impacts, but also to ensure good practices are followed through into the respective Construction and Operational Environmental & Social Management Plans (i.e. CESMP and OESMP).

Following the decision to 'scope in' or 'scope out' potential impacts, this scoping report sets out a scope of work for the main Environmental Statement (main ESIA document), and the methods that will be used to achieve this.

The Scoping Report intends to provide an amount of factual information about the condition of the site and its surrounds prior to the commencement of the Project. An overview of the environmental baseline has been provided and is based on existing data sources and observations from the initial site visit in summer 2016. The initial site visit has allowed for the identification of sensitive receptors and land uses (site and surroundings) which may be sensitive to environmental and social impacts and risks. This is supplemented by secondary information and observations form satellite imagery and other available data sources.

4.4 ESIA Methodology

This chapter outlines the methodology that will be used to describe the sensitivity of environmental receptors, to predict the magnitude of environmental impacts and to assess the significance of the effect of the project activities on each relevant environmental aspect or component.

4.4.1 Baseline Studies and Research

Forming an integral part of the ESIA, the baseline surveys provide a benchmark of the existing conditions by which the potential impacts of the proposed project can be assessed for the construction and operational phases.

Baseline surveys will comprise primary or secondary data (or a combination), which may include physical surveys on-site, use of maps, satellite imagery, references from relevant studies and other available data sources.

The scope of the required studies is based upon the existing level of information available and a determination of what further information is required to provide a representative reference of the current environment. The determination of required further studies is set out in the relevant chapters of this scoping report, with suitable justification.

4.4.2 ESIA Consultation & Stakeholder Engagement

Statutory requirements for stakeholder engagement, ESIA consultation or disclosure have not been established in Oman, and are not recognised as a necessity in the EIA process.

In regard to the lender requirements, all of the IFC Performance Standards include requirements for an amount of stakeholder engagement (either in the ESIA, or as part of the future ESMS) and therefore the project will require a level of engagement. In particular, IFC Performance Standard 1 on "Social and Environmental Assessment and Management Systems" describes the stakeholder engagement requirements in more depth. It states the following:

"Stakeholder engagement is the basis for building strong, constructive, and responsive relationships that are essential for the successful management of a project's environmental and social impacts. Stakeholder engagement is an on-going process that may involve, in varying degrees, the following elements:

- Stakeholder analysis and planning;
- Disclosure and dissemination of information;
- Consultation and participation;
- Grievance mechanism; and
- On-going reporting to Affected Communities.

The nature, frequency, and level of effort of stakeholder engagement may vary considerably and will be commensurate with the project's risks and adverse impacts, and the project's phase of development."

As common and good practice, stakeholder engagement is considered a key aspect of all projects and should be undertaken at the ESIA stage in order to notify, gain views and enable a better understanding of the dynamics of the local environment.

With respect to Oman, a culturally relevant consultation process has been developed by 5 Capitals which will involve letter consultation with key project stakeholders, at the ESIA stage.

With respect to the project, it is recognised that there are few project stakeholders due to the lack of any required land acquisition, rights of way and the development of the project away from key residential areas. Despite this, the following stakeholders have been initially outlined for consultation.

Note: All consultation will be subject to prior agreement from ACWA Power, and therefore may change from the intentions outlined above.

Table 4-1 Proposed Stakeholders for Consultation

Stakeholders	Intention for Consultation
Ministry of Environment and Climate Affairs (MECA)	Submission of Environmental Scoping Report to MECA and feedback in regard to the proposed ESIA scope.
Ministry of Heritage & Culture (MOHC)	To request information in regard to known archaeological artefacts and cultural features at the project site or locally.
Dhofar Governorate	To request information in regard to the informal use of land locally, particularly with regard to the use of nearby land for camel shelters.
Environmental Society of Oman	To request information in regard to ecological sensitivities, and any designated sites locally, or sensitive habitats and species.
Sembcorp IWPP	To request information in regard to the previous use of the land as the construction laydown areas, interactions with local camel herders and the environmental and social management structures used at the facility, specifically in regard to provisions for emergency planning.

4.4.3 Impact Assessment Significance Criteria

In order to obtain a credible assessment of environmental impacts, the assignment of 'effect significance' to each identified impact needs to be a robust, consistent and transparent process. The methodology to assess 'effect significance' is outlined below and follows an International Best Practice[1] based on the assumption that the significance of an impact on resources or receptors is considered to result from an interaction between:

- The nature and magnitude of the impact (i.e. a change in the environment, social and/or health baseline conditions);
- The environmental value or sensitivity of receptors.

A three-step approach has been used to determine the significance of environmental effects, as follows:

- Step 1 – Evaluation of value/sensitivity of receptor;
- Step 2 – Assessing the magnitude of the impact on the receptor; a
- Step 3 – Determining the significance of effects.

4.4.4 Identification and Evaluation of Sensitive Receptors

Sensitive receptors are defined as:

- Elements of the ***environment*** that are of value to the functioning of natural systems (i.e. areas or elements of ecological, landscape or heritage value, species, habitats and ecosystems, soil, air and water bodies or land-use patterns);

[1] See for example Scottish Natural Heritage (2009) A handbook on environmental impact assessment or Highways Agency (2008) Assessment and Management of Environmental Effects design manual for roads and bridges HA 205/08 Volume 11, Section 2, Part 5.

- ***Social*** receptors, such as stakeholders (i.e. users of dwellings, places of recreation, places of employment, community facilities or household relocation) and human systems (e.g. employment market, population disease susceptibility and disease communicability, exposure to toxicity of chemicals).

The environmental value (or sensitivity) of the resource or receptor has been defined by using the criteria below in Table 4-2:

Table 4-2 Environmental Value of Receptor or Resource

Value (sensitivity)	Description of Value
Very High	• High importance and rarity on an international scale and limited or no potential for substitution. • The receptor has already reached its carrying capacity, so any further impact is likely to lead to an excessive damage to the system that it supports. • Locations or communities that are highly vulnerable to the environmental impact under consideration or critical for society (e.g. indigenous peoples, hospitals, schools).
High	• High importance and rarity on a national scale, and limited potential for substitution. • The receptor is close to reaching its carrying capacity, so a further impact may lead to a significant damage to the system that it supports. • Locations or communities that are particularly vulnerable to the environmental impact under consideration (e.g. residential areas, vulnerable/marginalized groups).
Medium	• High or medium importance and rarity on a regional scale, limited potential for substitution. • The receptor is already significantly impacted, but it is not close to reaching its carrying capacity. Further impacts will get increase the stress of the underlying system, but evidence does not suggest that it is about to reach a critical point. • Locations or groups that are relatively vulnerable to the environmental impact under consideration (e.g. commercial areas).
Low (or Lower)	• Low or medium importance and rarity on a local scale. • The receptor is not significantly impacted and shows a large spare carrying capacity. Impacts are not likely to generate any noticeable stress in the underlying system. • Locations or groups that show a low vulnerability to the environmental impact under consideration (e.g. industrial areas).
Very Low	• Very low importance and rarity on a local scale. • The receptor is not impacted and shows a very large spare carrying capacity. Impacts are very unlikely to generate any noticeable stress in the underlying system. • Locations or groups that show a very low vulnerability to the environmental impact under consideration (e.g. industrial areas).

4.4.5 Identification and Evaluation of Environmental Impacts

Magnitude refers to the extent of change that is anticipated to occur for the receptor(s) under consideration and is considered as a function

- Extent;
- Duration;
- Frequency;
- and Likelihood.

The following types of impacts have been considered in line with 5 Capitals assessment methodology:

- *Direct Impacts* - Potential impacts that may result from the construction and occupation of the Project acting directly on an environmental or social receptor (e.g. land take);
- *Indirect Impacts* – Potential impacts which are not a direct result of a Project activity, but are likely to occur in response to the project. (e.g. air quality impacts due to variations in local traffic conditions from changes in local population density).
- *Beneficial Impacts* – Impacts that have a positive, desirable or favourable effect on the sensitive resources or receptors (e.g. landscape providing artificial habitat for a variety of species, creating jobs during the construction and/or occupation phases of a project);
- *Adverse Impacts* – Impacts that are detrimental and have a negative influence on sensitive resources or receptors;
- *Cumulative Impacts* - The additive potential impacts that may result from the incremental potential impacts of the planned Project plus the potential impacts of reasonably anticipated future projects or future phases of a same development.

Magnitude designations that take into account all of the above and that are to be used throughout the ESIA process are described within Table 4-3.

Table 4-3 Criteria for Magnitude of Impacts

Magnitude of Impact	Description of Magnitude
Major	*Adverse:* Loss of resource and/or quality and integrity; severe damage to key characteristics, features or elements. A major impact is usually large scale, permanent and irreversible. *Beneficial:* Large scale or major improvement of resource quality; extensive restoration or enhancement; major improvement of attribute quality.
Moderate	*Adverse:* Significant impact on the resource, but not adversely affecting the integrity; Partial loss of/damage to key characteristics, features or elements. Moderate impacts usually extend above the site boundary, and are usually permanent, irreversible or cumulative. *Beneficial:* Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality.
Minor	*Adverse:* Some measurable change in attributes quality or vulnerability; minor loss of, or alteration to, one (maybe more) key characteristics, features or elements. Minor impacts usually are only noticeable within the site and are temporary and reversible. *Beneficial:* Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring.
Negligible	*Adverse:* Very minor loss or detrimental alteration to one or more characteristics, features or elements. *Beneficial:* Very minor benefit to or positive addition of one or more characteristics, features or elements.
No change	No loss or alteration of characteristics, features or elements; no observable impact in either direction.

4.4.6 Determination of Impact Significance

The impact significance is a combination of the environmental value (or sensitivity) of a receptor or resource and the magnitude of the project impact value (change). The greater the environmental sensitivity or value of the receptor or resource, and the greater the magnitude of impact, the more significant the effect. The consequences of a highly valued environmental resource suffering a major detrimental impact would be a very significant adverse effect. Table 4-4 provides the criteria used for determining the significance of environmental effects. Definitions of each significance categories are provided in Table 4-5

Table 4-4 Criteria for Determining Impact Significance

		Magnitude of impact (degree of change)				
		No change	**Negligible**	**Minor**	**Moderate**	**Major**
Sensitivity of Receptor	**Very High**	Neutral	Slight	Moderate or Large	Large or Very Large	Very Large
	High	Neutral	Slight	Slight or Moderate	Moderate or Large	Large or Very Large
	Medium	Neutral	Neutral or Slight	Slight	Moderate	Moderate or Large
	Low	Neutral	Neutral or Slight	Neutral or Slight	Slight	Slight or Moderate
	Very Low	Neutral	Neutral	Neutral or Slight	Neutral or Slight	Slight

Change can be either beneficial or adverse, and effects can also, therefore, be either beneficial or adverse. In some cases above the significance is shown as being one of two alternatives. In these cases a single description is decided upon with reasoned judgement for that level of significance chosen.

Table 4-5 Definition of Impact Significance

Significance Category	Criteria
Very Large	Only adverse effects are normally assigned this level of significance. They represent key factors in the decision-making process. These effects are generally, but not exclusively, associated with sites or features of international, national or regional importance that are likely to suffer a most damaging impact and loss of resource integrity. However, a major change in a site or feature of local importance may also enter this category.
Large	These beneficial or adverse effects are considered to be very important considerations and are likely to be material in the decision-making process.
Moderate	These beneficial or adverse effects may be important, but are not likely to be key decision-making factors. The cumulative effects of such factors may influence decision-making if they lead to an increase in the overall adverse effect on a particular resource or receptor.
Slight	These beneficial or adverse effects may be raised as local factors. They are unlikely to be critical in the decision-making process, but are important in enhancing the subsequent design of the project.
Neutral	No effects or those that are beneath levels of perception, within normal bounds of variation or within the margin of forecasting error.

The approach to assigning significance of effect relies on reasoned argument, professional judgement and taking on board the advice and views of appropriate organisations. For some disciplines, predicted effects may be compared with quantitative thresholds and scales in determining significance.

Assigning each effect to one of the five significance categories enables different topic issues to be placed upon the same scale.

4.4.7 Mitigation and/or Management Measures

The project includes a variety of measures to ensure that environmental standards and guidelines can be achieved by the project. Several of these have been discussed in the alternatives analysis section of this ESIA.

The projects impact assessment process as outlined above will therefore take into consideration those measures included to the projects design. In addition to specific measures included to the projects design, the ESIA will outline further mitigation and/or management measures for the construction & commissioning phases and the operational phase, upon which the project can further minimise or avoid negative impacts, and ameliorate positive impacts.

Upon approval of the project, the stated mitigation and management measures in the approved ESIA will be required for implementation as a condition of the environmental permit, or as the lenders as part of the loan agreement.

4.4.8 Residual Impacts

Following assessment of the inclusion of the mitigation and/or management measures, the projects residual impact significance will be considered. The significance of such impacts is based upon the same criteria used to determine the impact significance of the projects design referenced above.

4.5 ESIA Structure

The ESIA Report will be presented in the following format:

Volume 1: Non-Technical Summary

Volume 2: Main Text, Tables, Figures and Plates

Volume 3: Framework Environmental and Social Management and Monitoring Plan (ESMMP)

Volume 4: Appendices

Volume 2 will comprise of the main text of the ESIA and has been presented under the following chapter structure:

1. Introduction
    - The Project
    - Project Information and ESIA Team
    - Assessment Objectives
    - Report Structure
2. Policy, Legal and Administrative Framework
    - Requirements for Environmental and Social Assessment
    - Applicable Standards & Guidelines
3. Project Description
    - Project Rationale
    - Location of Project Site
    - Site Condition & Land Use
    - Project Surrounds
    - Project Design
    - Project Alternatives
    - Construction Logistics
    - Construction Management
    - Operational Phase Management
4. ESIA Methodology
    - Introduction
    - Delineation of Study Boundaries and Scope of Assessment
    - Baseline Surveys

- Consultation Process
- Impacts Assessment Significance Criteria
- Mitigation Measures
- Residual Impacts

5. Air Quality (same format for environmental aspects 5 to 16)

    - Introduction
    - Methodology
    - Applicable Regulation, Standards & Requirements
    - Baseline Environmental Conditions
    - Sensitive Receptors
    - Impact Assessment & Significance
    - Mitigation and Management Measures
    - Residual Impacts

6. Noise and Vibration
7. Terrestrial Ecology
8. Soil, Geology and Groundwater
9. Marine Environment
10. Surface Water Environment
11. Waste and Wastewater Management
12. Archaeology and Cultural Heritage
13. Landscape and Visual Impacts
14. Socio-Economics
15. Community Health, Safety & Security
16. Labour & Working Conditions
17. Cumulative Impact Assessment

Volume 3 ESMMP will provide a framework for the future development of the CESMP and OESMP, drawing on the applicable findings of the ESIA. The intention is for Volume 3 to be used by the EPC Contractor and O&M Company to develop the project specific environmental management plans, based on the specific findings and recommendations of the ESIA.

Volume 4 will include all appendices such as consultation letters, laboratory analysis results, modelling studies, drawings and any supplementary information.

5 AIR QUALITY

5.1 Standards and Regulatory Requirements

With regards to ambient air quality standards, MECA currently implements the USEPA's National Ambient Air Quality Standards (NAAQS) as an indicative guideline.

Financial institutions will require adherence to the World Health Organisation Ambient Air Quality requirements, as detailed in the IFC General EHS Guidelines.

The following tables detail these standards.

Table 5-1 USEPA NAAQS

Pollutant		Primary/ Secondary	Averaging Time	Level	Form
Carbon Monoxide		Primary	8-hour	9ppm	Not to be exceeded more than once per year
			1-hour	35ppm	
Lead		Primary and secondary	Rolling 3 month average	0.15 µg/m^3	Not to be exceeded
Ozone		Primary and secondary	8-hour	0.075 ppm	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Nitrogen Dioxide		Primary	1-hour	100ppb	98th percentile, average over 3 years
		Primary and secondary	Annual	53ppb	Annual Mean
Particulates	**PM 2.5**	Primary and secondary	Annual	15µg/m^3	Annual Mean, averaged over 3 years
			24-hour	35µg/m^3	98th percentile, average over 3 years
	PM$_{10}$	Primary and secondary	24-hour	150µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulphur Dioxide		Primary	1-hour	75 ppb	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		Secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

(Primary standards provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings).

MECA is in the process of developing Omani Ambient Air Quality Standards (AAQ). Although these have not yet been declared, the provisional standards are shown in the following table.

Table 5-2 Proposed MECA Ambient Air Quality Standards

Parameter	Averaging Period	Standard Limits (μg/m^3)
NO_2	24 Hr average	112
SO_2	24 Hr average	125
CO	8 Hr average	6000
H_2S	24 Hr average	40
O_3	8 Hr average	120
HCNM	3 Hr average	160
PM_{10}	24 Hr average	125

Table 5-3 WHO Ambient Air Quality Standards (ref: IFC General EHS Guidelines) (µg/m^3 unless otherwise specified)

Parameter	WHO Ambint Air Quality 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)
$PM_{2.5}$	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)
NO_2	200 (1 hour)	40
SO_2	125 (Interim target 1)	500 (10-minute guideline)
	50 (Interim target 2)	
	20 (guideline)	
O_3	160 (interim target 1) (8-hour daily maximum)	
	100 (8 hour daily maximum guideline)	

5.2 Observations and Baseline Condition

There are no known designated areas sensitive to changes in air quality condition or observable permanent residential or commercial properties within 1km of the proposed project area.

Several small shelters utilised as temporary refuge for camels believed to be owned by Bedouin were noted along the access road to the Sembcorp IWPP (people believed to be employed by Bedouin were seen attending to these camels).

Salalah Sembcorp IWPP is located adjacent to the western boundary of the proposed project area. This is a gas fired power plant with a total gross capacity of 490 megawatts and is anticipated to have the most significant impact on ambient air quality locally, particularly for concentrations of NO_2 and CO; due to the combustion of natural gas.

An access road to the west of the proposed project area links the Salalah Sembcorp IWPP with the main road to Salalah, however this is not a through-road and traffic is only likely to be associated with access requirements for the Salalah Sembcorp IWPP. It is not anticipated that this carriageway currently has any discernible impact on the existing air quality condition in the local area.

5.3 Sensitive Receptors

Table 5-4 Potential Air Quality Receptors

Receptor	Receptor Type	Justification
Salalah Sembcorp IWPP	**industrial**	The IWPP is an industrial facility that will be located adjacent to project site. As an industrial facility and as an emitter of air pollutants it is of low vulnerability to changes in ambient air quality.
Camel Shelters	**Agricultural**	Camel shelters understood to belong to Bedouin people were observed in several locations adjacent to the hardstanding from the proposed site access road. People employed by the Bedouin to tend to the camels were present at these areas, however, it is recognised that these receptors are not permanent features and are likely to be moved, depending on the season and availability of grazing land locally for the camels.

Figure 5-1 Potential Air Quality Receptor Locations

Satellite Image Source: Google Earth

5.4 Potential Impacts

5.4.1 Construction Phase

Activities associated with the construction phase are likely to result in fugitive emissions of dust and gaseous pollutants associated with the use of plant, vehicles and machinery.

In particular, impacts are likely to be associated with:

- Dust deposition, resulting in the soiling of surfaces;
- Visible dust plumes, which are evidence of dust emissions;
- Elevated PM_{10} concentrations, as a result of dust generating activities on site;
- Increase in concentrations of airborne particles and nitrogen dioxide due to exhaust emissions from diesel powered vehicles and equipment used on site (non-road mobile machinery) and vehicles accessing the site.
- Stored VOCs and other volatile hazardous materials; and
- Odour from temporary wastewater facilities, or containment.

5.4.2 Operational Phase

As the proposed projects power demand will be generated and supplied externally, there are no fuel combustion requirements or any other associated air emissions directly from the project.

The facility will result in a small additional number of commuter vehicles and delivery/removal vehicles along the access road to the IWP, however given current usage discernible impacts are not considered likely.

5.5 Proposed Assessment Requirements for ESIA

In accordance with the outlined potential impacts, the following table details those impacts that will be scoped in and scoped out of further assessment at the ESIA stage.

Table 5-5 Air Quality Impacts for further Assessment at the ESIA Stage

Potential Impact	Scoped In/Out of ESIA	Justification
Construction		
Dust Generation	**Scoped Out**	In accordance with screening guidance of the UK's Institute of Air Quality Management (IAQM) for construction dust, the need for detailed assessment relating to dust impacts will normally be required where: • There is a 'human receptor' within 350m of the boundary of the site, or within 50m of a route used by construction vehicles on public roads (up to 500m from the site entrance). • There is an 'ecological receptor' within 50m of the boundary of the site, or within 50m of a route used by construction vehicles on public roads (up to 500m from the site entrance).

Potential Impact	Scoped In/Out of ESIA	Justification
		With respect to the screening criteria above, the project is not within 350m of a human receptor (i.e. residential or recreational area), or within 50m of an ecological sensitivity. The camel shelters along the paved access road are also over 500m away from the project site. It is therefore considered that impacts relating to construction dust can be scoped out of further assessment. According to the UK-IAQM, 'where the need for a more detailed assessment is screened out, it can be concluded that the level of risk is "negligible", and any effects will not be significant.
Gaseous Emissions	**Scoped Out**	Emissions are not expected to result in noticeable cumulative impacts to the local air shed, which is already affected by major emission sources from the Sembcorp IWPP.
VOC's	**Scoped Out**	The potential for VOC impacts is expected to be minimal and expected to be negligible at off-site receptors, and as such is scoped out. This is primarily due to the limited potential for diffuse source VOC's from the site.
Odour	**Scoped Out**	The potential for odour impacts is expected to be minimal and expected to be negligible at off-site receptors, and as such is scoped out.
Operation		
Vehicle Gaseous Emissions	**Scoped Out**	Emission from vehicle movements are not expected to result in noticeable cumulative impacts to the local air shed, which is already affected by major emission sources from the Sembcorp IWPP.

Although the projects potential construction and operational impacts related to air quality have been scoped out of further assessment, the ESIA will include best practice mitigation and management measures for the construction phase to reduce the potential for any associated effects to air quality. The intention will be for these best practice measures to be included into the CESMP and construction phase ESMS for effective management and implementation on-site.

6 NOISE AND VIBRATION

6.1 Standards and Regulatory Requirements

Omani Noise Standards

Omani regulations for noise are applicable for both the workplace and ambient noise levels. The ambient noise levels are provided in M.D. 79/94 and the applicable limits of noise generated from industrial facilities, which includes desalination plants, is provided in the following table.

Table 6-1 Limits of noise generated by industrial sources

Type of District	Leq, T, dB(A)		
	Day Time 7am-6pm Workdays	Evening Time 6pm- 11pm Workdays	Night Time 11pm – 7am Workdays and holidays
Rural residential and recreational	45	40	35
Sub-urban residential	50	45	40
Urban residential	55	50	45
Urban residential with some workshops or business city hub	60	55	50
Industrial and commercial	70	70	70

Ministerial Decree 80/1994, describes the measures taken to control noise pollution in the working environment. The requirements specify that:

- Employees should not be exposed to noise levels exceeding 85 dB(A);
- If work place noises exceed 85 dB(A), then the employer should provide the workers with suitable personal hearing protection devices;
- The attenuation devices should minimise the noise levels to 80dB(A) or lower; and
- Machines must be designed and constructed in such a way that risks resulting from elevated noise are reduced to the lowest level possible using state-of-the-art technology and available means particularly at noise source.

Lender Requirements

The IFC General EHS Guidelines require that the project is in compliance with the WHO noise standards, though these relate to noise received at receptor locations rather than the project boundary.

Table 6-2 World Bank Noise Standards

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

Noise impacts should not exceed the levels presented above, or result in a maximum increase in background levels of 3 dB at the nearest sensitive receptor location off-site.

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 periodically.

6.2 Observations and Baseline Condition

On the day of the initial site visit there were no observable permanent residential or commercial properties within 1 km of the proposed project area.

Several small shelters believed to be utilised as temporary refuge for camels believed to be owned by Bedouin were noted along the access road to the Sembcorp IWPP, approximately 2km form the project site (people believed to be employed by Bedouin were seen attending to these camels).

Salalah Sembcorp IWPP is the only facility in the area likely to provide any anthropogenic source of noise or vibration, however on the day of the survey any noise from the IWPP was not audible over the sound of wave action from the shoreline. During the site visit, vibrations were not noticed.

Figure 6-1 Views of Sembcorp Facility from Project Area

The low vehicle flows using the access road to the west of the proposed project area did not result in any audible traffic noise within the project area.

For ease of reference, potential noise and vibration receptors are identified in Table 6-1.

Table 6-3 Potential Noise and Vibration Receptors

Receptor	Receptor Type	Location
Salalah Sembcorp IWPP	**Industrial**	Adjacent to western boundary of project area.
Bedouin Shelters	**Agricultural**	Adjacent to Sembcorp IWPP access road, approximately 2km form the project site

Figure 6-2 Potential Noise Receptor Locations

Satellite Image Source: Google Earth

6.3 Potential Impacts

6.3.1 Construction Phase

Construction Noise

Construction activities will likely result in temporary and short duration increases in the noise and vibration levels emanating from the project site, access road and the laydown areas.

Noise will be generated by construction and propagated to the surrounding areas via a range of processes. Pertinent construction activities at the project site in relation to noise are likely to include earthworks, movement of vehicles, compaction works and piling.

The accumulation of noise from the above sources can also introduce potential cumulative impacts when generated in tandem. All of these impacts may have a negative effect on the amenity at nearby receptors.

Construction Access Road Noise

Increases in traffic during construction may also lead to increases in the noise level at off-site receptors, such as the camel shelters, which are adjacent to the existing public access road.

Vibration

Certain construction processes, particularly those involved with site preparation and civil works, e.g. breaking, piling, vibratory rollers etc. have the potential to create vibration within the vicinity of the works.

Vibratory impacts at the IWPP may be discernible, but impacts ere are not expected at the camel shelters over 2km form the project site; due to the attenuation of vibrations over distance.

6.3.2 Operational Phase

Operational Noise

Principle noise and vibration sources are anticipated to be associated with pumping stations and the flow of highly pressurised water. The reverse osmosis components of the project are typically not noisy and will be housed within internal structures, further attenuating any generated noise.

Given that similar noise sources are already present at the Sembcorp IWPP (or potentially greater due noises related to power generation) there will unlikely be a discernible impact to off-site receptors

Vibration

As the SWRO plant will not contain rotating, vibrating, or other major moving parts, impacts from vibration are not expected.

6.4 Proposed Assessment Requirements for ESIA

In accordance with the outlined potential impacts, the following table details those impacts that will be scoped in and scoped out of further assessment at the ESIA stage.

Table 6-4 Noise & Vibration Impacts for further Assessment at the ESIA Stage

Potential Impact	Scoped In/Out of ESIA	Justification
Construction		
Construction Site Noise	**Scoped Out**	As an industrial facility, the adjacent IWPP is less sensitive to noise impacts, and is unlikely to have any discernible effects on staff engaged in power plant activities. Construction noise may not be discernible above the operational noise from the IWPP facility, which is the primary anthropogenic noise source locally.
Construction Access Road Noise	**Scoped In**	The increase in vehicle traffic due to the construction phase may be noticeable along the public access road located adjacent to the camel shelters. Additional vehicle movements along the site access road may result in discernible noise impacts at the camel shelters.
Vibration	**Scoped Out**	Vibration impacts are expected to be negligible and will not impact more sensitive receptors such as the camel shelters.
Operation		
Operational Noise	**Scoped Out**	Operational noise will be minimal and largely attenuated by the SWRO housing and pump housing. Impacts will unlikely be discernible above the noise from the adjacent IWPP.
Vibration	**Scoped Out**	Impacts related to vibration are not expected.

Although some of the projects potential construction and operational impacts related to noise and vibration have been scoped out of further assessment, the ESIA will include best practice mitigation and management measures for the construction phase to reduce the potential for any associated effects to receptors. The intention will be for these best practice measures to be included into the CESMP and construction phase ESMS for effective management and implementation on-site.

In order to provide a representative assessment of the significance of potential impacts at the ESIA stage, the following methods have been proposed for those topics scoped in to further assessment.

Table 6-5 Noise & Vibration Impacts Assessment Methodology at the ESIA Stage

Potential Impact	ESIA Assessment Methodology
Construction Phase	
Construction Access Road Noise	<u>Baseline Study:</u> In order to determine a representative baseline for existing noise levels at the Camel Shelters along the existing public access road a noise monitoring survey will be undertaken with a noise meter compliant with Class 1 specification, as set out in BS EN 60804:2001. It is proposed that up to four (4) locations will be monitored and will be located at the various camel shelter locations. Given that the camel shelters are temporary structures, the specific proposed locations cannot be provided in this scoping report, and will rely on the specific locations of the shelters at the time of the monitoring. If there are no shelters in the areas at the time of the monitoring, representative monitoring will be undertaken at a distance of 50m from the public access road at 4 separate locations. The survey will monitor ambient noise levels for 20-minute periods to provide measurements of Leq(A) readings for daytime periods. As night time construction works are not expected, night-time noise surveys are excluded. 20-minute periods are considered representative to ensure that a baseline can be achieved from the primary noise source locally at the camel shelters, which is the vehicle movements along the public access road. The ESIA baseline noise section will include: • GPS coordinates, photographic record and map of the monitoring locations. • Presentation of monitoring results. • Comparison of results to applicable Omani & WHO standards.
	<u>Assessment of Impact Significance:</u> Assessment of impact significance will be made by considering the existing baseline condition in combination with the potential additional construction phase noise impacts from vehicular sources. The determination of impact magnitude will be made based upon an estimation of vehicle trips, vehicle speed and vehicle type along the access road; for construction vehicles. A basic model for the calculation of road noise propagation will be used to predict the expected additional impact of the vehicles. The potential impacts will be based upon the degree of change in decibels at the receptor location. A degree of change above 3dB(A) will be considered as potentially significant in accordance with guidance of the UK Control of Road Traffic Noise.

7 TERRESTRIAL ECOLOGY

7.1 Regulatory Requirements

7.1.1 Omani Requirements

RD 6/2003: Law on Nature Reserves and Wildlife Conservation established requirements for the protection of designated nature reserves with in the sultanate of Oman and identifies a list of species that are protected against killing, hunting or smuggling (no evidence suggesting the presence of any species were noted during the initial site visit).

7.1.2 Lender Requirements

IFC Performance Standard 6 requires the consideration of relevant threats to biodiversity and ecosystem services, especially focusing on habitat loss, degradation and fragmentation, invasive alien species, overexploitation, hydrological changes, nutrient loading, and pollution. Performance Standard 6 outlines that impacts on biodiversity and ecosystem services should be avoided where possible. When avoidance of impacts is not possible, measures to minimise impacts and restore biodiversity and ecosystem services should be implemented.

7.2 Observations and Baseline Condition

The nearest designated ecological area is the Khawr Rawi Nature Reserve located Approximately 5km to the west of the project area. This is the largest of the Khawrs (or Khor / Creek) found along the Salalah coastline at approximately 2.5km long and up to 400m wide. This intertidal habitat provides an important are for birds and fish.

The proposed project site is predominantly an open plain with little vegetation, due to the previous use of this areas as the construction laydown area for the Sembcorp IWPP. As such, much of this land was already levelled and used to house temporary facilities and used for temporary roads.

Any vegetation that is present is dominated by small pioneer shrub species and grasses. Small scattered boulders and cobbles provide refugia for invertebrates and small reptiles. It was noted that there were active demobilisation works where a previous compound area was being demolished. Camels were grazing on the palm trees that had been uprooted and Passerine birds were foraging amongst root systems and excavation areas.

Figure 7-1 Typical Site Condition

A steep sided slope at the southern extend of the site leads to the shoreline. Sporadic vegetation is scattered throughout the slope. A Deathstalker scorpion (*Leiurus quinquestriatus*) was identifies amongst the cobbles.

Figure 7-2 Slope Leading to Shoreline.

The beach habitat is predominantly free of any flora however, a number of ghost crabs were identifies to be foraging and burrowing along the shoreline. Remains of shellfish and crustaceans were scattered amongst the beach sands.

Figure 7-3 Typical Beach Habitat.

To the north of the project area, in close proximity to the proposed access road the landscape falls away to a deep and wide Wadi channel. During the initial site visit, the Wadi was dry but substrates suggest that it is wet for periods of the year, and vegetation cover was much more substantial relative to areas outside the Wadi. The area was being grazed by camels and 2 Tristram's starlings (*Onychognathus tristramii*) were identified following the course of the wadi.

Figure 7-4 Typical Wadi Habitat

No coastal or wading birds were identified during the initial site visit and given local topography, it is unlikely that this Wadi is associated the Khawr Rawi Nature Reserve.

Potential terrestrial ecology receptors have been identified in the table below.

Table 7-1 Potential Terrestrial Ecology Receptors

Receptor	Receptor Type	Location
Khawr Rawi Nature Reserve	Designated Nature Reserve	Approximately 6km to the west
Shoreline/Beach Habitat	Distinctive Habitat Type	Within the project area.
Wadi Habitat	Distinctive Habitat Type	Approximately 100m To the north of the project area.

7.3 Potential Impacts

7.3.1 Construction Phase

Habitat Loss

It is expected that site preparation activities will include the removal of any remaining vegetation in the project footprint, followed by grading for foundations, excavations for below ground infrastructures, and trenching and backfilling for cables and pipelines.

Loss of remaining on-site flora will be permanent however this is considered to be an extremely minor loss in regard to the extensive habitat of a similar nature within the local areas and immediately east of the project site.

Disturbance of Fauna

Construction activities are likely to result in disturbance, or would trigger a flight response from fauna within the project area. However, given the ample availability of refuge and foraging areas, this is unlikely to have any discernible impact upon local terrestrial ecology, or result in carrying capacity impacts to other neighbouring habitats.

7.3.2 Operational Phase

The open plain area to be utilised for the proposed project is common for the local shoreline area and not considered sensitive. As such, its permanent loss is not anticipated to have a discernible impact on local terrestrial ecology or any nature reserves in the region. Careful selection and placement of landscaping features could result in a net benefit for avian fauna.

Due to the likely paving and hard standing construction over the majority of the proposed site, it is anticipated that impacts during the operational phase to any on site vegetation will be minimal. As such, the only activities that could negatively impact the ecology of the site would be through indirect measures, relating to poor management practices of any designated landscaped areas; or to the fauna species inhabiting/using these areas.

7.4 Proposed Assessment Requirements for ESIA

In accordance with the outlined potential impacts, the following table details those impacts that will be scoped in and scoped out of further assessment at the ESIA stage.

Table 7-2 Noise & Vibration Impacts for further Assessment at the ESIA Stage

Potential Impact	Scoped In/Out of ESIA	Justification
Construction		
Habitat Loss	**Scoped In**	Impacts are expected to be very minor as the site habitats are common for the local area. The project site location will also not result in the severance of habitats. However, without undertaking a baseline assessment of flora species in the project footprint, it is not appropriate to scope this impact out at this stage.
Disturbance of Fauna	**Scoped In**	The preliminary site visit and baseline observations did not identify faunal species of importance. Impacts (if any to fauna) are not expected to be of significance. However, without undertaking a baseline review of potential faunal species, it is not appropriate to scope this impact out at this stage.
Operation		
All operational impacts to terrestrial ecology have been scoped out as there are not expected to be any further impacts of significance during the operational phase.		

Although the projects operational impacts related to terrestrial ecology have been scoped out of further assessment, the ESIA will include best practice mitigation and management measures for the construction phase to reduce the potential for any associated effects to receptors; such as the management of landscaped areas and attraction of pests. The intention will be for these best practice measures to be included into the OESMP and operational phase ESMS for effective management and implementation on-site.

In order to provide a representative assessment of the significance of potential impacts at the ESIA stage, the following methods have been proposed for those topics scoped in to further assessment.

Table 7-3 Noise & Vibration Impacts Assessment Methodology at the ESIA Stage

Potential Impact	ESIA Assessment Methodology
Construction Phase	
Habitat Loss	<u>Baseline Study:</u> The ESIA will incorporate the undertaking of a plant species inventory to confirm that flora within the project area is not afforded national protection or associated with any international conservation status. A review of available data sources will be assessed for the potential presence of species of importance of conservation concern on the site. This will be validated by site based observations. The baseline surveys will output inventories for flora and fauna with details of any related conservation status (e.g. in alignment with IUCN). The importance and sensitives of habitats on-site will be assessed in accordance with a best practice methodology. Sensitive habitats will be delineated on habitat maps.
	<u>Assessment of Impact Significance:</u> If sensitive species or habitats of concern are identified by the baseline surveys, further detailed assessment will be undertaken to assess the significance of impacts. Specifically, construction activities will need to be controlled to ensure against any unnecessary impacts for the potentially sensitive habitats associated with the shoreline and wadi area. This should be achievable through the implementation of a robust CEMP.

8 GEOLOGY, SOILS AND GROUNDWATER

8.1 Regulatory Requirements

8.1.1 Omani Requirements

Several legal instruments in the Sultanate of Oman are in place to control the handling and management of potential dangerous substances. These include:

- RD No. 46/1995: Issuing the Law of Handling and Use of Chemicals;
- MD 140/93 Regulations for Chemical Materials Registration and Related Permits;
- MD No. 248/1997: Regulation for the Registration of Chemical Substances and the Relevant Permits.

In addition, RD No. 114/2001: Law for the Conservation of Environment and Prevention of Pollution establishes strict prohibition against the release of environmental pollutants.

8.1.2 Lender Requirements

Financial institutions will require adherence to IFC Performance Standard 3 which aims to prevent pollution and requires that in the instance of historical pollution it is necessary to determine project responsibility for associated mitigation measures.

Omani standards do not exist for soil or groundwater quality. As such, the use of the Dutch standards is common practice for the analysis of soils and groundwater, and these are viewed as international best practice. Where contaminants are found to exceed 'action' levels, this is considered to be a case of soil contamination, which is dangerous to the health of humans and the natural environment. Such a level of contamination should prompt a need for remediation, appropriate treatment and disposal.

Table 8-1 Dutch Soil and Groundwater Standards – For Heavy Metals

Contaminant	Dutch Soil (mg/kg dry weight)		Dutch Groundwater (µg/l)	
	optimum	action	optimum	action
Arsenic	29	55	10	60
Barium	200	625	50	625
Cadmium	0.8	12	0.4	6
Chromium (total)	100	380	1	30
Cobalt	20	240	20	100
Copper	36	190	15	75
Lead	85	530	15	75
Nickel	35	210	15	75
Mercury	0.3	10	0.05	0.3
Zinc	140	720	65	800
Benzene	0.05	2	0.2	30

8.2 Observations and Baseline Condition

Soils within the project area are homogenous, consisting of sandy silt with cobbles and boulders intermixed throughout. The soil surface presents little evidence of any organic material and appears to be free draining.

Figure 8-1 Typical Surface Soil Conditions

Existing geotechnical information gathered for the Sembcorp IWPP and supplied with the RFP identifies that the underlying geology consists of a highly fractured limestone from 0.40-0.80m to 2.10-3.00m, a moderately weathered and moderately fractured limestone from 0.40-0.80m to 20.00-30.00 and a moderately weathered, moderately fractured calcareous sandstone from 8.30-18.50m to 21.80-20.50m.

Groundwater was not encountered during the investigation up to a depth of 20m. The site is substantially elevated in comparison to the adjacent shoreline to the south and wadi channel to the north. Given the nature of the geology at the site it is considered unlikely that groundwater will be encountered during any project earthworks. Groundwater is likely to be present at depth and is expected to be consistent with the quality of sea water (i.e. with elevated concentrations of chloride, sodium and sulfate).

Historic satellite imagery from August 2011 (sourced from Google Earth) identifies that the majority of the project area has previously been used as a site construction compound.

Figure 8-2 Historic Satellite imagery of Project Area (August 2011)

On the day of the site visit, part of the old site compound was in the process of being demobilised and remediated.

Site compounds commonly introduce risk of spills and leaks associated with the storage of fuels, oils, chemicals and sanitary requirements which may have resulted in soil contamination within the project area.

8.3 Potential Impacts

8.3.1 Construction Phase

Cross Contamination of Historic Contamination

Given the historic use of the site as a construction compound, there is an inherent risk of encountering contaminated materials during excavations and earthworks. This could result in the cross-contamination of materials and potential direct exposure of site staff to hazardous substances.

Spill and Leaks Associated with Construction

Storage and usage of fuels, chemicals and sanitary provision during the construction phase will introduce risks associated with spills and leaks to ground. Given the free draining nature of the soils and the geology at the site, groundwater at depth may be vulnerable to contamination events.

8.3.2 Operational Phase

Spill and Leaks Associated with Operation

Storage and usage of any hazardous materials (e.g. chemicals) and sanitary provision during the operational phase will introduce risks associated with spills and leaks to ground. Given the free draining nature of the soils and the geology at the site, groundwater at depth may be particularly vulnerable to any contamination events.

8.4 Proposed Assessment Requirements for EIA

Given the potential risks associated with encountering contaminated materials within the project site, the EIA should incorporate a contaminated land investigation to determine:

- Likely extent of contamination;
- Whether any contaminated areas incorporate hazardous qualities; and
- Suitable control/remediation measures given likely exposure pathways during construction and operation.

8.4.1 Initial Conceptual Model and Preliminary Risk Assessment

The following initial conceptual model has been developed to determine the level of risk of contamination that may exist at the project site. The conceptual model has been prepared based on observations during the site visit.

Table 8-2 Source – Pathway – Receptor Model

Potential Source	Potential Receptor	Potential Transport Pathways
Historic Contaminants from IWP construction laydown area (i.e. oils & greases, hydrocarbons and heavy metals)	Soil	Direct contamination to surface and top-soils.
	Groundwater	Leaching through high porosity soils
Fuel & chemical storage (at adjacent IWPP)	Groundwater	Leaching through high porosity soils and transfer via groundwater movement

The Contaminated Land Risk Assessment methodology used for this assessment is based on CIRIA C552 (2001) Contaminated Land Risk Assessment – A Guide to Good Practice, in order to quantify potential risk via risk estimation and risk evaluation, which can be adopted at the Phase I stage. This will then determine an overall risk category which can be used to identify likely actions for the site. This methodology uses qualitative descriptors and therefore is a qualitative approach (see Appendix C).

Table 8-3 Source – Pathway – Receptor Analysis

Potential Source	Potential Receptor	Potential Transport Pathways	Likelihood of Source – Receptor Linkage	Potential Consequence of linkage	Risk Classification
Historic Contaminants from IWPP construction laydown area (i.e. oils & greases, hydrocarbons and heavy metals)	Soil	Direct contamination to surface and top-soils.	Likely	Minor	Moderate Risk
	Groundwater	Leaching through high porosity soils	Low Likelihood	Mild	Low Risk
Fuel & chemical storage (at adjacent power and water plants)	Groundwater	Leaching through high porosity soils and transfer via groundwater movement	Low Likelihood	Mild	Low Risk

In accordance with the described potential impacts, the following table details those impacts that will be scoped in and scoped out of detailed assessment at the ESIA stage.

Table 8-4 Soil, Geology & Groundwater Impacts for further Assessment at the ESIA

Potential Impact	Scoped In/Out of ESIA	Justification
Construction		
Cross Contamination of Historic Contamination	**Scoped Out**	Due to the historic land use of the site as a construction laydown areas the Initial Conceptual Model has identified a 'Moderate' risk of encountering contamination on site. Due to the requirement for excavations and land grading on-site during construction, there are potential risks of cross-contamination of potentially contaminated soils.
Spill and Leaks Associated with Construction	**Scoped Out**	Hazardous materials, fuels and chemicals will be on-site during the construction phase and there is a risk of direct contamination if not handled or stored correctly. Such risks will be managed through the implementation of a CESMP.
Operation		
Spill and Leaks Associated with Operation	**Scoped Out**	Small quantities of hazardous materials, fuels and chemicals will be on-site during the operations phase and there is a risk of direct contamination if not handled or stored correctly. Such risks will be managed through the implementation of a OESMP.

In order to provide a representative assessment of the significance of potential impacts at the ESIA stage, the following methods have been proposed for those topics scoped in to further assessment.

Table 8-5 Soil, Geology & Groundwater Impacts Assessment Methodology at the ESIA Stage

Potential Impact	ESIA Assessment Methodology
Construction Phase	
Cross Contamination of Historic Contamination	Baseline Study: Based on the initial conceptual overview of potential pollution sources, pollution pathways and receptors outlined in the chapter above, it will be necessary to undertake a Phase II survey for evidence of potential contamination on-site in the site soils at the main project area and along the proposed access road. A survey of soil quality will therefore be undertaken at representative location in both these areas. • For the SWRO site, this will include four (4) soil sampling locations in the perceived highest risk areas of the site (specific sampling locations will be determined by olfactory evidence on-site at the time of sampling). • For the site access road, two (2) samples will be taken on the expected routing. A topsoil sample will be collected from each sampling location up to a depth of 10cm (after scraping away the immediate surface layer). The purpose of sampling in the topsoil is based on the likely influence of historic above ground features (i.e. construction laydown area). Soil samples will be sent for analysis at an accredited laboratory where they will be analysed for concentrations of Oils & Greases, TPH and a suite of heavy metals.
	Assessment of Impact Significance: The assessment of impact significance will be determined on the baseline condition of the soils and groundwater in combination with the expected likelihood and magnitude of impacts of cross-contamination to soils.

9 MARINE ENVIRONMENT

9.1 Regulatory Requirements

9.1.1 Omani Requirements

MD 159/ 2005: Regulations for the Discharge of Liquid Effluents to the Marine Environment establishes the requirement for a permit for any discharge to the marine environment and established strict thresholds for specific chemical parameters intended for discharge. It should be noted that impact to corals and macro algae habitats is prohibited and any intended discharge should be modelled in order to adequately identify any potential associated impacts.

9.1.2 Lender Requirements

IFC Performance Standard 6 required the consideration of relevant threats to biodiversity and ecosystem services, especially focusing on habitat loss, degradation, hydrological changes, nutrient loading, and pollution. The standard requires that where possible impacts on biodiversity and ecosystem services should be avoided. When avoidance of impacts is not possible, measures to minimise impacts and restore biodiversity and ecosystem services should be implemented.

9.2 Observations and Baseline Condition

On the day of the site visit, observations of the marine environment did not identify any evidence of natural rock outcrops or reef systems from wave action and there was no evidence of any macroscopic algae, marine plants or coral fragments having been washed up on the shoreline.

Figure 9-1 View of Marine Environment from the Shoreline

On the day of the initial site visit, strong wave action prevented an estimate of the sea depth, however the inlet/outlet to the adjacent SembCorp IWPP was identifiable by its rock armour protection.

A dead and decaying puffer fish was found on the shoreline. These fish typically inhabit pelagic zones and therefore are not suggestive of any definite coral or algal habitats.

9.3 Potential Impacts

9.3.1 Construction Phase

The greatest potential for adverse impacts during the construction phase will be associated with the construction of the seawater intake and outfall facilities. Such activities will permanently alter the sea bed, including potential loss of associated benthic fauna and adverse impacts to water chemistry associated with increases in suspended sediments.

The requirements for dredging are currently unknown, however, where dredging is required, there is the potential for significant dispersion of sediment which will increase TSS and turbidity within the water column as well as potentially smothering any surrounding sea bed benthic habitats and disturbing fish species.

If necessary the storage of dredged material will result in the runoff of water to the sea, which may include high loads of suspended sediments, potentially reducing water quality.

Seawater intake and outfall facilities above the sea bed could influence wave action within the intertidal zone thereby affecting shoreline erosion/deposition.

Given the anticipated depth of groundwater (ref: Soil, Geology and Groundwater chapter) dewatering to the sea is considered unlikely.

Site runoff during the construction phase could adversely affect water chemistry within the foreshore. However, this should be suitably prevented through implementation of a robust CESMP.

9.3.2 Operational Phase

During operation, brine and backwash generated from the reverse osmosis process will be discharged to the marine environment and will impact water chemistry within proximity to the discharge point with potential adverse impacts for the local ecosystem. Such impacts will include increases in the salinity of ambient water quality.

Dependant on intake design and local habitat type, the intake could also result in the entrainment and/or impingement of fish, with adverse impacts for local populations.

Wastewater treatment will be afforded to all wastewater streams on-site. However, the discharge of treated effluents, may result in certain residual pollutants being discharged (e.g. chlorine).

Note: Project design guarantees ensure that any discharged effluents will be compliant with the necessary Omani wastewater discharge standards..

9.4 Proposed Consideration for Project EIA

The EIA should incorporate an assessment of offshore habitats likely to be impacted by the installation of infrastructure associated want the intake/outfall such that a suitable mitigation plan can be implemented (if required).

The EIA will also need to incorporate a dispersion model suitable to identify any potential impacts associated with necessary discharge from the outfall.

Suitable controls will need to be implemented during the construction phase to minimise direct physical impacts to the sea bed and associated silt dispersion. Habitat surveys may identify the requirement for translocation of sensitive habitats in advance of the commencement of works, however this is not considered likely based on local observations of the shoreline.

9.5 Proposed Assessment Requirements for EIA

In accordance with the described potential impacts, the following table details those impacts that will be scoped in and scoped out of detailed assessment at the ESIA stage.

Table 9-1 Marine Environment Impacts for further Assessment at the ESIA

Potential Impact	Scoped In/Out of ESIA	Justification
Construction		
Dredging of Seabed / Installation of Intake and Outfall	**Scoped In**	Marine habitats may be sensitive to such activities, and may result in the loss of any benthic fauna as well as any seagrass that may be present.
Disturbance of Marine Fauna	**Scoped In**	It is generally expected that fish will avoid the working area during construction due to noise and a slight reduction in ambient water quality. However, the potential impact will be scoped in.
Degradation of Water Quality	**Scoped In**	Impacts to ambient water quality from marine works could potentially be significant. Any impacts will be managed through a CESMP which will include measures to limit this temporary impact.
Operation		
Entrainment of fauna to intake	**Scoped Out**	Impacts upon fish are expected to be minimal as the intake velocity will be optimised to reduce such effects. The ESIA will not further assess the impacts upon marine fauna, but will provide mitigation measures to reduce the impacts.
Increased Salinity	**Scoped In**	It is necessary to determine the extent of the brine mixing zone to ensure that it can meet the necessary standards and to ensure that the size of the mixing zone can be reduced as far as practically possible in accordance with the IFC EHS Guidelines.
Discharge of Treated Wastewater Effluents	**Scoped In**	Given that the project will be designed to comply with the applicable Omani and IFC EHS discharge standards, it is expected that compliance will be achieved, however, further assessment is required to determine any potential impacts upon marine habitats.

In order to provide a representative assessment of the significance of potential impacts at the ESIA stage, the following methods have been proposed for those topics scoped in to further assessment.

Table 9-2 Marine Environment Impacts Assessment Methodology at the ESIA Stage

Potential Impact	ESIA Assessment Methodology
Construction Phase	
Dredging of Seabed / Installation of Intake and Outfall	Baseline Study: The ESIA phase will include a marine baseline survey that will be undertaken to provide a baseline assessment of habitat, flora & faunal species, water quality and sediment quality. The marine survey will be undertaken by Scuba techniques and will collect survey results at up to 4 locations, expected to be along the intake and outfall corridor, as well as at least one control location, most likely to the east of the project away from the Sembcorp IWPP influences. The marine survey methods will include 25m transects at 2 depths per location, as well as quadrat analysis every 5m along the transect. The intention is to compile an inventory of present flora and faunal species and to assess their health, density, and abundance. All siting's of fish and other marine fauna will be noted and recorded as an inventory at each location. Water quality samples will also be taken at mid water column depth, and a sediment sample will be collected at each location. The results of the marine survey will be compiled in the baseline assessment and evaluated against a past baseline survey undertaken at the feasibility stage of the project (that has been supplied with the RfP). The baseline section will identify any sensitive habitats and will identify species with respect to any conservation status (e.g. IUCN). The marine survey report will full data, methods and photographs will append the ESIA.
	Assessment of Impact Significance: The ESIA will predict area of seabed that will be damaged from the works (including construction working area – if any) and will seek to estimate the extent of impacts upon marine habitats based upon the density and health of any flora.
Disturbance of Marine Fauna	Baseline Study: The baseline assessment will be linked to the marine survey to identify fish species and any other marine fauna., and their significance.
	Assessment of Impact Significance: Based on the sensitivity of the fauna identified, a qualitative assessment in regard to the impacts upon fish and marine fauna will be made.
Operational Phase	
Increased Salinity	Baseline Study: The ESIA will compile ambient water quality data from the marine survey and contained within the OPWP RfP provided.
	Assessment of Impact Significance: The hydrodynamic environment will be simulated for a single post-development physical environment utilising GCOM3D. This hydrodynamic simulation will drive subsequent plume simulations. The brine effluent will be simulated using CORMIX for the near-field behavior and PLUME3D for the far-field behavior. Plume simulations will be conducted for a representative summer and winter scenario, utilising tidal data from the OSU Tidal Inversion mode, meteorological data

	sourced from the ECMWF and bathymetry sourced from the optional surveys and/or data provided by the Client. Plumes will be assessed to determine the potential for re-circulation, and to determine the spatial extent of a variety of differential salinity conditions. The model will be set up to represent the preferred layout of the proposed intake/outfall configuration, in relation to the existing shoreline, bathymetry and marine structures. The model will also have inputs from the discharge of the existing IWPP outfall, to assess cumulative impacts. Environmental conditions will be selected to provide a suitable range of conditions to examine the likely recirculation and effluent dispersion.
Discharge of Treated Wastewater Effluents	<u>Baseline Study:</u> The ESIA will compile ambient water quality data from the marine survey and contained within the OPWP RfP provided.
	<u>Assessment of Impact Significance:</u> Based on the ambient water quality analysis, a qualitative assessment in regard to the impacts upon water quality will be made based on the projects discharge guarantees.

10 SURFACE WATER ENVIRONMENT

10.1 Regulatory Requirements

RD 114/2001 Law on Conservation of the Environment and Prevention of Pollution prohibits the discharge of environmental pollutants unless the levels of such pollutants are equal to or less than that identified within an associated environmental permit.

International financial institutions will require adherence to IFC Performance Standard 3 which requires the avoidance of pollution or, when avoidance is not feasible, minimise and/or control the intensity and mass flow of their release.

10.2 Observations and Baseline Condition

Historical satellite imagery and observations from the initial site visit did not identify any evidence of surface water within the proposed project footprint. The wadi to the north of the project site has a large channel and is expected to have flows of water during the Khareef season, or during significant rainfall events locally.

Following a significant rainfall event, waters are likely to percolate through the free draining site soils, or would runoff to the sea or nearby wadi channel to the north.

10.3 Potential Impacts

10.3.1 Construction Phase

During construction, the presence of unprotected stockpiles, fuels and chemical stores could introduce the risk of pollution to the wadi to the north and foreshore marine environment in the event of a significant rain event.

Instances of pollution could potentially result from the wash off of surface pollutants, particularly during the first flush of rainfall.

Suitable controls will need to be implemented as part of a robust CEMP.

10.3.2 Operational Phase

Increased areas of hardstanding are likely to result in an increase in runoff rates and sediment loading associated with first flush. Depending on the discharge point of storm water, this may impact the adjacent wadi or immediate marine environment; with potential impacts, due to the runoff of pollutants.

10.4 Proposed Consideration for ESIA

The EIA will consider meteorological data for the project site and consider potential impacts associated with increased surface runoff and potential sediment loading from storm water runoff.

Mitigation options including sediment traps and oil interceptors may be appropriate, but will be confirmed at the ESIA stage.

11 WASTE & WASTEWATER MANAGEMENT

11.1 Regulatory Requirements

11.1.1 Omani Requirements

The Sultanate of Oman established principle controls for waste legislation through 2 ministerial decisions:

- Ministerial Decision No. (17/93) for the Regulations for the Management of Solid Non-Hazardous Waste
- Ministerial Decision No (18/93) for the Regulations for the Management of Hazardous Waste.

Omani Permissible Discharge Re-Use Limits

Omani regulation MD 159/2005 describes the requirements and maximum allowable limits for wastewater discharge to the marine environment. Maximum permissible levels of organic and inorganic pollutants are provided below.

Table 11-1 Limits for Discharge to the Marine Environment

Parameter	Units	Standard
pH		6 - 9
Temperature	<10°C	
Biochemical Oxygen Demand (5 day BOD)		20.0
Chemical Oxygen Demand	mg/L	200.0
TSS	mg/L	30.0
Aluminum (as Al)	mg/L	5.0
TSS		30
Arsenic (as As)	mg/L	0.10
Barium (as Ba)	mg/L	2.0
Beryllium (as Be)	mg/L	1.0
Boron (as B)	mg/L	1.0
Cadmium (as Ca)	mg/L	0.010
Chromium (Total as Cr)	mg/L	0.05
Cobalt (as Co)	mg/L	0.05
Copper (as Cu)	mg/L	0.50
Cyanide (Total as CN)	mg/L	0.05
Electrical conductivity (EC)	µs/cm	2000
Faecal coliform bacteria	Number per 100 mL	200
Fluoride (as F)	mg/L	1
Iron (Total as Fe)	mg/L	1
Lead (as Pb)	mg/L	0.10

Parameter	Units	Standard
Lithium (as Li)	mg/L	0.07
Magnesium (as Mg)	mg/L	150
Manganese (as Mn)	mg/L	0.10
Mercury (as Hg)	mg/L	0.001
Molybdenum (as Mo)	mg/L	0.01
Nickel (as Ni)	mg/L	0.10
Nitrogen: Ammoniacal (as N): Nitrate (as NO3) : Organic (Kjeldahl as N)	mg/L	5 50 5
Oil and grease (Total extractable)	mg/L	0.50
pH	--	6–9
Phenols (Total)	mg/L	0.001
Phosphorus (Total as P)	mg/L	30
Selenium (as Se)	mg/L	0.02
Silver (as Ag)	mg/L	0.01
Sodium (as Na)	mg/L	200
Sodium absorption ratio (SAR)	--	10
Sulphate (as SO_4)	mg/L	400
Sulphide (Total as S)	mg/L	0.10
Suspended solids (SS)	mg/L	15
Total dissolved solids (TDS)	mg/L	1500
Vanadium (as V)	mg/L	0.10
Viable nematode ova	Number per L	<1
Zinc (as Zn)	mg/L	5

The following are Omani standards for re-use or disposal of sludge resulting from wastewater treatment. The sludge generated from the wastewater treatment may be applied on land for agricultural use (after obtaining permit from MECA for the same), subject to the conditions given in the table below.

Table 11-2 Wastewater Treatment Sludge re-use standards

Metal	Maximum concentration (mg/kg of dry solids)	Maximum Applicable rate (kg/ha)	Maximum permitted concentration in soil (mg/kg of dry solids)
Cadmium	20	0.15	3
Chromium	1000	10.00	400
Copper	1000	10.00	150
Lead	1000	15.00	150
Mercury	10	0.10	1

Molybdenum	20	0.10	3
Nickel	300	3.00	75
Selenium	50	0.15	5
Zinc	3000	15.00	300

After the spreading of the sludge, there must be at least three weeks period before grazing or harvesting of forage crops. Sludge use is prohibited in the following cases:

- On soils whilst fruits or vegetable crops, other than fruit trees, are growing or being harvested;
- For six months preceding the harvesting of fruit or vegetables, which grow in contact with the soil and which are normally eaten raw; and
- On soils with a pH < 7.0.

11.1.2 Lender Requirements

International financial institutions will require adherence to IFC General EHS Guidelines. These guidelines require that projects undertaken:

- 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.

11.2 Observations and Baseline Condition

As outlined in the soil, geology and groundwater chapter, there is a risk of encountering contaminated soils within the project footprint associated with past land use as a construction site compound.

Subsoils, sediments and rock are anticipated to be the primary waste requirement associated with the construction phase of the project site given the open barren nature of the site and the excavation requirements for foundations, cabling, pipework and access road construction.

During operation, the principle wastewater stream will be the discharge of brine and RO backwash to the marine environment (as discussed in the Marine Environment Chapter). In addition, solid wastes are likely to be generated from routine maintenance and occupation of the site; some of which may be hazardous.

Waste streams likely to be associated with the project are listed in the table below.

Table 11-3 Anticipated Waste Streams Associated with the Project

Subject	Construction	Operation
Inert	Subsoil and Rock	-
	Glass	
Non-Hazardous	Marine sediments	Landscaping waste
	Concrete	
	Asphalt	Replacement parts (e.g. RO Membranes) and packaging
	Scrap metal	
	Plastic	Municipal waste from site staff
	Wood	
	Municipal waste from construction workers	
Hazardous	Contaminated subsoil and rock	Resins and paints
	Resins and paints	Waste oils
	Waste oil	Waste solvents and thinners
	Waste solvents and thinners	Waste fuel and chemicals
	Waste fuel and chemicals	Batteries
	Batteries	Used spill kits and clean up materials.
	Used spill kits and clean up materials	Wastewater treatment sludge
Wastewater	Sanitary waste water	RO Brine discharge
	Commissioning wastewater (e.g. hydro-test, steam and acid cleaning)	Sanitary Waste Water
		Storm water
		Other wastewater (e.g. oily or chemical)

11.3 Potential Impacts

11.3.1 Construction Phase

Waste

The construction phase can often be the most environmentally damaging phase of a project, particularly in regard to the volumes of waste that are generated, if not properly managed. Such impacts relate to the management of such wastes, particularly hazardous streams.

A robust CEMP for the project should outline the requirements for a waste management plan for the construction phase that incorporates the waste hierarchy (as identified below).

Wastewater

The project will require on-site sanitation facilities for the construction workers (expected to be toilets with collection septic tanks). These facilities will require regular emptying and removal from the project site.

The commissioning phase of construction will likely require the hydro-testing, steam cleaning and perhaps chemical cleaning of plant components such as tanks and pipework. These

commissioning activities will generate large volumes of wastewater that may contain heavy metals, as well as oils and greases.

During the Khareef season rainfall can be intense, and storm water may occur on a prolonged basis during this season. Under all rainfall conditions pollutants from polluted construction surfaces can potentially runoff from the site and lead to a transfer of pollutants externally from the project.

11.3.2 Operational Phase

Waste

Solid waste is not expected in significant quantities during the operational phase of the SWRO, besides maintenance for RO membranes and general day to day maintenance activities.

Disposal of material from operations can contribute to wastes directed to landfill resulting in subsequent risk of damage to local hydrological systems and emissions associated with necessary transport.

Wastewater

When in operation, the project will use seawater to generate potable water. In order to generate potable water, the reverse osmosis process will separate the saltwater component, hence resulting in a residual volume of brine wastewater.

Brine wastewater will be discharged directly to the Red Sea where it will mix and dilute with seawater to background concentrations within the projects mixing zone. Given that the brine wastewater is more dense than ambient seawater, it will likely sink through the water column as mixing takes place; such impacts of brine will be assessed in the marine environment section of the ESIA as described in the relevant section of this scoping report.

Other wastewater will be generated from sanitary systems on site and from general operational building (e.g. kitchen's, office buildings etc.). Wastewater will be treated at the on-site treatment facilities prior to discharge to the Sea via mixing at the outfall.

11.4 Proposed Consideration for Project EIA

11.4.1 Waste

Should any evidence of contaminated materials be identified from the site soil investigation (as outlined in the soils, geology and groundwater chapter), the ESIA will consider appropriate disposal routes and potential acceptance criteria for any contaminated materials. This may include a requirement for additional analysis to provide a robust hazard classification.

The mitigation section of the ESIA will consider the requirements established by Good International Industry Practice (GIIP) for general waste, hazardous waste and construction/demolition waste.

The outcomes of the contaminated land assessment undertaken as part of the EIA will need to consider appropriate disposal routes and potential acceptance criteria for any contaminated materials. This may include a requirement for sufficient analysis to provide a robust hazard classification.

Also, in preparation of the environmental management plans for the construction and operational phases, a principle component should be application of the waste hierarchy.

Sourced from Waste Resource Action Programme

The waste hierarchy illustrates best practice for waste management considerations by ensuring consideration of the most sustainable available application for waste management in preference of disposal and eventual contribution to adverse environmental and economic impacts associated with landfill.

The waste hierarchy should form a key element of any waste management plan and if implemented effectively will achieve maximum reductions in waste generation. Application also has the potential to reduce costs associated with material procurement, handling, transportation and disposal.

The Operational Environmental & Social Management Plan (OESMP) for the project should include a requirement for a Waste Management Plan to outline the projects waste strategy in accordance with the waste hierarchy.

11.4.2 Wastewater

The ESIA will inventories all wastewater streams and indicate the pathway and receptor of each stream. Any mitigation and control requirements for treatment will be fully outlined in the ESIA.

12 ARCHAEOLOGY & CULTURAL HERITAGE

12.1 Regulatory Requirements

12.1.1 Omani Requirements

The safeguard of cultural heritage and archaeology in the sultanate of Oman is established through the 1980 Law on the protection of National Cultural Heritage as implemented though the Ministry of Heritage and Culture.

12.1.2 Lender Requirements

International financial institutions will require adherence to IFC Performance Standard 8, which requires the identification and protection of features of cultural heritage value.

12.2 Observations and Baseline Condition

The local Khawr Rawi Nature Reserve incorporates a recognised important archaeological site. Remains found on the banks of the reserve are believed to be associated with an outpost of the Kingdom of Ḥaḍramawt around the 1st century CE.

Figure 12-1 Archaeological Site at Khawr Rawi Nature Reserve

However, as this site is over 5km from the proposed project footprint, it will not be affected. During the initial site visit, no features of cultural value or evidence suggesting the presence of archaeological features were noted within the project footprint.

Due to the close proximity of the archaeological site, it is possible that archaeological remnants may be present on the project site. However, if any important archaeological features were present, these are likely to have been uncovered during past works and use of the project land as a construction compound.

12.3 Assessment of Potential Impacts

12.3.1 Construction Phase

Excavation and earthwork activities can result in damage and destruction of undiscovered archaeological artefacts.

Given the absence of cultural heritage features and previous use of the land as a construction compound, the presence of archaeological features within the project footprint is likely to be low.

A chance find procedure should be incorporated within the project CESMP such that in the unlikely event any items of archaeological significance are uncovered, these can be appropriately identified and preserved.

12.3.2 Operational Phase

The operational phase will not result in further impacts to archaeology, as the site will be static and excavations will not be required.

12.4 Proposed Assessment Requirements for ESIA

In accordance with the described potential impacts, the following table details those impacts that will be scoped in and scoped out of detailed assessment at the ESIA stage.

Table 12-1 Cultural Heritage & Archaeology Impacts for further Assessment at the ESIA

Potential Impact	Scoped In/Out of ESIA	Justification
Construction		
Damage to Unknown Buried Archaeology	**Scoped In**	Impacts are generally not expected due to the lack of cultural or known archaeological features at the project site. However, due to the rich heritage of the local area, the impacts cannot be scoped out at this stage.

In order to provide a representative assessment of the significance of potential impacts at the ESIA stage, the following methods have been proposed for those topics scoped in to further assessment.

Table 12-2 Cultural Heritage & Archaeology Impacts Assessment Methodology at the ESIA Stage

Potential Impact	ESIA Assessment Methodology
Construction Phase	
Damage to Unknown Buried Archaeology	Baseline Study: During the EIA process, the Omani Ministry of Heritage and Culture will be consulted to confirm the expected absence of archaeological and cultural features of significance within the project area.

	Any observations in relation to cultural heritage and archaeology made during site visits will be recorded in the ESIA and mapped. The ESIA will not include further survey work such as archaeological digs or other investigations. The ESIA will include best practice mitigation measures for the construction phase. The intention is to include these mitigation measures into the respective CESMP for effective management and implementation on-site. This will include a chance finds procedure.
	<u>Assessment of Impact Significance:</u> Where there is a risk of unknown buried archaeology being uncovered, the ESIA will base the assessment of significance on a high potential value of the unknown artefacts, but assess this with respect to the likelihood of an encounter.

13 LANDSCAPE AND VISUAL IMPACTS

13.1 Observations and Baseline Condition

No existing residential or commercial visual receptors were identified from satellite imagery or during the initial site visit.

No records have been identified of the site having been afforded any national or international status for landscape importance.

The wider landscape to the north of the project site is dominated by an undulating horizon of mountainous terrain and valley slopes predominantly free of vegetation. Some patches of vegetation are evident, which are anticipated to become more apparent during the Khareef season and winter months.

Figure 13-1 Wider Landscape to the North

Besides the rock armour protection on the adjacent IWPP intake and outfall structures, the seascape to the south was free of peninsulas or island outcrops (note: visibility restricted to light drizzle).

Figure 13-2 Seascape from Project Site

The project site is a dominated by open, gravel/rocky plain with minimal vegetation cover. Views of the adjacent IWPP and the construction compound demobilisation works being undertaken on-site provide a developed sense of place amongst the largely rural area.

Figure 13-3 Typical Views Across the Main Project Area

The only anticipated visual receptor for the site is the adjacent Sembcorp IWPP.

Table 13-1 Potential Landscape and Visual Receptors

Receptor	Receptor Type	Location
Salalah Sembcorp IWPP	Industrial Facility	Adjacent to western boundary of project area.

13.2 Assessment of Potential Impacts

13.2.1 Construction Phase

The construction phase will result in further development and will contribute to the growing industrial landscape of this area. Views of the area are likely to be similar to those experienced during the construction phase of the Sembcorp IWPP, with mobile construction equipment, temporary buildings and general construction works. Given the absence of any residential or commercial receptors, discernible impacts are not anticipated.

13.2.2 Operational Phase

Once operational, the project will continue to contribute to the urban and developed feel of the project area. Given the size of the proposed plant in relation to the adjacent IWPP, it is anticipated that the IWPP will remain the most prominent landscape feature in the vicinity.

The site area will be visible at night due to the requirement for security lighting and the on-going continuous operations of the project.

13.3 Proposed Assessment Requirements for EIA

In accordance with the described potential impacts, the following table details those impacts that will be scoped in and scoped out of detailed assessment at the ESIA stage.

Table 13-2 Potential Landscape and Visual Impacts for further Assessment at the ESIA

Potential Impact	Scoped In/Out of ESIA	Justification
Construction		
Change in Landscape Character	**Scoped Out**	Impacts in regard to landscape and visual impacts are likely to be minimal and are therefore not scoped in for further assessment.
Reduction in Visual Amenity	**Scoped Out**	

As all the potential impacts in relation to Landscape & Visual Impacts have been scoped out (as per the process above), specific assessment at the ESIA phase will not be undertaken.

The ESIA will however include best practice mitigation measures so that any potential impacts can be reduced. The intention is to include these mitigation measures into the respective CESMP for effective management and implementation on-site.

The ESIA should consider whether the Plant has been designed to be as visibly and environmentally discreet as possible and ensure that the setting of the Plant is sympathetic to its surroundings and consistent with the design of existing buildings in the area.

14 SOCIO-ECONOMICS

14.1 Regulatory Requirements

14.1.1 Lender Requirements

International financial institutions will require adherence to the following:

IFC Performance Standard 5: Land Acquisition and Involuntary Resettlement

Establishes requirements associated with to physical and/or economic displacement as a result of project-related land acquisition and/or restrictions on land use.

IFC Performance Standard 7: Indigenous Peoples

Establishes requirements to ensure that the development process fosters full respect for the human rights, dignity, aspirations, culture, and natural resource-based livelihoods of Indigenous Peoples.

14.2 Observations and Baseline Condition

The project site is owned by the Ministry of Housing and will be leased under a Land Lease Agreement for the duration of the construction and operational phases. Therefore, no land acquisition or compensation will be required.

There are no permanent residential settlements or community provisions within or adjacent to the proposed project area.

Access to the proposed project site is only available via the access road for the Sembcorp IWPP and a gravel track to the north of the plant. There are no existing through-routes or expectations for the general public to visit area.

During the intimal site visit, en-route to the proposed project site, several small temporary Bedouin camps were noted on the hillside to the north, more than 1km from the project site. During the site visit, workers for Bedouin people were observed collecting camels from the project site. These camels had come to the site to graze on the exposed root systems of palm trees that were being removed as part of the previous Sembcorp IWPP construction laydown demobilisation works.

Figure 14-1 People Tending to Camels at the Site

Given the lack of vegetation on the site, it is not anticipated that the project area is regularly used for grazing and that the camels present on the day of the site visit were only there because of the demobilisation works. It was noted that camels were grazing within the wadi area to the north of the project area. These camels were using the area planned for the project access road as a means of entering the wadi.

Table 14-1 Potential Receptors

Receptor	Receptor Type	Location
Local Bedouin	Indigenous People	Identified on the hillside over 1km from the project, but likely to only frequently use the wadi area to the north of the project

14.3 Assessment of Potential Impacts

14.3.1 Construction Phase

It is unlikely that the proposed project will have any discernible negative impacts for any local community. However, there is potential for adverse perception of the project from local Bedouins associated with land-use change affiliated with the project.

The primary economic impact during construction is likely to result from employment creation during this phase. As well as the direct monetary uplift to the families of those employed, money paid to workers will also stimulate the local economy via the multiplier effect, whereby money earned on the project expended locally will re-circulate within the local economy. Whilst we have no evidence quantifying the multiplier effect within Oman, studies undertaken in Europe and the US suggests the impact of expenditure on a local economy prior to leakage to be in the order of 4:1.

In addition to the direct monetary impact of employment created during construction, there also exists the potential for the project to promote the dissemination of construction and construction support skills from expatriate workers into the local labour force.

A secondary impact that is likely to arise from spending on local and foreign goods and services during the construction process. The nature of the development, and specialised nature of required materials, suggests that these will be sourced internationally, apart from construction materials (e.g. concrete, cabling, etc.).

14.3.2 Operational Phase

At a strategic level the operation of the SWRO facility offers potential to support the continued growth of the local and national economies, through the ability to provide an important source of potable water to the Omani potable water network.

As with the construction phase, a significant economic impact during operation will result from any local employment created by the project. Whilst the size of the required workforce is significantly smaller, the type of work and the increased time-scales involved offer an opportunity for greater dissemination of skills. A targeted system of local recruitment and

investment in the human capital of the local workforce will enhance this process and consequently increase the benefit to the local economy.

14.4 Proposed Assessment Requirements for ESIA

In accordance with the described potential impacts, the following table details those impacts that will be scoped in and scoped out of detailed assessment at the ESIA stage.

Table 14-2 Socio-Economic Impacts for further Assessment ain the ESIA

Potential Impact	Scoped In/Out of ESIA	Justification
Construction & Operation		
Land Use Change & Restrictions on Access	**Scoped In**	During the initial site visit a small camel herd was observed on-site. Although h project will not result in land acquisition, itis necessary for the ESIA to identify any informal land users and the rights of these land users, to determine what (and if any) mitigation measures, or compensation requirements may need to be issued to such users.

In order to provide a representative assessment of the significance of potential impacts at the ESIA stage, the following methods have been proposed for those topics scoped in to further assessment.

Table 14-3 Cultural Heritage & Archaeology Impacts Assessment Methodology at the ESIA Stage

Potential Impact	ESIA Assessment Methodology
Construction Phase	
Land Use Change & Restrictions on Access	Consultation is proposed with Dhofar Governorate and the Sembcorp IWPP with respect to the use of the local area and project land by the Bedouin and camel herders. Direct consultation with the Bedouin is not included as part of the ESIA scope. Based on the outcomes of the consultation, the ESIA will consider the value of the project area for local Bedouins and camel herders and use this as the basis for determining appropriate mitigation measures, to ensure against potential negative impacts for these land users.

15 COMMUNITY HEALTH, SAFETY & SECURITY

15.1 Standards and Regulatory Requirements

15.1.1 Lender Requirements

The project lenders will require compliance with IFC Performance Standard 4: Community Health, Safety and Security. The objectives of IFC PS4 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 minimizes risks to the Affected Communities.*

The project will therefore need to ensure:

- Suitable design of the SWRO and related infrastructure to ensure safe operation.
- Minimising the potential for community exposure to hazardous materials and substances that may be released by the project.
- Avoidance of community exposure to disease (e.g. from worker influx or supply of contaminants or other water related illness in the supply of potable water).
- Consideration of any third-party impacts to project emergencies and disaster scenarios (or vice versa impacts form external sources to the project), including preparing emergency response plans.
- Appropriate training of security personnel employed by the projects, including appropriate consideration of hiring protocols, training of staff, code of conduct, provision of weapons and weapons protocols.

IFC PS4 also has considerations for impacts to ecosystem services, however the project is not expected to impacts such ecosystem services.

15.2 Observations and Baseline Condition

Community Risks

The project will be located adjacent to a power and desalination facility (Sembcorp IWPP), that has the potential to impact local communities and any future facilities, such as, significant fuel stores on-site. Furthermore, these facilities discharge treated wastewater effluents directly to the sea.

External risks to the Project

These operations of external facilities also present risks that may affect the SWRO projects operation in the event of fire, or spillage to sea.

Security

The Sembcorp IWPP is expected to employ its own security team, but is likely to receive support from the Omani military as a facility of key importance. It is therefore likely that security staff at the entrances to the facility will be armed.

Transportation

Road Transportation

The major road network leading to the project site is Highway 49, which runs parallel to the coastline from Salalah.

Access to the project can be made via an exit from Highway 49 and then a short journey along tarmacked roads to the Sembcorp IWPP. Access to the project site can currently be gained via a compacted track to the north of the Sembcorp IWPP.

15.3 Potential Impacts

15.3.1 Construction Phase

Public/Community Safety

Where the public has access to any construction areas (including laydowns or off-site storage areas) there are potential risks relating to public safety from the use of high powered equipment, heavy construction plant, excavations, and vehicle movements amongst others.

During the construction phase of the SWRO project there are not expected to be specific works that could result in widespread pollution incidents, due to the lack of hazardous material or chemical storage on-site. There is a risk of isolated incidents around the shoreline, but the risks in regard to these are expected to be suitably managed through the implementation of a robust CESMP and construction phases ESMS.

Worker Influx and Disease

Due to the required workforce during the construction phase, there is the potential for additional influx to the local area and for associated impacts such as spread of disease to any local communities. The locations of worker accommodation areas have not been confirmed at this stage, however it is expected that the majority of site staff will be sub-contractor workers who will be based off-site, but in the local area, and therefore may come into contact with local populations.

Security Staff

The project will also include site based security at the gates and on patrol around the site.

Following suitable security risk assessment by the EPC Contractor, the security arrangements should be guided by UN Code of conducts for law enforcement officials and UN basic principles on the use of Force and Firearms by law enforcement officials (if staff are armed). 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 community.

Transportation

The key reason for vehicle use during construction will be the transfer of labourers on the site on a daily basis, as well as the delivery of materials and equipment for construction activities.

It is anticipated that traffic levels (particularly HGV's) will increase on local roads during the construction phase. The volume of traffic will vary over the course of construction depending on the phases of construction and the demand for materials, removals and construction personnel on site. The main factors that will affect the number of vehicles on the roads will be related to manpower needs, material usage and waste generation.

The site will be accessed via the proposed access road to the immediate north of the existing IWPP. The access road will connect the hardstanding roads in the secure industrial zone to the site.

Other forms of direct transport to the site (e.g. by sea, or by air) are not anticipated to be widely used, however sea transportation of large items may initially come through Salalah Port, before being delivered by road to the site. Such deliveries will be guided by a Traffic Management Plan.

15.3.2 Operational Phase

Public/Community Safety

The project will carry various risks that could result in impacts to public safety where such impacts are transferred or received outside of the project site. Such impacts may relate to fire, un-warranted releases of wastewater and security/safety concerns of trespassers.

The extent of such impacts may range outside of the projects boundaries and require the involvement of outside agencies to help manage and abate such impacts (e.g. Civil Defence, Police and Army).

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 sea. Risks to public safety will be appropriately addressed and prepared for in the operational phase 'Emergency Preparedness and Disaster Plan' and via appropriate training of staff.

Security Staff

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 access road entrance and at the project gates, who will patrol the site.

As is consistent with the construction phase, the O&M Contractor will undertake a security risk assessment to determine the appropriate level of security require at the facility. Security arrangements should be guided by UN Code of conducts for law enforcement officials and UN basic principles on the use of Force and Firearms by law enforcement officials (if staff are armed). 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 community.

Transportation

In general transportation impacts during operations are not expected to be significant, as the operation of the SWRO will not require continuous delivery of materials, or other equipment in order to operate.

Occasional deliveries and waste removals will add a very small amount of traffic on local roads, but is not expected to result in a noticeable increase of vehicle traffic.

Staff movements will also contribute to a minimal additional vehicle flows on local roads.

15.4 Proposed Assessment Requirements for EIA

An overview of the risks relating to community health, safety and security will be presented in the ESIA, which will also include recommendation of suitable mitigation measures to avoid/minimise such risks.

16 LABOUR & WORKING CONDITIONS

16.1 Standards and Regulatory Requirements

16.1.1 Omani Requirements

'Oman's 2003 Labor Law governs employee/employer relations in the private sector, and enumerates the protections afforded all legally resident workers, except for domestic workers. The law sets the minimum working age at 15, provides clear guidelines on working hours, and specifies the penalties for noncompliance with its provisions.' (Source: https://www.export.gov/article?id=Oman-Labor, Accessed on 31/05/2017).

16.1.2 Lender Requirements

The following applicable IFC Performance Standards aim to identify and ensure that social and economic impacts of a project are addressed in the relevant areas, in particular:

- Performance Standard 2: Labour and Working Conditions;

In accordance with IFC Performance Standard 2 (Labor and Working Conditions) there is a requirement to align with the following conventions:

- ILO Convention 87 on Freedom of Association and Protection of the Right to Organize;
- ILO Convention 98 on the Right to Organize and Collective Bargaining;
- ILO Convention 29 on Forced Labor;
- ILO Convention 105 on the Abolition of Forced Labor;
- ILO Convention 138 on Minimum Age (of Employment);
- ILO Convention 182 on the Worst Forms of Child Labor;
- ILO Convention 100 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.

16.2 Risks & Risk Management

16.2.1 Construction phase

HR Policy, Freedom of Association and Collective Bargaining

The overarching ACWA Power HR Policy will provide the basis upon which the projects HR Policy will be developed (to be adopted by the EPC Contractor in their construction HR policy).

The HR Policy will ensure alignment with Omani labour law and will ensure consistency with international ILO and UN conventions required by the lenders.

Note: In line with the above, the ACWA Power HR Policy the minimum age of working is 18 years. Freedom of Association (FoA)and collective bargaining is included to the ACWA Power annual sustainability reports and our "Our Commitments" policy under "making certain of human rights, the safety and welfare of workers, fair employment and equal opportunity practices across our operations", where Human Rights is intended to cover FoA and Collective Bargaining.

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 significant risk to the health and safety for the associated work force. 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 dependant on the construction methods employed and the degree of control implemented by the EPC and affiliated sub-contractor. It is therefore of the utmost importance that the EPC and affiliated sub-contractors demonstrate consideration of health and safety risks as part of their chosen construction methods and that these risks are appropriately mitigated.

The EPC Contractor will manage Occupational Health and Safety on site via a dedicated Health, Safety and Environment (HSE) Team. Sub-contractor companies will have dedicated HSE Managers who will be responsible for implementing the sites HSE plan in their working areas. The EPC's HSE Plan will be subject to approval by ACWA Power and the Project Company. ACWA Power and the Project Company will periodically audit the project in line with the necessary HSE requirements.

Working Conditions

Labour exploitation on construction sites unfortunately has become a reality in some parts of the world. Inequalities 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 subcontractors will need to plan for necessary provisions relative to the requirement of the of the required workforce. This includes appropriate labour accommodation plans and mechanism for inspections and corrective actions.

16.2.2 Operational Phase

Occupational Health and Safety

The risks associated with the operational phase of the project are anticipated to be significantly less than during the construction phase due to reduced site activity and requirements for heavy plant and machinery.

There will however be incoming electrical connections on-site and the 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 health and safety.

The Severity and likelihood of risks during the operational phase will be dependent on the frequency and requirements for planned and unplanned maintenance. The operation and maintenance team will need to ensure that a robust plan is in place to appropriately manage these risks.

16.3 Proposed Assessment Requirements for EIA

An overview of the risks relating to labour & working conditions will be presented in the ESIA, which will also include recommendation of suitable mitigation measures to avoid/minimise such risks.

17 CUMULATIVE IMPACTS

Cumulative impacts result from the incremental impact of an action when combined to impacts (e.g. past, present, and reasonably foreseeable future actions) regardless of what agency or person undertakes such other actions.

In practice, the assessment of cumulative effects requires consideration of some concepts:

- Assessment of effects over a larger (i.e., "regional") area that may transboundary/cross-jurisdictional; (Including effects due to natural perturbations affecting environmental components and human actions).
- Assessment of effects during a longer period of time into the past and future;
- Assessment of effects on Valued Environmental Components due to interactions with other actions, and not just the effects of the single action under review;
- Evaluation of significance in consideration of other than just local, direct effects.

The Cumulative Impacts Assessment (CIA) will be undertaken as part of the ESIA to establish whether there are barriers to future development within the projects area of influence. For instance: is there sufficient environmental carrying capacity available for future development; are there any factors that may restrict future development; and, are there any key factors of concern that may relate to the development/operation of other projects in tandem with the proposed project.

The ESIA will assess the cumulative impacts of several environmental parameters in the main sections of the ESIA. For instance, noise impacts will be considered by the measured baseline in combination with the predicted process contributions. This will provide an assessment of cumulative impacts, as a result of the project itself.

The specific cumulative impact assessment chapter will therefore consider the cumulative impacts relating to potential future development and works in the projects area of influence. In this instance, the projects predicted impacts will be assessed in combination with other potential future developments to determine the potential longer term impacts upon related environmental parameters.

The assessment of cumulative impacts will be based upon solid documented development plans/strategies and announced projects.

The assessment of cumulative impacts will be made using the IFC (2013) Good Practicee Handbook: Cumulative Impact Assessment and Management.

17.1 Potential Cumulative Impacts

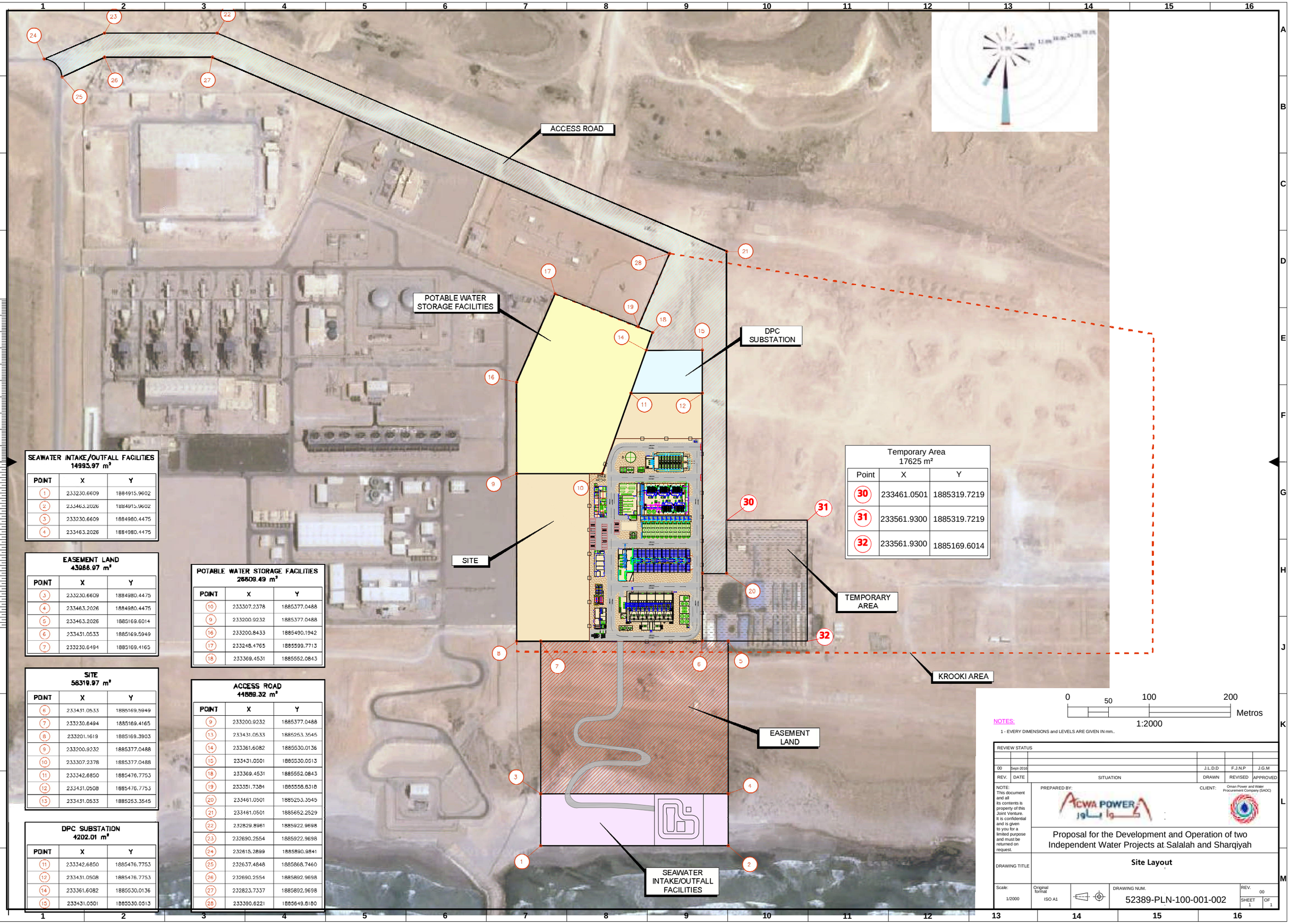
Table 17-1 Potential Cumulative Impacts

Potential Cumulative Impact	Justification
Increase in Salinity	The discharge of brine effluent via the outfall will result in the increase of salinity to the sea within the mixing zone of the project. Given the location of the outfall in proximity to the outfall of the IWPP plant, there may be a resulting cumulative impact of brine.

17.2 Proposed Assessment Requirements for EIA

The brine dispersion model as described in the Marine Environment section of this document will incorporate a simulation of the brine discharge from the existing IWPP outfall in combination with the brine discharge from the proposed IWPP. The results will be reported in the Marine Environment section of the ESIA with a determination of compliance in regard to the respective standards for mixing zones.

APPENDIX A – PROJECT LAYOUT



SEAWATER INTAKE/OUTFALL FACILITIES
14993.97 m²

POINT	X	Y
1	233230.6609	1884915.9602
2	233463.2026	1884915.9602
3	233230.6609	1884980.4475
4	233463.2026	1884980.4475

EASEMENT LAND
43988.97 m²

POINT	X	Y
3	233230.6609	1884980.4475
4	233463.2026	1884980.4475
5	233463.2026	1885169.6014
6	233431.0533	1885169.5949
7	233230.6494	1885169.4165

SITE
58319.97 m²

POINT	X	Y
6	233431.0533	1885169.5949
7	233230.6494	1885169.4165
8	233201.1619	1885169.3903
9	233200.9232	1885377.0488
10	233307.2378	1885377.0488
11	233342.6850	1885476.7753
12	233431.0508	1885476.7753
13	233431.0533	1885253.3545

DPC SUBSTATION
4202.01 m²

POINT	X	Y
11	233342.6850	1885476.7753
12	233431.0508	1885476.7753
14	233361.6082	1885530.0136
15	233431.0501	1885530.0513

POTABLE WATER STORAGE FACILITIES
26809.49 m²

POINT	X	Y
10	233307.2378	1885377.0488
9	233200.9232	1885377.0488
16	233200.8433	1885490.1942
17	233248.4765	1885599.7713
18	233369.4531	1885552.0843

ACCESS ROAD
44889.32 m²

POINT	X	Y
9	233200.9232	1885377.0488
13	233431.0533	1885253.3545
14	233361.6082	1885530.0136
15	233431.0501	1885530.0513
18	233369.4531	1885552.0843
19	233351.7384	1885556.8318
20	233461.0501	1885253.3545
21	233461.0501	1885652.2529
22	232829.8961	1885922.9698
23	232690.2554	1885922.9698
24	232615.2899	1885890.9841
25	232637.4848	1885868.7460
26	232690.2554	1885892.9698
27	232823.7337	1885892.9698
28	233390.6221	1885649.8180

Temporary Area
17625 m²

Point	X	Y
30	233461.0501	1885319.7219
31	233561.9300	1885319.7219
32	233561.9300	1885169.6014

0 50 100 200 Metros
1:2000

NOTES:
1 - EVERY DIMENSIONS and LEVELS ARE GIVEN IN mm..

REVIEW STATUS

REV.	DATE	SITUATION	DRAWN	REVISED	APPROVED
00	Sept-2016		J.L.D.D	F.J.N.P	J.G.M

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PREPARED BY: ACWA POWER

CLIENT: Oman Power and Water Procurement Company (SAOC)

Proposal for the Development and Operation of two Independent Water Projects at Salalah and Sharqiyah

DRAWING TITLE: **Site Layout**

Scale:	Original format	DRAWING NUM.	REV.
1/2000	ISO A1	52389-PLN-100-001-002	00

SHEET 1 OF 1

Scale For Microfilming
Millimeters
Inches

Site Layout Coordenate		
Point	X	Y
1	233292,6346	1885169,7654
2	233292,6346	1885375,3159
3	233307,8113	1885375,3159
4	233323,2067	1885418,4908
5	233430,5778	1885418,4908
6	233430,5778	1885169,7600

N
W E
S

01 DAF System
02 Gravity Filters
03 Intermediate Pumping Station
04 Pressurized Filters
05 RO Building
06 Calcite Beds
07 Product Water Pumping Station
08 Effluent Treatment
09 DAF System Chemical Dosing
10 Chemical Storage
11 RO System Chemical Dosing
12 Post-Treatment Chemical Dosing
13 Administration & Social Building
14 Electrical Building
15 Workshop and Store Building
16 Firefighting System
17 Sewage Treatment System
18 Guard House
19 Access road from Seawater Intake Facilities
20 Entrances
21 Retention Pond

Site Area 25 MIGD = 33,322 m²

Metros
15 0 15 30
1:500

NOTES:
1 - EVERY DIMENSIONS and LEVELS ARE GIVEN IN mm..

REVIEW STATUS					
00	Sept-2016		M.D.B.C	F.J.N.P	J.V.E
REV.	DATE	SITUATION	DRAWN	REVISED	APPROVED

NOTE: This document and all its contents is property of this Joint Venture. It is confidential and is given to you for a limited purpose and must be returned on request.

PREPARED BY: ACWA POWER

CLIENT: Oman Power and Water Procurement Company (SAOC)

Proposal for the Development and Operation of two Independent Water Projects at Salalah and Sharqiyah

DRAWING TITLE: **General Layout** — **Plant**

Scale:	Original format	DRAWING NUM.	REV.
1:500	ISO A1	52389-PLN-101-002-001	00

SHEET 1 OF 1

APPENDIX B – KROOKI (MINISTRY OF HOUSING)

Ministry of Housing,
Directorate General of Housing
Government of Dhofar
Department of Planning & Survey

وزارة الإسكان
المديرية العامة للإسكان
بمحافظة ظفار
دائرة التخطيط والمساحة

رسم مساحي لقطعة أرض

رقم مسلسل: 7-47-017-01-003

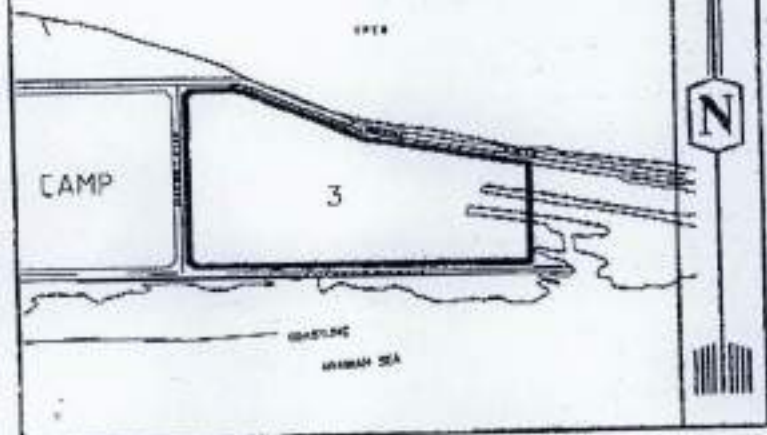
المنطقة	رقم الخارطة
MARBAT SADAH / SAHAL ASHOOR	400/BD/320-350/07

بيانات القطعة وشروط البناء

رقم الخارطة التخطيطية 320-B50E/AA
رقم القطعة ٣ / ٣ رقم المربع ١ / ٨
المساحة ٧٢٧٥٩١,٥٠ م٢ / 727591.50 SQ. M.
الإستعمال محطة كهرباء وتحلية مياة
الإرتفاع ٢٥ م عدد الطوابق خمسه طوابق/٥
نسبة البناء ٢٠ ٪ النسبة الطابقية ٤٠ ٪
الإرتدادات الأمام ١٠ م الخلف ١٠ م
الأيمن ١٠ م الأيسر ١٠ م
موقف السيارات موقف شاحنة لكل ١٨٠ م٢
شروط أخرى الحصول على الأذن التخطيطي
لايزيد ارتفاع مداخن التوربينات عن ١١٠ م فوق سطح البحر
المخطط الإلتزام بإشتراطات المطار التاريخ / / ٢٠٠ م

الموقع العام

مقياس رسم Scale 1= 30000



مقياس رسم SCALE 1= 20000

SCALE FACTOR = 1.00049

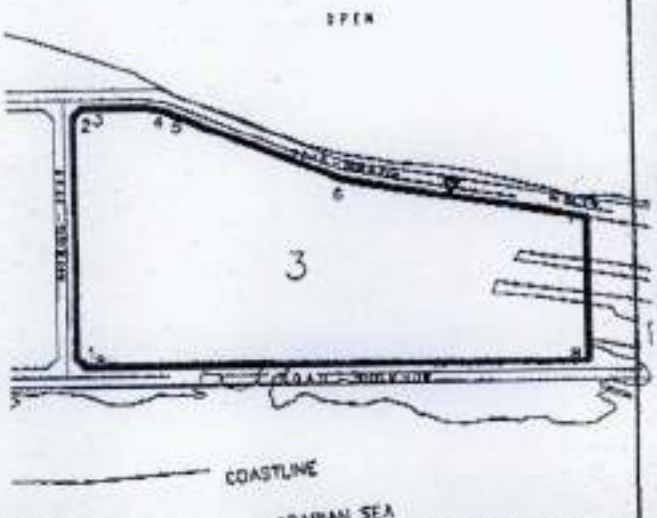
LINE		UTM GRID (WGS 84) NORTHING	EASTING	DISTANCE(m) GRID	PLAN
1	2	1885183.26	232663.90	661.37	661.05
2	3	1885844.63	232615.88	35.37	35.28
3	4	1885869.57	232593.95	164.77	164.09
4	5	1885999.11	232658.13	48.00	48.97
5	6	1885858.09	232903.09	493.54	493.10
6	7	1885662.85	233395.72	644.88	648.54
7	8	1885649.98	233990.62	386.73	393.54
8	9	1885154.23	233689.50	1300.87	1300.03
9	1	1885158.17	232988.84	35.38	35.38

PLAN AREA = 727591.50 SQ M

DIAGONAL/S FOR CHECKING

LINE		PLAN DIST(m)
1	3	886.51
1	4	711.08
1	5	716.96
1	6	841.38
1	7	1375.79
1	8	1325.27

NOTE:-
THIS LAND FORM SUPERSEDES
7-46-009-01-003



المساح ____ التوقيع ____ التاريخ / 05 / 10
الرسام ____ التوقيع ____ التاريخ / 05 / 10
التدقيق ____ التوقيع ____ التاريخ / 05 / 10
الإسقاط ____ التوقيع ____ التاريخ / 05 / 10

سلطنة عمان
وزارة الإسكان
المديرية العامة للإسكان
بمحافظة ظفار
ختم الدائرة

مدير التخطيط والمساحة

APPENDIX C – CONTAMINATED LAND PRELIMINARY RISK ASSESSMENT

The Contaminated Land Risk Assessment methodology used for this assessment is based on CIRIA C552 (2001) Contaminated Land Risk Assessment – A Guide to Good Practice, in order to quantify potential risk via risk estimation and risk evaluation, which can be adopted at the Phase I stage. This will then determine an overall risk category which can be used to identify likely actions for the cable route. This methodology uses qualitative descriptors and therefore is a qualitative approach.

The methodology requires the classification of:

- the magnitude of the **consequence** (severity) of a risk occurring, and
- the magnitude of the **probability** (likelihood) of a risk occurring.

The potential consequences of contamination risks occurring at this site are classified in accordance with the Table below, which is adapted from the CIRIA guidance.

Classification of Consequence

Classification	Definition of Consequence
Severe	Short-term (acute) risks to human health. Short-term risk of pollution of sensitive water resource or ecosystem. Catastrophic damage to crops/buildings/property/infrastructure, including off-site soils.
Medium	Medium/long-term (chronic) risks to human health. Medium/long-term risk of pollution of sensitive water resource or ecosystem. Significant damage to crops/buildings/property/infrastructure (on or off-site). Contamination of off-site soils.
Mild	Easily preventable, permanent health effects on humans. Pollution of non-sensitive water resources. Localised damage to crops/buildings/property/infrastructure (on or off-site).
Minor	Easily preventable, non-permanent health effects on humans, or no effects. Minor, low-level and localised contamination of on-site soils. Easily repairable damage to crops/buildings/property/infrastructure.

The probability of contamination risks occurring at this site will be classified in accordance with Table below, which is also adapted from the CIRIA guidance. Note that for each category, it is assumed that a pollution linkage exists. Where a pollution linkage does not exist, the likelihood is zero, as is the risk.

Classification of Probability

Classification	Definition of Probability
High Likelihood	Circumstances are such that an event appears very likely in the short-term or almost inevitable in the long-term; or there is already evidence that such an event has occurred.
Likely	Circumstances are such that such an event is not inevitable, but is possible in the short-term and is likely over the long-term.
Low Likelihood	Circumstances are such that it is by no means certain that an event would occur even over a longer period, and it is less likely in the short-term.
Unlikely	Circumstances are such that it is improbable that an event would occur even in the very long-term.

For each possible pollution linkage (source-pathway-receptor) identified, the potential risk can be evaluated, as presented in the Table below. Based upon this, CIRIA C552 presents definitions of the risk categories, together with the investigatory and remedial actions that are likely to be necessary in each case. These risk categories apply to each pollutant linkage, not simply to each hazard or receptor.

Overall Contamination Risk Matrix

		Consequence			
		Severe	**Medium**	**Mild**	**Minor**
Probability	**High likelihood**	Very high risk	High risk	Moderate risk	Low risk
	Likely	High risk	Moderate risk	Moderate risk	Low risk
	Low likelihood	Moderate risk	Moderate risk	Low risk	Very low risk
	Unlikely	Low risk	Low risk	Very low risk	Very low risk

Definition of Risk Categories and Likely Actions Required

Risk Category	Definition and likely actions required
Very high	Severe harm to a defined receptor is very likely, or has already occurred. The risk is likely to result in a substantial liability. Urgent investigation (if not already undertaken) is likely to be required. Urgent remediation is likely to be required.
High	Harm to a defined receptor is likely. The risk, if realised, may result in a substantial liability. Urgent investigation (if not already undertaken) is likely to be required. Remediation is likely to be required in the long term, possibly sooner.
Moderate	Harm to a defined receptor is possible, but severe harm is unlikely. Investigation is likely to be required to clarify the level of potential liability and risk. Some remediation may be required in the longer term.
Low	Harm to a defined receptor is possible, but is likely to be mild at worst. Liabilities could theoretically arise, but are unlikely. Further investigation is not required at this stage. Remediation is unlikely to be required.

Risk Category	Definition and likely actions required
Very low	Harm to a defined receptor is unlikely, and would be minor at worst. No liabilities are likely to arise. Further investigation is not required at this stage. Remediation is very unlikely to be required.

Appendix B

Environmental Scoping Study: Approval Letter from MECA

سلطنة عمان
SULTANATE OF OMAN
وزارة البيئة والشؤون المناخية
MINISTRY OF ENVIRONMENT AND CLIMATE AFFAIRS

الرقم: ٧٢ /٨٣٢٠/ ٥٩٨ /١٧

التاريخ: ٢٧/رمضان/١٤٣٨هـ
الموافق: ٢٢/ يونيو/٢٠١٧م

المحترم

الفاضل/ راجيت ناندا
كبير موظفي الاستثمارات
شركة أكوا باور
ص. ب. : ٢٢٦١٦ الرياض ١١٤١٦
المملكة العربية السعودية

تحية طيبة .. وبعد ..

الموضوع : إقامة محطة تحليةالمياه بسهل آشور بمحافظة ظفار/ سلطنة عُمان

بالإشارة إلى خطابكم رقم (بدون) بتاريخ ٢٠١٧/٠٦/٠٥م حول طلب إعداد دراسة تقييم التأثيرات البيئية للمشروع أعلاه والمرفق به المستندات الخاصة بطلب الحصول على التصريح البيئي وتقرير الشروط المرجعية للدراسة البيئية المطلوبة Environmental Social & Scoping Study (ESS) . عليه يسرنا الإفادة بأنه وبعد دراسة الطلب المشار إليه فإنه لا مانع من وجهة النظر البيئية من قيام مكتب العواصم الخمس للاستشارات البيئية والإدارية (5 Capitals) بالبدء في إعداد الدراسة البيئية المطلوبة للمشروع المشار إليه .

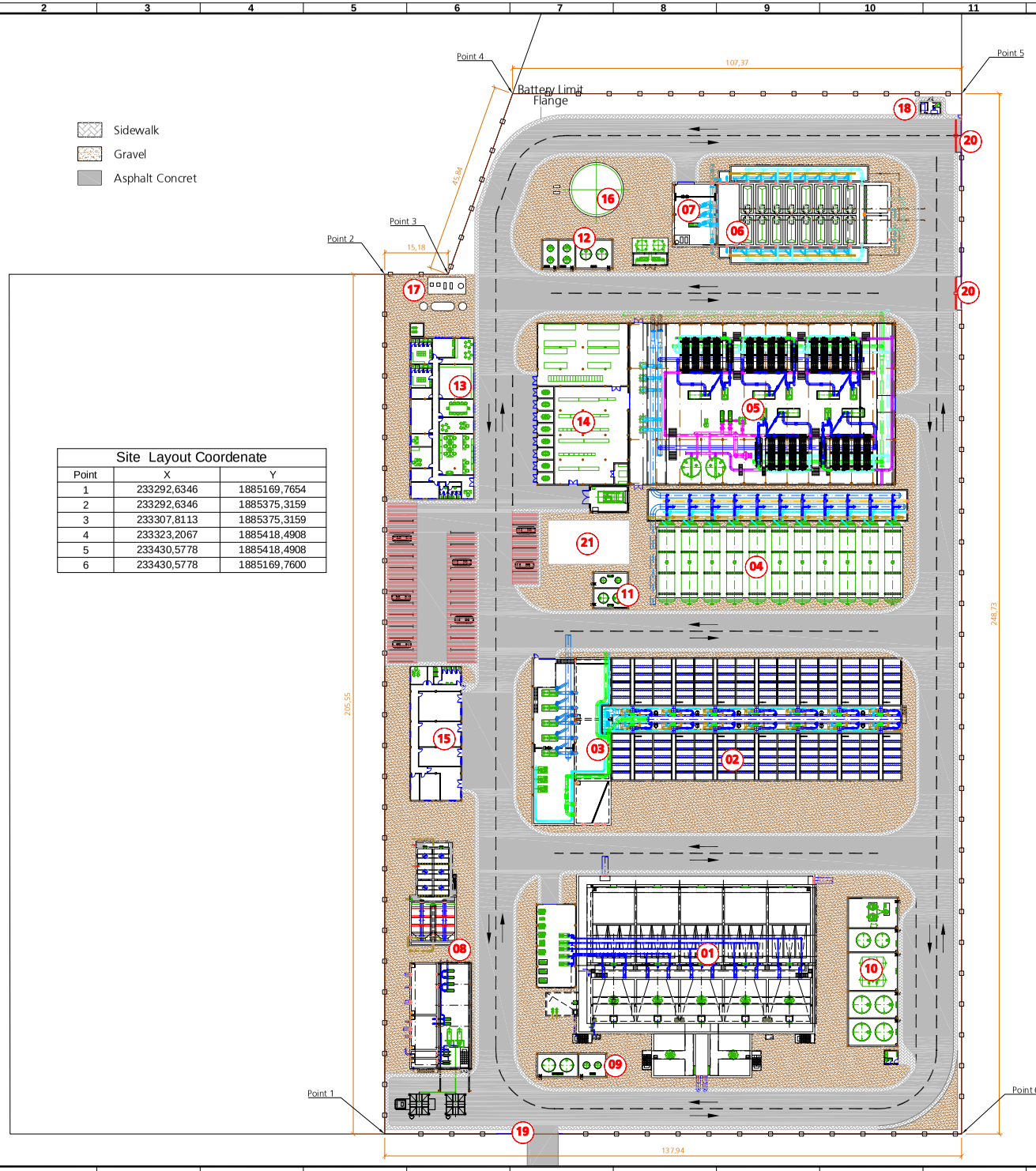
وتفضلوا بقبول فائق الاحترام

د. أحمد بن عبدالله محروس الصيعري
مدير عام البيئة والشؤون المناخية بمحافظة ظفار

@moecaoman | moecaoman | @moecaoman | www.mecca.gov.om | pd.dhofar@moeca.gov.om
هاتف: ٠٢٣٢٠٢٧٥٥٠ | فاكس: ٠٢٣٢٠٢٧٥٩٩
ص.ب: ٢٣٠، صلالة، الرمز: ٢١١، سلطنة عمان
Tel: +968 23 270555 | Fax: +968 23 270599
P.O. Box 2030, Salalah, P.C.211, Sultanate of Oman

Appendix C

Project Layout



Site Layout Coordenate		
Point	X	Y
1	233292,6346	1885169,7654
2	233292,6346	1885375,3159
3	233307,8113	1885375,3159
4	233323,2067	1885418,4908
5	233430,5778	1885418,4908
6	233430,5778	1885169,7600

N
W E
S

01 DAF System
02 Gravity Filters
03 Intermediate Pumping Station
04 Pressurized Filters
05 RO Building
06 Calcite Beds
07 Product Water Pumping Station
08 Effluent Treatment
09 DAF System Chemical Dosing
10 Chemical Storage
11 RO System Chemical Dosing
12 Post-Treatment Chemical Dosing
13 Administration & Social Building
14 Electrical Building
15 Workshop and Store Building
16 Firefighting System
17 Sewage Treatment System
18 Guard House
19 Access road from Seawater Intake Facilities
20 Entrances
21 Retention Pond

Site Area 25 MIGD = 33,322 m²

Metros
15 0 15 30
1:500

NOTES:
1 - EVERY DIMENSIONS and LEVELS ARE GIVEN IN mm..

REVIEW STATUS					
00	Sept 2016		M.D.B.C	F.J.N.P	J.V.E
REV.	DATE	SITUATION	DRAWN	REVISED	APPROVED

NOTE: This document and all its contents is property of this Joint Venture. It is confidential and is given to you for a limited purpose and must be returned on request.

PREPARED BY: ACWA POWER

CLIENT: Oman Power and Water Procurement Company (SAOC)

Proposal for the Development and Operation of two Independent Water Projects at Salalah and Sharqiyah

DRAWING TITLE: General Layout — Plant

Scale:	Original format	DRAWING NUM.	REV.
1:500	ISO A1	52389-PLN-101-002-001	00
			SHEET 1 OF 1

Appendix D

Krooki (Ministry of Housing)

Ministry of Housing,
Directorate General of Housing
Government of Dhofar
Department of Planning & Survey

وزارة الإسكان
المديرية العامة للإسكان
بمحافظة ظفار
دائرة التخطيط والمساحة

رسم مساحي لقطعة أرض

رقم مسلسل: 7-47-017-01-003

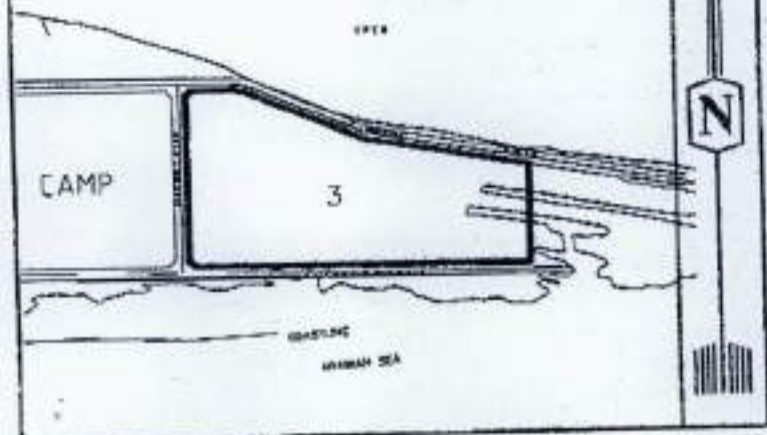
المنطقة	رقم الخارطة
MARBAT SADAH / SAHAL ASHOOR	400/BD/320-350/07

بيانات القطعة وشروط البناء

رقم الخارطة التخطيطية 320-B50E/AA
رقم القطعة ٣ / ٣ رقم المربع ١ / ٨
المساحة ٧٢٧٥٩١,٥٠ م٢ / 727591.50 SQ. M.
الإستعمال محطة كهرباء وتحلية مياة
الإرتفاع ٢٥ م عدد الطوابق خمسه طوابق/٥
نسبة البناء ٢٠ ٪ النسبة الطابقية ٤٠ ٪
الإرتدادات الأمام ١٠ م الخلف ١٠ م
الأيمن ١٠ م الأيسر ١٠ م
موقف السيارات موقف شاحنة لكل ١٨٠ م٢
شروط أخرى الحصول على الأذن التخطيطي
لايزيد ارتفاع مداخن التوربينات عن ١١٠ م فوق سطح البحر
المخطط الإلتزام بإشتراطات المطار التاريخ / / ٢٠٠ م

الموقع العام

مقياس رسم Scale 1= 30000



مقياس رسم SCALE 1= 20000

SCALE FACTOR = 1.00049

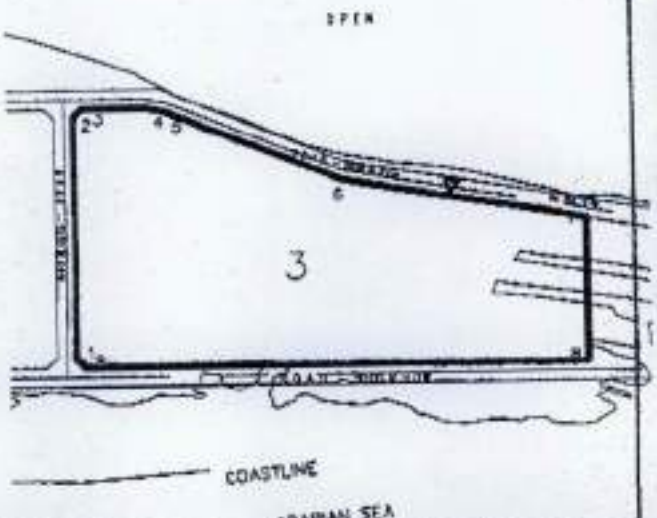
LINE		UTM GRID (WGS 84) NORTHING	EASTING	DISTANCE(m) GRID	PLAN
1	2	1885183.26	232663.90	661.37	661.05
2	3	1885844.63	232615.88	35.37	35.28
3	4	1885869.57	232593.95	164.77	164.09
4	5	1885999.11	232658.13	48.00	48.97
5	6	1885858.09	232903.09	493.54	493.10
6	7	1885662.85	233395.72	644.88	648.54
7	8	1885649.98	233990.62	386.73	393.54
8	9	1885154.23	233689.50	1300.87	1300.03
9	1	1885158.17	232988.84	35.38	35.38

PLAN AREA = 727591.50 SQ M

DIAGONAL/S FOR CHECKING

LINE		PLAN DIST(m)
1	3	886.51
1	4	711.08
1	5	716.96
1	6	841.38
1	7	1375.79
1	8	1325.27

NOTE:-
THIS LAND FORM SUPERSEDES
7-46-009-01-003



المساح ____ التوقيع ____ التاريخ / 05 / 10
الرسام ____ التوقيع ____ التاريخ / 05 / 10
التدقيق ____ التوقيع ____ التاريخ / 05 / 10
الإسقاط ____ التوقيع ____ التاريخ / 05 / 10

سلطنة عمان
وزارة الإسكان
المديرية العامة للإسكان
بمحافظة ظفار
ختم الدائرة

مدير التخطيط والمساحة

Appendix E

Contaminated Land Preliminary Risk Assessment Guidelines

GUIDELINE - CONTAMINATED LAND PRELIMINARY RISK ASSESSMENT

The Contaminated Land Risk Assessment methodology used for this assessment is based on CIRIA C552 (2001) Contaminated Land Risk Assessment – A Guide to Good Practice, in order to quantify potential risk via risk estimation and risk evaluation, which can be adopted at the Phase I stage. This will then determine an overall risk category which can be used to identify likely actions for the cable route. This methodology uses qualitative descriptors and therefore is a qualitative approach.

The methodology requires the classification of:

- the magnitude of the **consequence** (severity) of a risk occurring, and
- the magnitude of the **probability** (likelihood) of a risk occurring.

The potential consequences of contamination risks occurring at this site are classified in accordance with the Table below, which is adapted from the CIRIA guidance.

Classification of Consequence

Classification	Definition of Consequence
Severe	Short-term (acute) risks to human health. Short-term risk of pollution of sensitive water resource or ecosystem. Catastrophic damage to crops/buildings/property/infrastructure, including off-site soils.
Medium	Medium/long-term (chronic) risks to human health. Medium/long-term risk of pollution of sensitive water resource or ecosystem. Significant damage to crops/buildings/property/infrastructure (on or off-site). Contamination of off-site soils.
Mild	Easily preventable, permanent health effects on humans. Pollution of non-sensitive water resources. Localised damage to crops/buildings/property/infrastructure (on or off-site).
Minor	Easily preventable, non-permanent health effects on humans, or no effects. Minor, low-level and localised contamination of on-site soils. Easily repairable damage to crops/buildings/property/infrastructure.

The probability of contamination risks occurring at this site will be classified in accordance with Table below, which is also adapted from the CIRIA guidance. Note that for each category, it is assumed that a pollution linkage exists. Where a pollution linkage does not exist, the likelihood is zero, as is the risk.

Classification of Probability

Classification	Definition of Probability
High Likelihood	Circumstances are such that an event appears very likely in the short-term or almost inevitable in the long-term; or there is already evidence that such an event has occurred.
Likely	Circumstances are such that such an event is not inevitable, but is possible in the short-term and is likely over the long-term.
Low Likelihood	Circumstances are such that it is by no means certain that an event would occur even over a longer period, and it is less likely in the short-term.
Unlikely	Circumstances are such that it is improbable that an event would occur even in the very long-term.

For each possible pollution linkage (source-pathway-receptor) identified, the potential risk can be evaluated, as presented in the Table below. Based upon this, CIRIA C552 presents definitions of the risk categories, together with the investigatory and remedial actions that are likely to be necessary in each case. These risk categories apply to each pollutant linkage, not simply to each hazard or receptor.

Overall Contamination Risk Matrix

		Consequence			
		Severe	**Medium**	**Mild**	**Minor**
Probability	**High likelihood**	Very high risk	High risk	Moderate risk	Low risk
	Likely	High risk	Moderate risk	Moderate risk	Low risk
	Low likelihood	Moderate risk	Moderate risk	Low risk	Very low risk
	Unlikely	Low risk	Low risk	Very low risk	Very low risk

Definition of Risk Categories and Likely Actions Required

Risk Category	Definition and likely actions required
Very high	Severe harm to a defined receptor is very likely, or has already occurred. The risk is likely to result in a substantial liability. Urgent investigation (if not already undertaken) is likely to be required. Urgent remediation is likely to be required.
High	Harm to a defined receptor is likely. The risk, if realised, may result in a substantial liability. Urgent investigation (if not already undertaken) is likely to be required. Remediation is likely to be required in the long term, possibly sooner.
Moderate	Harm to a defined receptor is possible, but severe harm is unlikely. Investigation is likely to be required to clarify the level of potential liability and risk. Some remediation may be required in the longer term.
Low	Harm to a defined receptor is possible, but is likely to be mild at worst. Liabilities could theoretically arise, but are unlikely. Further investigation is not required at this stage. Remediation is unlikely to be required.
Very low	Harm to a defined receptor is unlikely, and would be minor at worst. No liabilities are likely to arise. Further investigation is not required at this stage. Remediation is very unlikely to be required.

Appendix F

Noise Meter Calibration Certificate

Certificate of Calibration

Cirrus Research plc
dedicated to noise measurement

Equipment Details

Instrument Manufacturer	Cirrus Research plc
Instrument Type	CR:881C
Description	Sound Level Meter
Serial Number	D20573F0

Calibration Procedure

The instrument detailed above has been calibrated to the publish test and calibration data as detailed in the instrument handbook, using the techniques recommended in the latest revisions of the International Standards IEC 61672-1:2013, IEC 61672-1:2002, IEC 60651:1979, IEC 60804:2001, IEC 61260:1995, IEC 60942:2003, IEC 60942:1997, IEC 61252:1993, ANSI S1.4-1983, ANSI S1.11-1986 and ANSI S1.43-1997 where applicable. Sound Level Meters. All Calibration procedures were carried out by substituting the microphone capsule with a suitable electrical signal, apart from the final acoustic calibration.

Calibration Traceability

The equipment detailed above was calibrated against the calibration laboratory standards held by Cirrus Research plc. These are traceable to International Standards [A.0.6]. The standards are:

Microphone Type	B&K 4192	Serial Number	1920791	Calibration Ref	86450
Pistonphone Type	B&K 4220	Serial Number	613843	Calibration Ref	86388

Calibrated by T. A. Goodhill

Calibration Date	27 March 2017
Calibration Certificate Number	247511

This Calibration Certificate is valid for 12 months from the date above.

Cirrus Research plc, Acoustic House, Bridlington Road, Hunmanby, North Yorkshire, YO14 0PH
Telephone: +44 (0) 1723 891655 Fax: +44 (0) 1723 891742
Email: sales@cirrusresearch.co.uk

Certificate of Calibration

Cirrus Research plc
dedicated to your measurement

Certificate Number: **111298**

Date of Issue: **27 March 2017**

Microphone Capsule

Manufacturer: **Cirrus Research plc** Serial Number: **20044089**

Model Number: **MK224**

Calibration Procedure

The microphone capsule detailed above has been calibrated to the published data as described in the operating manual of the associated sound level meter (where applicable).

The frequency response was measured using an electrostatic actuator in accordance with BS EN 61094-6:2005 with the free-field response derived via standard correction data traceable to the National Physical Laboratory, Middlesex, UK

The absolute sensitivity at 1 kHz was measured using an acoustic calibrator conforming to IEC 60942:2003 Class 1

Date of Calibration **24 March 2017**

Open Circuit Sensitivity at 1 kHz: **58.9 mV/Pa**

-24.6 dB rel 1 V/Pa

Environmental Conditions

Pressure: **102.50 kPa**

Temperature: **20.0 °C**

Humidity: **33.0 %**

Calibration Laboratory

Laboratory. Cirrus Research plc
Acoustic House, Bridlington Road, Hunmanby
North Yorkshire, YO14 0PH. United Kingdom

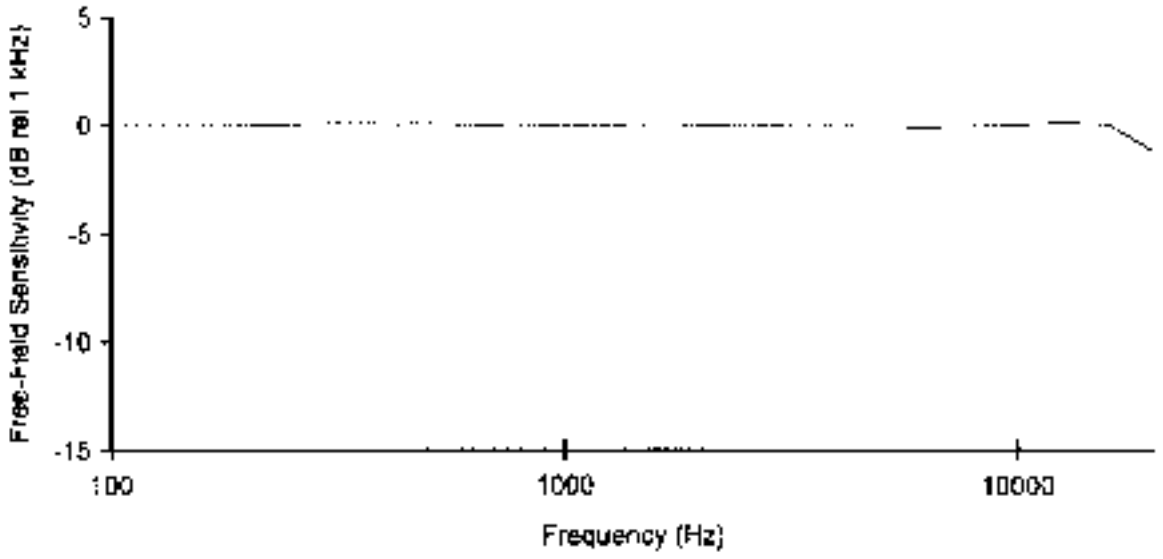
Test Engineer: Debra Swalwell

Cirrus Research plc, Acoustic House, Bridlington Road
Hunmanby, North Yorkshire, YO14 0PH, United Kingdom
Telephone: 0845 330 2434 **Int**: +44 (0) 1723 891655
Email: sales@cirrusresearch.co.uk
Web: www.cirrusresearch.co.uk
UK Registration No: 967150

bsi. ISO 9001 Quality Management FM 531001
ISO 14001 Environmental Management EMS 552104

Free-Field Frequency Response

Frequency (Hz)	Free-Field Sensitivity (dB rel 1 kHz)	Actuator to Free-Field Correction (dB)
100	-0.02	0.05
125	-0.03	0.05
160	-0.01	0.08
200	-0.01	0.10
250	0.04	0.14
315	0.10	0.20
400	0.09	0.17
500	0.10	0.19
630	0.01	0.07
800	0.06	0.10
1 000	0.00	0.02
1 250	0.03	0.01
1 600	0.09	0.01
2 000	0.01	-0.18
2 500	0.05	-0.29
3 150	-0.02	-0.62
4 000	-0.01	-0.95
5 000	-0.02	-1.45
6 300	-0.08	-2.28
8 000	0.00	-3.31
10 000	0.04	-4.92
12 500	0.18	-6.39
16 000	0.06	-7.90
20 000	-1.09	-10.31



Certificate of Calibration

Certificate Number **111299**

Date of Issue: **27 March 2017**

Acoustic Calibrator

Manufacturer: **Cirrus Research plc** Serial Number: **50571**

Model Number: **CR:515**

Calibration Procedure

The sound calibrator detailed above has been calibrated to the published data as described in the operating manual and in the half-inch configuration. The procedures and techniques used are as described in IEC 60942:2003 Annex B – Periodic Tests and three determinations of the sound pressure level, frequency and total distortion were made.

The sound pressure level was measured using a WS2F condenser microphone type MK 224 manufactured by Cirrus Research plc.

The results have been corrected to the reference pressure of 101.33 kPa using the manufacturer's data.

Date of Calibration: **27 March 2017**

Initial Calibration Results

Measurement	Level (dB)	Frequency (Hz)	Distortion (% THD + Noise)
1	94.12	1000.1	0.31
2	94.11	1000.1	0.30
3	94.13	1000.1	0.30
Average	**94.12**	**1000.1**	**0.31**
Uncertainty	± 0.13	± 0.1	± 0.10

The reported uncertainties of measurement are expanded by a coverage factor of k=2, providing a 95% confidence level

Adjusted Calibration Results

Measurement	Level (dB)	Frequency (Hz)	Distortion (% THD + Noise)
1	94.00	1000.1	0.30
2	93.99	1000.1	0.30
3	94.01	1000.1	0.30
Average	**94.00**	**1000.1**	**0.30**
Uncertainty	± 0.13	± 0.1	± 0.10

The reported uncertainties of measurement are expanded by a coverage factor of k=2, providing a 95% confidence level

Cirrus Research plc, Acoustic House, Bradlington Road
Hunmanby, North Yorkshire, YO14 0PH, United Kingdom
Telephone: 0845 230 2484 **Int** +44 1723 891655
Email: sales@cirrusresearch.co.uk
Web: www.cirrusresearch.co.uk
UK Registration No. 987160

bsi. ISO 9001 Quality Management ISO 14001 Environmental Management
FM 531001 EMS 552104

Environmental Conditions

Pressure:	**101.75 kPa**
Temperature:	**21.5 °C**
Humidity:	**45.6 %**

Evidence of Pattern Approval

The manufacturer's product information indicates that this model of sound calibrator has been formally pattern approved to IEC 60942:2003 Annex A to Class 1. This has been confirmed with the PhysikalischTechnische Bundesanstalt (PTB).

Statement of Calibration

As public evidence was available, from a testing organisation responsible for approving the results of pattern evaluation tests, to demonstrate that the model of sound calibrator fully conformed to the requirements for pattern evaluation described in Annex A of IEC 60942:2003 the sound calibrator tested is considered to conform to all the Class 1 requirements of IEC 60942:2003.

Calibration Laboratory

Laboratory:	Cirrus Research plc Acoustic House, Bridlington Road, Hunmanby North Yorkshire, YO14 0PH, United Kingdom
Test Engineer:	Shane Doveton

Appendix G

Soil Quality: Laboratory Analysis

Lonestar Alpha Laboratories

Muscat : P.O. Box 1197, P.C 130, Muscat, Sultanate of Oman - Tel.: +968 24501524 / 5690, Fax : +968 24502514
Muscat Chemistry Lab : P.O. Box 1197, P.C 130, Muscat, Sultanate of Oman - Tel.: +968 24504206, 24504924, Fax : +968 24502635
Sohar : P.O. Box 64, P.C 327, Sohar Industrial Estate, Sultanate of Oman - Tel.: +968 26751755 / 930 / 976, Fax : +968 26751331
Duqm : Tel : +968 99278040, E-mail: duqmlab@lonestaralpha.com
Salalah : P.O. Box 1697, P.C 211, Tel: +968 23213990, Fax: +968 23213991, E-mail: salalahlab@lonestaralpha.com
E-mail : info@lonestaralpha.com, Website: www.lonestaralpha.com

TEST CERTIFICATE - ANALYSIS OF SOIL

Report No.	LMCHE - 17-06691	**Date Reported**	09 Aug 2017
Cust Ref.	-	**Date Received**	13 Jul 2017

1. Information Provided By Customer

Customer	S CAPITALS PO Box 119899, Sheikh Zayed Road Dubai UAE
Project	Not Given
Sample Description	Soil - S-1
Sampling Location	SALALAH IWP

Sampled By	Customer	**Sampling Date & Time**	10/07/2017; 10:50
Sample Brought By	Customer	**Sampling Method**	NG

2. Information Provided By Laboratory

Date Tested	13 Jul 2017 ~ 09 Aug 2017	**Method Variation**	NIL
Test Location	MCT	**LAL Sample No.**	CHE / 1941
Remarks	None		

3. Test Results

TEST	UNIT	TEST METHOD	MDL	RESULTS
Chemical Tests				
Arsenic	mg/Kg	USEPA SW 846/6010 C	0.3	2.33
Barium	mg/Kg	USEPA SW 846/6010 C	1	24.5
Cadmium	mg/kg	USEPA SW846/6010 C	0.2	<0.2
Chromium	mg/Kg	USEPA SW 846/6010 C	1	32.8
Cobalt	mg/kg	USEPA SW846/6010 C	1	6.52
Copper	mg/kg	USEPA SW846/6010 C	1	<1.0
Lead	mg/kg	USEPA SW846/6010 C	1	<1.0
Manganese	mg/Kg	USEPA SW 846/6010 C	1	194
Mercury	mg/kg	USEPA SW846/6010 C	0.1	<0.1
Nickel	mg/kg	USEPA SW846/6010 C	1	33.4
Oil & Grease	mg/kg	USEPA 1664	10	<10
Selenium	mg/Kg	USEPA SW 846/6010 C	0.3	<0.3
Zinc	mg/Kg	USEPA SW 846/6010 C	2	20.0
Total petroleum Hydrocarbons				
n-Octane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Decane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Undecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Dodecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tridecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetradecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05

Terms and Conditions on the Reverse side of the sheet

Lonestar Alpha Laboratories

Muscat : P.O. Box 1197, P.C 130, Muscat, Sultanate of Oman - Tel.: +968 24501524 / 5590, Fax.: +968 24503814
Muscat Chemistry Lab : P.O. Box 1197, P.C 130, Muscat, Sultanate of Oman - Tel.: +968 24504200, 24504324, Fax.: +968 24502835
Sohar : P.O. Box 84, P.C 327, Sohar Industrial Estate, Sultanate of Oman - Tel.: +968 26751755 / 920 / 976, Fax.: +968 26751331
Duqm : Tel.: +968 99278546, E-mail: duqm.lab@lonestaralpha.com
Salalah : P.O. Box 1887, P.C 211, Tel.: +968 23213392, Fax: +968 23213391, E-mail: salalah.lab@lonestaralpha.com
E-mail : info@lonestaralpha.com, Website: www.lonestaralpha.com

Report No.	LMCHE - 17-0669/1	Date Reported	09 Aug 2017
Cust Ref.	-	Date Received	13 Jul 2017

TEST	UNIT	TEST METHOD	MDL	RESULTS
n-Hexadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
Pristane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
Phytane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Eicosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heneicosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Docosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tricosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetracosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hexacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Triacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hentriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Dotriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tritriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetratriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hexatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetracontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05

MDL = Method Detection Limit

QC CHECKED

For and behalf of Lonestar Alpha Laboratories
Muscat
Tejali Parsekar
Laboratory Manager
Chemistry & Microbiology

*** End of the test report

Lonestar Alpha Laboratories

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TEST CERTIFICATE - ANALYSIS OF SOIL

Report No.	LMCHE - 17-0859/2	Date Reported	09 Aug 2017
Cust Ref.	-	Date Received	13 Jul 2017

1. Information Provided By Customer

Customer	6 CAPITALS PO Box 119699, Sheikh Zayed Road Dubai UAE
Project	Not Given
Sample Description	Soil - S-2
Sampling Location	SALALAH IWP

Sampled By	Customer	Sampling Date & Time	10/07/2017; 11:05
Sample Brought By	Customer	Sampling Method	NG

2. Information Provided By Laboratory

Date Tested	13 Jul 2017 ~ 09 Aug 2017	Method Variation	NIL
Test Location	MCT	LAL Sample No.	CHE / 1942
Remarks	None		

3. Test Results

TEST	UNIT	TEST METHOD	MDL	RESULTS
Chemical Tests				
Arsenic	mg/Kg	USEPA SW 846/6010 C	0.3	3.00
Barium	mg/Kg	USEPA SW 846/6010 C	1	49.5
Cadmium	mg/kg	USEPA SW846/6010 C	0.2	0.29
Chromium	mg/Kg	USEPA SW 846/6010 C	1	26.3
Cobalt	mg/kg	USEPA SW846/6010 C	1	1.55
Copper	mg/kg	USEPA SW846/6010 C	1	3.00
Lead	mg/kg	USEPA SW846/6010 C	1	1.07
Manganese	mg/Kg	USEPA SW 846/6010 C	1	116
Mercury	mg/kg	USEPA SW846/6010 C	0.1	<0.1
Nickel	mg/kg	USEPA SW846/6010 C	1	25.5
Oil & Grease	mg/kg	USEPA 1664	10	<10
Selenium	mg/Kg	USEPA SW 846/6010 C	0.3	<0.3
Zinc	mg/Kg	USEPA SW 846/6010 C	2	22.7
Total petroleum Hydrocarbons				
n-Octane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Decane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Undecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Dodecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tridecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetradecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05

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Report No.	LMCHE - 17-0669/2	**Date Reported**	09 Aug 2017
Cust Ref.	-	**Date Received**	13 Jul 2017

TEST	UNIT	TEST METHOD	MDL	RESULTS
n-Hexadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
Pristane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
Phytane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Eicosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heneicosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Docosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tricosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetracosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hexacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Triacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hentriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Dotriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tritriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetratriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hexatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetracontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05

MDL = Method Detection Limit

QC CHECKED

For and behalf of Lonestar Alpha Laboratories
Muscat

Tejali Parsekar
Laboratory Manager
Chemistry & Microbiology

*** End of the test report

Lonestar Alpha Laboratories

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TEST CERTIFICATE - ANALYSIS OF SOIL

Report No.	LMCHE - 17-0669/3	**Date Reported**	09 Aug 2017
Cust Ref.	-	**Date Received**	13 Jul 2017

1. Information Provided By Customer

Customer	5 CAPITALS PO Box 119698, Sheikh Zayed Road Dubai UAE
Project	Not Given
Sample Description	Soil - S-3
Sampling Location	SALALAH IWP

Sampled By	Customer	**Sampling Date & Time**	10/07/2017; 11:40
Sample Brought By	Customer	**Sampling Method**	NG

2. Information Provided By Laboratory

Date Tested	13 Jul 2017 ~ 09 Aug 2017	**Method Variation**	NIL
Test Location	MCT	**LAL Sample No.**	CHE / 1943
Remarks	None		

3. Test Results

TEST	UNIT	TEST METHOD	MDL	RESULTS
Chemical Tests				
Arsenic	mg/Kg	USEPA SW 846/6010 C	0.3	2.18
Barium	mg/Kg	USEPA SW 846/6010 C	1	56.5
Cadmium	mg/kg	USEPA SW846/6010 C	0.2	0.27
Chromium	mg/Kg	USEPA SW 846/6010 C	1	44.5
Cobalt	mg/kg	USEPA SW846/6010 C	1	10.6
Copper	mg/kg	USEPA SW846/6010 C	1	3.91
Lead	mg/kg	USEPA SW846/6010 C	1	4.64
Manganese	mg/Kg	USEPA SW 846/6010 C	1	312
Mercury	mg/kg	USEPA SW846/6010 C	0.1	<0.1
Nickel	mg/kg	USEPA SW846/6010 C	1	64.3
Oil & Grease	mg/kg	USEPA 1664	10	<10
Selenium	mg/Kg	USEPA SW 846/6010 C	0.3	<0.3
Zinc	mg/Kg	USEPA SW 846/6010 C	2	59.7
Total petroleum Hydrocarbons				
n-Octane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Decane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Undecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Dodecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tridecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetradecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05

Lonestar Alpha Laboratories

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Report No.	LMCHE - 17-06683	Date Reported	09 Aug 2017
Cust Ref.	-	Date Received	13 Jul 2017

TEST	UNIT	TEST METHOD	MDL	RESULTS
n-Hexadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
Pristane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
Phytane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Eicosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heneicosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Docosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tricosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetracosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hexacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Triacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hentriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Dotriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tritriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetratriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hexatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetracontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05

MDL = Method Detection Limit

QC CHECKED

For and behalf of Lonestar Alpha Laboratories
Muscat
Tejali Parsekar
Laboratory Manager
Chemistry & Microbiology

End of the test report

Lonestar Alpha Laboratories

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TEST CERTIFICATE - ANALYSIS OF SOIL

Report No.	LMCHE - 17-0689/4	**Date Reported**	09 Aug 2017
Cust Ref.	-	**Date Received**	13 Jul 2017

1. Information Provided By Customer

Customer	**5 CAPITALS** PO Box 119898, Sheikh Zayed Road Dubai UAE
Project	Not Given
Sample Description	Soil - S-4
Sampling Location	SALALAH IWP

Sampled By	Customer	**Sampling Date & Time**	10/07/2017; 12:45
Sample Brought By	Customer	**Sampling Method**	NG

2. Information Provided By Laboratory

Date Tested	13 Jul 2017 - 09 Aug 2017	**Method Variation**	NIL
Test Location	MCT	**LAL Sample No.**	CHE / 1944
Remarks	None		

3. Test Results

TEST	UNIT	TEST METHOD	MDL	RESULTS
Chemical Tests				
Arsenic	mg/Kg	USEPA SW 846/6010 C	0.3	2.34
Barium	mg/Kg	USEPA SW 846/6010 C	1	37.3
Cadmium	mg/kg	USEPA SW846/6010 C	0.2	<0.2
Chromium	mg/Kg	USEPA SW 846/6010 C	1	35.9
Cobalt	mg/kg	USEPA SW846/6010 C	1	8.48
Copper	mg/kg	USEPA SW846/6010 C	1	2.05
Lead	mg/kg	USEPA SW846/6010 C	1	3.12
Manganese	mg/Kg	USEPA SW 846/6010 C	1	257
Mercury	mg/kg	USEPA SW846/6010 C	0.1	<0.1
Nickel	mg/kg	USEPA SW846/6010 C	1	43.9
Oil & Grease	mg/kg	USEPA 1664	10	<10
Selenium	mg/Kg	USEPA SW 846/6010 C	0.3	<0.3
Zinc	mg/Kg	USEPA SW 846/6010 C	2	25.2
Total petroleum Hydrocarbons				
n-Octane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Decane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Undecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Dodecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tridecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetradecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05

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Report No.	LMCHE - 17-086974	Date Reported	09 Aug 2017
Cust Ref.	-	Date Received	13 Jul 2017

TEST	UNIT	TEST METHOD	MDL	RESULTS
n-Hexadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
Pristane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
Phytane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Eicosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heneicosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Docosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tricosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetracosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hexacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Triacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hentriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Dotriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tritriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetratriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hexatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetracontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05

MDL = Method Detection Limit

QC CHECKED

For and behalf of Lonestar Alpha Laboratories
Muscat
End of the test report

Tejali Parsekar
Laboratory Manager
Chemistry & Microbiology

Lonestar Alpha Laboratories

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TEST CERTIFICATE - ANALYSIS OF SOIL

Report No.	LMCHE - 17-0869/5	Date Reported	09 Aug 2017
Cust Ref.	-	Date Received	13 Jul 2017

1. Information Provided By Customer

Customer	5 CAPITALS PO Box 119899, Sheikh Zayed Road Dubai UAE
Project	Not Given
Sample Description	Soil - S-5
Sampling Location	SALALAH IWP

Sampled By	Customer	Sampling Date & Time	10/07/2017, 13:00
Sample Brought By	Customer	Sampling Method	NG

2. Information Provided By Laboratory

Date Tested	13 Jul 2017 ~ 09 Aug 2017	Method Variation	NIL
Test Location	MCT	LAL Sample No.	CHE / 1945
Remarks	None		

3. Test Results

TEST	UNIT	TEST METHOD	MDL	RESULTS
Chemical Tests				
Arsenic	mg/Kg	USEPA SW 846/6010 C	0.3	2.41
Barium	mg/Kg	USEPA SW 846/6010 C	1	48.5
Cadmium	mg/kg	USEPA SW846/6010 C	0.2	0.39
Chromium	mg/Kg	USEPA SW 846/6010 C	1	22.3
Cobalt	mg/kg	USEPA SW846/6010 C	1	3.57
Copper	mg/kg	USEPA SW846/6010 C	1	1.83
Lead	mg/kg	USEPA SW846/6010 C	1	1.55
Manganese	mg/Kg	USEPA SW 846/6010 C	1	96.8
Mercury	mg/kg	USEPA SW846/6010 C	0.1	<0.1
Nickel	mg/kg	USEPA SW846/6010 C	1	18.4
Oil & Grease	mg/kg	USEPA 1664	10	<10
Selenium	mg/Kg	USEPA SW 846/6010 C	0.3	<0.3
Zinc	mg/Kg	USEPA SW 846/6010 C	2	19.3
Total petroleum Hydrocarbons				
n-Octane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Decane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Undecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Dodecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tridecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetradecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05

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Report No.	LMCHE - 17-0668/5	**Date Reported**	09 Aug 2017
Cust Ref.	-	**Date Received**	13 Jul 2017

TEST	UNIT	TEST METHOD	MDL	RESULTS
n-Hexadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
Pristane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
Phytane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Eicosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heneicosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Docosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tricosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetracosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hexacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Triacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hentriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Dotriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tritriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetratriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hexatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetracontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05

MDL = Method Detection Limit

QC CHECKED

For and behalf of Lonestar Alpha Laboratories
Muscat
End of the test report

Tejali Parsekar
Laboratory Manager
Chemistry & Microbiology

Lonestar Alpha Laboratories

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TEST CERTIFICATE - ANALYSIS OF SOIL

Report No.	LMCHE - 17-0669/6	**Date Reported**	09 Aug 2017
Cust Ref.	-	**Date Received**	13 Jul 2017

1. Information Provided By Customer

Customer	6 CAPITALS PO Box 119899, Sheikh Zayed Road Dubai UAE
Project	Not Given
Sample Description	Soil - S-6
Sampling Location	SALALAH IWP

Sampled By	Customer	**Sampling Date & Time**	10/07/2017; 13:10
Sample Brought By	Customer	**Sampling Method**	NG

2. Information Provided By Laboratory

Date Tested	13 Jul 2017 ~ 09 Aug 2017	**Method Variation**	NIL
Test Location	MCT	**LAL Sample No.**	CHE / 1946
Remarks	None		

3. Test Results

TEST	UNIT	TEST METHOD	MDL	RESULTS
Chemical Tests				
Arsenic	mg/Kg	USEPA SW 846/6010 C	0.3	2.90
Barium	mg/Kg	USEPA SW 846/6010 C	1	58.1
Cadmium	mg/kg	USEPA SW846/6010 C	0.2	0.47
Chromium	mg/Kg	USEPA SW 846/6010 C	1	32.4
Cobalt	mg/kg	USEPA SW846/6010 C	1	5.15
Copper	mg/kg	USEPA SW846/6010 C	1	2.25
Lead	mg/kg	USEPA SW846/6010 C	1	2.53
Manganese	mg/Kg	USEPA SW 846/6010 C	1	165
Mercury	mg/kg	USEPA SW846/6010 C	0.1	<0.1
Nickel	mg/kg	USEPA SW846/6010 C	1	27.6
Oil & Grease	mg/kg	USEPA 1664	10	<10
Selenium	mg/Kg	USEPA SW 846/6010 C	0.3	<0.3
Zinc	mg/Kg	USEPA SW 846/6010 C	2	31.7
Total petroleum Hydrocarbons				
n-Octane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Decane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Undecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Dodecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tridecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetradecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05

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Report No.	LMCHE - 17-0669/6	Date Reported	09 Aug 2017
Cust Ref.	-	Date Received	13 Jul 2017

TEST	UNIT	TEST METHOD	MDL	RESULTS
n-Hexadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
Pristane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
Phytane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonadecane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Eicosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heneicosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Docosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tricosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
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n-Pentacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hexacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Heptacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Octacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonacosane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Triacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hentriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Dotriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tritriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetratriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Pentatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Hexatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
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n-Octatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Nonatriacontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05
n-Tetracontane	mg/kg	USEPA SW 846/8015B	0.05	<0.05

MDL = Method Detection Limit

QC CHECKED

For and behalf of Lonestar Alpha Laboratories
Muscat

Tejali Parsekar
Laboratory Manager
Chemistry & Microbiology

End of the test report

Appendix H

Marine Survey: 'Environmental Survey for Salalah IWP' (ref. Al Safa Environmental & Technology Services (2016), commissioned by Masirah International, on behalf of OPWP)

مصيرة العالمية لخدمات التقنية البحرية ش.م.م
Masirah International Technical and Marine Services L.L.C

Environmental Survey for the Salalah IWP

March 2016

ALSAFA Environmental & Technical Services LLC

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Environmental Survey for the Salalah IWP

AETS 102/2015

March 2016

Revisions:

Item	**Name**	**Date**
Prepared by:	Taymour Bagheri & Christopher Clarke	12th March 2016
Description	Environmental Survey for the Salalah IWP	

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Table of Contents

1 Scope of Work

1.1 Introduction

Oman Power and Water Procurement (OPWP) Company, the single buyer of power and water for all independent water and power projects within the sultanate is planning a new independent water project (IWP) in Dhofar Governorate, including a desalination plant with 80,000 to 100,000 cubic metres capacity per day at Taqah.

Natural sea bed communities play an important role when checking out the consequences of possible impacts upon the environment due to the execution of the intake and outfall pipes of a desalination plant. Specifically, from an environmental point of view, these communities are environmental indicators of the seawater quality. Therefore, monitoring the evolution of these communities is a very useful tool to forecast potential effects upon the natural site. Thus, a survey of seafloor conditions and communities is to be carried out focusing the effort towards the evaluation of the natural communities and the sedimentary material withstanding them.

As part of this development, OPWP have engaged Masirah International to carry out bathymetric and environmental surveys of the area at the proposed IWP plant. As part of this contract, Masirah International have contracted Al Safa Environmental & Technical Services to identify all species found in photographs and videos taken by another contractor, and to report on findings made.

1.2 Environmental Survey

The scope of work is as follows:

- Identify species from photographs and videos presented by Masirah International.
- Deliver a qualitative inventory of existing species, including fauna and flora, which live in the area of study.
- Categorize species according to international conservation status and detect protected species that may imply environmental concern
- A map of the situation of the main detected species and an overview of their density (e.g, low, medium and high density is enough, it is not necessary to give accurate numbers of density); including other relevant information as seabed formations and existing infrastructures. This map will include also other relevant information as seabed formations and the location of existing infrastructures.
- A qualitative interpretation of their relevance from an environmental point of view

2 Project Location

The proposed project site is located in the coastal area about 45 km northeast of the city of Salalah. The coastline of this region is directly under the influence of southwest monsoon and strong up-welling. This plays an important role for the rich marine resources in and along the coast where some of the most varied and biologically productive waters are found.

The figure below shows the location of the project site. The area of survey extends 1.5km out to sea and is 2 km wide, covering an area of 3km^2, and this area is referred to as the Project Area in the rest of this report. The project site beachfront is flat and consist of sandy beaches and small rocky outcrops. At the western end of the survey area lies the existing Sembcorp power station. This is shown in the figure below, along with the results of the bathymetric survey, giving the depth of the sea and the three proposed intake locations. The location of the intake and outfall of the existing Sembcorp Power Station are also shown, with the intake extending further out to sea.

Note that the proposed intake locations are to the west of the existing intake, and all extend further out to sea. They are numbered 1 to 3, with Seawater Intake 3 extending furthest out to sea.

In the following sections of this report, the Project Area or Survey Area is the area shown in the figure below.

Table 1: Co-ordinates of proposed intake locations

Intake Location		**Approx depth**
Intake Location 1	233348.34 m E 1884330.69 m N	11m
Intake Location 2	233375.00 m E, 1884158.00 m N	13m
Intake Location 3	233722.00 m E, 1883998.00 m N	15m

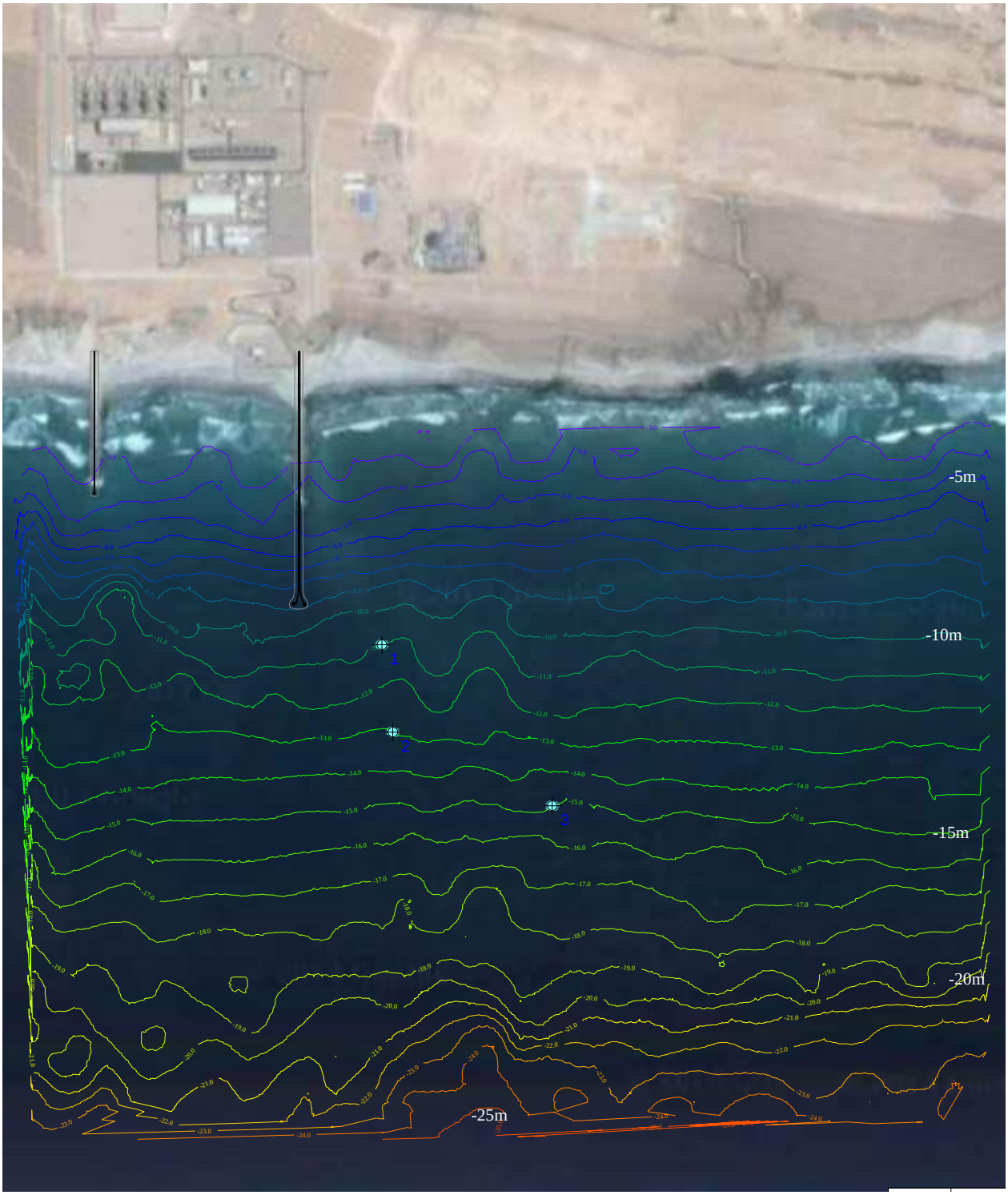


Figure 1: Site Survey area showing depth and proposed intake locations

4 Past Surveys carried out at or near Project Area

4.1 Algal Surveys

Figure 2: Algal survey locations and Project Area

Algal surveys have been carried out on beaches and the sea 5 km and 10 km west of the Project Area in the early 1980s and 2000. Although the date and distance preclude these being used as a baseline, they nonetheless provide an idea of what kinds of algae may be found in the waters at the Project site.

Table 1 : Algae found near project site

Species name	Location 1	Location 2	Location 3	Habitat
Latitude & longitude	17.02997 54.43437	17.03051 54.43103	17.02889 54.38599	
Year	09/09/2000	09/09/2000	23/09/1983 & 12/10/1983	
Chlorophyta Green Algae				
Ulva lactuca				Can be present in intertidal and sublittoral.
Phaeophyta Brown Algae				
Padina glabra				Marine species
Rhodophyta Red Algae				
Gelidium omanense				Attached to mid-littoral exposed rocky shore.
Champia compressa				Marine Species

Dasya rigidula				Marine species
Acanthophora dendroides				Marine species
Portieria hornemannii				Marine species
Melanothamnus somalensis				Marine species
Dermonema abbottiae				Marine species

Source: Macroalgal herbarium portal

4.2 2008 EIA Study

A marine survey was carried out within the Project Area as part of an Environmental Impact Assessment for the first Power Station. This survey included an assessment of marine species and coral at four locations as shown in the table below. One of these was at the then proposed location of the intake, and two others at two possible locations for the outfall. Actually, none of those locations was chosen, and this is why the names are given in quotes. A control location was also selected; this is outside the Project Area

Figure 3: Survey locations for 2008 EIA Study in relation to this Project Area

Subtidal observations were conducted for a period of 20 to 30 minutes each at the sites by using open-circuit SCUBA. Standard transect methodology was employed to identify and mark various communities represented within the survey area.

Table 2: Species recorded during 2008 dive survey

Genus	Species	IUCN Status	"Intake Station"	"Outfall A"	"Outfall B"	Control
Moray Eels Muraenidae	*Gymnothorax sp.*	U				
Groupers and Sea Basses Serranidae	**Epaulet Grouper** *Epinephelus stoliczkae*	U				
Cardinalfishes Apogonidae	**Persian Cardinalfish** *Cheilodipterus persicus*	U				
	Indian Ocean Cardinalfish *Cheilodipterus novemstriatus*	U				
	Golden Cardinalfish *Apogon aureus*	U				
Snappers Lutjanidae	*Lutjanus sp.*	U				
Sweetlips & Grunts Haemulidae	*Pomadasys sp.*	U				
Breams Nemipteridae	**Dotted Bream** *Scolopsis ghanam*	U				
	Seabream *Rhabdosargus* sp	U				
Mullets Mugilidae	*Mugil spp*	U				
Goatfishes Mullidae	*Mulloidicththys sp.*	U				
	Yellowfin Goatfish *Mulloidichthys vanicolensis*	U				
	Pearly Goatfish *Parupeneus marga*	U				
	Long barbel Goatfish *Parupeneus macronemus*					
Damselfish Pomacentridae	**Indo-Pacific Sergeant** *Abudefduf vaigensis*	U				
	Neopomacentrus sp.	U				
	Dameselfish sp.	U				
Wrasses Labridae	**Black-and-Blue Cleaner Wrasse** *Labroides dimidiatus*	LC				
	Moon Wrasse *Thalassoma lunare*	LC				
Parrotfishes Family Scaridae	*Scarus sp.*					
Butterflyfishes Chaetodontidae	**Black spotted butterfly fish** *Chaetodon nigropunctatus*					
	Longfin Bannerfish *Heniochus acuminatus*					
Surgeon fishes Acanthuridae	*Acanthurus sp.*		✓			
Triggerfishes Balistidae	**Largescale triggerfish** *Canthidermis macrolepis*	U				
	Triggerfish sp.	U				
Porcupine Fish Diodontidae	**Porcupinefish** *Diodon hystrix*	U				
TOTAL			**17**	**4**	**0**	□□

4.3 Survey Methodology

Videos and photographs were taken by 3rd party contractor at the project site and supplied to AETS for analysis and interpretation. Surveys were done on Friday 4th March 2016.

The videos and photographs were from four spot dives and six line transects. The four spot dives were of 'Objects' located on the seafloor as identified by the bathymetric survey and requested by OPWP as requiring further examination (see Appendix B for information from bathymetric survey regarding each 'object'). These four objects may be a coral reef, shipwreck, rock outcrop or some other object and may have some ecological importance, and it was necessary to carry out ground truthing of these sites to determine their significance.

In addition to the spot dives, six dive transects were made, from SWI Point 3 to SWI Point 2 to SWI Point 1 and from SWI Point 1 to the shore. Videos were taken of these transects and the figure below shows the location and approximate length of the transects (see Appendix A for more details). The total lengths of the transects was approximately 1011m. Lengths of individual sections was 463m from Point 1 to the shore, 172m from point 1 to point 2 and 376m from point 3 to point 2. Each section was divided into two.

A total of 81 photographs (named IMG_7871.jpg to IMG_7957.jpg) were taken, along with six videos. Details of the videos (length and distance covered) are given in Appendix A.

The co-ordinates of the dive locations are shown in the table below:

Table 3: Dive Survey locations

OBJECT	E	N	DEPTH	REMARKS
OBJECT - 1	232390	1883776	18m	Identified by bathymetric survey
OBJECT - 2	233891	1883648	19m	Identified by bathymetric survey
OBJECT - 3	232738	1883906	16m	Identified by bathymetric survey
OBJECT - 4	232718	1883989	14m	Identified by bathymetric survey
SWI POINT – 1	233321	1884336	11m	Proposed Intake 1
SWI POINT – 2	233380	1884159	13m	Proposed Intake 2
SWI POINT – 3	233728	1883999	15m	Proposed Intake 3

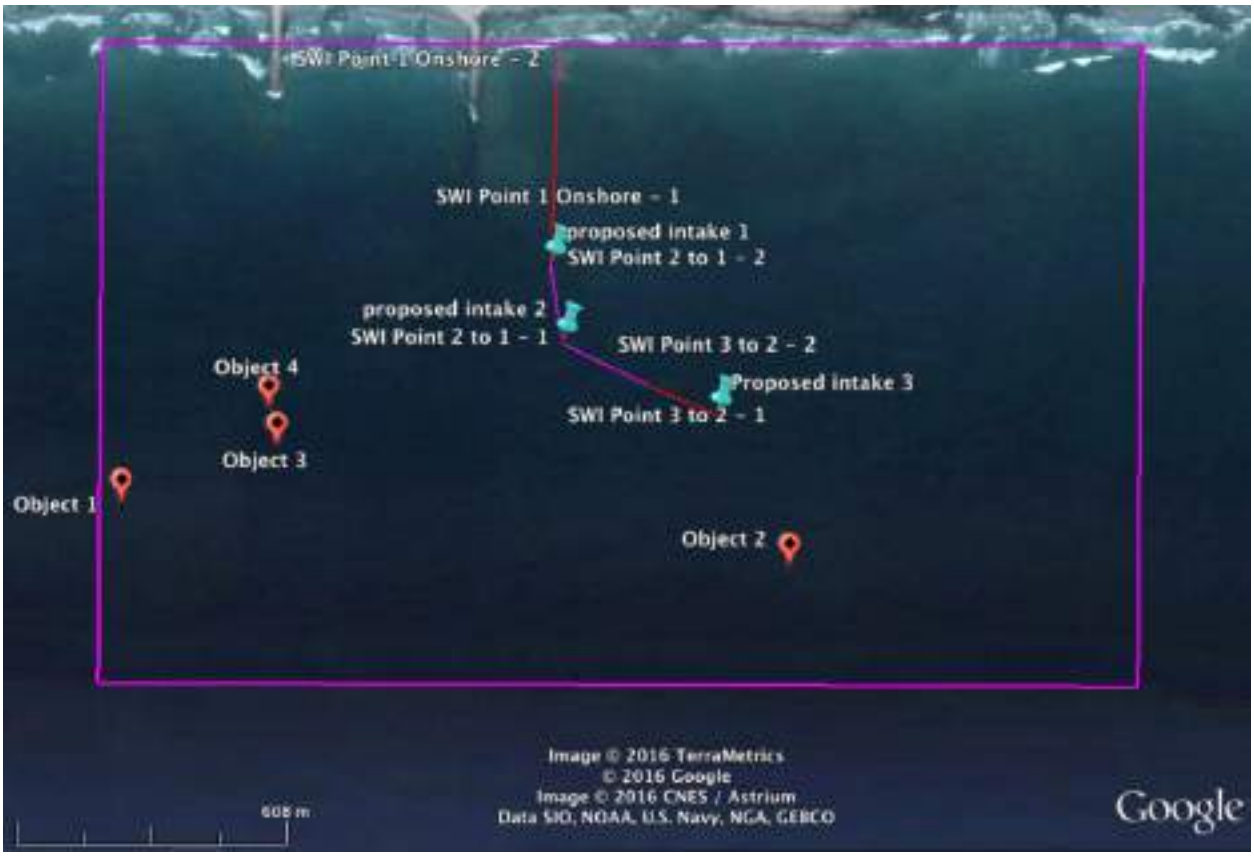


Figure 4: Dive transects and Objects (spot dive locations).

Figure 5: Detail of Dive transects

5 Species Inventory

Table 4: Fish species recorded within Project Area

Genus	Species	Object 1	Object 2	Object 3	Object 4	Intake 3 to Intake 2	Intake 2 to Intake 1	Intake 1 to Shore
Rays Dasyatidae	Unidentified ray1	L						
	Unidentified ray2			L				
	Unidentified ray3							L
Eel Catfishes Plotosidae	Striped eel catfish *Plotosus lineatus*					L		
	Darkfin eel catfish *Plotosus limbatus*		L					L
Sardines Clupeidae	Indian oil sardine *Sardinella longiceps*					H		
Groupers Serranidae	Epaulet Grouper *Epinephelus stoliczkae*							L
Cardinalfishes, Apogonidae	Persian Cardinalfish *Cheilodipterus persicus*		H					H
	Golden cardinalfish *Apogon aureus*		L					
	Blackbanded Cardinalfish *Apogon cookii*							M
	Dhofar Cardinalfish *Apogon dhofar*		H			M		M
Grunts, Haemulidae	Bronzestriped Grunt *Pomadasys taeniatus*							M
Breams, Nemipteridae	Dotted Bream *Scolopsis ghanam*		L					M
	Whitecheek monocle bream *Scolopsis vosmeri*		H					
	Black-streaked monocle bream *Scolopsis taeniata*		M					
	Onespot Porgy *Diplodus sargus kotschyi*							L

Genus	Species	Object 1	Object 2	Object 3	Object 4	Intake 3 to Intake 2	Intake 2 to Intake 1	Intake 1 to Shore
Emperors Lethrinidae	Blackspot Emperor *Lethrinus harak*		L					L
Goatfishes, Mullidae	Rosy Goatfish *Parupeneus rubescens*							H
Damselfish, Pomacentridae	Indo-Pacific Sargeant *Abudefduf vaigensis*							M
	Miry's Damselfish *Neopomacentrus miryae*		H					H
	Sheila's Damselfish *Chrysiptera sheila*							L
Wrasses, Lubridae	Black-and-Blue Cleaner Wrasse *Labroides dimidiatus*		M					
	Blackbar Coris *Coris nigrotaenia*							M
Parrotfishes, Scaridae	Bridled parrotfish *Scarus frenatus*							L
Sandperches Pinguipedidae	Smallscale sandperch *Parapercis robinsoni*		M					L
Butterflyfishes, Chaetodonitidae	Vagabond Butterflyfish *Chaetodon vagabundus*							L
Triggerfishes, Balistidae	Bridled Triggerfish *Sufflamen fraenatus*					L		L
Filefishes Monacanthidae	Scrawled filefish *Aluterus scriptus*					L		
Puffers, Tetraodontidae	Spiny Puffer *Diodon holocanthus*							L
Mullets, Mugilidae	Fringelip mullet *Crenimugil crenilabis*					H		
TOTAL		**1**	**11**	**1**	**0**	**6**	**0**	**20**

L - Low Density (2 or less) species encountered during transect. M - Medium Density (2 -10 species encountered). H - High Density >10 species encountered.

A total of 29 species were recorded within the Project Area. Noteworthy fish include the Blackspot Emperor *Lethrinus harak*, found close to the shore at the transect from SWI 1 to shore (13 mins), that is rare in Oman though has a distribution from Red Sea to Natal. Sheila's Damselfish *Chrysiptera sheila* is a common resident of tidepools and exposed rock shore generally less than 3m depth but only known from the Arabian sea coast of Oman to Muscat in the Gulf of Oman, so is endemic to Oman. It was found close to the Blackspot Emperor. Diversity varied greatly across sites, according to habitat-types found at the site or transect. See section on habitat-types for further information. The most important habitat was the artificial reef found near Intake 2; diversity here was low (due to poor image quality) but fish numbers were extremely high per unit area. It is very likely that species diversity would be much higher if a proper survey were to be carried out at this location.

Of the 991 fish recorded in Omani waters, 3 species are classified by the IUCN as critically endangered, 2 species are classified as Endangered, 1 as Threatened, and 22 as Vulnerable, according to the IUCN 2016 website. The species mentioned above are shown in the table below. None were found within the Survey Area.

Table 5: Threatened fish of Oman

Scientific Name	Common Name (where known)	Conservation Status
Anoxypristis cuspidata	Narrow Sawfish	IUCN: Critically endangered
Pristis zijsron	Olive Sawfish	IUCN: Critically endangered
Carcharhinus hemiodon	Pondicherry Shark	IUCN: Critically endangered
Sphyrna lewini	Scalloped Hammerhead Shark	IUCN: Endangered
Sphyrna mokarran	Great Hammerhead Shark	IUCN: Endangered
Stegostoma fasciatum	Zebra Shark	IUCN: Threatened
Albula glossodonta	Shortjaw Bonefish	IUCN: Vulnerable
Alopias pelagicus	Pelagic Thresher	IUCN: Vulnerable

Epinephelus gabriellae	Multispotted Grouper	IUCN: Vulnerable
Glaucostegus thouin	Clubnose Guitarfish	IUCN: Vulnerable
Manta alfredi	Reef Manta Ray	IUCN: Vulnerable
Carcharhinus longimanus	Oceanic Whitetip Shark	IUCN: Vulnerable
Carcharhinus plumbeus	Sandbar Shark	IUCN: Vulnerable
Hemipristis elongata	Fossil Shark	IUCN: Vulnerable
Isurus oxyrinchus	Shortfin Mako	IUCN: Vulnerable
Makaira nigricans	Blue Marlin	IUCN: Vulnerable
Mola mola	Ocean Sunfish	IUCN: Vulnerable
Oman ypsilon	Oman Blenny	IUCN: Vulnerable
Pomatomus saltatrix	Bluefish	IUCN: Vulnerable
Rhina ancylostoma	Shark Ray	IUCN: Vulnerable
Rhynchobatus djiddensis	Whitespotted Wedgefish	IUCN: Vulnerable
Rhynchobatus laevis	Smoothnose Wedgefish	IUCN: Vulnerable
Sphyrna zygaena	Smooth Hammerhead	IUCN: Vulnerable
Stichopus herrmanni	Curryfish	IUCN: Vulnerable
Taeniurops meyeni	Blotched Fantail Ray	IUCN: Vulnerable
Thelenota ananas	Prickly Redfish	IUCN: Vulnerable
Thunnus obesus	Bigeye Tuna	IUCN: Vulnerable
Urogymnus asperrimus	Porcupine Ray	IUCN: Vulnerable

As with fish, corals varied greatly between survey sites and this was also due to the habitats encountered. The most important coral habitats were found at Object 2 and Intake 1 to shore.

Table 6: Corals found within Project Area

Species	Photo No.	Object 1	Object 2	Object 3	Object 4	Intake 3 to Intake 2	Intake 2 to Intake 1	Intake 1 to shore
Stylophora danae	(7896/7897), 7910, 7911, 7912, 7915,		L					
Favites peresi	7912,		L					
Favia	7898, 7914,		L					
Leptastrea	7908, 7909,		L/M					L
Parasimplastrea			L/M					L
Plesiastrea	7907, 7908,		L/M					
Pseudosiderastrea	7898, 7902, 7908, 7909, 7910, 7915,		L/M					L
Montipora cf. danae	1 to shore 1 6:31							L
Turbinaria (mesenterina)	(7888/7889)							L
Goniopora	7898, 7902, 7895,		L/M					
Subsessifloridae						M	L	L
TOTAL		**0**	**8**	**0**	**0**	**1**	**1**	**6**

L - Low Density (2 or less) species encountered during transect. M - Medium Density (2 -10 species encountered). H - High Density >10 species encountered.

There are 17 corals classified by the IUCN as Vulnerable and 1 species is Endangered (see below) and there are at least 10 endemic species.

Table 7: Threatened corals of Oman

Scientific Name	Common Name (where known)	Conservation Status
Parasimplastrea sheppardi		IUCN: Endangered
Acanthastrea ishigakiensis		IUCN: Vulnerable
Acropora aspera		IUCN: Vulnerable
Acropora hemprichii		IUCN: Vulnerable
Acropora horrida		IUCN: Vulnerable
Acropora pharaonis		IUCN: Vulnerable
Acropora spicifera		IUCN: Vulnerable
Anomastraea irregularis		IUCN: Vulnerable
Fungia curvata		IUCN: Vulnerable
Goniastrea deformis		IUCN: Vulnerable
Goniopora albiconus		IUCN: Vulnerable
Heliopora coerulea	Blue Coral	IUCN: Vulnerable
Montipora stilosa		IUCN: Vulnerable
Pavona cactus		IUCN: Vulnerable
Pavona decussata	Cactus Coral	IUCN: Vulnerable
Pavona diffluens		IUCN: Vulnerable
Pavona venosa		IUCN: Vulnerable
Physogyra lichtensteini		IUCN: Vulnerable
Symphyllia hassi		IUCN: Vulnerable

There was a general low diversity of benthic epifauna. In contrast to fish and coral, the sandy habitats were more diverse than the rock/algae habitats, though this may be because they are easier to see on the sandy habitats. None of the benthic epifaunal species were rare or threatened (see lower table).

Table 8: Benthic epifauna found within Project Area

Species	Object 1	Object 2	Object 3	Object 4	Intake 3 to Intake 2	Intake 2 to Intake 1	Intake 1 to shore
Cerianthidae				L			
Polychaeta					M	M	L
Ophistobranchia					L		
Holothuria atra					L		
Asteronotus cespitosus						L	
	0	0	0	1	3	2	1

L - Low Density (2 or less) species encountered during transect. M - Medium Density (2 -10 species encountered). H - High Density >10 species encountered.

Table 9: Threatened benthic epifauna of Oman

Scientific Name	Common Name (where known)	Conservation Status
Holothuria nobilis	Black Teatfish	IUCN: Endangered
Holothuria scabra	Golden Sandfish	IUCN: Endangered
Holothuria fuscogilva		IUCN: Vulnerable

Table 10: Examples of fish found within the Survey Area

Spiny puffer *Diodon holocanthus* with Persian cardinalfish *Cheilodipterus persic*us

Striped eel catfish *Plotosus lineatus 7890, & 3 to 2-2 08:09 & 08:27*

Indian oil sardine *Sardinella longiceps* 7874

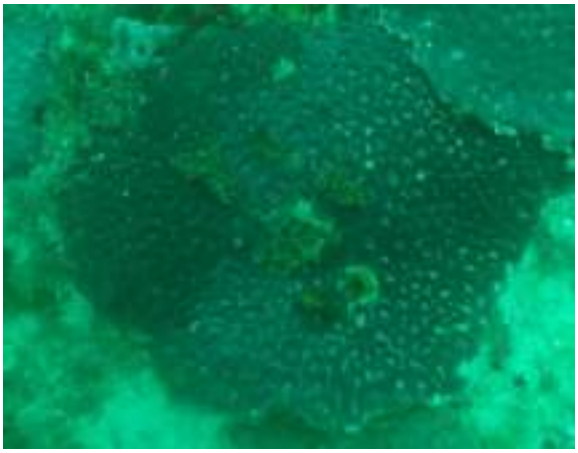
	
Miry's Damselfish *Neopomacentrus miryae*	Darkfin eel catfish *Plotosus limbatus*
	
Striped eel catfish *Plotosus lineatus 7890, & 3 to 2-2 08:09 & 08:27*	Dotted Bream *Scolopsis ghanam 7902*
	
Dhofar Cardinalfish *Apogon dhofar 7902* SWI Point 1 to onshore Object 2	Smallscale sandperch *Parapercis robinsoni* SWI Point 1 to onshore; Object 2

	
Epaulet Grouper *Epinephelus stoliczkae* SWI Point 1 to onshore	Blackbar Coris *Coris nigrotaenia* SWI Point 1 to onshore
	
Persian Cardinalfish *Cheilodipterus persicus* SWI Point 1 to onshore	Black-streaked monocle bream *Scolopsis taeniata*
	
Sting ray Dasyatidae near Object 3 (photo no. 7930, possibly *Taeniura lymna*	Sting ray Dasyatidae near Object 1 (photo no. 7919). A different species to 7939, possibly

	Himantura jenkinnsii.

Table 11: Coral species found within the Survey Area

Stylophora danae



Favia

Leptastrea

Pseudosiderastrea

Parasimplastrea

Favites peresi

Turbinaria

Goniopora

Examples of benthic epifauna and soft coral found are shown in the table below.

Table 12: Bentic epifauna/soft coral found at site

	
Burrowing anemone Cerianthidae found at Object 4	Polychaete worm cast (photo 7871) & video 3 to 2-2 (2:52, 06:13, 10:11, 10:24, 11;40, 12:00); 2 to 1-2 (04:49, 04:53, 05:29,05;49, 06:13, 06:45, 07:07, 08:39); 1 to onshore 1-1 (01:06, 2;32)

	
Sea slug (Opisthobranchia)? (SWI point 3 to 2 -1: 03:45-04:10)	Sea cucumber *Holothuria atra* (SWI point 3 to 2-2, 5:30, 7:43)
	
Polychaete worm mounds SWI point 3 to 2-2, (9:49); 2 to 1-2(01:36, 06:04, 06:48, 07:30, 08:05); 1 to onshore 1-1 (01:26)	Sea slug *Asteronotus cespitosus?*: SWI point 2 to 1-2 (05:31)

	
Sea pen (Subsessiflorae) *Virgularidae*?, 3 to 2-1 (06:03 & 09:29); 3 to 2-2 (01:07, 2:52, 3:28, 5:46, 9:31) ; 2 to 1 (00:51); SWI point 2 to 1-2 (05:32), SWI 1 to onshore -1 (01:42)	

6 Key Habitats

There are 8 habitat-types found within the survey area and these are mapped on the figure below based on satellite imagery, bathymetric map and ground truthing through spot dives and video transects.

The difference between some habitat-types is dramatic and is evident by looking at the video SWI Point 1 Onshore - 1.MP4 at 02:49, that shows the transition from the sandy sea bed habitat to the rocky area with algal mats. Even more dramatic is the change from habitat 1 to 7 as shown in the table below. As discussed, the best habitat for fish was the artifical reef (habitat 7) due to the sheer numbers of fish present and its diversity was likely to be underestimated. The next best habitat was the shallow rocky area with algae and sand (habitat 2) followed by the deep rocky area with algae and sand (habitat 8). For corals the latter was better than the former , and no corals were present in any of the other habitats, except for occasional sea pens (soft coral) in the sandy areas (identification not certain due to low quality of pictures).

Table 13: Habitat-type examples

	
Habitat 7: Man-made object colonised by large numbers of fish.	Transition between Habitat 1 and 2, moving north. Note the fish.
	
Habitat 1: sand with scattered *Ulva* algae.	Habitat 8: Deep rock area with algae, coral and sand

Table 14: Key habitats found within the Survey Area

	Habitat-type	Fish	Coral	Benthic epifauna	Algae & Seagrass	Video examples
1	Sandy sea bed	Stingrays Striped eel catfish	Virgularidae sea pens?	Arenicola lugworms	Few green algae, mostly loose. Few *Thalassodendron ciliatum*	SWI Point 1 Onshore - 1.MP4 before 02:49
2	Rocky areas with algal mats and coral	Second best habitat for fish	Isolated patches of corals	None found	Several species of algae, rock and sand	SWI Point 1 Onshore - 1.MP4 after 02:49
3	Disturbed ground, not surveyed but identified by bathymetric survey as different from other sandy areas.	Not surveyed	Not surveyed	Not known	Not known	No videos
4	Sandy beach exposed at low tide -eulittoral zone, often turbid due to wave action	Occasional fish during high tide	None	Ocypoda polychaetes, amphipods, bivalves (*Phaphia undulate, Callista* sp, *Tivela* sp) gastropods	Patches of much floating loose broken algae, mostly Ulva spp. during high tide	SWI Point 1 - Onshore - 2.MP4
5	Land never covered by sea (supralittoral, terrestrial)	None	None	None	None	Not videoed
6	Boulders exposed at low tide	Not surveyed	Unlikely to have many corals	Likely to be colonised by crabs, the rocky oyster *Saccostrea cucullata* and barnacles *Balanites* spp.	Padina spp.	Not videoed
7	Wrecks or other man-made objects	Highest numbers of fish. Also diverse.	No corals	None found	Several algal species	SWI Point 3 to 2.MP4
8	Deep rocky areas with algal mats and coral e.g Object 2	*Parapercis robinsoni,*	Scattered patches	None found	Sand and rock, algae and seaweed	Object 2

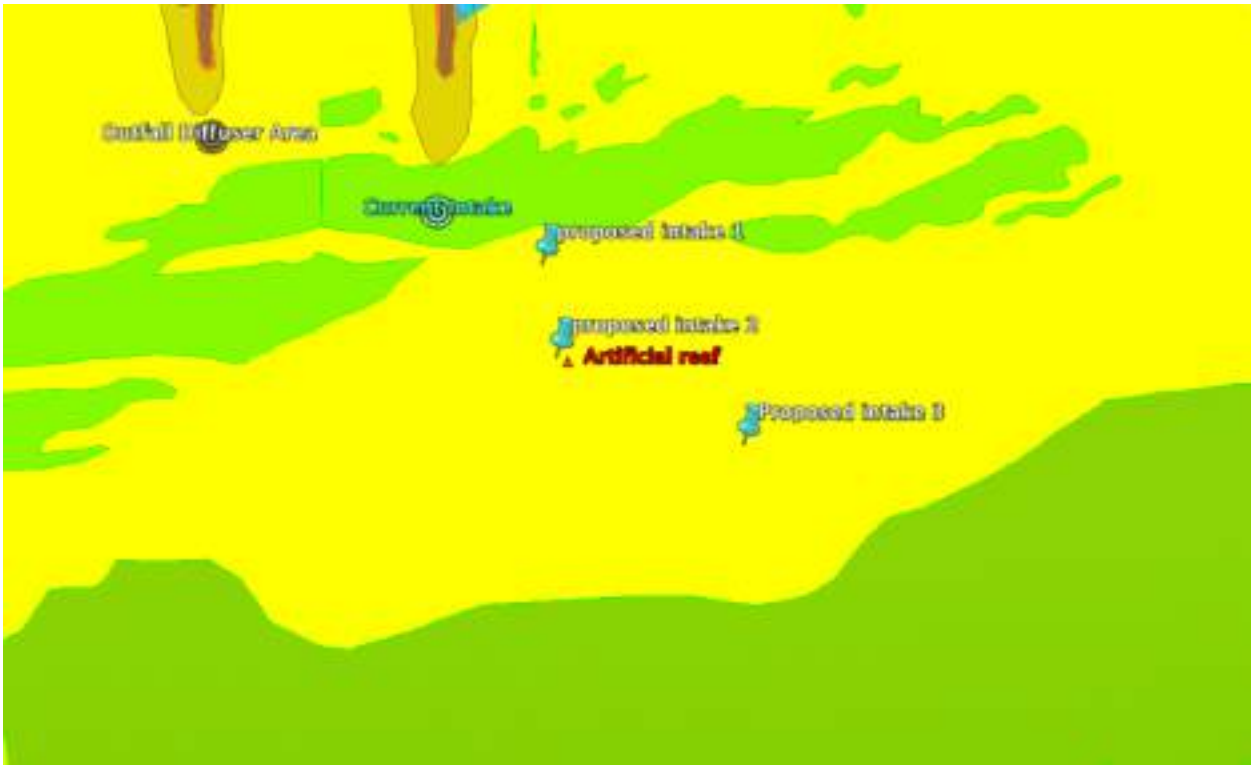


Figure 6: Main habitat-types found within the Survey Area

Key

No.		
1		Sandy sea bed
2		Rocky areas with algal mats and coral
3		Disturbed ground
4		Sandy beach exposed at low tide -eulittoral zone, often turbid due to wave action
5		Land never covered by sea (supralittoral, terrestrial)
6		Boulders exposed at low tide
7	Δ	Wrecks or other man-made objects
8		Deep rocky areas with algal mats and coral

7 References For Taxonomic Identification

Claereboudt, M. R. (2006) Reef corals and coral reefs of the Gulf of Oman. Historical Association of Oman, Muscat.

Coles, S.L. (1995). Corals of Oman. Muscat Printing Press, Sultanate of Oman.

Field, R. (2013). Reef Fishes of Oman. Downloadable e-book from marinefisharabia.com.

Randall, J. E. (1995) Coastal Fishes of Oman. Crawford House, Bathurst, Australia.

Richmond, M. D. (1997) A Field Guide to the Seashores of Eastern Africa and the Western Indian Ocean Islands.

Wehe, T. and Fiege, D. (2002). Annotated checklist of the polychaete species of the seas surrounding the Arabian Peninsula: Red Sea, Gulf of Aden, Arabian Sea, Gulf of Oman, Arabian Gulf. Fauna Of Arabia **19**: 7–238

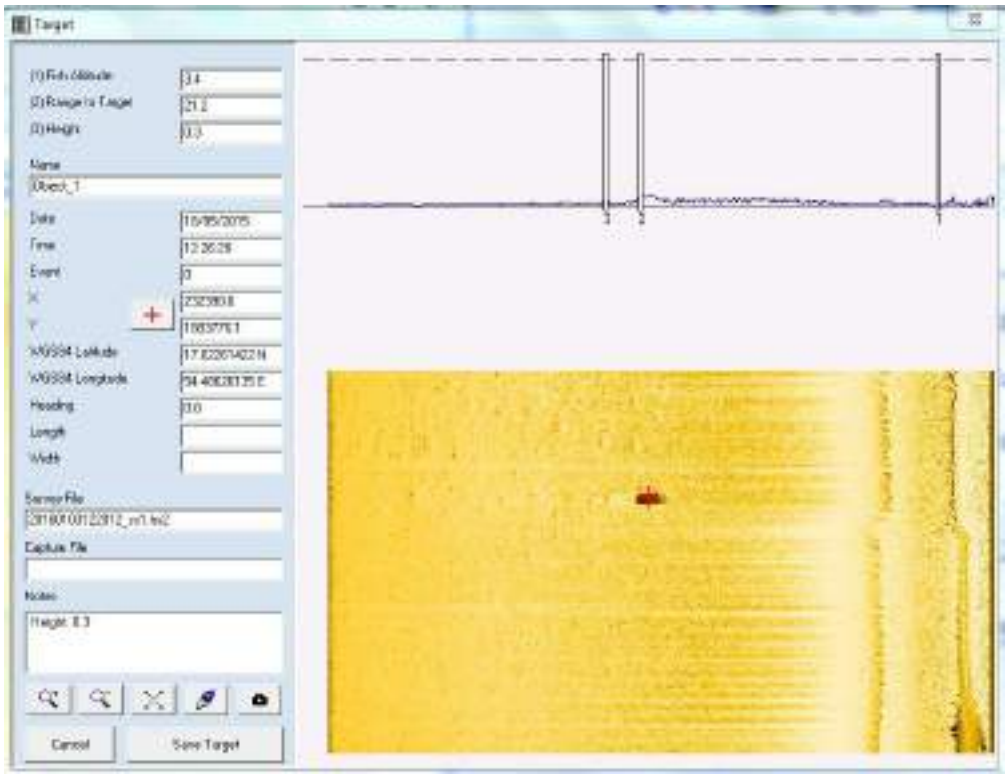
8 Appendix A: Dive Survey videos

The dive survey videos are included on a flash drive that is submitted along with this report

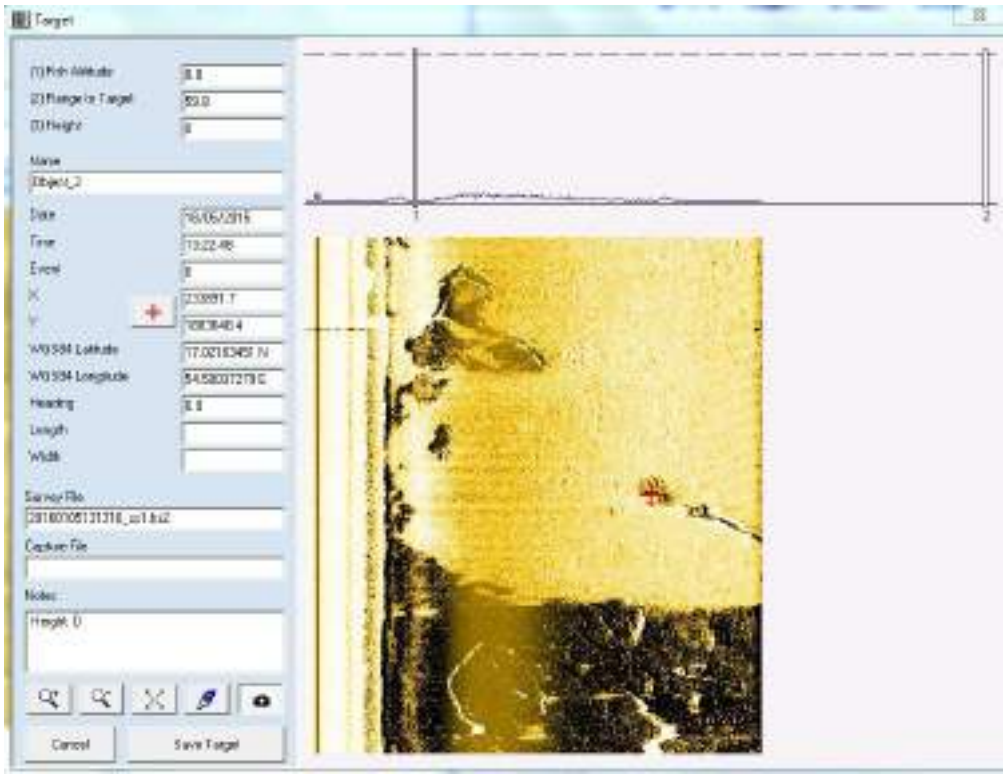
Video Name	Time (on 6 Mar)	Order	Approx transect length (m)	Duration (min)	Size (GB)
OBJECT 2.MP4	10:13	1		13:44	3.100 GB
OBJECT 2 - CORAL.MP4	10:20	2		6:53	1.560 GB
OBJECT 1.MP4	11:02	3		12:31	2.830 GB
OBJECT 3.MP4	11:34	4		09:01	2.040 GB
OBJECT 4.MP4	12:06	5		09:51	2.230 GB
SWI Point 3 to 2 - 1.MP4	16:36	6	161	10:55	2.460 GB
SWI Point 3 to 2 - 2.MP4	16:51	7	215	13:19	3.010 GB
SWI Point 2 to 1 - 1.MP4	17:07	8	153	00:91	0.193 GB
SWI Point 2 to 1 - 2.MP4	17:17	9	19	9:44	2.200 GB
SWI Point 1 Onshore - 1.MP4	17:39	10	396	17:43	4.000 GB
SWI Point 1 Onshore - 2.MP4	17:43	11	67	2:40	0.602 GB

9 Appendix B: Sea floor Anomalies or "Objects"

9.1 Object 1



9.2 Object 2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Object_2
Date
Time
Event
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WGS84 Longitude
Heading
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Width
Survey File
Capture File
Notes
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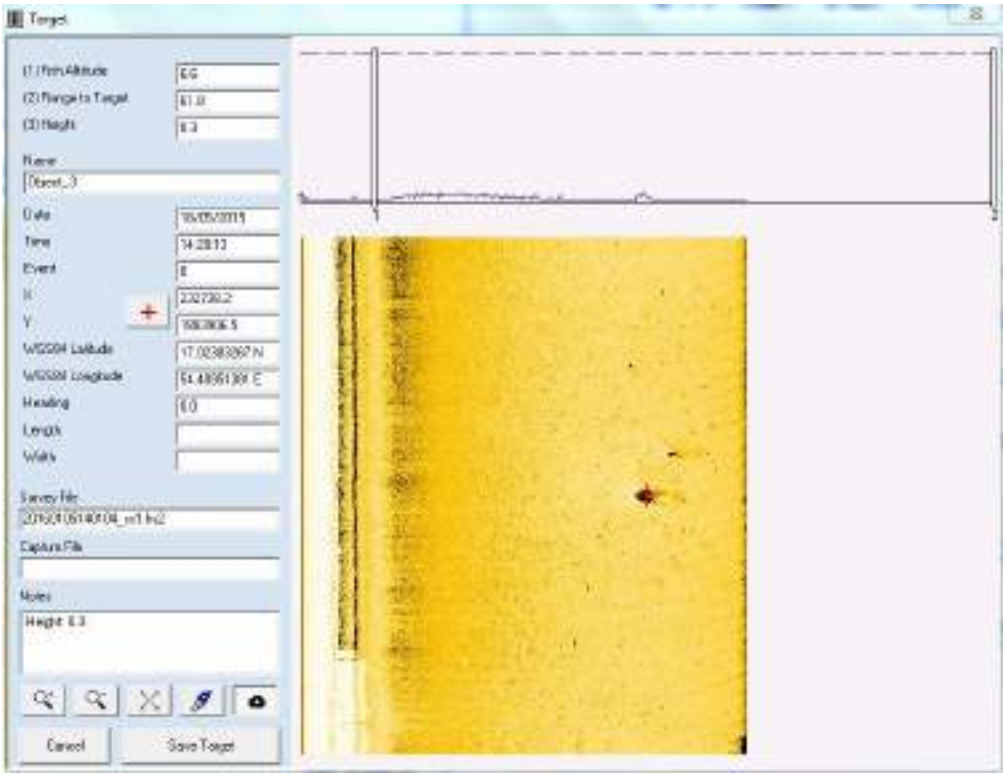
Save Target

9.3 Object 3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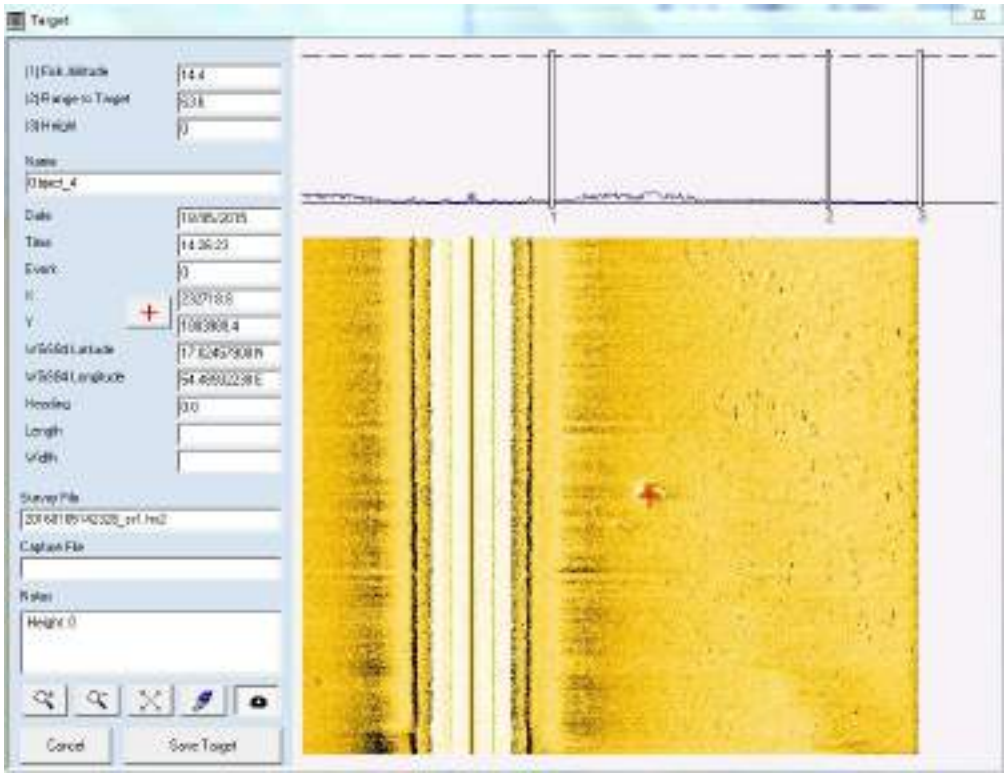
9.4 Object 4


Target
Name
Object_4
Date
Time
Event
Survey File
Capture File
Notes
Height: 0
Cancel
Save Target

Appendix I

Ambient Water Quality: Laboratory Analysis (ref. Analysis by Lonestar Laboratory (2016), commissioned by Masirah International, on behalf of OPWP)

Lonestar Alpha Laboratories

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E-mail : info@lonestaralpha.com, Website: www.lonestaralpha.com

TEST CERTIFICATE - ANALYSIS OF WATER

Report No.	LMCHE / 9060/1	**Date Reported**	28 Aug 2016
Cust Ref.	-	**Date Received**	18 Aug 2016

1. Information Provided By Customer

Customer	**MASIRAH INTERNATIONAL TECHNICAL AND MARINE SERVICE LLC** PO Box 3293, PC 112 Ruwi, Sultanate of Oman
Project	Not Given
Sample Description	Sea Water
Sampling Location	SALALAH

Sampled By	Customer	**Sampling Date & Time**	NG
Sample Brought By	Customer	**Sampling Method**	NG

2. Information Provided By Laboratory

Date Tested	18 Aug 2016 ~ 28 Aug 2016	**Method Variation**	NIL
Test Location	MCT	**LAL Sample No.**	CHE / 5284
Remarks	None		

3. Test Results

TEST	UNIT	TEST METHOD	MDL	RESULTS
Chemical Tests				
Arsenic	mg/L	APHA 3120 B	0.01	<0.01
* Barium	mg/L	APHA 3120 B	0.1	<0.1
Bicarbonates	mg/L	APHA 2320 B	1	140
Biochemical Oxygen Demand	mg/L	APHA 5210 B	2	<2
* Boron	mg/L	APHA 3120 B	0.10	4.54
* Bromide	mg/l	APHA 4110 B	0.01	67.19
Chlorides	mg/L	APHA 4500 Cl-B	1	20207
Total Kjeldahl Nitrogen	mg/L	APHA 4500 Norg B	0.6	<0.6
* Cadmium	mg/L	APHA 3120 B	0.003	<0.003
Calcium	mg/L	APHA 3500 Ca B	1	436
Chemical Oxygen Demand	mg/L	HACH 8000	5	<5
* Cobalt	mg/L	APHA 3120 B	0.03	<0.03
Color	Pt.Co	HACH 8025	1	<1
* Copper	mg/L	APHA 3120 B	0.02	<0.02
Cyanide	mg/L	HACH 8027	0.001	<0.001
Fluoride	mg/L	HACH 8029	0.01	1.71
Magnesium	mg/L	APHA 3500 Mg B	1	1374
* Mercury	mg/L	APHA 3120 B	0.001	<0.001
* Molybdenum	mg/L	APHA 3120 B	0.01	<0.01
* Nickel	mg/L	APHA 3120 B	0.02	<0.02
Nitrite	mg/L	HACH 8507	0.001	0.033
Sulphide	mg/L	HACH 8131	0.01	<0.01

LONESTAR ALPHA LABORATORIES L.L.C. C.R. No. 3746339 P.O. Box 1197, P.C. 130, Sultanate of Oman

Lonestar Alpha Laboratories

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E-mail : info@lonestaralpha.com, Website: www.lonestaralpha.com

Report No.	LMCHE / 9060/1	**Date Reported**	28 Aug 2016
Cust Ref.	-	**Date Received**	18 Aug 2016

TEST	UNIT	TEST METHOD	MDL	RESULTS
Carbonates	mg/L	APHA 2320 B	1	10
Tin	mg/L	APHA 3120 B	0.01	<0.01
Dissolved Silica as SiO_2	mg/L	HACH 8186	0.01	0.15
Silicates	mg/L	HACH 8186	0.01	0.19
* Dissolved Iron as Fe	mg/L	APHA 3120 B	0.02	<0.02
* Dissolved Manganese as Mn	mg/L	APHA 3120 B	0.02	<0.02
* Dissolved Aluminium as Al	mg/L	APHA 3120 B	0.03	<0.03
* Total Iron	mg/L	APHA 3120 B	0.02	<0.02
* Total Manganese	mg/L	APHA 3120 B	0.02	<0.02
* Total Aluminium	mg/L	APHA 3120 B	0.03	<0.03
* Potassium	mg/L	APHA 3120 B	0.2	421
Salinity	ppt	APHA 2520 B	0.01	36.51
Selenium	mg/L	APHA 3120 B	0.01	<0.01
* Strontium	mg/L	APHA 3120 B	0.03	7.13
Sulphate	mg/L	APHA 4500 SO42-C	1	2710
* Total Dissolved Solids	mg/L	APHA 2540 C	5	37800
* Total Suspended Solids	mg/L	APHA 2540 D	-	3
Oil & Grease	mg/L	APHA 5520 B	5	<5
Organic matter	-	Qualitative test	-	Nil
* Sodium	mg/L	APHA 3120 B	0.2	10950
Turbidity	NTU	HACH 8237	0.1	0.7
* Zinc	mg/L	APHA 3120 B	0.1	<0.1
Phosphate as PO_4	mg/L	HACH 8048	0.01	0.05
Density @ 25°C	g/mL	by Hydrometer	0.001	1.026
Carbon dioxide	mg/L	APHA 4500 CO2	1	<1
Nitrate	mg/L	HACH 8171	0.1	3.70
Plumb as Lead	mg/L	APHA 3120 B	0.01	<0.01
Ammonium as NH4	mg/L	HACH 8155	0.01	<0.01
**Enumeration of Phytoplankton	No/L	APHA 10200 F	-	4800
Total Organic Carbon	mg/L	HACH 10129	0.5	1.9
Dissolved Organic Carbon	mg/L	HACH 10129	0.5	1.7
Total petroleum Hydrocarbons				
n-Hentriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Octane	mg/L	USEPA SW 846/8015B	0.01	<0.01

Terms and Conditions on the Reverse side of the sheet

Lonestar Alpha Laboratories

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Report No.	LMCHE / 9060/1	**Date Reported**	28 Aug 2016
Cust Ref.	-	**Date Received**	18 Aug 2016

TEST	UNIT	TEST METHOD	MDL	RESULTS
n-Dotriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Tritriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Tetratriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Pentatriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Hexatriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Heptatriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Octatriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Nonatriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Tetracontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
Phytane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Nonadecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Eicosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Heneicosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Docosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Tricosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Tetracosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Pentacosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Hexacosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Heptacosane	mg/L	USEPA SW 846/8015B	0.01	<0.01

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Report No.	LMCHE / 9060/1	Date Reported	28 Aug 2016
Cust Ref.	-	Date Received	18 Aug 2016

TEST	UNIT	TEST METHOD	MDL	RESULTS
n-Octacosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Nonacosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Triacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Octadecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Nonane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Decane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Tridecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Tetradecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Pentadecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Hexadecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Heptadecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
Pristane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Undecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Dodecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
Total Petroleum Hydrocarbons	mg/l	USEPA SW 846/8015B	0.01	<0.01
Microbiological Tests				
* Total coliforms	CFU/100mL	APHA 9222 B	1	<1
Fecal coliforms	CFU/100mL	APHA 9222 D	1	<1
Fecal streptococci	CFU/100mL	APHA 9230 C	1	<1

* This parameter is under the scope of accreditation.
APHA = American Public Health Association, Standard Methods 22nd Edition.
MDL = Method Detection Limit
** Subcontracted
CFU = Colony Forming Unit
< 1 is considered as absent

For and behalf of Lonestar Alpha Laboratories Muscat

Manokaran
Manager Chemistry

QC CHECKED

Lonestar Alpha Laboratories

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TEST CERTIFICATE - ANALYSIS OF WATER

Report No.	LMCHE / 8900/1	**Date Reported**	09 Aug 2016
Cust Ref.	-	**Date Received**	20 Jul 2016

1. Information Provided By Customer

Customer	**MASIRAH INTERNATIONAL TECHNICAL AND MARINE SERVICE LLC** PO Box 3293, PC 112 Ruwi, Sultanate of Oman
Project	Not Given
Sample Description	Sea Water
Sampling Location	SALALAH

Sampled By	Customer	**Sampling Date & Time**	NG
Sample Brought By	Customer	**Sampling Method**	NG

2. Information Provided By Laboratory

Date Tested	20 Jul 2016 ~ 09 Aug 2016	**Method Variation**	NIL
Test Location	MCT	**LAL Sample No.**	CHE / 4816
Remarks	None		

3. Test Results

TEST	UNIT	TEST METHOD	MDL	RESULTS
Chemical Tests				
Arsenic	mg/L	APHA 3120 B	0.01	<0.01
* Barium	mg/L	APHA 3120 B	0.1	<0.1
Bicarbonates	mg/L	APHA 2320 B	1	131
Biochemical Oxygen Demand	mg/L	APHA 5210 B	2	<2
* Boron	mg/L	APHA 3120 B	0.10	4.39
* Bromide	mg/l	APHA 4110 B	0.01	64.81
Chlorides	mg/L	APHA 4500 Cl-B	1	19398
Total Kjeldahl Nitrogen	mg/L	APHA 4500 Norg B	0.6	<0.6
* Cadmium	mg/L	APHA 3120 B	0.003	<0.003
Calcium	mg/L	APHA 3500 Ca B	1	445
Chemical Oxygen Demand	mg/L	HACH 8000	5	<5
* Cobalt	mg/L	APHA 3120 B	0.03	<0.03
Color	Pt,Co	HACH 8025	1	<1
* Copper	mg/L	APHA 3120 B	0.02	<0.02
Cyanide	mg/L	HACH 8027	0.001	<0.0001
Fluoride	mg/L	HACH 8029	0.01	1.83
Magnesium	mg/L	APHA 3500 Mg B	1	1374
* Mercury	mg/L	APHA 3120 B	0.001	<0.001
* Molybdenum	mg/L	APHA 3120 B	0.01	<0.01
* Nickel	mg/L	APHA 3120 B	0.02	<0.02
Nitrite	mg/L	HACH 8507	0.001	0.012
Sulphide	mg/L	HACH 8131	0.01	<0.01

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E-mail : info@lonestaralpha.com, Website: www.lonestaralpha.com

Report No.	LMCHE / 8900/1	**Date Reported**	09 Aug 2016
Cust Ref.	-	**Date Received**	20 Jul 2016

TEST	UNIT	TEST METHOD	MDL	RESULTS
Carbonates	mg/L	APHA 2320 B	1	<1
Tin	mg/L	APHA 3120 B	0.01	<0.01
Dissolved Silica as SiO_2	mg/L	HACH 8186	0.01	0.15
Silicates	mg/L	HACH 8186	0.01	0.20
* Dissolved Iron as Fe	mg/L	APHA 3120 B	0.02	<0.02
* Dissolved Manganese as Mn	mg/L	APHA 3120 B	0.02	<0.02
* Dissolved Aluminium as Al	mg/L	APHA 3120 B	0.03	<0.03
* Total Iron	mg/L	APHA 3120 B	0.02	<0.02
* Total Manganese	mg/L	APHA 3120 B	0.02	<0.02
* Total Aluminium	mg/L	APHA 3120 B	0.03	<0.03
* Potassium	mg/L	APHA 3120 B	0.2	422
Salinity	ppt	APHA 2520 B	0.01	35.04
Selenium	mg/L	APHA 3120 B	0.01	<0.01
* Strontium	mg/L	APHA 3120 B	0.03	7.15
Sulphate	mg/L	APHA 4500 SO42-C	1	2702
* Total Dissolved Solids	mg/L	APHA 2540 C	5	35850
* Total Suspended Solids	mg/L	APHA 2540 D	5	3
* Zinc	mg/L	APHA 3120 B	0.1	<0.1
Oil & Grease	mg/L	APHA 5520 B	5	<5
Organic matter	-	Qualitative test	-	NIL
* Sodium	mg/L	APHA 3120 B	0.2	11430
Phosphate as PO_4	mg/L	HACH 8048	0.01	0.22
Density @ 25°C	g/mL	by Hydrometer	0.001	1.026
Carbon dioxide	mg/L	APHA 4500 CO2	1	<1
Nitrate	mg/L	HACH 8171	0.1	4.1
Plumb as Lead	mg/L	APHA 3120 B	0.01	<0.01
Ammonium as NH4	mg/L	HACH 8155	0.01	<0.01
**Enumeration of Phytoplankton	No/L	APHA 10200 F	-	880
Total Organic Carbon	mg/L	HACH 10129	0.5	1.9
Dissolved Organic Carbon	mg/L	HACH 10129	0.5	1.7
Turbidity	NTU	HACH 8237	0.1	5.6
Total petroleum Hydrocarbons				
n-Hentriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Nonane	mg/L	USEPA SW 846/8015B	0.01	<0.01

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Report No.	LMCHE / 8900/1	**Date Reported**	09 Aug 2016
Cust Ref.	-	**Date Received**	20 Jul 2016

TEST	UNIT	TEST METHOD	MDL	RESULTS
n-Decane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Tridecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Tetradecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Pentadecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Hexadecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
Phytane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Nonadecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Eicosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Heneicosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Docosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Tricosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Tetracosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Pentacosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Hexacosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Heptacosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Octacosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Nonacosane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Triacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Dotriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01

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Report No.	LMCHE / 8900/1	**Date Reported**	09 Aug 2016
Cust Ref.	-	**Date Received**	20 Jul 2016

TEST	UNIT	TEST METHOD	MDL	RESULTS
n-Tritriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Tetratriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Pentatriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Hexatriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Heptatriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Octatriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Nonatriacontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Tetracontane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Heptadecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
Pristane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Octadecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Undecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Dodecane	mg/L	USEPA SW 846/8015B	0.01	<0.01
n-Octane	mg/L	USEPA SW 846/8015B	0.01	<0.01
Total Petroleum Hydrocarbons	mg/l	USEPA SW 846/8015B	0.01	<0.01
Microbiological Tests				
* Total coliforms	CFU/100mL	APHA 9222 B	1	$1.0x10^2$
Fecal coliforms	CFU/100mL	APHA 9222 D	1	$1.0x10^2$
Fecal streptococci	CFU/100mL	APHA 9230 C	1	$1.1x10^2$

* This parameter is under the scope of accreditation.
APHA = American Public Health Association, Standard Methods 22nd Edition.
CFU = Colony Forming Unit
MDL = Method Detection Limit
ND = Not detected

QC CHECKED

For and behalf of Lonestar Alpha Laboratories Muscat

Manokaran
Manager Chemistry

Appendix J

Brine Modelling Study

ACWA Power, Salalah IWP Project

Marine Modelling Report

Prepared for: 5 Capitals

Ref.: J18006_01

Date: 25-10-2017

Disclaimer

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Report Approval & Revision Record

Project:	ACWA Power, Salalah IWP Project
Document Title:	Marine Modelling Report
Client:	5 Capitals
Report Number:	J18006_01

Rev	Date	Prepared	Reviewed	Approved
01	15th August 2017	Douglas Tilbury Environmental Engineer	Gregory Ashcroft Principal Consultant	Richard Palmer Partner
02	25th October 2017	Douglas Tilbury Environmental Engineer	Gregory Ashcroft Principal Consultant	Richard Palmer Partner

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List of Figures

Acronyms

°C	Degrees Celsius
µg/l	Microgram per litre
AWQO	Ambient Water Quality Objectives
CFD	Computation Fluid Dynamics
CORMIX	Cornell Mixing Zone Model
CORR	Correlation Coefficient
ECMWF	European Centre for Medium Range Weather Forecasting
EHS	Environment, Health and Safety
EPC	Engineering, Procurement and Construction
ESIA	Environmental and Social Impact Assessment
GEBCO	General Bathymetric Chart of the Oceans
IFC	International Finance Corporation
IOA	Index Of Agreements
IWP	Salalah Independent Water Projects
IWPP	Salalah Independent Water and Power Plant
MECA	Ministry of Environment and Climate Change
MSL	Mean Sea Level
NWP	Numerical Weather Prediction
OSU	Oregon State University
RMSE	Root Mean Square Error
RMZ	Regulatory Mixing Zone
UKHO	United Kingdom Hydrographic Office
US EPA	United States Environmental Protection Agency
WKC	WKC Environment Consultancy

1 Introduction

1.1 Background

WKC Environment Consultancy (WKC) have been contracted by 5 Capitals Environmental and Management Consulting (5 Capitals) to conduct hydrodynamic modelling and a brine plume assessment for the proposed outfall conditions from the proposed ACWA Power, Salalah and Shairqiyah Independent Water Project (hereinafter referred to as the "Salalah IWP"), located in the Salalah region of the Dhofar Province of south western Oman.

The overall project involves the assessment of brine plumes for the existing and proposed outfalls in the area, based on one existing, and two future design scenarios. The flow of brine from the nearby existing Salalah Independent Water and Power Plant (IWPP) outfall has also been included in the study but is not expected to change based on the scope of works of this study. 5 Capitals have been commissioned to prepare an Environmental and Social Impact Assessment (ESIA) for submission to the regulatory authorities. The scope of works outlined within this report were commissioned in support of this ESIA to aid in 5 Capital's impacts assessment.

The future Salalah IWP and existing IWPP outfalls are located approximately 750m and 170m perpendicularly south of the shoreline respectively, with the IWPP outfall at the end of a man-made rock groyne. The IWPP and IWP facilities are located within Salalah Bay and are approximately 50 km ENE of the Port of Salalah. The project location in relation to the surrounding area is presented in Figure 1-1.

1.2 Study Objectives

Two key objectives form the basis for this study:

- Simulation of hydrodynamics to feed into subsequent plume assessments; and,
- Simulations to determine the mixing zone of brine plumes discharged from the IWP and IWPP outfalls;

1.3 Assessment Method

The discharges from the proposed development have been simulated using sophisticated atmospheric and ocean models:

- Analysis of European Centre for Medium Range Weather Forecast (ECMWF) data to obtain wind and atmospheric pressure fields over the Project area;
- Analysis and incorporation of the Oregon State University (OSU) Barotropic Tidal Inversion Model for tidal prediction and model boundaries;

- Simulation of tidal and wind driven ocean currents using the GEMMS 3D Coastal Ocean Model (GCOM3D) which predicts the variation horizontally and vertically of the currents in the Project area;

- Simulation of near-field brine plume behaviour using the United States Environmental Protection Agency (US EPA) approved Cornell Mixing Zone Model (CORMIX), which simulates the 'jet-like' dispersion of the discharge; and,

- Simulation of far-field brine plume behaviour using the GEMMS 3D Plume Dispersion Model (PLUME3D), which simulates the 'plume-like' dispersion of the discharge.

The major stages of the methodology were:

- Setup an accurate bathymetric representation of the study region from the General Bathymetric Chart of the Oceans (GEBCO), digitised chart data and local bathymetric data collected as part of this study;

- Extract two representative periods (summer and winter) of 6-hourly wind fields from the ECMWF Global Atmospheric Prediction Model;

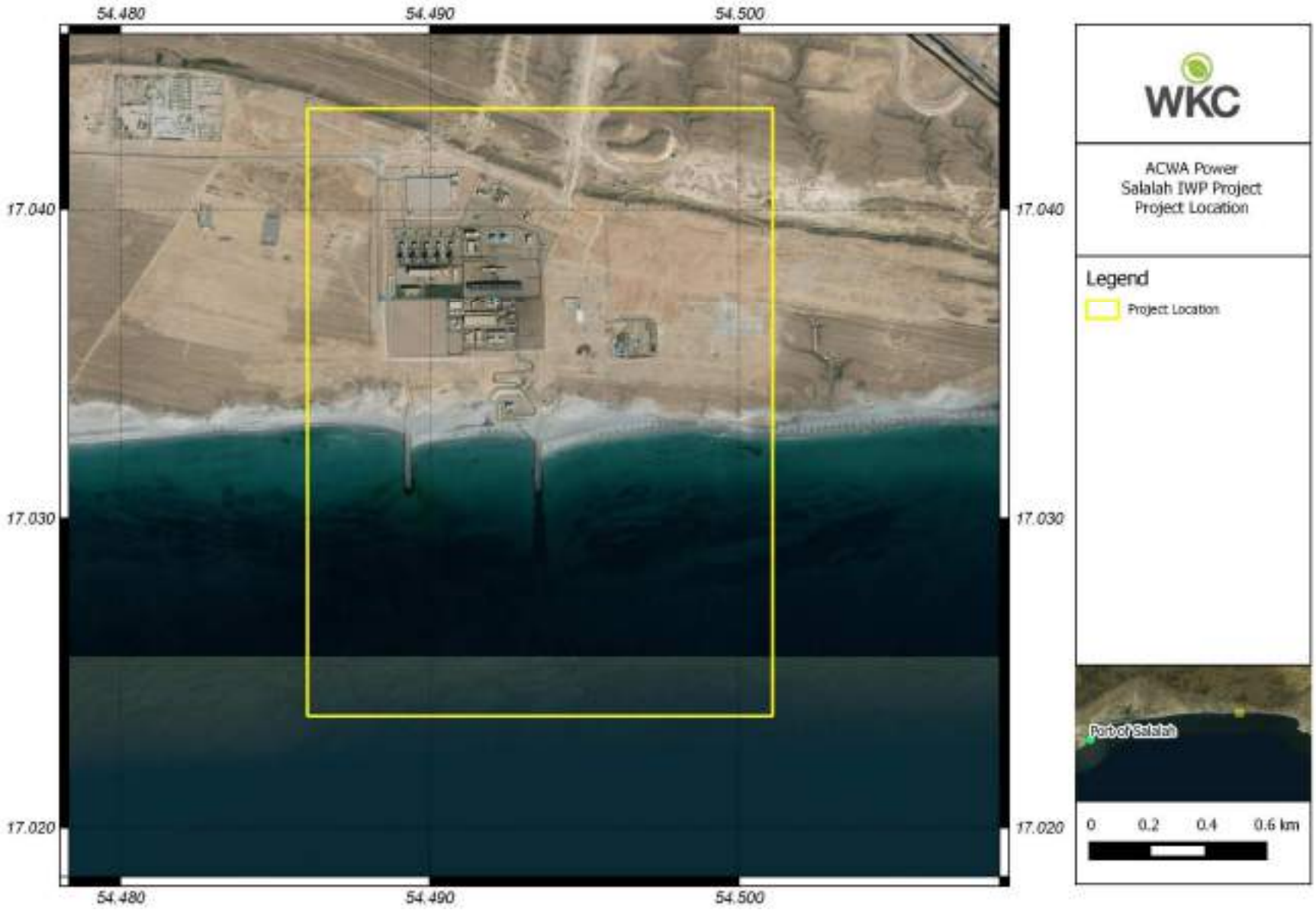
- Establish a hydrodynamic model for the area of interest;

- Incorporate OSU tidal data at model boundaries;

- Predict 3D currents with GCOM3D within a summer and winter scenario; and,

- Investigate the dispersion of the brine plumes discharged from the outfall using the CORMIX and PLUME3D models driven by the currents predicted by GCOM3D.

Figure 1-1 - Project Location



2 Project Standards

The environmental legislature of Oman is governed primarily by the Law on the Conservation of the Environment and Combating of Pollution (Royal Decree No. 114/01) [1]. Although its forerunner (of the same name – Royal Decree No. 10/82 [2]) now stands repealed, it enabled the enactment of a series of environmental legislations, most of which continues to be in force today.

The legislative requirements for the operation of a brine outfall are outlined in the sections that follow, along with the guidance from the International Finance Corporation.

2.1 Ministry of Environment and Climate Affairs

The Council for Conservation of Environment and Prevention of Pollution established the Ministry of Environment in 1984, which pursuant to Royal Decree 90 or 2007, is now called the Ministry of Environment and Climate Affairs (MECA) [3].

MECA and conjunction with the Council for Conservation of Environment and Prevention of Pollution published Ministerial Decision No: 159 of 2005 - Promulgating the bylaws to discharge liquid waste in the marine environment [4]. These bylaws express the requirements of all facilities to obtain discharge permits subject to the following requirements:

1. Set the end of the liquid waste discharge pipe at a depth of not less than one meter below the lowest tide line;

2. The temperature of liquid waste at the discharge point should not exceed 10 degrees centigrade over the temperature of the water surrounding the seawater intake, if any. The Ministry may request continuous monitoring of the water temperature at the discharge inlet and outlet, in the form of monthly reports. The Ministry may also request, every now and then, continuous monitoring to ensure that the temperature of the inlet is equal to the temperature of the surrounding water;

3. Set the end of the discharge pipe where it will not allow the liquid waste to impact the corals and seaweeds at the seabed;

4. The special utilities and equipment should be maintained by taking samples of the seawater and liquid waste in accordance with the conditions set by the Ministry;

5. Specify a circular area of 300-meter diameter, with the point of liquid waste discharge as its centre, as the initial mitigating area, whereby the discharge of liquid waste in this area should not result in the followings:

    a. Increase of the temperature of surrounding water for more than one degree centigrade (weekly average);

b. Reduction of average dissolved oxygen for more than 10% (weekly average);

c. Changes in the pH by more than 0.2 unit; and,

d. Increase or decrease in rate of salinity for more than 2 salinity units (2 parts per thousand) of the daily surrounding averages.

Additionally, the discharge should be characterised in the form of three-dimensional modelling covering one seasonal year and high and low tides cycles. Provided that this modelling shall be applied in the worst initial mitigation conditions, i.e. the lowest wind speed concurrent with the diminishing high and low tides, the lowest recorded current speed in the location and the tidal reflection in view of such conditions, unless otherwise decided by the ministry.

Said modelling should include the following considerations and information as a minimum requirement:

1. Meteorology measurements: Wind speed and direction for at least one month during the south-western and north-eastern seasonal winds (winter and summer);

2. Marine currents measurements: High and low tide currents and the currents resulting from wind action on the surface, the central and seabed waters covering an area of (1) km on either sides of the discharging point and for (1) km into the sea;

3. Seabed bathymetry: Depth contours covering an area of (1) km on either sides of the discharging point and for (1) km into the sea; and,

4. Multi-port diffusers should be used at the pipe-end, provided they allow gradual dispersion and assist in preventing the liquid from reverting to the beach area.

The following minimum discharge standards, as outlined in Table 2-1, are applied at the point of discharge, with all standards expressed in terms of milligrams per litre (mg/l) unless stated to the contrary:

Table 2-1 - Omani Federal Discharge Quality Standards [4]

Parameter	Standard
pH	Between 6 - 9
Temperature	<10 ºC above ambient temp
Biochemical Oxygen Demand (BOD) (5d@20degrees centigrade)	20.0
Chemical oxygen demand (COD)	200.0
Total Suspended Solids	30.0
Aluminium (as Al)	5.0
Arsenic (as As)	0.100
Barium (as Ba)	2.0
Beryllium (as Be)	0.300
Boron (as B)	1.0
Cadmium (as Cd)	0.010
Chromium (as Cr)	0.050
Cobalt (as Co)	0.050
Copper (as Cu)	0.200
Cyanide (total as CN)	0.100
Fluoride (as F)	2.0

Parameter	Standard
Iron (as Fe)	1.5
Lead (as Pb)	0.08
Lithium (as Li)	0.070
Mercury (as Hg)	0.001
Molybdenum (as Mo)	0.05
Nickel (as Ni)	0.100
Nitrogen: Ammoniacal (as N)	1.0
Nitrogen: Nitrate (as N)	15.0
Nitrogen: Organic (Kjeldahl) (as N)	5.0
Total-Nitrogen	15.0
Oil & Grease	15.0
Phenols (total)	0.002
Phosphorus (total as P)	2.0
Selenium (as Se)	0.020
Silver (as Ag)	0.010
Sulphide (total as S)	0.100
Total chlorine (as Cl_2)	**0.4**
Vanadium (as V)	0.100
Zinc (as Zn)	1.0
Faecal Coliform Bacteria (per litre)	1,000
Viable Nematode Ova (per litre)	<1
Organo-halogens	<0.001
Pesticides or their by-products	<0.001
Organosilicon compounds	<0.001
Organocopper compounds	<0.001
Organotin compounds	0.00002

2.2 US EPA Chronic and Acute Toxicity Thresholds

The United States Environmental Protection Agency (US EPA) provides acute and chronic toxicity thresholds for various pollutants as maintained in the National Recommended Water Quality Criteria - Aquatic Life Criteria Table [5]. These thresholds are terms as the Criterion Maximum Concentration (CMC) and Criterion Continuous Concentration (CCC) respectively.

The toxicity thresholds are described for both acute (1 hour) and chronic (96 hour) averaging periods and each have a maximum 1 period exceedance over any three-year period.

The CMC criterion (applicable to non-continuous discharge concentrations) must be met within a set distance of the outfall, as defined by the most stringent of the following three options:

- Option 1: 10% of the RMZ;
- Option 2: 50 times the discharge length scale (square root of the area of each discharge port) in any spatial direction; or,
- Option 3: 5 times the local water depth at the point of discharge.

Based on these options, the most stringent standard would therefore be applied over a distance of 17.7 m (Option 2).

A summary of these limits is provided in Table 2-2.

Table 2-2 – US EPA Toxicity Thresholds for Residual Chlorine [5]

Pollutant	CMC	CCC
Descriptor	Acute	Chronic
Averaging period	1 hour	96 hours
Allowable Exceedances	1 every three years	1 every three years
Concentration (Chlorine)	**13 µg/L**	**7.5 µg/L**
Required to be met within	17.7 m	300 m

It should be noted that toxicity thresholds are defined based on eco-toxicity testing at up to three trophic levels and generally include zooplankton species (e.g. *Daphnia*), the most stringent of which is selected in an attempt to ensure the majority of species are protected. The values therefore do not necessarily represent toxicity values for macro fauna species.

2.3 International Finance Corporation

In keeping with a conservative approach, international best practice standards are also considered for application to this project.

Therefore, the IFC EHS guidelines for Thermal Power Plants [6], can be applied to the discharges to thermal desalination plants due to general similarities in the discharge contents. Despite the fact that this project involves the development of a reverse osmosis desalination system, the IFC standards are considered applicable to this scope of works.

Based on this approach, the following discharge standards for residual chlorine are applied for the purposes of assessment in this study.

Table 2-3 – IFC EHS Guidelines for Thermal Power Plants [6]

Parameter	Standard
Chlorine (residual)	0.2 mg/l

2.4 Summary

A review of relevant regulations indicates that a target water quality objective of less than 2 parts per thousand (ppt) at the edge of the regulatory mixing zone (RMZ) of 300 metres is suitable for brine discharges into the marine environment. In terms of the modelling assessment, this requirement will be converted to a target dilution ratio and incorporated into the model set up.

Residual chlorine at the point of discharge will be assessed against the IFC EHS Guidelines for Thermal Power Plants [6], with ambient concentrations compared to the US EPA CMC and CCC toxicity thresholds [5].

3 Modelling Systems

3.1 3D Hydrodynamics (GEMMS 3D Coastal Ocean Model)

GCOM3D has a proven record for modelling ocean currents the world over, and has been validated extensively in many locations.

GCOM3D calculates water currents in both the horizontal and vertical planes. The model operates on a regular horizontal grid and uses a z-coordinate vertical-layering scheme (there is a varying number of layers, depending on the depth of water, and each layer has a constant thickness). This scheme avoids errors in current predictions at a particular depth caused by averaging of currents over varying depths, as used in sigma co-ordinate and “depth-averaged” model schemes.

3.2 Plume Dispersion

3.2.1 Mixing Processes

The mixing and dilution of brine from the marine outfall can be considered in two distinct phases, near-field and far-field dilution.

The initial near-field dilution is a function of several parameters including:

- The physical properties of the discharge;
- The momentum flux of the discharge velocity, which induces entrainment of the surrounding ambient fluid;
- The speed (and direction) of the receiving waters; and
- The design of the diffuser/outfall.

Far-field mixing and dilution rely on the ambient conditions of the receiving waters (tidal and wind driven currents, wave induced turbulence and thermodynamic gradients) to induce horizontal and vertical mixing.

Some plumes are positively buoyant and will rise to the surface (e.g. oil) whilst denser (negatively buoyant) plumes (such as brine) will sink to the bottom of the water column. While both plumes will undergo similar near-field mixing processes of entrainment induced by momentum flux, buoyant plumes experience more mixing in the far-field than dense plumes, as buoyant plumes ultimately reside near the surface where the actions of turbulent mixing due to winds (and waves if in the ocean) are more pronounced.

In the far-field, dense plumes tend to move in the lower part of the water column where mixing occurs predominantly due to bed velocities, baroclinic flows and turbulent mixing down from the surface, which are typically less energetic, depending on the depth of the water, than the processes closer to the surface.

Simulation of these processes can be carried out in three ways:

- The use of near field dilution algorithms which define the near-field dilution achieved by different discharge/diffuser configurations;

- The use of specific near-field CFD (computational fluid dynamics) sub-models such as the US EPA CORMIX and PLUME3D models to define the behaviour of the water in the first few metres from the outlet; or

- Undertake laboratory studies with scaled down models of diffusers to measure initial dilution under a range of receiving water conditions. A relationship can then be determined which can be used in far-field modelling to define the initial dilution.

3.2.2 Cornell Mixing Zone Expert (CORMIX)

The CORMIX model is an approved US EPA mixing zone model and primarily used for the assessment of regulatory mixing zones resulting from continuous point source discharges. Mixing behaviour can be assessed from a range of discharge designs within bounded channels (e.g. rivers, estuaries or industrial discharge channels) and unbounded channels (e.g. coastline or lakes). The mixing behaviour is modelled based on discharge characteristics and ambient conditions such as current speed, buoyancy of the brine, stratification of the ambient fluid, brine flow rate and port diameter/design. CORMIX is particularly effective at determining near field mixing characteristics based on outfall design and the ambient conditions at the point of discharge.

3.2.3 GEMMS 3D Plume Discharge Model (PLUME3D)

The more advanced 3D model was required in order to accurately simulate the behaviour of the plume when influenced by ambient parameters, such as winds and tides in the far-field.

PLUME3D is a Lagrangian random walk far-field plume dispersion model which obtains oceanic conditions from GCOM3D and includes 3D plume dispersion algorithms for modelling the far-field behaviour of a wide variety of discharge materials including sediments, sewerage, thermal discharges, oils and chemicals, accounting for processes such as dispersion and dissolution, under defined release conditions (quantity, rate etc).

PLUME3D uses predictions from GCOM3D to provide the ocean conditions into which the discharge is released. The Lagrangian nature of the model allows the discharge plume to be simulated throughout the water column taking into account the effects of natural processes such as surface waves, horizontal diffusion and dispersion. The model is free from numerical diffusion problems (such as experienced by Eulerian models) because it is not run on a grid.

The plume model can be used stochastically if required, to simulate a large number of random events over time or can be used for specific case studies in a deterministic mode.

PLUME3D can model the behaviour of a variety of constituents within a single release volume given information on the density and other physical and chemical parameters. The model reports mass and concentration levels on the water surface, on shorelines, in the sediments or through the water column. Where multiple constituents are involved, the model can report the distribution of each constituent individually. Horizontal and vertical cross-sections are also available to better illustrate the three-dimensional distributions.

4 Methodology

4.1 Overview

The hydrodynamic model is used to generate ocean tide and 3D current data, a pre-requisite to the subsequent plume modelling. The results of this hydrodynamic modelling have been used to 'drive' the plume and coastal processes assessments.

The assessment was broken down into the following components to enable a full and comprehensive assessment to be carried out:

- Hydrodynamic Modelling;
    - 3D Hydrodynamic Modelling (GCOM3D);
- Brine Plume Assessment;
    - Near-Field Plume Dispersion Assessment (CORMIX);
    - Far-Field 3D Plume Dispersion Assessment (PLUME3D);

4.2 Hydrodynamic Modelling

4.2.1 Overview

The hydrodynamics of the project area were simulated utilising the GEMMS 3D Coastal Ocean Model (GCOM3D) driven by tidal constituent amplitude and phase predictions for the Arabian Gulf by the Oregon State University (OSU) global tidal model and by meteorological data from the European Centre for Medium-range Weather Forecast (ECMWF). An overview of the hydrodynamic modelling approach is presented in Figure 4-1 and Table 4-1 for reference.

Figure 4-1 –Modelling Flow Chart

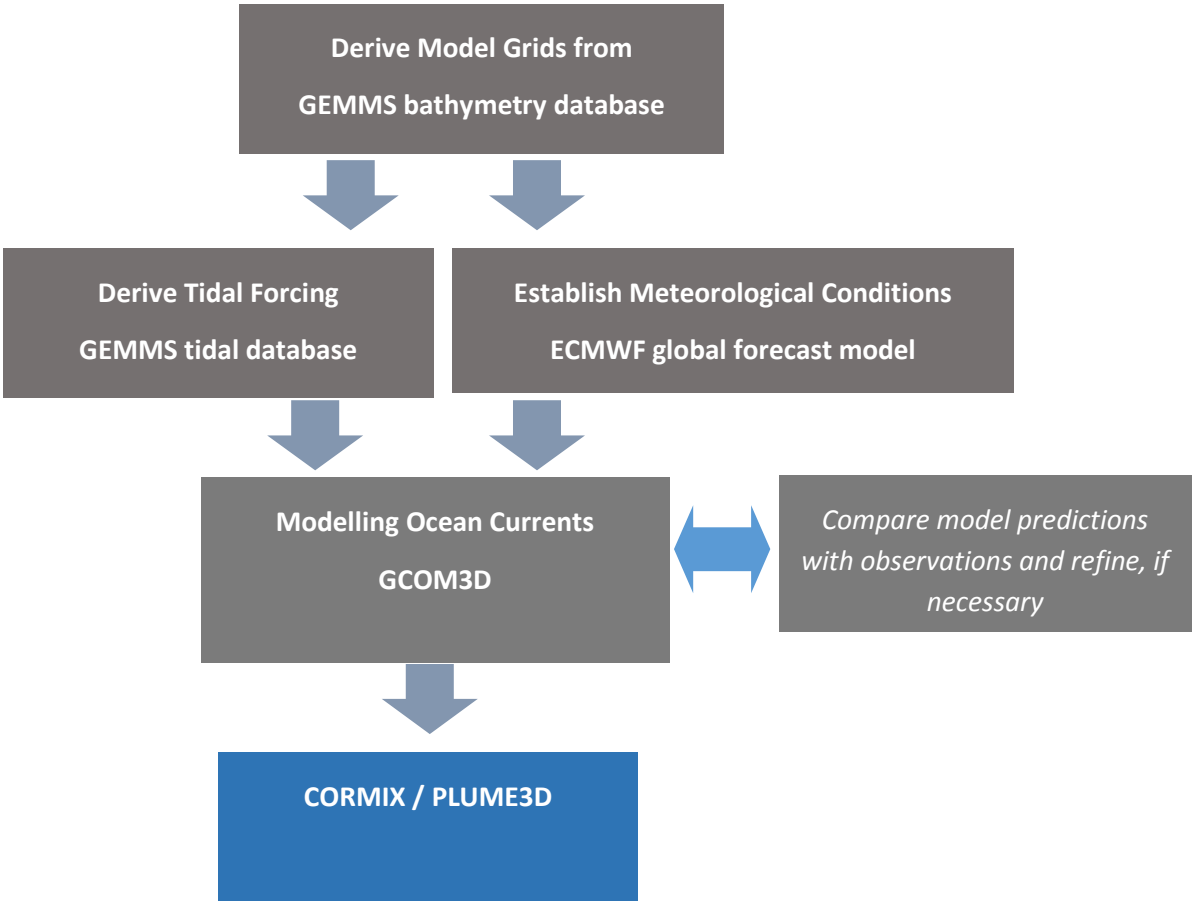


Table 4-1 – Summary of Hydrodynamic Modelling Approach

Task	Hydrodynamic Modelling
Model	GCOM3D
Model Features	3-dimensional Horizontal and vertical planes z-coordinate vertical layering scheme
Meteorological Data	European Centre for Medium Range Weather Forecasting (ECMWF) Re-Analysis Interim Data (ERA-Interim) at 80 km spatial and 6-hour temporal resolution.
Period Modelled	Two simulations for 1 month from 01/01/2016 and 01/07/2016 to cover both winter and summer conditions respectively.
Bathymetry	Simulations were conducted for the existing physical bathymetry only.
Model Verification	Verification was conducted against water heights predicted using harmonic constituents at the nearest tide station at the Port of Salalah over a period of 30 days in January 2017.
Resolution	50 m

4.2.2 Ocean Model Setup

The modelling domains were driven by the best available tidal and meteorological data, with the physical domains being developed utilising multiple sources of bathymetric and topographic data. The model set-up is considered the most suitable, considering the availability of relevant project specific data.

4.2.3 Model Grids and Bathymetry

Bathymetry within the project area was obtained from a number of sources in order to accurately portray the physical environment within the modelling domain. The sources of data utilised, in the order that they were used, are summarised below:

- General Bathymetric Chart of the Oceans [7];
- British Admiralty Bathymetric Charts 2895 [8];
- A bathymetric survey of the coastal areas in the vicinity of the project; and,
- Manual manipulation of the bathymetric grid data to better define existing coastal features identified via satellite imagery.

Specific bathymetric data collected in in the area of the Salalah IWP project included both a physical bathymetric and topographic survey.

The physical surveys were conducted by Masirah International Technical and Marine Services LLC between 18th December 2015 and 23rd December 2015. The survey was conducted over an area of approximately 300 hectares which covered 2,000 m of coastline and approximately 1,500 m out to sea with a survey line spacing of 50 m. Additional detail can be found within the Bathymetric Survey Report within Appendix A.

The final small and large bathymetric grids (immediate Project Area and Overall Salalah Bay respectively), created from all data sets described, and which incorporate the entire modelling domain over the project area are presented within Figure 4-2 and Figure 4-3.

The modelling was conducted on a 50 m spatial and 30-minute temporal resolution. Pre-determined locations were inserted into the model to generate numerical outputs for comparison purposes. The location of these ‘stations’ are provided within Figure 4-4. High definition figures of the physical model set-up are provided within Appendix C.

Figure 4-2 –Project Area Bathymetric Grid

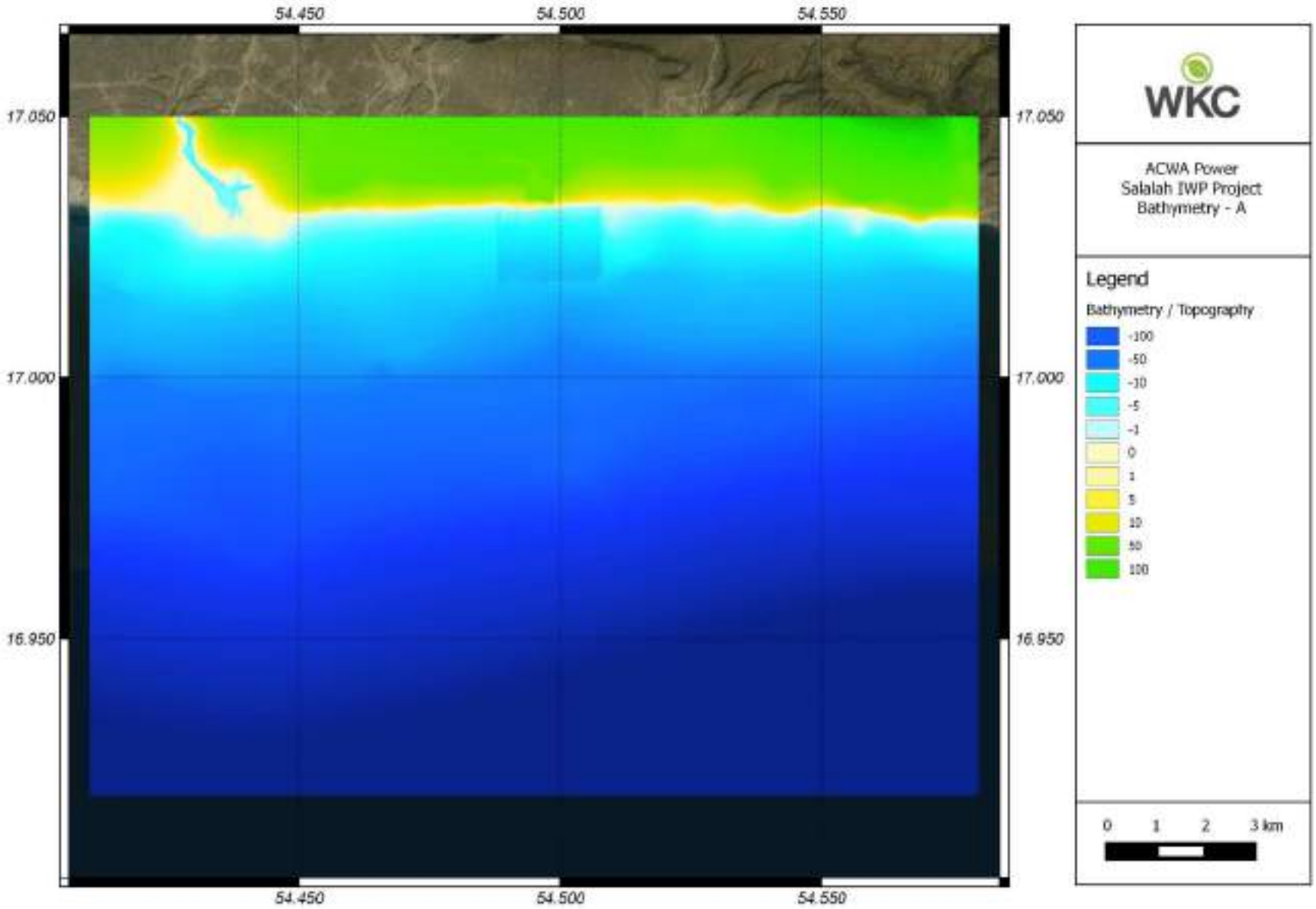


Figure 4-3 – Salalah Bay Area Bathymetric Grid

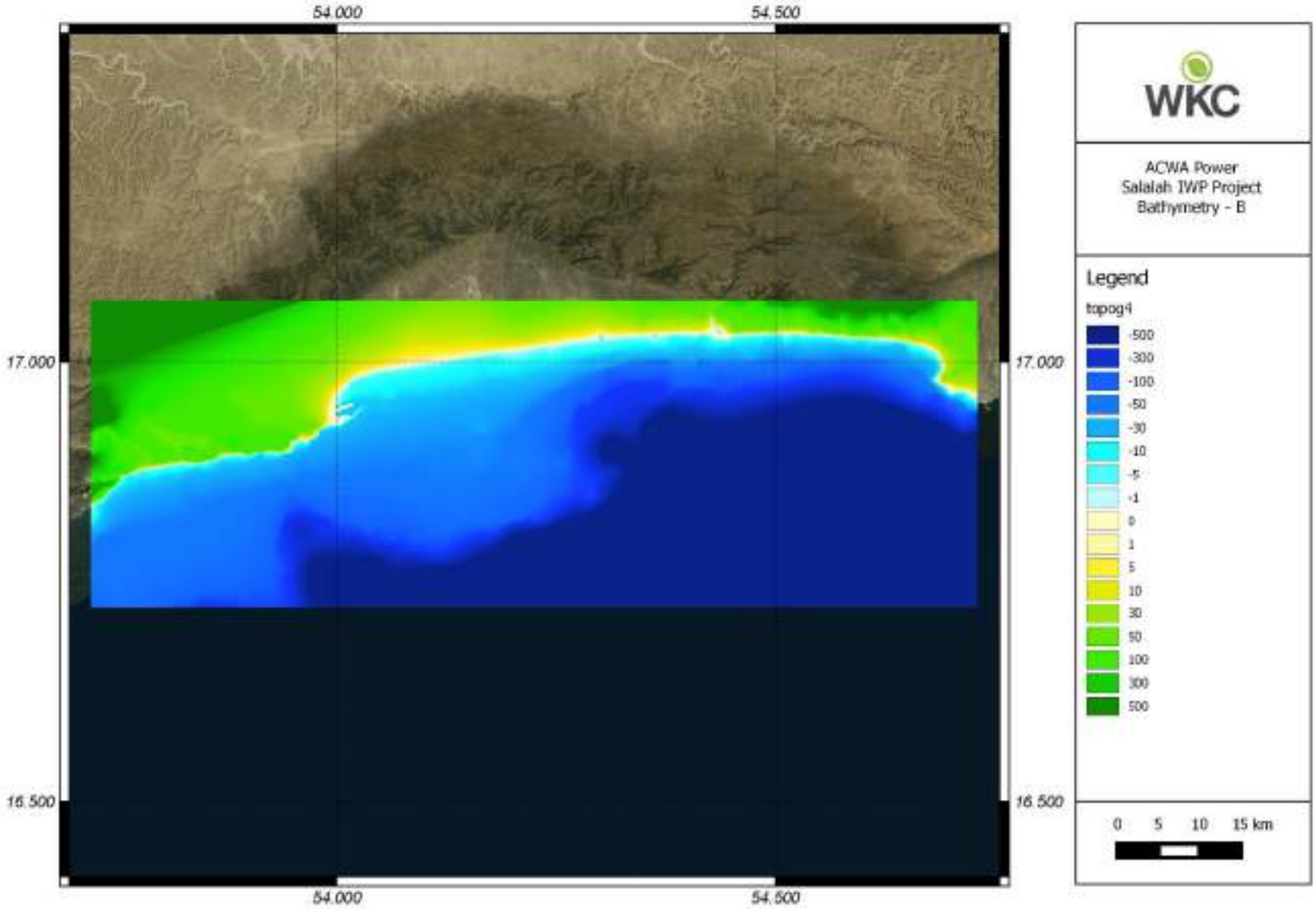
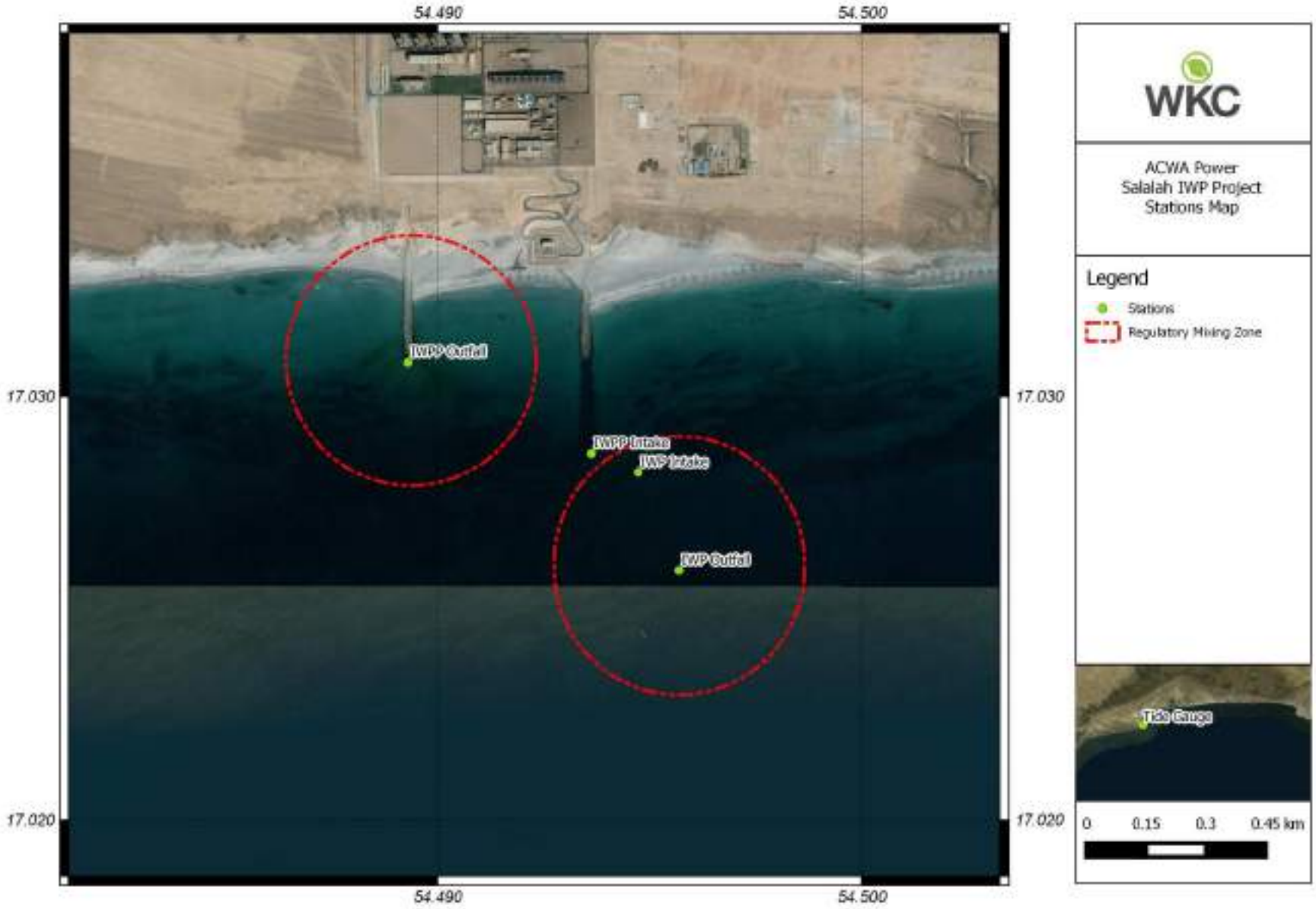


Figure 4-4 - Station Locations



4.2.4 Winds

Wind data was obtained from WKC's data base of global reanalysed forecast data from the ECMWF. The ECMWF routinely operates a suite of Numerical Weather Prediction (NWP) models at a range of spatial and temporal resolutions.

Data from a routinely archived data set of these winds have been used to force the GCOM3D models. For the model grids, the ECMWF winds are available at a grid resolution of approximately 70km and at every six hours.

Wind roses in the months of January 2017 and July 2016 at the project location (IWP Outfall) are provided within Figure 4-5 and Figure 4-6. The dominant wind direction at the site changes dramatically between the seasons, which in summer is the primary cause of the Khareef weather between June and October.

Figure 4-5 - Wind Rose (ECMWF) at IWP Outfall (January 2017)

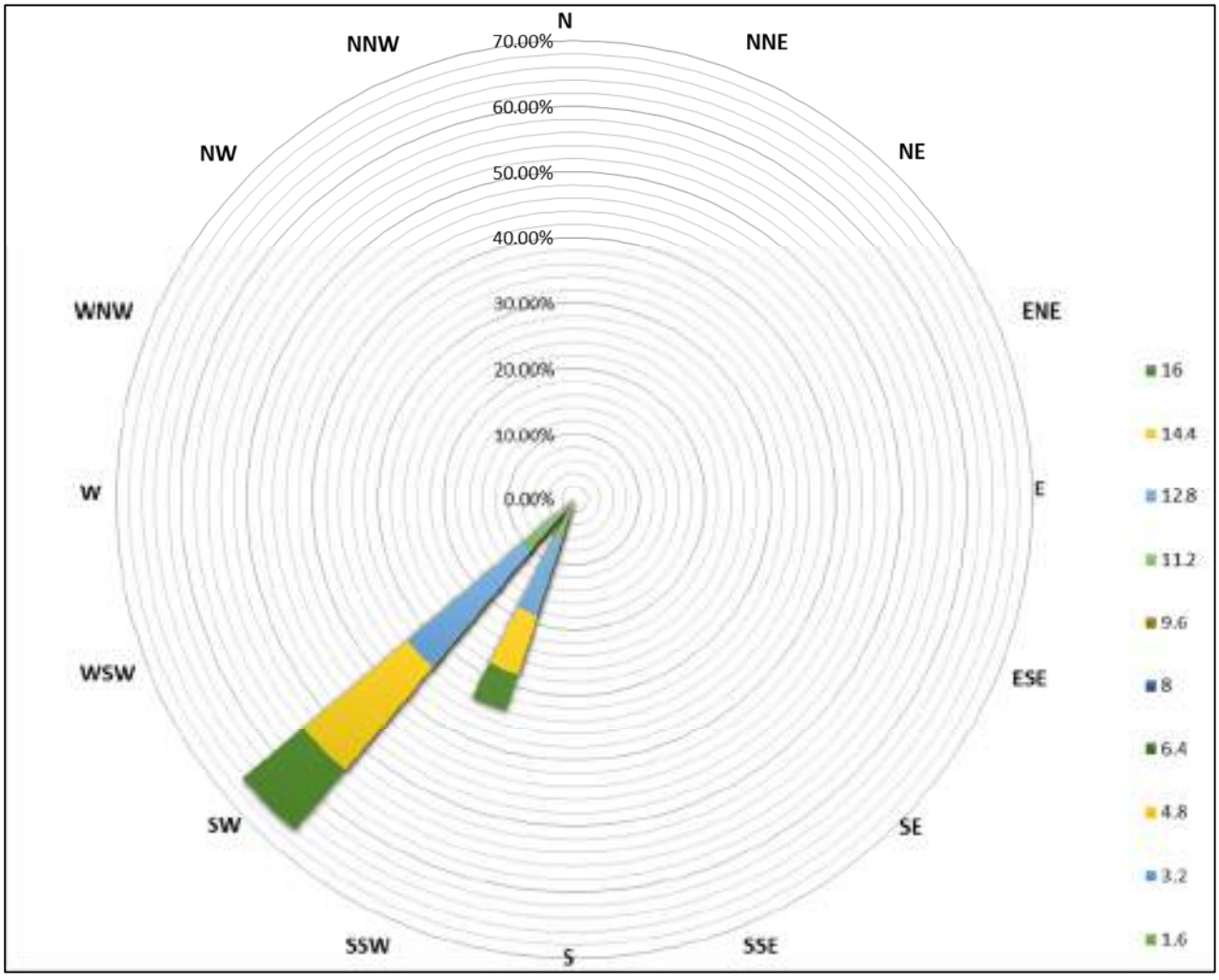
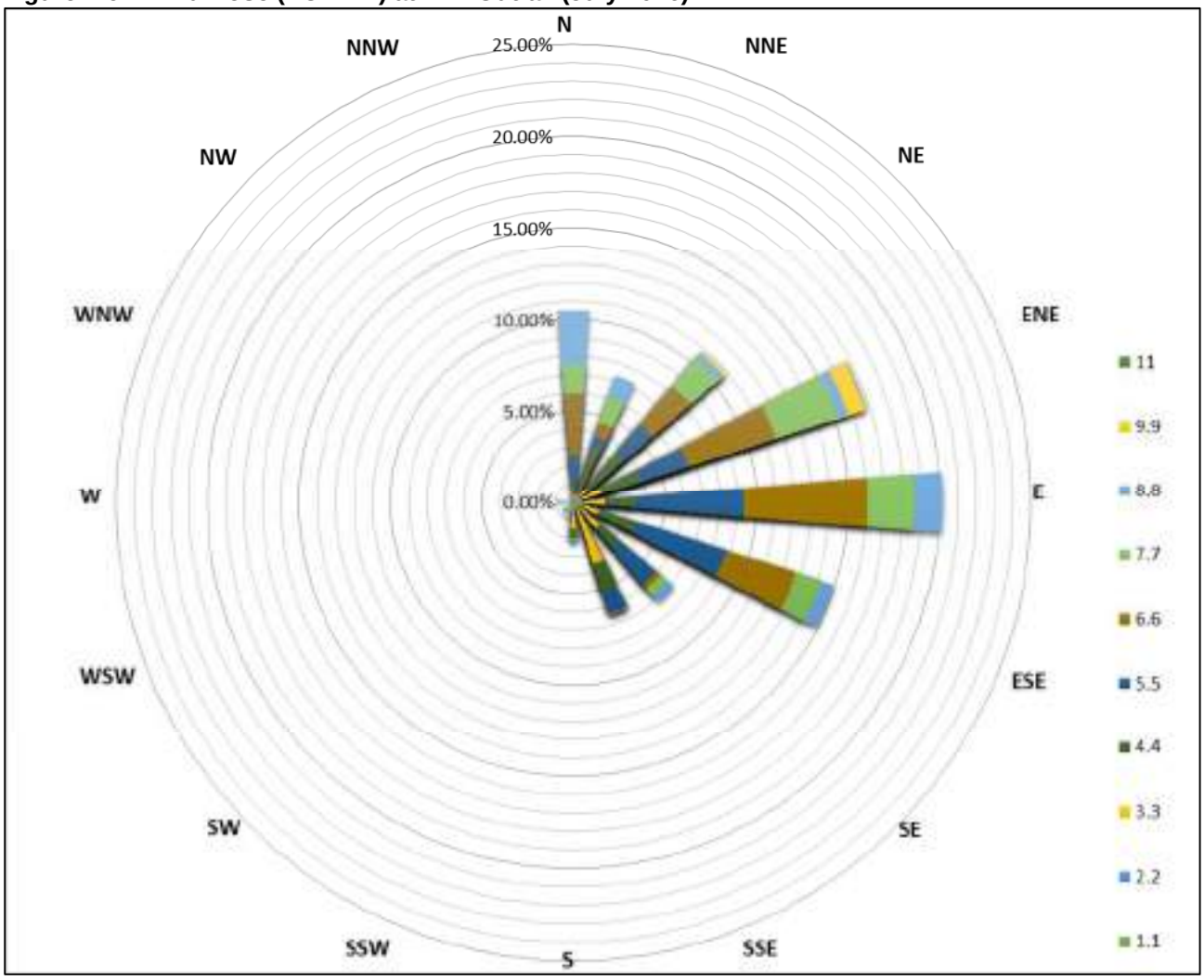


Figure 4-6 - Wind Rose (ECMWF) at IWP Outfall (July 2016)



4.2.5 Tides

In order to accurately simulate the propagation of the tides to the project area within the modelling domain, boundary tidal conditions were sourced from the Oregon State University (OSU) Tidal Data Inversion Model [9]. The modelled tidal constituent data was checked against constituents obtained through measurements at local ports, sourced from the UKHO Admiralty Tide Tables [10].

4.3 Simulation of Brine Discharges

4.3.1 Overview

The Salalah IWP will make use of a single diffuser outfall located approximately 800 m from the shoreline. The diffuser will have five risers with a spacing of 5 m (totalling 20 m in length) with each riser has two ports facing in opposite directions at a vertical angle of 45°. Each of the ten (10) diffuser ports has a diameter of 0.4 m. The flowrate of brine through this outfall will vary from 11,680 m^3/hr to 12,270 m^3/hr (represented in the modelling as Scenarios 2 and 3 respectively). The IWP project is currently in the Engineering, Procurement and Construction (EPC) phase and once operational, will produce a concentrated brine stream which will be discharged through the Salalah IWP diffuser outfall

An additional existing outfall (known as the IWPP outfall) is located closer to the shoreline at the end of a man-made rock groyne and is included in the modelling assessment. The IWPP outfall consists of a single outfall

pipe, approximately 1.8 m below the surface which is orientated vertically upwards. The outfall has a diameter of 1.29 m and has a flowrate of approximately 6,000 m^3 of brine per hour. This outfall is represented in isolation for Scenario 1 (existing conditions) and is not expected to change during the development of the IWP outfall.

In summation, the following scenarios and outfalls were selected for assessment within this study:

1. Existing Conditions;
    a. IWPP Outfall – 6,000 m^3/hr.
2. Nominal Future Conditions;
    a. IWPP Outfall – 6,000 m^3/hr; and,
    b. IWP Outfall - 11,680 m^3/hr.
3. Exigency Conditions;
    a. IWPP Outfall – 6,000 m^3/hr; and,
    b. IWP Outfall – 12,270 m^3/hr.

In order to capture the near-field mixing facilitated initial momentum as the brine leaves the outfalls, the plume was first simulated utilising CORMIX. The far-field modelling was conducted utilising PLUME3D, with ambient conditions driven using outputs from GCOM3D.

The 'near field' can be defined as the zone where mixing behaviour is influenced by the momentum and buoyancy (influenced by discharge design and brine characteristics) of the discharge as well as boundary interactions. CORMIX is particularly useful in determining plume behaviour in the near field based on discharge brine parameters and is therefore considered suitable for this task.

The behaviour of the brine plumes at distance (within the 'far-field') is influenced by ambient parameters such as tidal currents (and tidal reversal), and meteorological conditions.

Brine characteristics and discharge design parameters were obtained from the client where possible and schematised into the CORMIX model to simulate mixing within short distances. The output from CORMIX was then interrogated by PLUME3D to determine the point where momentum no longer influenced plume trajectory. PLUME3D takes relevant data from this point (such as plume velocity, trajectory, density, dimensions, dilution etc.) to create an input file for use within the far-field assessment.

An overview of the 2-stage approach to modelling is presented in Table 4-2, with additional information provided in the following sections.

Table 4-2 – Plume Discharge Modelling Overview

Stage	Near-field Plume Modelling	Far-field Plume Modelling
Model	CORMIX	PLUME3D
Task Pre-requisite	GCOM3D Hydrodynamic Modelling	GCOM3D Hydrodynamic Modelling Near-field Plume Modelling
Model Features	Approved US EPA mixing zone model for near-field applications	Lagrangian random walk far-field plume dispersion model

Stage	Near-field Plume Modelling	Far-field Plume Modelling
Scenarios	Discharges from each outfall were simulated to determine mixing characteristics during mean current and ambient conditions.	The results of the near-field mixing simulations with CORMIX were incorporated at the end of the near field zone using the dilutions attained from CORMIX. In addition, variance in ambient parameters were considered for two seasons (summer and winter).
No. of Sources	2	2
Parameters Simulated	Dilution and Salinity	Dilution and Salinity

4.3.2 Near-Field Simulation methodology

Discharge Parameters

The brine parameters are important to define the differential of the parameters of concern with the ambient concentration in order that an assessment against criteria can be carried out. The brine parameters also define the buoyancy of the plume which will determine the plume trajectory and determine how the plume will interact with the ambient environment (i.e. will the plume rise to the surface, sink or remain neutrally buoyant), all of which can significantly affect mixing behaviour.

Parameter data was supplied by the Client based on historic works carried out as part of the design works. Where data gaps existed, parameters were calculated or conservatively assumed based on industry knowledge. A summary of the brine parameters for the undiluted and diluted scenarios is provided within Table 4-3.

Table 4-3 - Summary of Brine Parameters *

Parameter	Units	Value					
		Summer			Winter		
		Sc_1	Sc_2	Sc_3	Sc_1	Sc_2	Sc_3
Outfalls Included		IWPP	IWPP IWP	IWPP IWP	IWPP	IWPP IWP	IWPP IWP
Brine Flow Rate	m^3/s	1.277	3.245	3.408	1.277	3.245	3.408
Brine Temperature	°C	32	32	32	19	19	19
Brine Δ Temperature	Δ °C	2	2	2	2	2	2
Brine Salinity	ppt	50	67	67	50	67	67
Brine Δ Salinity	ppt	10	27	27	10	27	27
Brine Density	kg/m^3	1031.9	1044.8	1044.8	1036.2	1049.2	1049.2
Brine Δ Density	Δ kg/m^3	6.78	19.7	19.7	7.0	20.0	20.0

* - note that the IWPP outfall is included in all three modelled scenarios.

It is noted that the rate of dosing of chlorine in the IWP system is expected to be 5-15 mg/l of raw seawater. Shock dosing will occur for a period of 3 hours once every 72 hours. It should be noted that based on the understanding of the Project, residual chlorine at the point of discharge will meet the IFC EHS Guidelines for Thermal Power Plants [6] as one of the EPC requirements. Therefore, for the purposes of assessment, it is assumed that a maximum concentration of 0.2 mg/l will occur during dosing periods, with the average residual chlorine then calculated over a 72-hour period.

Table 4-4 – Semi-quantitative Chlorination Mixing Requirements

Maximum Cl_2 at Outfall	Average Cl_2 at Outfall	Dilutions Required	
mg/l	mg/l	US EPA CMC [5]	US EPA CCC [5]
0.2	0.00833	15.4	1.1
Notes			
Note that ambient chlorine dispersion and degradation in the environment (or within the IWP system) has not been simulated as shock dosing is not continuous and will only occur for 3-hour periods, once every 72 hours. As a result, the outfall concentration of chlorine is not expected to be constant			

Ambient Parameters

Ambient parameters, such as depth, current velocity, current direction, tidal period etc. were obtained from the GCOM3D simulations, and the bathymetric grid; and are time dependent in nature. However, certain parameters were assumed to be static in each near-field scenario.

For reference purposes, a summary of the ambient parameters is provided in Table 4-5.

Table 4-5 - Summary of Ambient Parameters

Parameter	Units	Summer		Winter	
		IWPP Outfall	IWP Outfall	IWPP Outfall	IWP Outfall
Depth at Discharge (MSL)	m	5.4	13.1	5.4	13.1
Ambient Velocity (mean)	m/s	0.233	0.449	0.242	0.427
Ambient Temperature (mean)	°C	30	30	17	17
Ambient Density (mean)	kg/m^3	1025.2	1025.2	1029.1	1029.1

Outfall Design Parameters

The outfall design was provided in the EPC data package for the Salalah IWP outfall and the diffuser parameters are shown in Table 4-6 below with schematics for both the IWP and IWPP outfalls shown in Appendix B.

Table 4-6 – Summary of Actual Outfall Design Parameters

Parameter	Units	Value (Actual)		Comment
		IWPP	IWP	
Outfall Distance from Shoreline	m	200	800	Approximate values
Number of risers	#	1	5	
Number of ports	#	1	10	
Riser Spacing	m	N/A	5	
Port Diameter	m	1.29	0.4	
Mean depth at discharge	m	5.4	13.1	
Port elevation above seafloor	m	3.6	1.5	Assumed
Discharge angle (vertical) [1]	°	90	45	
Discharge angle (horizontal) [2]	°	N/A	0 and 180	IWP Diffuser ports face in opposite directions, parallel to the shoreline
Notes				

Parameter	Units	Value (Actual)		Comment
		IWPP	IWP	
1: Vertical angle is measured from the horizontal plane. Positive values indicate the ports are oriented towards the water surface. 2: Horizontal angle is measured from the direction/position of the nearest bank (in this case the shoreline).				

The CORMIX software is based on laboratory experiments, therefore outfall designs must be 'schematised' (or simplified) to fit within the parameter confines that have been assessed within laboratory, or to a degree of similarity that it is considered likely that the same plume behaviour (or flow-class) will result. In addition, as CORMIX is often used as a design tool, the software does not allow parameters that the developers consider impractical. Please note however that none of the parameters listed in Table 4-6 were changed for the schematisation of these outfalls, however the gradient of the seafloor was assumed in each case to align with the required schematisation parameters.

The far-field modelling (Section 4.3.3) utilises the results from CORMIX to simulate the near-field mixing behaviour caused by turbulence associated with the initial momentum and buoyancy of the brine due to the exit velocity from the diffuser and the initial differential in density between the brine and ambient waters. During this near-field phase, the brine can be considered as 'jet-like', where the discharge and brine parameters are more significant in influencing mixing behaviour than ambient current speeds and directions.

Within this jet phase, the ambient conditions, such as current speed and direction will influence the behaviour and trajectory of the jet. However, CORMIX is a straight line, scenario model that cannot take into account differences in ambient conditions over time. Due to the design of the IWP diffuser and IWPP outfall, the ambient current will vary in strength and direction, however due to the constraints of CORMIX, these currents were assumed as per Table 4-5 in a single direction (average current speed taken from GCOM3D simulations).

The results of the near-field simulations are then utilised as input into the far-field simulations at a representative set distance where the momentum of the jet is minimal. This distance is representative only, as the actual jet behaviour and trajectory will vary depending on the influence from ambient current speeds and directions. The link between the near-field and far-field simulations is not an exact science. However, the estimation of near-field behaviour utilising near-field modelling software such as CORMIX is preferable to utilising simplified algorithms for this behaviour within the far-field modelling software itself.

4.3.3 Far-Field Simulation methodology

CORMIX is a steady state model (i.e. cannot take into account variables within the ambient environment e.g. variance in current speed and direction) therefore the brine plume has been simulated in the far-field using the sophisticated three-dimensional plume simulation model PLUME3D. This plume was simulated in both summer (July 2016) and winter (January 2017) for a period of 30 days.

PLUME3D has been linked to CORMIX so that the results output from CORMIX are automatically read into PLUME3D as inputs at a set, representative distance to account for the jet phase trajectory of the brine. Therefore, the input parameters within PLUME3D are identical to those within CORMIX, with the exception that additional time and space dependent ambient parameters are also considered.

Ambient parameters, such as three-dimensional currents speeds and velocities, surface wind speed and direction and temperature, are obtained directly from the hydrodynamic simulations obtained through GCOM3D.

4.4 Assumptions and Limitations

The modelling assessment has been carried out utilising the most accurate data available at this time, however a number of assumptions/calculations were used, these are summarised below:

4.4.1 Hydrodynamic Modelling

- Meteorological data input is derived from the ECMWF public domain model data and is relatively coarse spatially and temporally. The spatial resolution is not anticipated to produce significant error but the temporal resolution of 6 hours may tend to smooth out significant changes in the weather and underestimate peak conditions;

- Tidal forcing is based on tidal constituent amplitudes and phases from the OSU global tidal inversion model.

- The majority of bathymetric data was imported from a digitised British Admiralty chart [8]. This may result in some variation between modelled bathymetry and actual bathymetry due to the quality and spatial resolution of the chart soundings, or variance in actual bathymetry due to physical changes (such as dredging activity) across the domain.

- Validation of 3D current speeds and directions was not conducted due to lack of available 'observed' current data.

- Validation was carried out against tidal harmonic data collected at Salalah Port and published in the Admiralty Tide Tables for the Indian Ocean [11]. Tidal harmonic data is available for only four of the tidal constituents; namely the M2, S2, K1 and O1 harmonics, when in reality the tidal height at any location can be affected by many more. Therefore, the tidal heights predicted using the available tide tables may result in a perceived weaker correlation between simulated and observed findings.

4.4.2 Plume Simulations

- CORMIX simulations were carried out of a 'schematised' outfall design i.e. some variation between the simulated and actual design conditions exist, in order to fit the design within the parameter confines of the software.

- The linkage between near and far-field models is not an exact science. However, this method is considered more accurate that excluding the near-field factors, or using simplified algorithms to simulate this complicated behaviour.

- The outfalls simulated are based on designs provided by the EPC data package and other available information provided by the Client. No attempt at optimising the outfall/intake design has been carried out as part of this assessment.

- In mapping and presentation of the plume data, the 95^{th} percentile highest salinity concentration at each point in the modelling domain is calculated as an average through the depth of the water column.

- Shock dosing of chlorine is non-continuous, with dosing occurring for 3-hours, once every 72-hour period and has therefore not been included in the continuous outfall modelling assessment. It has been assumed for the purposes of assessment of chlorine dosing that Cl_2 at the point of discharge will meet an absolute maximum of 0.2 mg/l at the point of discharge [6] during shock dosing. The average concentration of chlorine over any 72-hour period is therefore 0.008333 mg/l.

5 Results

5.1 Hydrodynamic Modelling (GCOM3D)

5.1.1 Overview

In order to provide preliminary data, which captured a full tidal cycle and achieved steady state equilibrium, GCOM3D was run for one month (30 days) for the month of July 2016, and January 2017 to represent a summer and winter scenario respectively.

Figure 5-1 and Figure 5-2 show the typical circulation within the project area modelled during representative summer conditions. It is noted that particularly during summer, there is very little tidal influence as the strong monsoon (or Khareef) south westerly winds and the forcing effect of the coast line drive the currents in a generally constant direction from west to east across the bay.

Similarly, Figure 5-3 and Figure 5-4 shows a typical winter circulation although the tidal influence during this period is more pronounced. This is in part due to the generally lower wind speeds.

High definition plots of the currents of both summer and winter conditions are provided within Appendix D.

Figure 5-1 – GCOM3D Currents and Winds for Typical Summer Conditions (02/07/2016 22:30) – Wider Salalah Area

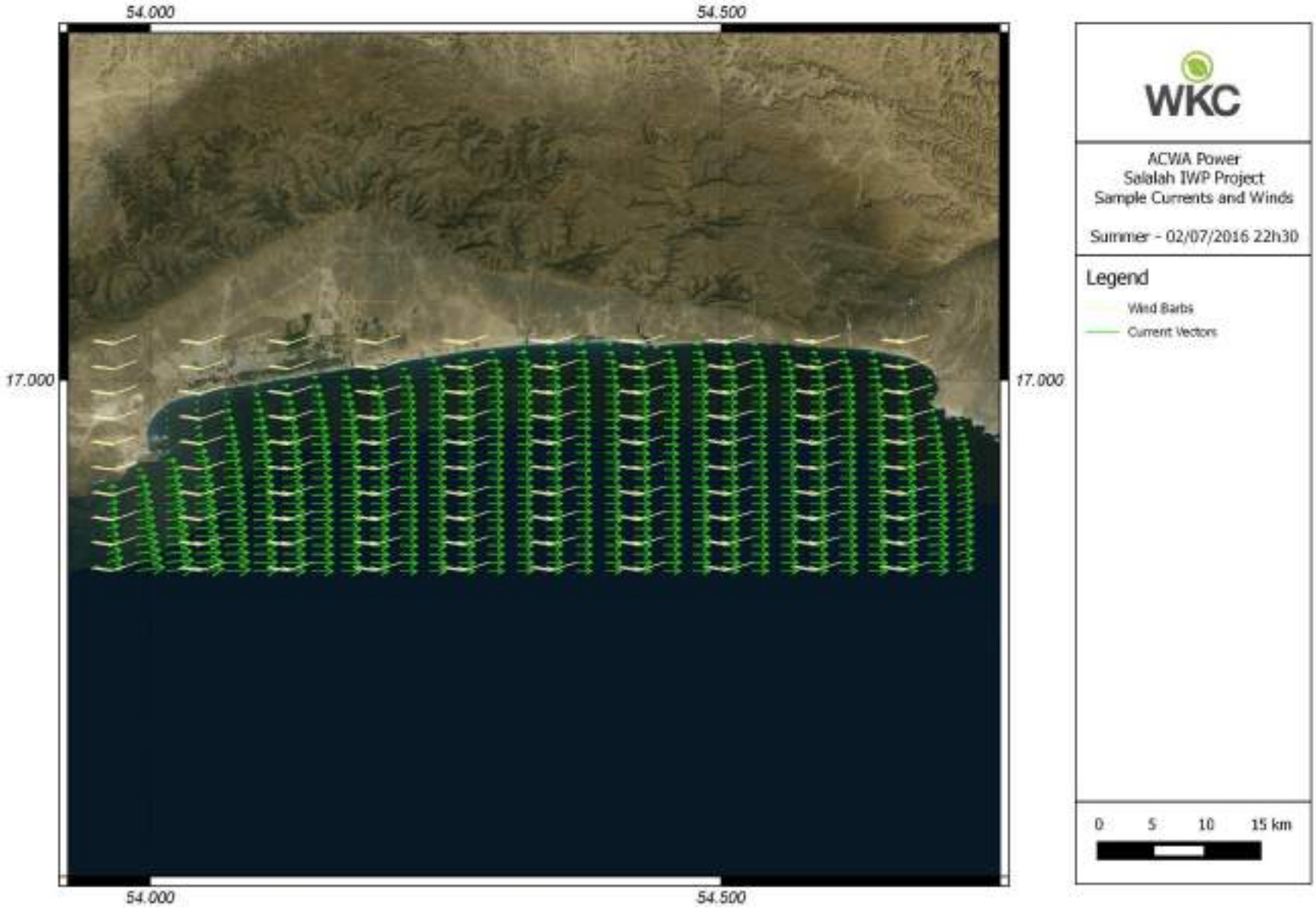


Figure 5-2 – GCOM3D Currents and Winds for Typical Summer Conditions (02/07/2016 22:30) – Project Area

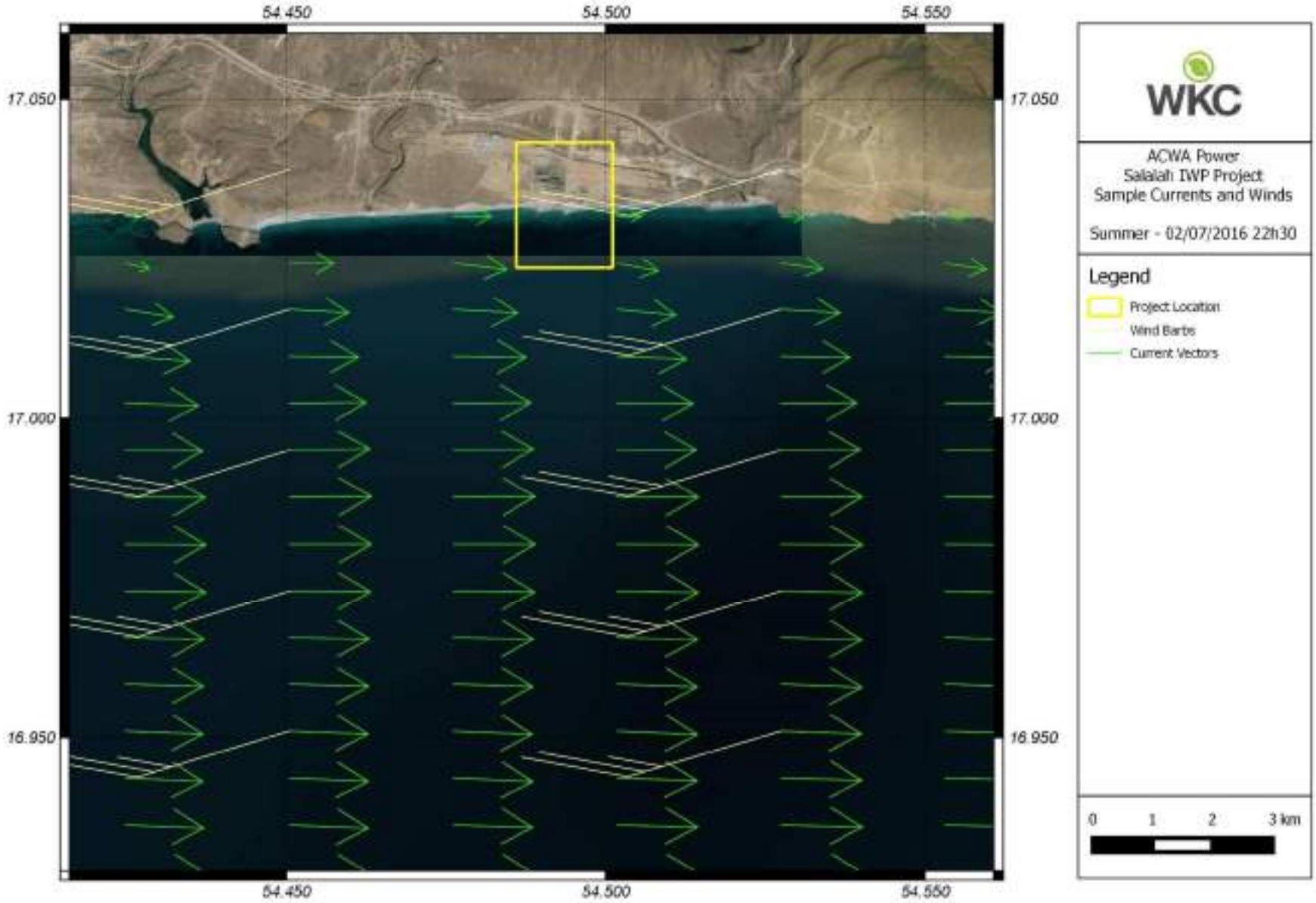


Figure 5-3 – GCOM3D Currents and Winds for Typical Winter Conditions (11/01/2017 11:00) – Wider Salalah Area

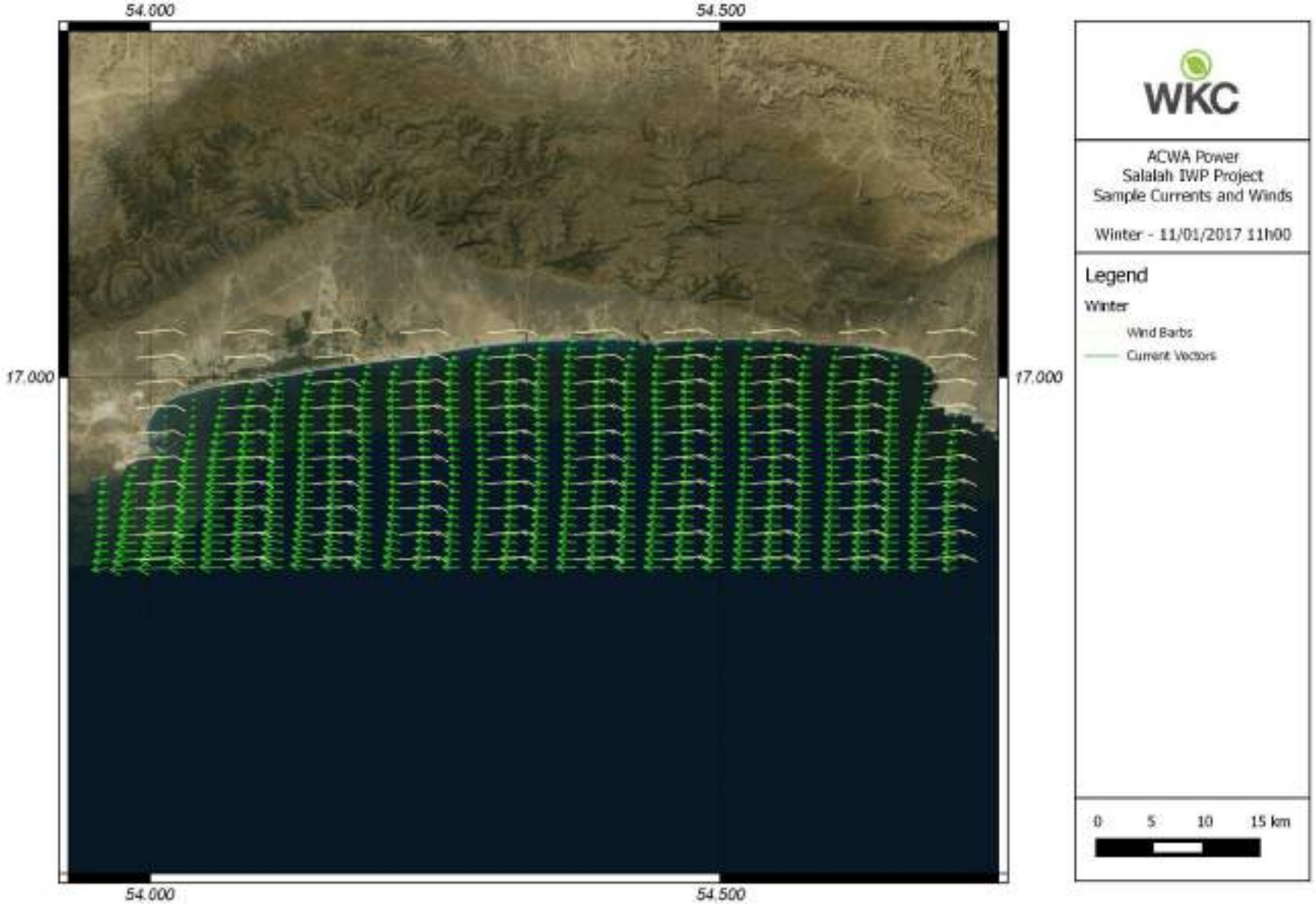
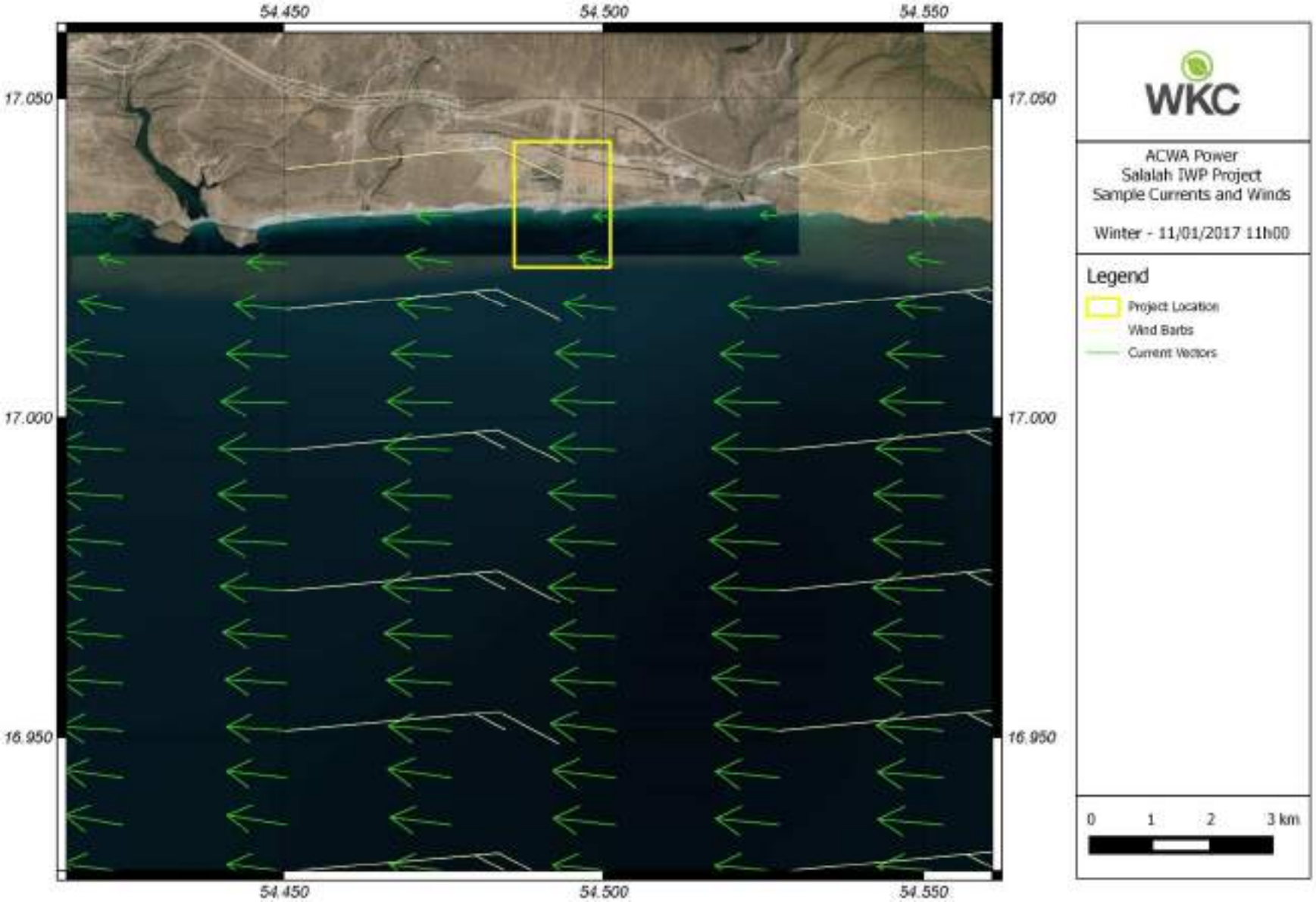


Figure 5-4 – GCOM3D Currents and Winds for Typical Winter Conditions (11/01/2017 11:00) – Project Area



The current velocities are relatively high, particularly during summer when strong Khareef winds create faster flowing surface currents across the bay from west to east. The influence of the tide during these periods is virtually unnoticeable beyond the immediate inshore area as the deeper waters are less affected by comparatively minor changes in sea level.

During winter, the effect of the wind is diminished and tidal influence and eddy-currents become more evident when considering prolonged periods. The general trend is however for winds and currents to flow from east to west during winter months. “Time-lapse” videos series for both summer and winter periods are shown in Appendix D.

Current speeds and constituent velocity profiles (u- and v-directions) are shown for summer and winter periods at the IWP outfall location

Figure 5-5 – IWP Outfall Ambient Surface Current Speed Profile - Summer

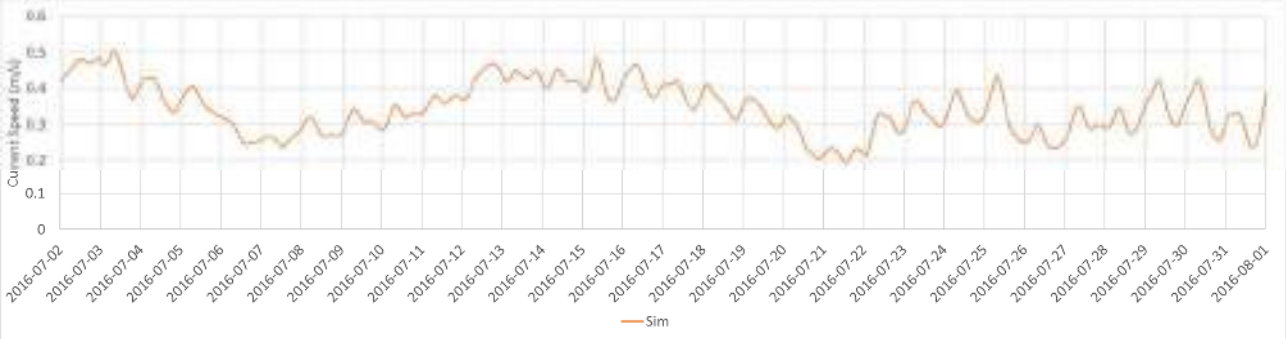


Figure 5-6 – IWP Outfall Ambient Surface Current U-velocity Profile - Summer

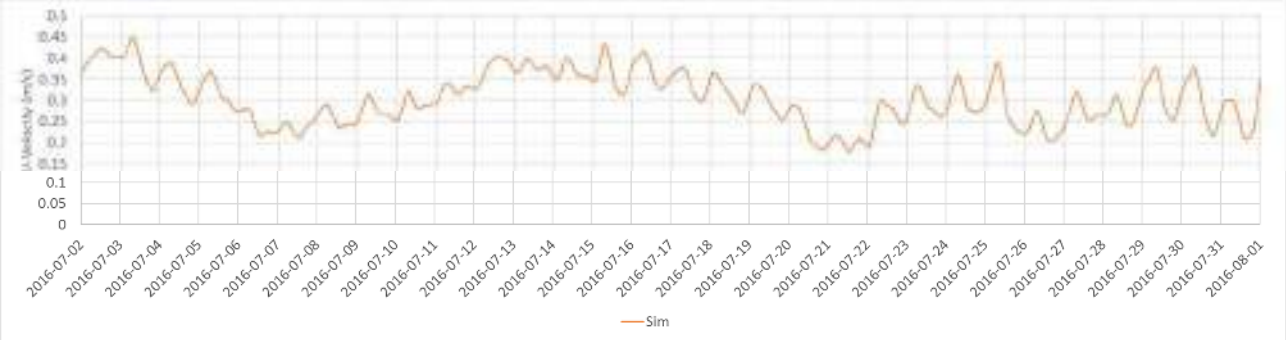


Figure 5-7 – IWP Outfall Ambient Surface V-velocity Profile - Summer

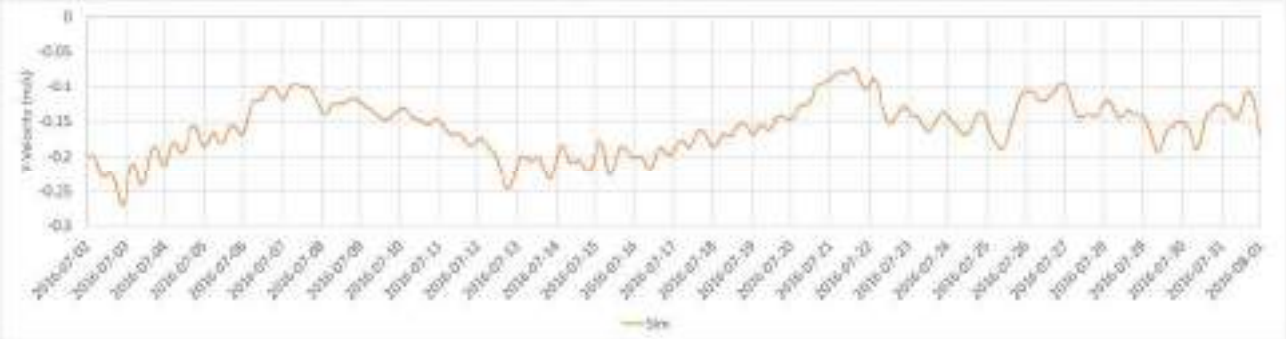


Figure 5-8 – IWP Outfall Ambient Surface Current Speed Profile - Winter

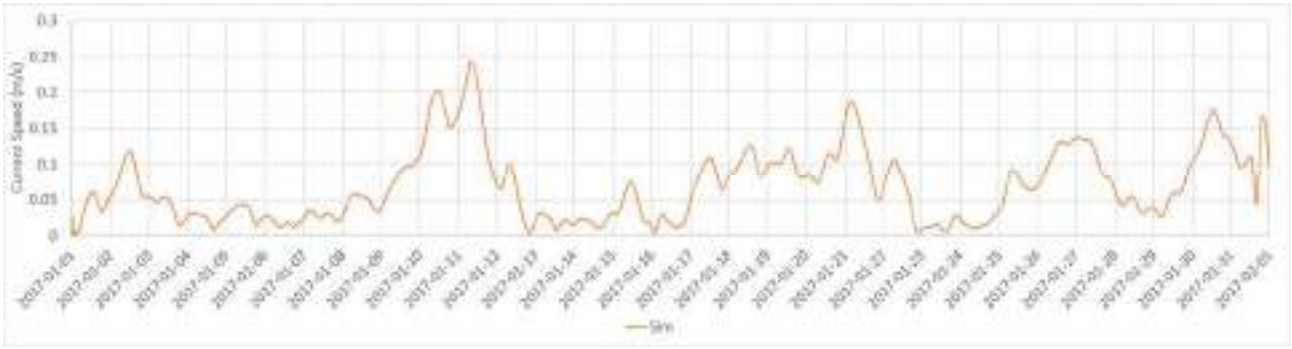


Figure 5-9 – IWP Outfall Ambient Surface Current U-velocity Profile - Winter

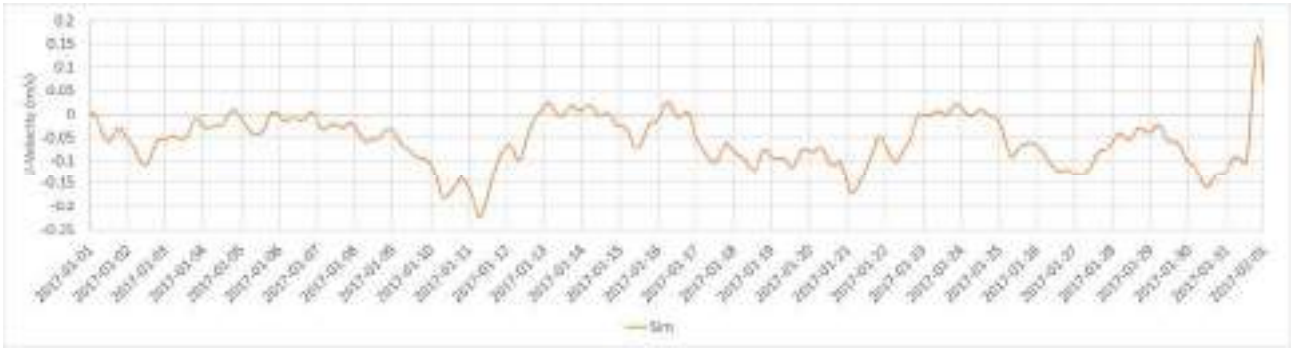
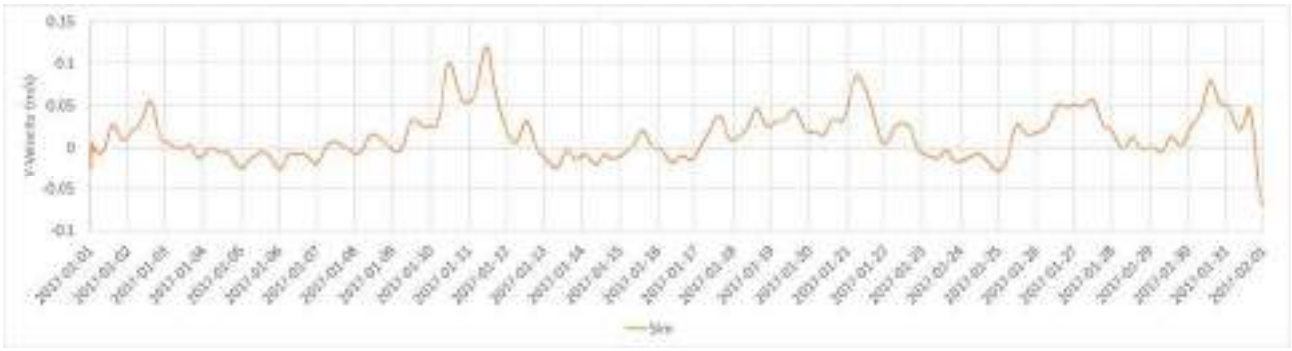
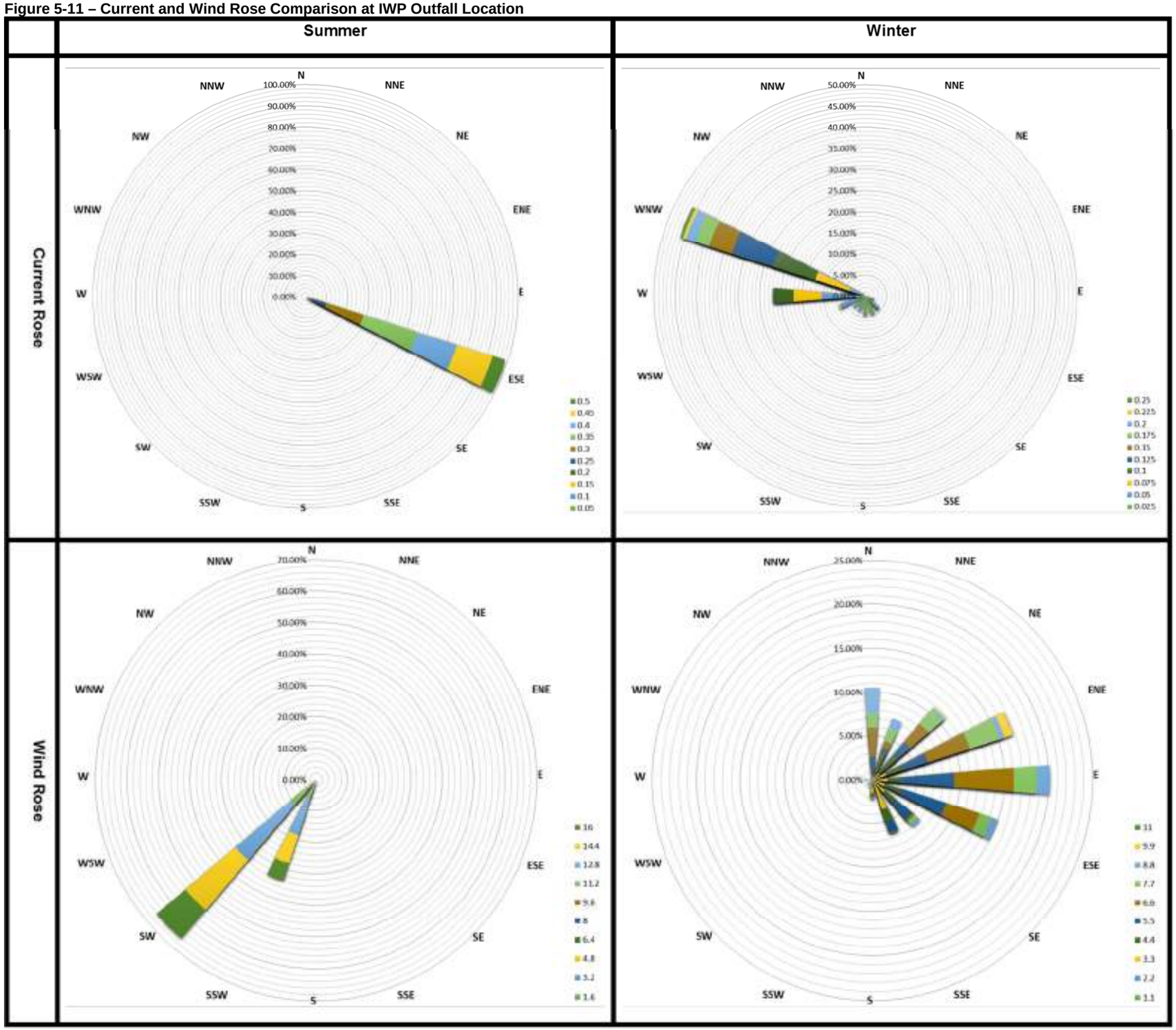


Figure 5-10 – IWP Outfall Ambient Surface Current V-velocity Profile - Winter



A comparison between wind and current roses for the IWP outfall location for summer and winter periods is provided within Figure 5-11. These current roses allow greater understanding of current direction, and subsequent plume dispersion. The current roses clearly show the increase in velocity of the currents at the IWP outfall location for the summer period, as the currents are forced by stringer surface winds. As expected, the roses also indicate a change in orientation for both wind and currents, caused by the seasonal Khareef conditions for which the Salalah region is famous.

Figure 5-11 – Current and Wind Rose Comparison at IWP Outfall Location



Current and wind speeds are shown in m/s

5.1.2 Verification of Tide and Current Predictions

The tidal water heights utilised within the assessment were simulated for the summer and winter periods using OSU and Admiralty Tide Tables in order to compare the model performance at simulating tidal variations in the area. In order to ensure that the hydrodynamic model is accurately simulating the physics of the area of interest correctly, a statistical analysis of tidal water height predictions was carried out for the tide gauge station at the Port of Salalah, for which the tidal constituent data is known. Due to the lack of available 'observed' data, validation of current speeds and constituent (u- and v-velocity) vectors was not carried out.

Please note that WKC do not calibrate our hydrodynamic models as this potentially leads to spurious results elsewhere within the modelling domain. Calibrating an entire modelling domain to ensure correlation between simulated and measured data at a single grid point does not provide a model validation, as if significant calibration is required then the behaviour of the ocean physics is not being accurately represented in the model. In addition, although calibration can ensure that the simulated data correlates with measured data at a single point of interest, the correlation factors utilised will also influence the simulated data at grid points where measured data is unavailable which a) may result in the modification of simulated data elsewhere that cannot be validated due to the use of a correlation factor not suitable to that point, and b) may result in unrealistic simulated data (due to correction of magnitude or direction) resulting from the use of an unsuitable correlation factor at that point.

GCOM3D utilises both tidal and meteorological data to simulate currents and water heights and, ideally, site specific current and water height data is utilised within the verification process. However, in this instance, no observed current or tidal height data is available and the model validation has therefore been carried out against tidal water height data from the tide station at the Port of Salalah only.

To statistically analyse the modelled data, the Index of Agreement (IOA) is compared to the semantic scale presented in Table 5-1. The statistical agreement and analysis of the data has been conducted for both periods and is shown in Table 5-2 below with explanation of the various metrics and indices given in the text that follows:

Table 5-1 – Correlation / Agreement Score Qualifications

Range	Qualification
0.8 < x < 1.0	Excellent
0.6 < x < 0.8	Good
0.3 < x < 0.6	Reasonable
0.0 < x < 0.3	Poor
x < 0.0	Bad

Table 5-2 – Statistical Performance of GCOM3D for Water Height

	RMSE	IOA	CORR	SkillV	SkillR
Ideal score	**0**	**1**	**1**	**1**	**<1**
Water Height	0.10	0.96	0.97	1.10	0.28

Table 5-2 presents the root-mean-square error (RMSE), the IOA, and the results of the Skill V and Skill R statistical test for water height, along with the ideal score for each test.

The RMSE can be described as the standard deviation of the difference for predicted and observed pairing at the tide gauge location. The RMSE is a quadratic scoring rule which measures the average magnitude of the error. The RMSE is a good measure of model performance, but since large errors are weighted heavily, its value can be distorted. RMSE is equal to the unit of the values being analysed.

The IOA can take a value between 0 and 1, with 1 indicating perfect agreement. The IOA is the ratio of the total RMSE to the sum of two differences, the difference between each prediction and the observed mean, and the difference between each observation and the observed mean. Therefore, the IOA is a measure of the match between departure of each prediction from the observed mean and the departure of each observation from the observed mean.

The correlation coefficient (CORR) gives the general correlation of any two sets of data, in this case the agreement of the observed and modelled water height at the Salalah tidal station located at the Port.

The Skill V test shows how closely the modelled standard deviation matches the observed standard deviation (close to 1 shows model skill), whereas Skill R takes into account systematic and unsystematic errors in relation to the observed standard deviation (less than 1 shows model skill).

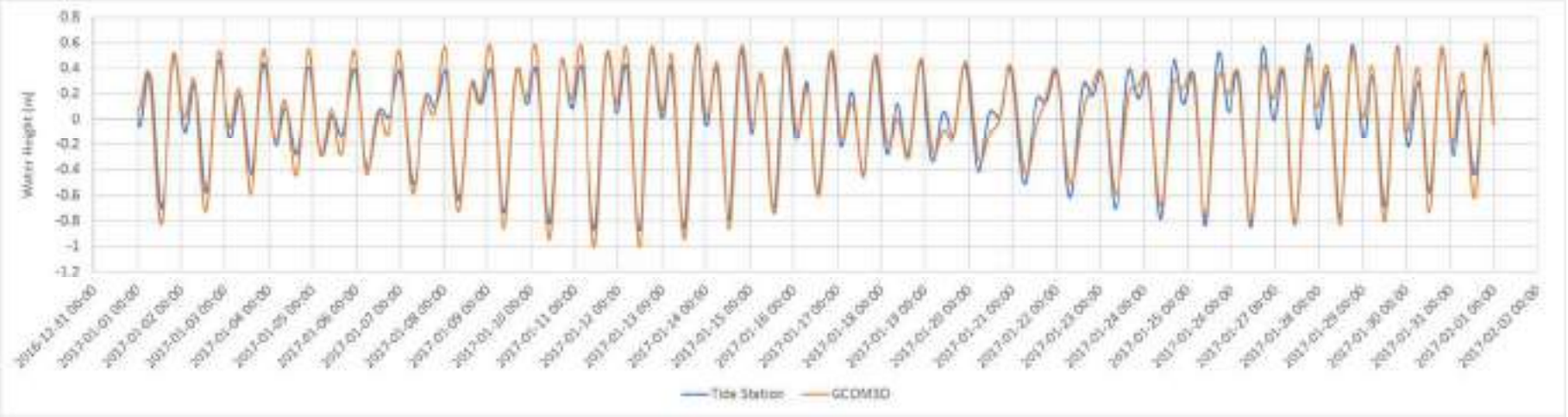
5.1.3 Discussion

Although no site-specific observed data is available, the correlation of the modelled water height data against the constituent predicted tidal heights shows excellent statistical, and good visual agreement as shown in Figure 5-12.

Due to the fact that only four constituents are known for the Salalah tidal station, it is expected that some disagreement will be present. Tidal water heights are influenced by upwards of 50 constituents around the world and only the four most prominent are included in the analysis carried out for the tide station in this instance. Additionally, observed current data is not available therefore more robust validation against observed currents was not carried out.

It is worth noting that due to the complexity of predicting ocean currents, WKC aim internally for an IOA of greater than 0.5, which was achieved for the water height analysis for modelled and constituent predicted tidal water height.

Figure 5-12 – Verification of sea level heights for the month of January 2017



5.2 Simulation of Brine Discharges

5.2.1 Near Field Simulations

The near-field simulations were carried out utilising CORMIX, the methodology of which is summarised in Section 4.3. The purpose of the near-field modelling is to accurately determine the dilution of the brine at short distances where plume momentum, initial spreading and buoyancy are more significant to dilution rate than ambient parameters. Dilution at this distance is heavily influenced by the outfall design (See Appendix B) and the brines physical characteristics (Table 4-3).

The near-field modelling did not attempt to 'optimise' the design of the outfall, as the design has already been finalised as per the EPC data package provided.

The CORMIX predictions indicated that the negatively buoyant, highly saline 'jet' is released at a marginally differential temperature of approximately 2°C from both the IWPP and IWP outfalls and in both cases, tends to sink to the seafloor.

In the instance of the IWP diffuser outfall, the flow is classified by CORMIX as an 'MNU1' class plume. This flow class describes a negatively buoyant plume emanating from a deeply submerged discharge port (or in this case diffuser) and sinking to the bottom in a crossflow current of less than 1 m/s.

At this point, the mixing is dominated by the initial momentum causing relatively constant spreading in the horizontal direction as the heavy plume disperses against the seafloor. Initial momentum begins to subside at approximately 7 m from the outfall structure, and the negatively buoyant plume centreline flows down the seafloor gradient into deeper water.

Due to the vertical design, the IWPP outfall produces a plume with a flow class of 'NV5'. This applies to "negatively buoyant plumes emanating from a vertical or near-vertical port, located near the surface". The initial momentum at the discharge point causes the plume to reach the surface and spread horizontally until the negative buoyancy takes over and the plume sinks back towards the bottom and is carried away by the ambient current.

For both simulations, the simulations continue after this point and into the far field region; however, they are beyond the intended scope of the CORMIX nearfield model (the far field is more accurately simulated with PLUME3D). Note that any inaccuracies further down the plume trajectory do not impact upon the accuracy of the assessment as a whole, as the far-field modelling commenced at approximately 8 m for both outfalls, where these inaccuracies were not yet evident.

5.2.2 Far-Field Simulations

The far-field modelling was conducted using PLUME3D utilising the predictions of the near-field CORMIX simulations to represent the dilution behaviour of the brine at distances where momentum and buoyancy are significant factors. It must be noted that CORMIX is a steady state model which does not take into account pooling effects, or re-entrainment due to tidal reversal. These effects are however accounted for within PLUME3D.

CORMIX is a straight-line, scenario based model which cannot vary plume trajectory or mixing behaviour due to variance in ambient current speed and direction that will occur at different points in time over the tidal cycle. It is therefore necessary to select a representative ambient condition, and distance along the plume trajectory at which the inputs to the far field simulations can be formulated.

PLUME3D automatically reads the CORMIX predictions files at these locations (approximately 8 m) to determine the geometry of the jet/plume, the depth, the number of dilutions achieved prior to this location, and the remaining momentum (if any). The concentration of the pollutant of concern is distributed within the jet in a Gaussian distribution from the plume centreline. PLUME3D is a modified Lagrangian particle

model, and therefore does not run on a grid, however analysis of the results was conducted at a spatial resolution of 20 m, with the results being analysed to determine the minimum plume centreline dilution (converted to excess salinity above ambient for ease of understanding) exceeded 5% of the time (otherwise known as the 95th percentile).

The assessment has considered the discharge of brine during representative summer and winter conditions. A comparison of the 95th percentile (below which 95% of simulations can be found) dilutions for summer and winter are provided in Figure 5-13 to Figure 5-18 with plots of dilution shown in Figure 5-19 to Figure 5-22. High definition plots are included within Appendix E.

Figure 5-13 – Differential Salinity (95th Percentile) – Scenario 1 – Existing Conditions (Summer)

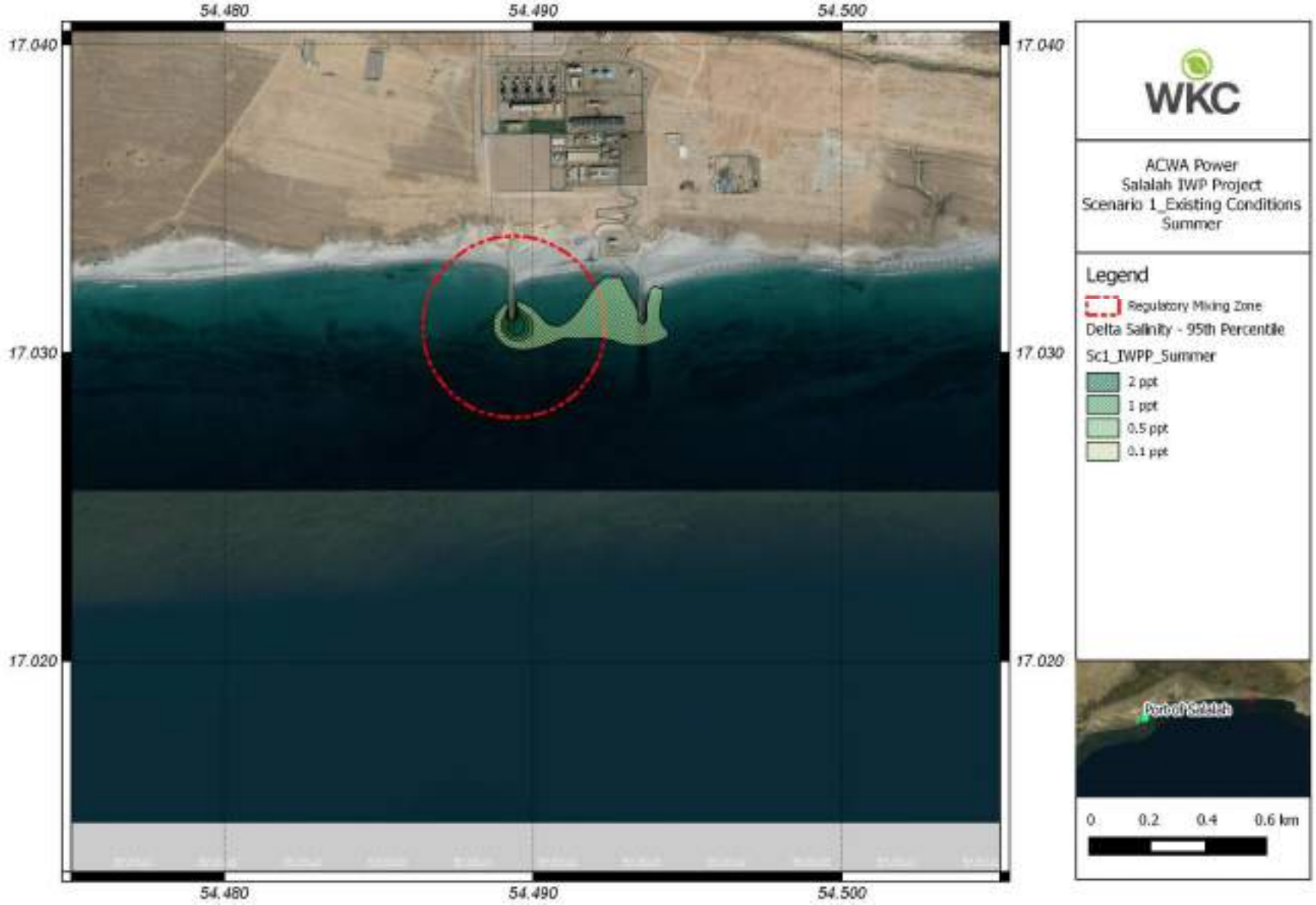


Figure 5-14 – Differential Salinity (95th Percentile) – Scenario 1 – Existing Conditions (Winter)

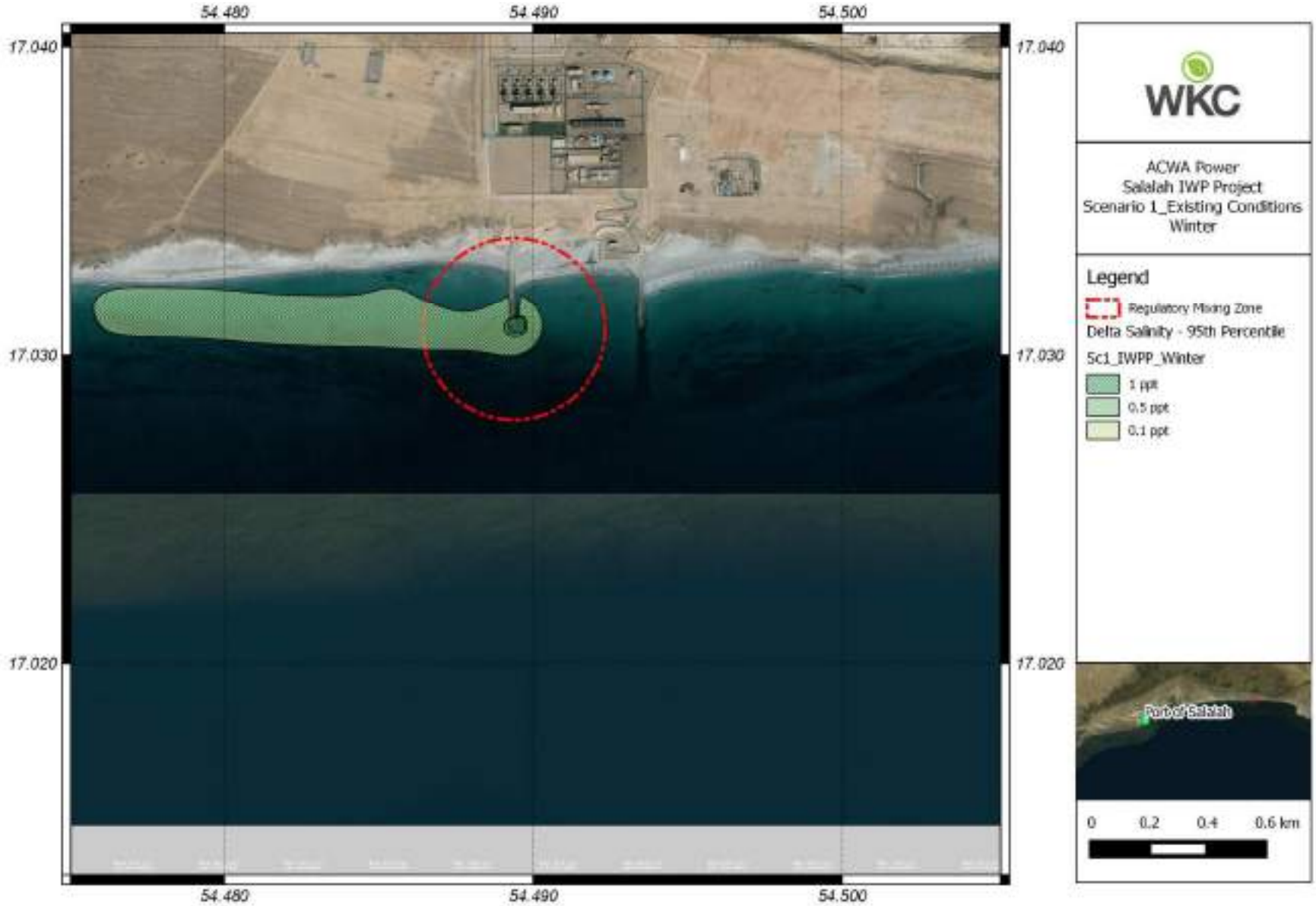


Figure 5-15 – Differential Salinity (95th Percentile) – Scenario 2 – Nominal Conditions (Summer)

Figure 5-16 – Differential Salinity (95th Percentile) – Scenario 2 – Nominal Conditions (Winter)

Figure 5-17 – Differential Salinity (95th Percentile) – Scenario 3 – Exigency Conditions (Summer)

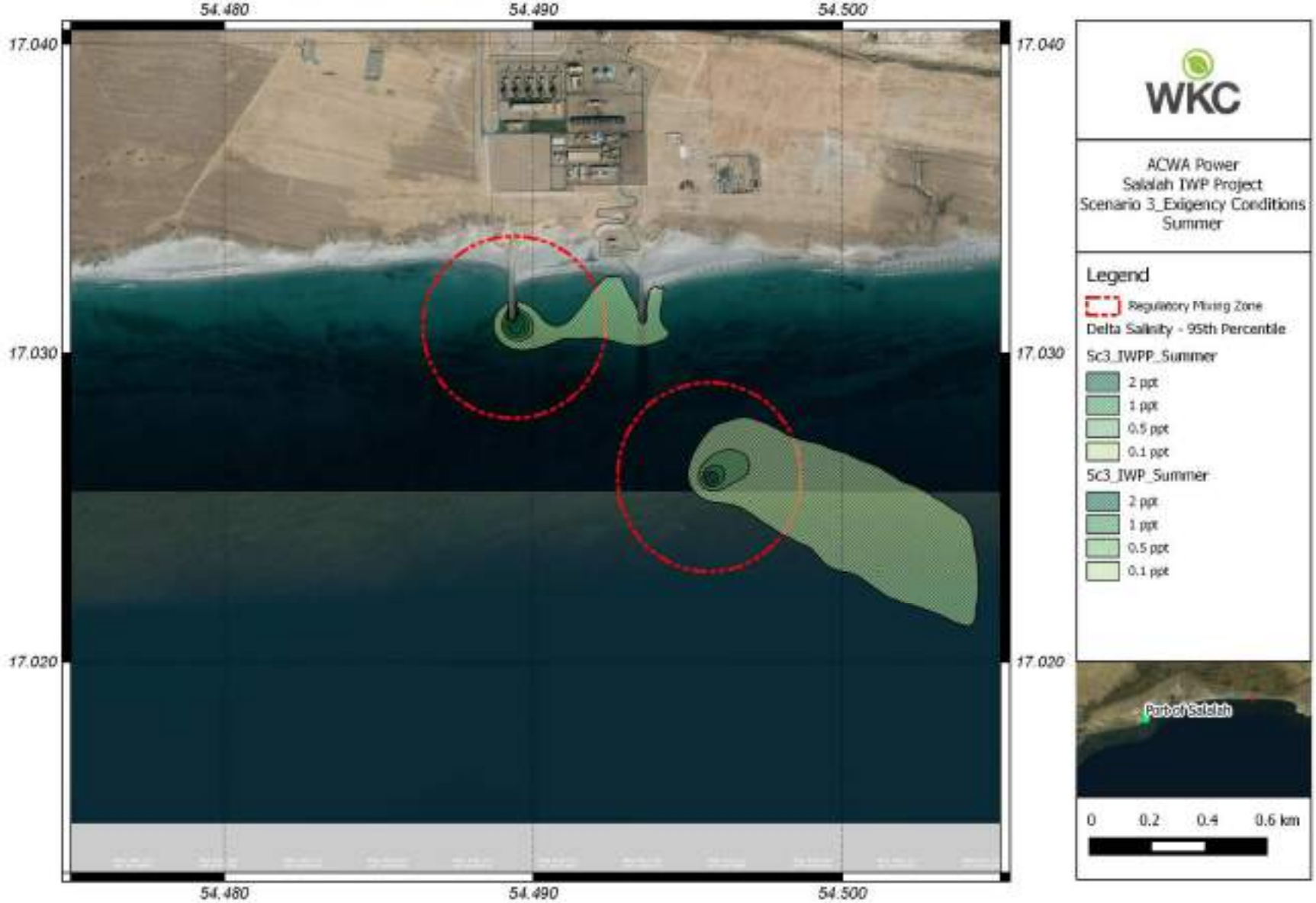


Figure 5-18 – Differential Salinity (95th Percentile) – Scenario 3 – Exigency Conditions (Winter)

Figure 5-19 – Dilutions (95th Percentile) – Scenario 2 – Nominal Conditions (Summer)

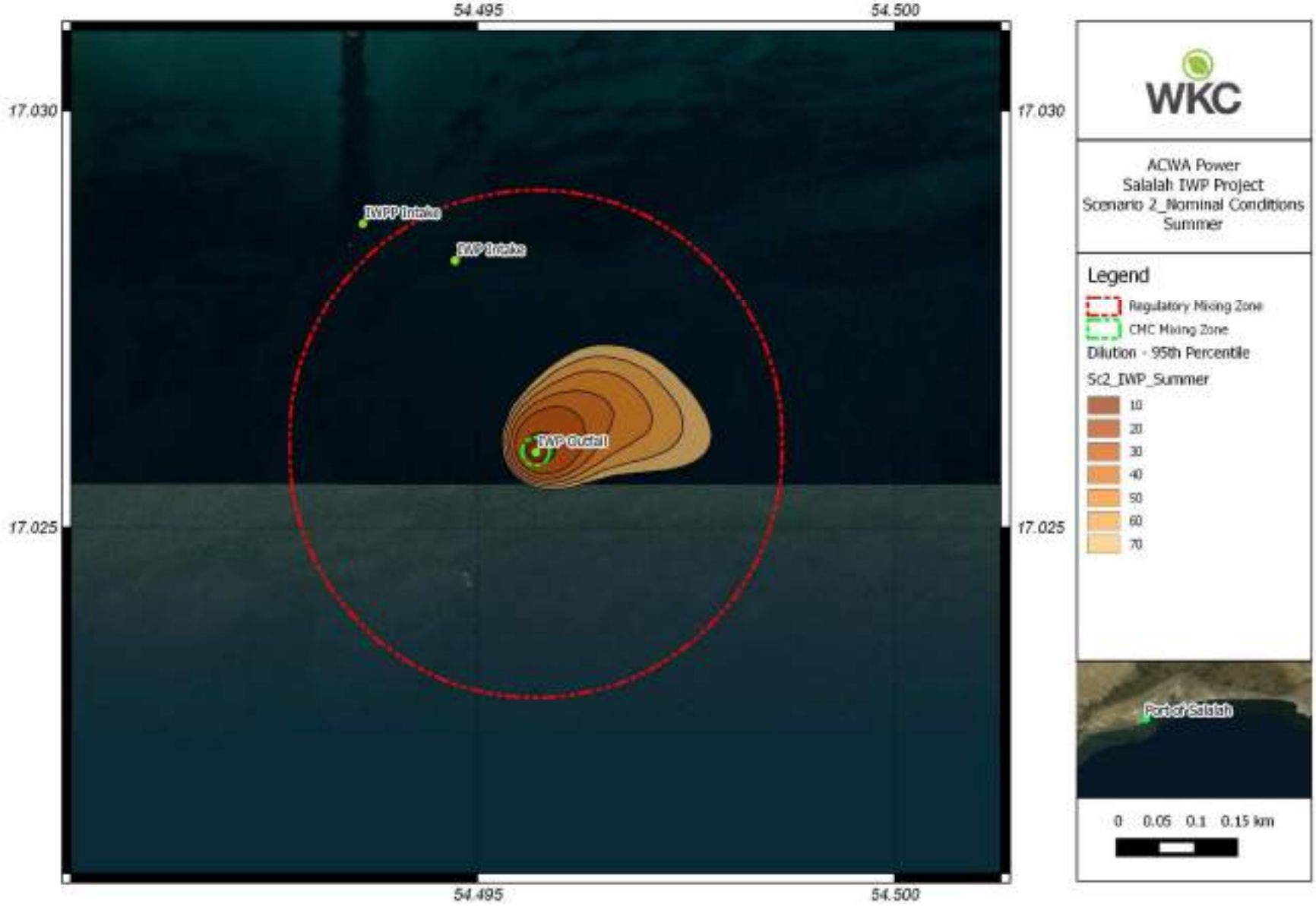


Figure 5-20 – Dilutions (95th Percentile) – Scenario 2 – Nominal Conditions (Winter)

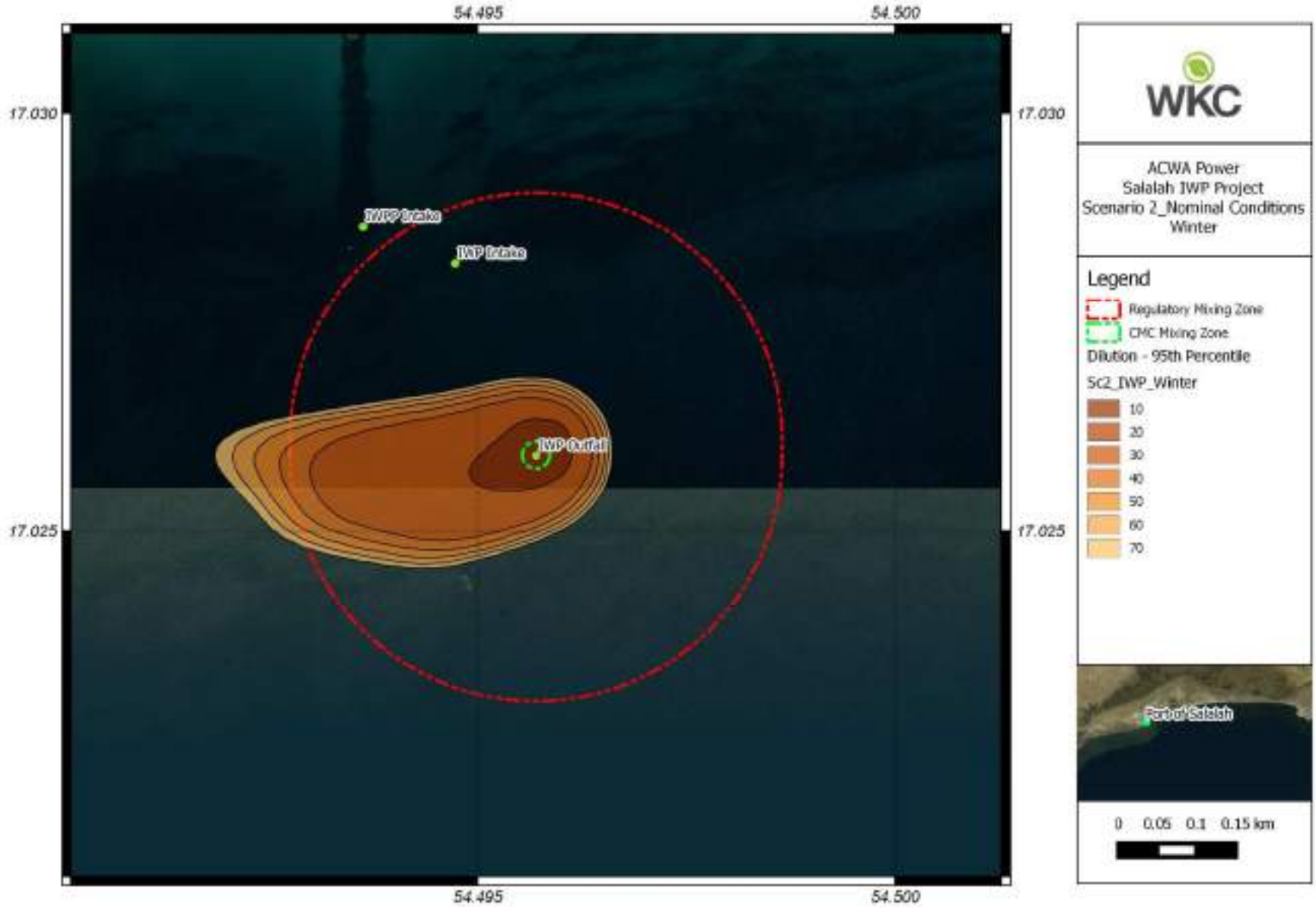


Figure 5-21 – Dilutions (95th Percentile) – Scenario 3 – Exigency Conditions (Summer)

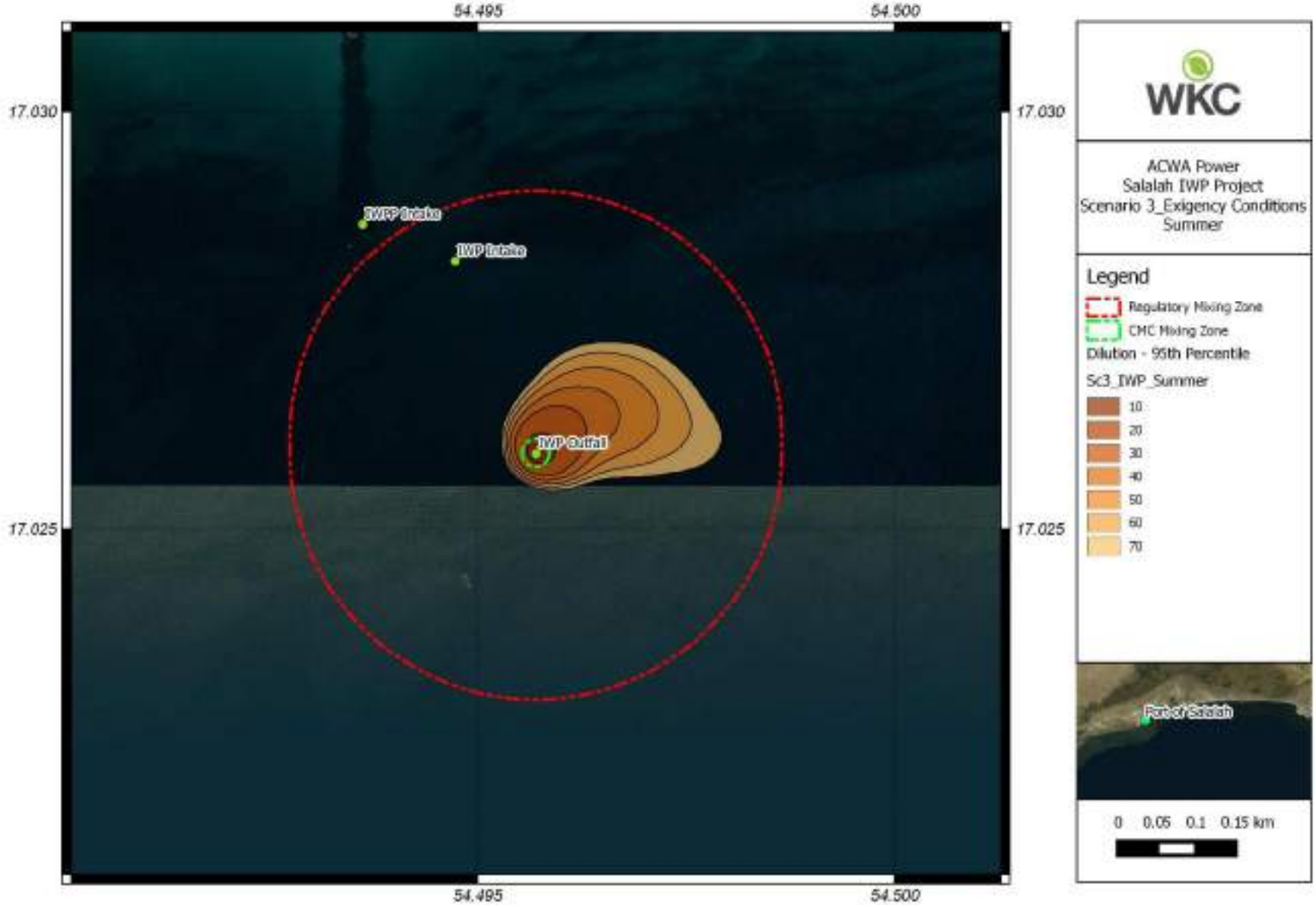
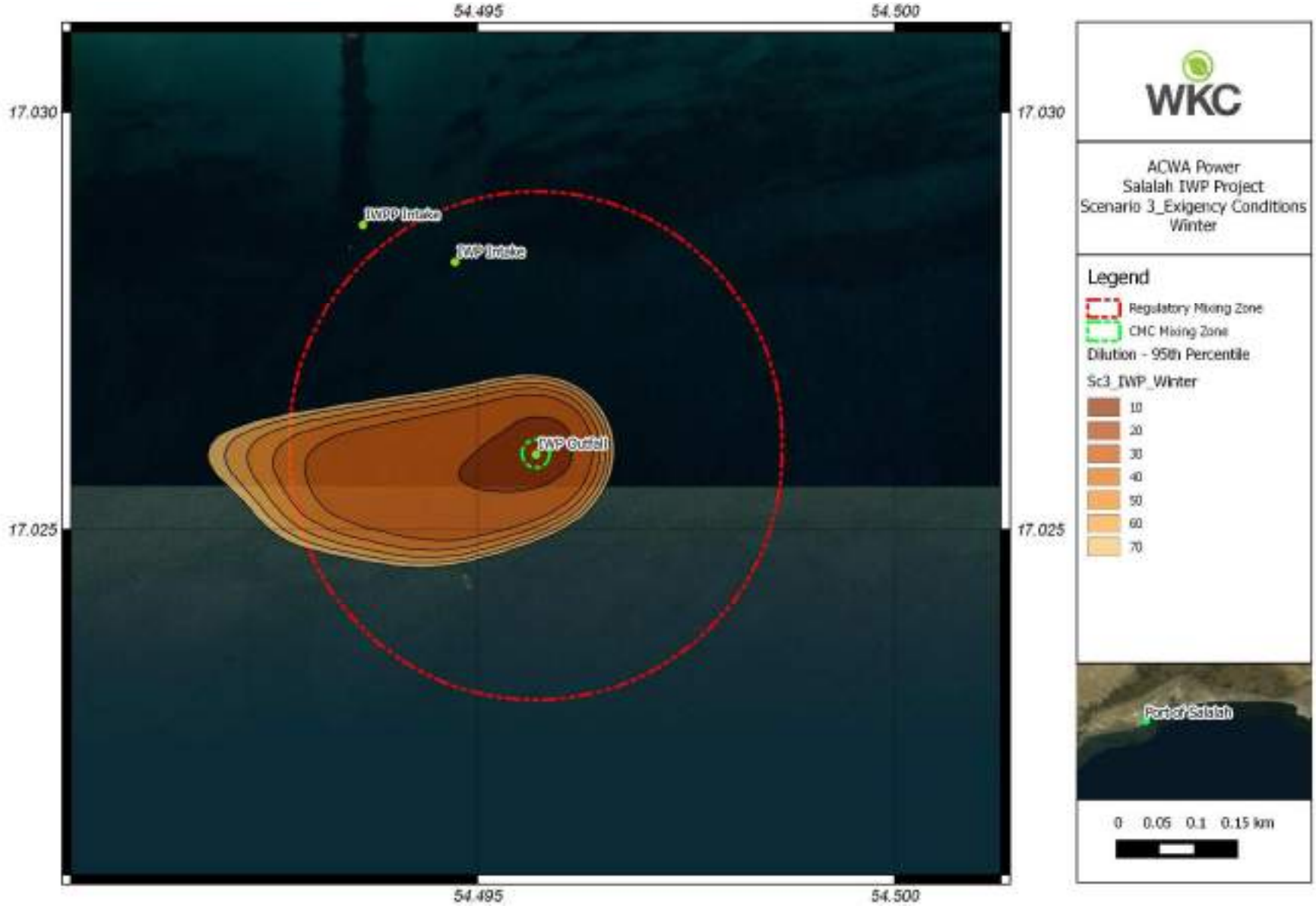


Figure 5-22 – Dilutions (95th Percentile) – Scenario 3 – Exigency Conditions (Winter)



Mixing within the far-field zone occurs within a relatively short distance due to the velocity of the tidal and wind driven currents as they are forced around the outfall structure, and the fully re-stratified geometry of the brine at the end of the near-field zone (which increases the availability of ambient water for dilution purposes). A differential salinity of less than 2 ppt is anticipated to be met within less than 60 m and 220 m for the IWPP and IWP outfalls respectively, for at least 95% of the time in both summer and winter. It is therefore predicted that ambient water quality thresholds will be met within the RMZ, minimising the outfall's potential to impact upon the surrounding marine environment and beaches.

The plume is anticipated to dilute less during the winter months, due to weaker and less sustained winds. The influence of wind direction is more pronounced however with the summer and winter plume trajectories at both outfalls showing almost complete reversal. The summer monsoon (Khareef) winds force currents (and subsequently plumes) to flow from west to east while in winter the direction is ostensibly reversed.

A minor reduction in dilution (and hence increase in salinity effected area) is anticipated to occur in winter, due to pooling effects caused by the low current speeds during these periods.

Overall however, the regulatory water quality guidelines for salinity are anticipated to be met within the RMZ. The lack of ecologically sensitive features within the outfall area, and the limited mixing zones predicted, the overall impact associated with the discharge of brine is not anticipated to be significant.

It is expected that the US EPA CCC [5] thresholds for chronic residual chlorine toxicity will be met within the requisite distance of 300 m from the outfall for all scenarios, however the acute (CMC) standard will not be met within the 17.7m radius for either season. Note that this is considered only as an indicative absolute worst case where the maximum chlorine concentration is discharged and coincides with worst case mixing conditions. Note further that maximum dosing rates will occur for approximately 4% of any 72 hour period.

6 Conclusions and Discussion

WKC Environment Consultancy (WKC) was contracted by 5 Capitals Environmental and Management Consulting (5 Capitals) to conduct hydrodynamic modelling and a brine plume assessment for the proposed Salalah Independent Water Project, located to the east of Salalah, Oman.

The hydrodynamics of the project area and the brine discharges, have been simulated utilising the GEMMS modelling suite and other 3rd party software.

The hydrodynamics of the project area were simulated for representative summer and winter scenarios using GCOM3D as well as for three different operating conditions; namely, existing, nominal and exigency conditions. The modelling domains were driven by the best available tidal and meteorological data, with physical domains being developed utilising multiple sources of bathymetric and topographic data.

Comparisons between modelled and predicted tidal water heights were used to validate the hydrodynamic modelling and showed an agreement which is considered to be satisfactory for this type of assessment, particularly given the lack of site specific data available.

Brine discharged from the newly installed IWP outfall were simulated in both the near and far-field in order to gain a complete understanding of both the 'jet-like' and 'plume-like' mixing behaviour. Near field simulations indicated that initial momentum in the near-field is relatively weak, resulting in limited turbulent mixing. However, horizontal spreading, and vertical stratification result in the brine being diluted by up to 2.2 times at approximately 8 m from the outfall mouth.

Far field modelling of the brine commenced at this point, 8 m from the outfall, where initial momentum begins to subside and the brine plume travels along the seafloor due to its high density. Mixing within the far-field zone occurs within a relatively short distance due to the velocity of the tidal and wind driven currents, and the geometry of the brine plume at the end of the near-field zone. A differential salinity of less than 2 ppt is anticipated to be met within less than 60 m and 220 m for the IWPP and IWP outfalls respectively, for at least 95% of the time in both summer and winter. It is therefore predicted that ambient water quality thresholds will be met within the RMZ, minimising the outfall's potential to impact upon the surrounding marine environment.

Similarly, the US EPA CCC toxicity thresholds are expected to be met for summer and winter conditions, however the acute toxicity threshold (CMC) will not be met for up to 55 m and 175 m during summer and winter respectively. These thresholds are developed for macro and infaunal species and would not be representative of acute or chronically toxic concentrations for fish or marine mammal species.

Note that this is considered only as an indicative absolute worst case where the maximum chlorine concentration is discharged and coincides with worst case mixing conditions. Further, this assessment considers only dilution of chlorine and not the breakdown of residual chlorine in the environment which would be expected to occur rapidly in sea water.

6.1 Recommendations

Based on the findings of this modelling study, the following recommendations are made with regards to the IWP outfall design and operating procedures:

- Monitoring of outfall residual chlorine concentration, particularly during shock dosing;
- Lowering of chlorine dosing concentration based on biocide performance and results of exit concentration monitoring;
- Use of sodium bisulphate (SBS) or other means to reduce residual free chlorine prior to discharge into the marine environment.

7 References

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Appendix A – Bathymetric Survey Report

Appendix B – Outfall Design Figures

Appendix C – Model Set-Up Graphics

Appendix D – GCOM3D Results

Appendix E – PLUME3D Results

Appendix K

Ministry of Heritage & Culture: Consultation Letter

التاريخ: ١٨ديسمبر ٢٠١٧م

الفاضل / أحمد بن سالم الحجري
المحترم
مدير عام التراث والثقافة
بمحافظة ظفار

تحية طيبة وبعد،،،

الموضوع: مشروع محطة صلالة لتحلية المياه

بالإشارة إلى الموضوع أعلاه، نود الإفادة بأن الشركة العمانية لشراء الطاقة والمياه قامت بمنح مشروع محطة صلالة المستقلة للمياه لمجموعة شركاء (شركة أكوا باور، وشركة فيوليا، وشركة ظفار الدولية للتنمية والإستثمار القابضة).

وستقوم الشركة العمانية لشراء الطاقة والمياه بشراء المياه بموجب إتفاقية شراء المياه مع شركة ظفار لتحلية ش.م.ع.م) ممثلة شركة المشروع. والمشروع عبارة عن محطة تحلية مياه البحر بإستخدام تكنولوجيا التناضح العكسي، وتبلغ التكلفة الإنتاجية من المياه إلى ٢٥ مليون جالون يوميا.

حيث يقع المشروع المقترح في محافظة ظفار على بعد حوالي ٣٠ كم شرق ولاية صلالة بالقرب من محطة القائمة التابعة لشركة سيمبكورب صلالة للمياه والكهرباء.

وعليه نرفق لكم نسخة من مخطط الموقع المقرر للمشروع، ونرجو منكم التكرم والإطلاع عليه وإعلامنا اذا يوجد لديكم أي ملاحظات بما يختص بشؤون الأثرية في الموقع.

مقدرين جهودكم وتعاونكم الدائم.

ولكم منا جزيل الشكر والتقدير،،،

المفوض بالتوقيع
راجيت ناندا

Appendix L

In principle NOC from MECA regarding boron, fluoride and lithium concentrations

Sultanate of Oman
Ministry of Environment & Climate Affairs
D.G.OF Environment & Climate Affairs
Governorate OF Dhofar

سلطنة عُمان
وزارة البيئة والشؤون المناخية
المديرية العامة للبيئة والشؤون المناخية
بمحافظة ظفار

Ref. : ....
Date : ....
C.Y. : ....

الرقم : ٧٢/٨٣٣٠/ ٦٠٨٥ /٢
التاريخ : ٢٥/ رجب /١٤٣٧هـ
الموافق : ٠١/ مايو /٢٠١٦م

المهندس/ احمد بن صالح الجهضمي المحترم
الرئيس التنفيذي
الشركة العمانية لشراء الطاقة والمياه "ش.م.ع.م"
ص.ب: ١٣٨٨ ر.ب ١١٢ الروي

السلام عليكم ورحمة الله وبركاته ... وبعد،

الموضوع مشروع إنشاء محطة جديدة لتحلية المياه في سهل الشصور بمحافظة ظفار

بالإشارة إلى خطابكم رقم opwp:gp.salwip/meca16/429 مؤرخ في ٣١ مارس ٢٠١٦م بشأن الموضوع اعلاه والمتضمن لبعض الملاحظات حول تراكيز عناصر البورون والفلورايد والليثيوم من حيث صعوبة الوصول إلى تركيز الموضح في اللائحة رقم (٢٠٠٥/١٥٩) الخاصة بتصريف المخلفات السائلة إلى البيئة البحرية لارتفاع تراكيزها في البيئة البحرية بشكل طبيعي.

عليه فإن هذه الوزارة لا تمانع من حيث المبدأ على التصريف المقترح للمياه المرتجعة من محطة التحلية المقترحة إلى البيئة البحرية بعد استكمال إنشاءها والتي هي عبارة عن مياه مالحة (Brine) شريطة الآتي:

١. إعداد دراسة التأثيرات البيئية للمشروع (EIA) على أن تشمل تحديد التراكيز الخاصة بالعناصر المذكورة وتأثيراتها على البيئة البحرية والإجراءات التي ستتخذها الشركة لضمان عدم التأثير على البيئة البحرية في محيط منطقة المشروع جراء أعمال الإنشاء والتشغيل.

ص.ب: ٢٠٣٥ - الرمز البريدي: ٢١١ صلالة - سلطنة عمان - هاتف: ٢٣٢٢٦٠١١ - فاكس: ٢٣٢٢٦٠١٢
P.O Box 2035 P.C 211 Salalah, Sultanate of Oman, Tel : 23226011, Fax. 23226012

بسم الله الرحمن الرحيم

Sultanate of Oman
Ministry of Environment & Climate Affairs

سلطنة عمان
وزارة البيئة والشؤون المناخية

٢. باستخدام أحدث الاجهزة الخاصة برصد الملوثات قبل التصريف بحيث تقوم الشركة بارسال البيانات الى الوزارة (online monitoring) واعداد برنامج رصد الملوثات البيئية في البيئة البحرية يتم من خلاله تقييم التاثيرات البيئية الناتجة عن عملية التصريف الى البيئة البحرية وبما يتناسب مع متطلبات هذه الوزارة.

٣. أن يتم التصريف عن طريق انبوب متعدد الفوهات في نهايته بحيث يتم اعداد نموذج رياضي (Numerical Modeling) لتحديد الطول والعمق المناسب له وبما يضمن تشتت المياه المصرفة في البيئة البحرية

٤. إعداد خطة للمخاطر والحوادث البيئية الطارئة الناتجة عن عدم تطابق حدود الملوثات الصناعية السائلة المعالجة مع الحدود البيئية المسموح بها في اللائحة رقم (٢٠٠٥/١٥٢) الخاصة بتصريف المخلفات السائلة الى البيئة البحرية وآليات التعامل الآمن معها بيئياً.

وتفضلوا بقبول فائق الاحترام

أحمد بن عبدالله محروس الصيعري
مدير عام البيئة والشؤون المناخية
بمحافظة ظفار

TRANSLATION

Date: 10 May 2016
Ref: 72/8320/485/16

Eng. Ahmed Saleh Al Jahdhami
CEO - OPWP

Subject: **Salalah IWP - Discharge Effluent into the Marine Environment**

Reference is made to your letter (Ref:opwp/gp.salwip/meca16/429) dated 31 March 2016 which indicates some observations on the high concentration levels for Boron, Fluoride and Lithium for the above project and the possibility of non-compliance with environmental regulation No. 159/2005 for the discharge of effluent into the marine environment.

We would like to inform you that the Ministry has no objection in principle to discharge effluent (Brine from desalination process) produced by Salalah IWP into the marine environment provided the following:

1. Prepare (EIA) for the project which should determine the concentrations of Boron, Fluoride and Lithium and to ensure that the marine environment within the project area won't be affected during the construction and operation of the project.

2. Use the latest equipment for monitoring contaminants prior to discharge with Online monitoring to send data directly to the ministry and to prepare a program to monitor contaminants in the marine environment through which the environmental impacts of the discharge process can be assessed in accordance with the requirements of the Ministry.

3. The discharge has to be done through a multi-nozzle tube, and a numerical model to be prepared to determine the appropriate length of the tube to ensure the dispersion of water discharged into the marine environment.

4. Prepare a risk mitigation plan to deal with any environmental incidents resulting from non-complaint discharge effluent in accordance with environmental limits allowable in Regulation No. 159/2005 for the discharge of effluent into the marine environment and mechanisms to deal with those incidents environmentally.

Yours Sincerely,

Ahmed Abdullah Mahroos
DG for Environmental Affairs in Dhofar Governorate