Project Lightning

Environmental & Social Impact Assessment

Prepared for KEPCO, KIC and EDF

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QUALITY ASSURANCE

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ABBREVIATIONS

Abbreviation	Definition
AC	Alternating Current
ADCP	Acoustic Doppler Current Profiler
ADDC	Abu Dhabi Distribution Company
ADM	Abu Dhabi Municipality
ADNOC	Abu Dhabi National Oil Company
ADPC	Abu Dhabi Power Company
ADQCC	Abu Dhabi Quality and Conformity Council
ADS	Abu Dhabi Specification
AEE	Assessment of Environmental Effects
AIMS	Australian Institute of Marine Science
AOI	Area of Interest
AQG	Air Quality Guideline
AQI	Air Quality Index
AR	Artificial Reef
ARMAE	Adjusted Relative Mean Absolute
AWQO	Ambient Water Quality Objectives
AWQS	Ambient Water Quality Standards
BAP	Biodiversity Action Plan
BHD	Back Hoe Dredger
BOD	Biological Oxygen Demand
BOOT	Build, own, operate, transfer
BOP	Balance of Plant
BRUV	Baited Remote Underwater Video

Abbreviation	Definition
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
C&D	Construction and Demolition
CBD	Convention on Biological Diversity
CCME	Canadian Council of Ministers of the Environment
CEMP	Construction Environmental Management Plan
CESMP	Construction Environmental and Social Management Plan
CFSR	Climate Forecast System Reanalysis
CGRFA	The International Treaty on Plant Genetic Resources for Food and Agriculture
CITES	Convention on International Trade in Endangered Species of wild Fauna and Flora
CLV	Cable Laying Vessel
CMREC	Marine Ecological Classification Standard
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CNTR	Control Location
COD	Chemical Oxygen Demand
COP	Code of Practice
CT	Current Transformer
dB	Decibel
DC	Direct Current
DCT	Department of Culture and Tourism
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichloro-diphenyl-trichloroethane
DDV	Drop Down Video
DEMP	Decommissioning Environmental Monitoring Plan
DIV	Dutch Intervention Values

Abbreviation	Definition
DMA	Department of Municipal Affairs
DMT	Department of Municipalities and Transport
DO	Dissolved Oxygen
DP	Dynamic Positioning
DSV	Diving Support Vessel
DTM	Digital Terrain Mode
E	Coefficient of Efficiency
EAD	Environment Agency Abu Dhabi
EAD HC	Environment Agency Abu Dhabi Habitat Classifications
EcIA	Ecological Impact Assessment
EDF	Electricité de France
EDG	Emergency Diesel Generator
EHS	Environmental Health and Safety Guidelines
EMF	Electromagnetic Fields
EMP	Environmental Management Plan
ENVID	Environmental Impact Identification
EPC	Engineering, Procurement and Construction
EPFI	Equator Principal Financial Institutions
EPs	Equator Principles
ESIA	Environmental and Social Impact Assessment
FC	Financial Close
FM	Flow Model
FOC	Fibre Optic Cable
FP	Fall Pipe
FPROV	Fallpipe Remotely Operated underwater Vehicle

Abbreviation	Definition
GCC	Gulf Cooperation Council
GCM	General Circulation Models
GHG	Greenhouse Gases
GIS	Gas Insulated Switchgear
GPS	Global Positioning System
GTG	Gas Turbine Generators
GW	Gigawatt
HA	Hectare
HAZID	Hazard Identification
HAZOPS	Hazard and Operability Studies
HCH	Hexachlorocyclohexane
HD	Hydrodynamic
HGV	Heavy Goods Vehicles
HSE	Health, Safety and Environment
HSEIA	Health, Safety and Environment Impact Assessment
HVAC	Heating Ventilation and Air Conditioning
HVDC	High Voltage Direct Current
HWTF	Hazardous Waste Transfer Facility
IAQM	Institute of Air Quality Management
IEEM	Institute of Ecology and Environmental Management
IFC	International Finance Corporation
IFP	Inclined Fall Pipe
ILO	International Labour Organisation
IPPC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature

Abbreviation	Definition
IWPP	Mirfa Independent Water and Power Project
JBIC	Japan Bank for International Cooperation
JDN	Jan De Nul Dredging Ltd., Abu Dhabi Branch
JNCC	Joint Nature Conservation Committee
KEPCO	Korea Electric Power Corporation
KEXIM	Korea Export Import Bank
KIC	Kyuden International Corporation
KV	Kilo Volt
LC	Least Concern
LCC	Local Control Cabinet
LDV	Leonardo Da Vinci
LV	Low Voltage
MAE	Mean Absolute Error
MCC	Motor Control Centre
MCPA	2-methyl-4-chlorophenoxyacetic acid
MDL	Minimum Detection Level
MEBS	Marine Environmental Baseline Survey
MGD	Million Gallons per Day
MGO	Marine Gas Oil
MLEAD	Marine Life of the Emirate of Abu Dhabi
MMBR	Marawah Marine Biosphere Reserve
MMRO	Marine Mammal and Reptile Observer
MOM	Minutes of Meeting
MOOPAM	Manual of Oceanographic Observations and Pollutant Analyses Methods
MPA	Marine Protected Area

Abbreviation	Definition
MRC	Metallic Return Cable
MRV	Minimum Reporting Value
MSDS	Material Safety Data Sheets
MT	Mud Transport
MV	Medium Voltage
MW	Megawatt
NCEP	National Centers for Environmental Prediction
ND	Not Detected
NE	Not Evaluated
NT	Near Threatened
NTM	Notice To Mariners
NTU	Turbidity
OEMP	Operational Environmental Management Plan
OESMP	Operation Environment and Social Management Plan
OHID	Occupational Health Identification
PAH	Polycyclic Aromatic Hydrocarbons
PAM	Passive Acoustic Monitoring
PC	Precast Concrete
PCBs	Polychlorinated Biphenyls
PCR	Preliminary Cultural Review
PERGSA	The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden
PHA	Process Hazard Analyses
PHSER	Project Health Safety and Environment Review
PLGR	Pre Lay Grapnel Run

Abbreviation	Definition
PM_{10}	Particulate Matter < 10 µm
PPE	Personnel Protective Equipment
PQ	Photo Quadrat
PS	Performance Standard
PSA	Particle Size Analysis
PTS	Permanent Hearing Loss
QHSSE	Quality Health Safety and Environment
RAP	Recommended Area for Protection
RC	Reinforced Concrete
RFP	Request for Proposal
RHIB	Rigid Hulled Inflatable Boat
RMAE	Relative Mean Absolute Error
RMS	Root Mean Square
RMSE	Root-Mean-Square Error
ROPME	Regional Organization for the Protection of the Marine Environment
ROV	Remotely Operated underwater Vehicle
SCAD	Statistics Centre Abu Dhabi
SCT	Samsung C&T Corporation
SEL	Sound Exposure Level
SF	Starfish
SHB	Split Hopper Barge
SLMXD	Sublittoral Mixed Deposit
SLSED	Sublittoral Sediment
SNA	Scientific and Natural Area
SPS	Convention on the sanitary and phytosanitary

Abbreviation	Definition
SRI	Subsea Rock Installation
SRIV	Subsea Rock Installation Vessel
SSS	Side Scan Sonar
SWMP	Site Waste Management Plan
TDS	Total Dissolved Solids
TEEB	The Economics of Ecosystems and Biodiversity Initiative
THC	Total Hydrocarbon Content
TJB	Transition Joint Bay
TOC	Total Organic Carbon
ToR	Terms of Reference
TRANSCO	Abu Dhabi Transmission and Dispatch Company
TSHD	Trailing Suction Hopper Dredger
TSS	Total Suspended Solids
TTS	Temporary Hearing Loss
TUV	Towed Underwater Video System
UAE	United Arab Emirates
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UPS	Uninterruptible Power Supply
VOC	Volatile Organic Compound
VP	Vantage Point
VT	Voltage Transformer
VU	Vulnerable
WHO	World Health Organisation
WNBR	World Network of Biosphere Reserves

GLOSSARY OF TERMS

Term	Description
Alternatives	Alternatives to the Project in its current form. This will include a 'no development' (or do nothing) option, or alternative approaches to the development such as an alternative location or design.
Avoidance	Amendments to a project which would result in an environmental impact being avoided. This could include for example a design change to avoid an area which is inhabited by a rare species. This is the most effective means of environmental protection.
Baseline Data	Existing or proposed baseline data which enumerates, or describes, the existing environmental conditions at a site prior to the implementation of a project. This would include, for example, the collection of air quality data to understand the current levels of pollutants or ecological surveys to identify the current status of habitats or protected species.
Compensation	Where impacts cannot be avoided or mitigated, a programme of compensation may be required. For example, if the habitat of a protected species would be lost it may be necessary to provide new compensation habitat at an alternative location.
Construction	The period of a project when it is under construction, which will include site preparation works through to commissioning.
Environmental and Social Impact Assessment	The process of Environmental and Social Impact Assessment (ESIA) which involves assessing existing baseline conditions and predicting impacts of a project. Where impacts are identified, the process requires that avoidance, mitigation or compensation measures are determined to reduce impacts to acceptable levels. Note that the process is distinct from an ESIA Report, which is a report which details the methodology, findings and outcomes of the ESIA process.
Impact Assessment	Prediction and evaluation of environmental impacts and their significance resulting from a project.
Mitigation	Where impacts cannot be avoided they can potentially be reduced through the application of mitigation measures. This could include, for example, technologies to reduce emissions of pollutants to air to more acceptable levels.
Operation	The period of a project following construction when it becomes operational in part or full as per its intended long-term use.
Significance	Environmental impacts are generally categorized according to their significance. For example, a small-scale impact upon a sensitive receptor of low value would be determined as an impact of minor significance. Conversely, a large impact upon a receptor of high sensitivity would be determined as being of major significance. Note that impacts can be positive as well as negative.
Sensitive Receptor	A sensitive receptor which could be adversely or positively impacted as a result of a project. This includes human receptors, such as a school or dwelling, ecological receptors such as an area of habitat or species or other environmental receptor such as soils and groundwater.

1. EXECUTIVE SUMMARY

1.1. Project Description

1.1.1. Overview

The Project involves the provision of high voltage sub-sea transmission cables to supply power from the Abu Dhabi utility grid network from Abu Dhabi Transmission and Dispatch Company (TRANSCO) to the Abu Dhabi offshore oil and gas facilities, operated by ADNOC, with connections to Das Island and Al Ghallan Island. The Project is being developed by ADNOC to provide an alternative source of power for offshore facilities, which will replace the existing offshore power generation sources with electricity generated on the mainland. This development is therefore expected to reduce the carbon footprint of ADNOC's offshore operations by more than 30%, which would be a significant contribution to Abu Dhabi and the UAE's carbon emissions targets.

The power supply will consist of the following cable routes:

- **Route 1 – Mirfa to Al Ghallan Island:** two high voltage direct current (HVDC) sub-sea transmission cables and a fibre-optic (FO) cable (bundled together) will be linking to the supply power via a converter station from the Al Mirfa Power & Water Complex to the Al Ghallan artificial island;
- **Route 2 – Shuweihat to Das Island:** Two HVDC sub-sea transmission cables, two FO cables and one Metallic Return Cable (MRC) will be linking to the supply power via a converter station from Al Shuweihat Power & Water Complex to Das artificial island.

In addition to the cable routes, the Project includes the onshore tie-ins with the TRANSCO networks within existing substations within both Al Mirfa Power & Water Complex and Al Shuweihat Power & Water Complex.

The proposed routes and Project location overview are illustrated below in Figure E-1 below.

The Project will be developed on a build, own, operate, transfer ("BOOT") basis. The consortium of EDF, KEPCO and KIC will create a Project Company with ADNOC and Abu Dhabi Power Company (ADPC) where the owners of the future company will consist of ADNOC (30%), ADPC (30%) and the consortium EDF/KEPCO/KIC (40%). The Project Company will start the design of the facilities immediately after financial close with a commercial operation target scheduled from Q4-2024 for Route 2 (Shuweihat to Das Island) and Q1-2025 for Route 1 (Mirfa to Al Ghallan Island).

The appointed Engineering, Procurement and Construction (EPC) Contractor is a consortium between Jan De Nul Dredging Ltd., Abu Dhabi Branch (JDN) and Samsung C&T Corporation (SCT). SCT will be responsible for the construction and installation of converter buildings and equipment, whilst JDN will be responsible for all cable installation works, dredging, backfilling and cable protection works, both onshore and offshore.

An overview of the Project cable routes locations are detailed as follows:

- **Route 1 – Mirfa to Al Ghallan Island:** The cables (two HVDC & one FO) will originate at the Mirfa substation within the Al Mirfa Power & Water Complex located approximately 110km south-west of Abu Dhabi city. The surrounding area predominantly features open desert, with residential housing located to the south-east of the Project site and approximately 5km to the east is located Mirfa Hotel and Mirfa Harbour. The cables will reach Al Ghallan Island located within the Zakum Oil Field approximately 80km north of Mirfa; and

- **Route 2 – Shuweihat to Das Island:** The cables (three HVDC & one FO) will connect from the Shuweihat substation within Al Shuweihat Power & Water Complex, located approximately 190km to the south-west of Abu Dhabi city. The surrounding areas are predominantly open desert, with the town of Al Ruwais situated approximately 8km to the south-east. Das Island is located approximately 110km north of Al Shuweihat Power & Water Complex and is inhabited by over 5,000 people working in the oil and gas industry.

Figure E-1: Project location overview

1.1.2. Project Rationale

In consideration of the rapid population growth and economic development within the UAE, the associated increases in water and power demand and the vulnerability of the country due to the low-lying coastal areas and hot arid climate, the UAE Government has recognised and is addressing the pressures and threats posed to the country by climate change. Over the past two decades, the UAE has been consistently and strongly committed to reducing environmental and climate impacts by reducing carbon emissions and moving towards a green and sustainable economy. For example, the UAE was one of the first major oil producing countries to become a signatory to the Kyoto Protocol to the UN Convention on Climate Change in 2005. A number of policies and frameworks and Government entities have been created, prepared and refined within the country and at Abu Dhabi Emirate level to guide the transition to a greener economy through the reduction of carbon emissions (1) (2).

In 1995, the UAE ratified the United Nations Framework Convention on Climate Change (UNFCCC) which focuses on the objective to '*stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference ith the climate system*'. Since this ratification, the UAE and Abu Dhabi have continued to make commitments and policies to address climate change issues, increase adaptability and reduce their carbon footprint. The UAE is listed as a non-Annex 1 country within the UNFCCC and therefore is not obligated to make reductions to emissions; despite this, the UAE is constantly striving to reduce emissions and adopt a greener and more sustainable economy.

The Ministry of Climate Change and Environment (MoCCaE) in collaboration with the EAD has developed the Abu Dhabi Greenhouse Gas (GHG) Emissions Inventory (1) (2), in conjunction with a number of government entities and companies, including ADNOC. The inventories identify baseline emissions levels and provide future projections to 2030 of emissions data, both direct and indirect, from a range of sources including waste, land use, industrial and energy sectors (1). The initial inventory was produced in 2010 (base year), followed by an updated inventory in 2012 which also identified emissions projections for 2030. The latest emissions inventory provided data for 2014-2016 plus updates to the emissions projections for 2030 (2).

The GHG Emissions Inventory will assist in and promote the reduction of carbon emissions and therefore will contribute in assisting the UAE and the Emirate of Abu Dhabi in meeting its commitment to the following policies and agreements, all of which share the same ultimate goal of reducing climate change impacts:

- Abu Dhabi Vision 2030;
- UAE Green Growth Strategy;
- UAE Energy Strategy (which aims to achieve 50% clean energy contributions by 2050);
- National Climate Change Plan of the UAE;
- The Paris Agreement (2016); and
- United Nations Framework Convention on Climate Change (UNFCCC) (1).

Currently all operating companies in the Abu Dhabi offshore area (ADNOC Offshore, ADNOC LNG, BUNDUQ, ADOC and Total ABK) manage their electrical power requirement locally and independently using gas turbine generators (GTGs). The electrical power requirement for sustained production and future development plans will substantially increase over time. Moreover, the existing GTGs currently being used will expire through their duration of use and can raise environmental concerns as well as concerns towards the economic impacts of maintenance.

The Project is therefore being developed by ADNOC to provide an alternative source of power for offshore facilities, which will replace the existing GTG power sources with electricity generated on the mainland. This development is therefore expected to reduce the carbon footprint of ADNOC's offshore operations by more than 30%, replacing existing offshore GTGs with more sustainable power sources available on the Abu Dhabi onshore power network, thereby ensuring that operational carbon emissions are reduced and that future operational demand requirements can be met. This progressive and collaborative approach will also drive operational efficiencies and improve system reliability of energy supply, while offering the potential for power supply cost optimisation.

This Project is therefore expected to result in both economic and sustainability benefits to Abu Dhabi Emirate and the UAE in terms of oil and gas activities and capabilities through reducing energy demands and associated maintenance costs, in addition to reducing the existing carbon footprint associated with the electrical power requirements for offshore activities. These objectives strongly align with the demonstrable and ongoing efforts made towards climate change and carbon footprint reduction described above.

Given the substantial focus placed upon addressing climate change drivers and moving the country towards a greener and more sustainable future, the Project can be considered to provide a significant contribution to this goal, through enabling and facilitating greener electricity sources to be used and creating the opportunity to reduce carbon emissions associated with offshore oil and gas activities.

1.2. Summary of Findings

1.2.1. Methodology

At the Project inception, a number of baseline studies were commissioned directly by ADNOC and undertaken by Mott MacDonald, Fugro and Nautica in support of Project Lightning. These studies have been reviewed, and where relevant, summarised within the baseline section for each technical chapter. Where changes to the baseline conditions are likely to have occurred, or where data gaps exist, a series of updated investigations were conducted.

The existing data which has been used to inform the assessment within this ESIA includes the following:

- **Noise:** Noise monitoring undertaken by Nautica in 2021 at Mirfa, Shuweihat and Das Island at three locations for each site;
- **Geology, Seismicity, Soil and Groundwater:** A Phase 1 non-intrusive investigation was undertaken by Nautica in 2021 at Mirfa, Shuweihat and Das Island. In addition, eight soil samples were taken at each Project site location, and one groundwater sample was collected at Shuweihat;
- **Terrestrial and Intertidal Ecology:** Field surveys were undertaken by Nautica during summer 2021 at Mirfa, Shuweihat and Das Island which provided a general overview of intertidal, mangrove and coastal areas; and
- **Marine Ecology and Water Quality:** Marine Environmental Baseline Surveys (MEBS) were undertaken for significant sections of both Route 1 and Route 2 corridors by Fugro in 2021.

The following additional environmental investigations have been undertaken to inform this ESIA:

- **General Conditions and Socio-Economics:** A site visit of the Project sites at Mirfa and Shuweihat to identify the general site conditions and sensitive receptors within or adjacent to the Project sites. It was not possible to access Das Island or Al Ghallan Island for the purposes of the Project;
- **Air Quality:** Desk-based baseline studies including a review of existing climatic data within published sources, existing data for Ruwais from the EAD network of air quality monitoring stations (AQMS) and air quality monitoring data from Das Island supplied by ADNOC;
- **Marine Ecology and Marine Water Quality:** The following additional MEBS was undertaken:
  - Route 1 – Mirfa landfalls and Route 2 – Shuweihat Landfalls:
    - Water quality sampling;
    - Sediment sampling;

    - Benthic ecology surveys;
    - Fish survey;
    - Underwater noise; and
    - Infauna sampling.
  - Route 1 – Mirfa Nearshore Area within and near Marawah Marine Biosphere Reserve (MMBR):
    - Sediment quality sampling;
    - Benthic ecology surveys;
    - Fish survey;
    - Benthic infauna; and
    - Underwater noise.
  - Route 1 – Zakum clusters route 1A &1B re-routing area:
    - Water quality sampling;
    - Sediment sampling; and
    - Benthic ecology.
- **Waste management**: Desk-based baseline studies;
- **Intertidal Ecology:** Winter and summer habitat and vegetation surveys, mangrove surveys (including estimates of individuals), night-time fauna surveys – Sherman and camera traps and vantage point bird surveys were undertaken at Mirfa and Shuweihat;
- **Traffic and Transportation:** Desk-based study and site visit to determine the local conditions of the road network.
- **Socio-Economic:** Desk-based study to determine the current socio-economic conditions and existing land uses within the Project site area.
- **Archaeology and Cultural Heritage:** An information request was made to the Historic Environment Department within the Abu Dhabi Department of Culture and Tourism (DCT) to identify any known sites of archaeological or cultural heritage value within, or within the vicinity of the Project sites; and
- **Climate Change:** A desktop survey was conducted to identify the future climatic trends based on climate simulations for the UAE, and calculations were made to determine the expected amount of blue carbon likely to be released due to the disturbance of habitats within the Project site e.g. sabkha, mangroves and saltmarshes.

1.2.2. Baseline Studies Results

The results of the baseline investigations described above have enabled the enumeration of the existing baseline conditions within the Project site. The key findings of the baseline investigations are as follows:

- **General Conditions and Socio-Economics:** There are very limited onshore socio-economic receptors near the Project sites at Mirfa and Shuweihat, and these are generally limited to operational staff at the adjacent power and water complexes, in addition to a limited number of residential properties within 300m of the Project site at Mirfa. Beyond the Project site buffer area, sensitive receptors are present within proximity to the construction traffic route, including commercial, residential, tourism and government facilities within Mirfa. Offshore, it has been identified that the Project area provides significant fishing opportunities to local fishermen, with three traditional fishing methods commonly being used within the area; Lansh, Tarad and Hadrah fishing methods, in addition to modern fishing methods utilising modern boats and trawlers. An aquaculture Project is also under development by EAD near to Dalma Island which will involve the installation of a Dalma Sea Cage for cultivating finfish. In addition, maritime traffic levels are significant within the area, associated with numerous ports and anchoring areas within the vicinity, and include a variety of vessels including, but not limited to commercial and recreational boats;

- **Air Quality:** It is considered that the airshed within both onshore Project locations, in addition to Das Island and Al Ghallan Island, are likely to already be degraded due to the presence of significant power and water generating facilities;
- **Marine Water**: The marine baseline results demonstrated that the marine water and sediment quality of the various Project areas / routes were generally excellent with majority of the physical, chemical and biological parameters having concentrations mostly below the Minimum Detection Levels (MDLs) or Minimum Reporting Values (MRVs). Where recorded concentrations were above the MDLs or MRVs, the levels were within the regulatory limits or referenced standards, where applicable. Whilst a number of samples have recorded values above the referenced standards, due to the general lack of mainly anthropogenic sources, such elevated levels particularly for some metals including nickel, arsenic, and chromium were considered to be of natural (geologic) origin. As such, these observed elevated levels over a large and wide-open water with relatively good dilution and flushing rates are not considered to be of particular environmental concern;
- **Waste Management:** Visual inspections identified the presence of a variety of fly tipped wastes and flotsam within the Project site areas at Mirfa and Shuweihat, although non appeared to be hazardous in nature, with the exception of an area of potential asbestos waste at Mirfa, although this was not located within the Project footprint;
- **Geology, Seismicity, Soil and Groundwater:** Visual inspections identified the presence of a variety of fly tipped wastes, although no obvious signs of potential sources of contamination were noted. Results of the soil and groundwater sampling by Nautica did not record any exceedances of allowable limits for soil or groundwater;
- **Marine Ecology:** comprehensive surveys have been undertaken along both cable routes by Fugro in 2021 and surveys of nearshore areas and the cable route within Marawah Marine Biosphere Reserve (MMBR) and new route alignments in the Zakum Cluster by WKC in 2022. The following habitat types of conservation importance were identified along the Routes:
  - 11100 – Fringing Reef;
  - 11200 – Patch Reef;
  - 12000 – Seagrass Bed;
  - 13000 – Hard-Bottom;
  - 13010 – Hard-Bottom with Macroalgae.

  For Route 1, the benthic habitat analysis identified the area is classified as Seagrass Bed with substantial macroalgae intermixed. Seagrass colonisation was extensive throughout the sand areas of the survey site, which are classified as critical habitat by the EAD. There was no extensive coral cover noted along the route except for some patchy reef colonised by young corals growing on hardbottom substrates found in the offshore areas (around KP 62.000 to KP68.000 & KP74.000 to KP76.000) as identified by Fugro in 2020. Fish species were abundant on the seagrass areas. Species observed during the survey are all associated with seagrass and demersal. Key species identified during the surveys include honeycomb whiptail, which is considered endangered by the IUCN, a high turtle population, including green and hawksbill turtles, which are included in the IUCN Red List as Endangered and Critically Endangered respectively. In addition, there was a single sighting of a dolphin and sightings of solitary Dugong on two occasions. This species is categorised by the IUCN Red List as Vulnerable.

In regard to the re-routing Zakum clusters section, most of the areas located within the Zakum oilfield is characterised by a wide expanse of hard bottom habitat with colonies of corals that are assessed to be dead potentially from coral bleaching. The species are dominated by Porites and Faviids. The colonies observed from their sizes are estimated to be <5 years old. The areas outside of the oil field and along deeper areas or 20 plus meters have unconsolidated bottom void of any macro flora and fauna. The sediment substrate was silty mud in structure and organisms found can be assigned to borrowing and infaunal community. Sampled areas within Mubarraz oil field were unconsolidated bottom but with substrate that are made up of coarse sand and shell fragments;

For Route 2, there are two critical habitat types, seagrass and fringing reef, found along the nearshore survey route and surrounding area. In addition, patch reefs were found during Fugro survey in 2020 at two locations offshore (around KP 58.000 to KP60.000 & KP77.000 to KP89.000). The coral colonies were assessed to be young (< 5 years old) growing as individual colonies on hardbottom substrate. The seagrass bed is healthy and seen as an extensive meadow with a wide distribution. A fringing reef is located nearshore along Route 2, near to the Shuweihat Power Plant. The condition of the reef is poor with dead coral from bleaching events and only sparse young coral colonies in evidence. Fish species identified were both reef associated demersal fish and the presence of commercially important species were also noted. During the fish study, Blacktip shark and Tawny Nurse Shark were documented. Sea turtles were observed on three occasions through records of surface breaks for breathing. And a pod of Indian Ocean humpback dolphins which are categorised by the IUCN as Endangered.

- **Terrestrial and Intertidal Ecology:** The following habitat types of conservation importance were identified within the Project sites:
  - 1010 – Mudflats and sand exposed at low tide (Critical Habitat);
  - 2020 – Coastal Sand Sheets and low dunes (Environmentally Sensitive Habitat)
  - 1040 – Mangroves (Critical Habitat);
  - 1030 – Saltmarsh (Critical Habitat); and
  - 3100 – Coastal sabkha, including sabkha matti (Environmentally Sensitive Habitat).

  Of key importance of the above habitats are mangroves, which are critical habitat, likely to be directly impacts at the Shuweihat landfall area. At Mirfa, mangrove habitat is not likely to be directly impacted but is likely to fall within the zone of influence of Project activities. Avifauna species richness was found to be moderate at Shuweihat and Mirfa. Several of these bird species are listed on the IUCN Red List. Of the mammal, reptile and arthropod species identified, non were species of conservation concern;

- **Noise:** No exceedances of UAE residential ambient noise limits were recorded at Shuweihat or Das Island. Two exceedances were identified at Mirfa, although the source of the exceedance was not able to be identified and is likely to be attributable to recreational off-road vehicle movements. No exceedances of IFC noise limits were recorded at any of the monitoring locations;
- **Cultural Heritage and Archaeology:** DCT have provided map locations of known archaeological and cultural heritage sites within proximity of the Project sites. Of these, none were located within the Project footprint.

1.2.3. Key Identified Impacts

The impact assessments conducted within the ESIA have identified that as the Project comprises of industrial infrastructure comprising HDVC subsea cables and onshore plant which will enable the decommissioning of GTG's, the majority of impacts are expected during the construction phase. The key identified impacts include the following:

- **Air Quality:** Construction dust and gaseous emissions which would result in impacts upon nearby receptors, particularly residential properties at Mirfa and operational workers associated with the adjacent water and power complexes at all Project sites. Operational traffic emissions associated with the Project sites are expected to be minimal. Largely, operational impacts are considered to be positive due to a reduction in emissions resulting from the decommissioning of older, less efficient offshore power generating facilities and replacement with more efficient conventional power generating facilities, nuclear and solar generation sources. Emissions from emergency back-up generators are expected to be negligible.
- **Marine Water:** Impacts to marine water (and sediment) due to Project activities are anticipated to arise from construction related works, mainly the potential release of sediments associated with marine dredging and other support vessels as well as the potential resuspension of sediments (both non-contaminated and potentially contaminated sediments) due to dredging or trenching that can directly (e.g. smothering of habitats and species especially sessile organisms) and indirectly (e.g. behavioural changes of marine species and other physical or physiological impacts associated with increased turbidity) affect marine features of the areas;
- **Waste Management:** Impacts are expected in relation to waste streams arising from the construction and operation phase particularly upon the local waste infrastructure and health impacts upon construction workers e.g. exposure to harmful waste materials and fire events resulting from inadequate management and storage of flammable materials. The presence of the Project sites (particularly at Mirfa) adjacent to the sensitive marine environment also renders the potential for contamination via waste pathways e.g. hazardous solid or liquid wastes as a significant impact;
- **Geology, Seismicity, Soil and Groundwater:** There is the potential for soil and groundwater contamination as a result of construction and operation activities. Due to the proximity of the sensitive marine environment containing sensitive habitats, potentially major impacts were predicted prior to the implementation of mitigation measures e.g. accidental leaks and spillages, mobilisation of existing contamination or during dewatering activities and/or accidental release of effluents;
- **Marine Ecology:** Due to the nature of the construction activities involved, i.e., trenching and backfilling, natural marine habitats will be lost: extensive areas of seagrass will be temporarily lost whereas some limited areas

of coral reefs will be permanently lost. In addition, the trenching and backfilling activities have the potential to result in resuspension of sediments that may result in increased sedimentation and turbidity. Other impacts considered include direct mortality or injury due to vessel collision risk as well disturbance from noise and discharges and releases of potentially hazardous and toxic substances. During operation, it is unlikely that significant impacts will arise. Nevertheless, there is the potential for marine fauna behaviour to be affected as a result of EMF emissions, although the potential extent of impacts is not well researched and at this stage cannot be quantified;

- **Terrestrial Ecology:** A number of habitats within the Project footprint will be lost, which includes some habitats of construction significance e.g. mangroves, saltmarsh and coastal sabkha. Disturbance and displacement to fauna species, particularly avifauna is likely, particularly within saltmarsh habitats at Shuweihat. Due to high species density and the semi aquatic and valuable nature of the habitats, any contamination events would be difficult to contain;
- **Noise:** Construction noise impacts were largely considered to be negligible with the exception of residential properties at Mirfa, and construction workers within the Project sites, which are likely to be significant prior to the implementation of mitigation measures;
- **Traffic and Transportation:** Impacts upon the local traffic network are expected to be minor negative at Mirfa and negligible at Shuweihat during construction. A detailed operational assessment relating to traffic levels has been scoped out as the predicted impacts were deemed insignificant;
- **Socio-economics:** Impacts upon sensitive receptors within the local project areas at Mirfa and Shuweihat e,g. residents, businesses and commercial properties are likely during construction due to degradation of local conditions relating to air quality, noise and traffic impacts, in addition to potential health and safety issues. In regard to impacts upon fishermen activities, due to the extent of fishing areas and the temporary nature of the works, the impacts were considered limited with appropriate mitigation measures. In addition, positive impacts may result, for example from the increased revenue generated for local businesses dur to the influx of workers;
- **Cultural Heritage and Archaeology:** No direct impacts upon known archaeological or cultural heritage sites are predicted, although the potential for undiscovered buried artefacts to be present within the Project footprint is acknowledged, the disturbance of which could potentially be significant; and
- **Climate Change:** Potential impacts resulting from climate change related variations in local conditions e.g. flooding events, extreme temperature or sea level rise may damage the Project infrastructure. Positive impacts are also predicted however, in relation to the reduction if GHG emissions enabled by the decommissioning of older GTG’s and their replacement with cleaner, lower carbon, electricity sources.

1.2.4. Cumulative Impacts

The potential for cumulative impacts is limited as few sensitive receptors are present within the local area other than a small number of residential properties at Mirfa. The key cumulative impacts identified as part of the study include:

- During construction:
  - Potential Type 1 cumulative effects upon nearby receptors based upon multiple impacts from noise, dust and traffic nuisance;
  - Potential Type 2 cumulative effects associated with impacts resulting from the concurrent construction of adjacent projects, namely, Project Wave at Mirfa, and Mugharraq Port Masterplan at Shuweihat. For example, concurrent construction activities at nearby project sites may amplify a number of impacts such as dust generation, gaseous emissions, noise levels and traffic on the local road networks, cumulatively resulting in more significant impact levels.
- During operation:
  - No significant cumulative impacts have been predicted during operation.

1.2.5. Key Mitigation and Monitoring Measures

The key mitigation measures which have been identified are as follows:

- In relation to the loss of terrestrial habitats of conservation importance, the following will be undertaken:

– Avoidance of vegetation clearing during the peak breeding season (April to July) unless a pre-construction survey is undertaken just before the clearance work. If any active nests are present, these cannot be disturbed and these areas must be protected, with a 300m stand-off until such time as the nest is no longer active. Once surveys by a qualified ecologist have confirmed that the nests are no longer active, these trees can also be cleared (subject to the necessary Authority permits being in place) and these areas will be considered to be clear for the remainder of the construction phase and no further restrictions would apply;
  - Restoration of the mudflats and saltmarshes that may be impacted;
  - The Project Company will appoint a qualified ecologist and landscape contractor to develop a Mangrove Planting and Management Plan (MPMP) for the area adjacent to Shuweihat in accordance with EAD requirements. This will include specific details of:
    - Area of mangrove loss and estimated number of individuals;
    - Proposed compensation site;
    - Proposed method of compensation – presumed at this stage to be planting of mangrove seedlings at a ration of 2:1 for the number of mangrove individuals lost;
    - Methodology for site preparation and planting;
    - Requirements for management and replacement during establishment phase; and
    - Long-term management and monitoring requirements.

- In relation to marine ecology, the following will be undertaken:
  - The design will take account of the adjacent sensitive receptors, particularly within the marine offshore and intertidal environment, and will ensure that impacts are avoided (where possible) and minimised;
  - Avoid the use of the South Disposal Area (wherever possible) as this will significantly reduce the direct loss of seagrass;
  - Enable further optimisation of the dredge trenching and floatation channel design and the construction methodology where possible to reduce the amount of required dredging wherever possible;
  - A Dredging Management Plan (DMP) shall be developed by the EPC Contractor as part of the CESMP;
  - Installation of Type IV silt curtain between source of plume and critical habitat receptors. Silt curtains should be deployed to protect sensitive receptor in the area;

- Strict adherence to mitigations relating to a dedicated on board Marine Mammal and Reptile Observer (MMRO) and application of JNCC protocols during encounters with marine mammals and turtles
- For Route 1 where the route is located within the MMBR boundary and transition zone as well as works associated with the floatation / dredged channel, it is recommended that the EPC construction programme consider limiting and reducing, where feasible, works during the following periods:
  - Dugong birthing / calving periods of pre-winter and post winter (October to November and March to April); and
  - Heightened spawning season of important fish species (March to July (as per Marine Environment Research Centre of MoCCAE));
- If feasible, construction work to not occur at the landfall areas during the turtle nesting season (April to June). If not feasible, a hatching and nesting survey shall be undertaken during the turtle nesting season (April to June 2023) to confirm the likely absence of turtle nesting in the landfall areas;
- The Project Company will appoint a qualified marine biologist to develop a Biodiversity Action Plan (BAP), which will be developed to achieve a net biodiversity gain. The BAP will include the following as a minimum:
  - Proposed methods to relocate healthy corals from the dredged corridors to adjacent areas suitable to act as receptor sites;
  - Proposed methods to reinstate the dredged corridor to enable the recolonisation of seagrass beds;
  - Allow natural seagrass seeding to occur post construction;
  - Proposed methods for extended monitoring of the natural re-establishment of seagrass beds, with potential trigger values for further targeted interventions if re-establishment is less successful than anticipated;
  - Additional actions to provide a net biodiversity gain, such as the placement of reef forming structures within the Project site;
  - Additional actions to provide a net biodiversity gain, where appropriate;
  - A long-term management plan; and
  - A long-term biodiversity monitoring and evaluation program.

The majority of significant or potentially significant impacts relate to the construction phase and therefore, a detailed Construction Environmental and Social Management Plan (CESMP) will be prepared based upon the identified mitigation measures set out within this ESIA by the construction contractor(s), which includes the following detailed control plans:

- Dust control plan;
- Marine works / sedimentation control plan;
- Dredging control plan including a Dredging Management Plan (DMP) to be attached with the CESMP;
- Dewatering control plan;
- Contamination control plan;
- Spill control plan;
- Site waste management plan;
- Erosion control plan;
- Noise control plan;
- Biodiversity management plan for terrestrial and marine environments;
- Archaeological chance finds procedure;
- Stakeholder engagement plan, to ensure that affected residents are consulted; and
- A monitoring programme for each of the above;

Due to the sensitivity of the surrounding environment, particularly the marine environment and associated habitats, it is also recommended to prepare an Operational Environmental and Social Management Plan (OESMP) to ensure the effective management of all Project components.

Key monitoring recommendations include the following:

- Daily visual dust monitoring during construction;
- Baseline noise measurements should be undertaken at the nearest receptor location off site (boundary of the property located 90m from Project site boundary at Mirfa) to understand the existing noise environment;
- Noise monitoring should then be carried out at the nearest sensitive receptors during critical periods of construction in order to identify non-compliance with UAE and IFC allowable noise limits and the need for additional noise control measures;
- Implementation of an archaeological watching brief during ground clearance and earthworks;
- Monitoring and auditing of all waste streams generated;
- Monitoring plan for the repropagation of mangrove trees lost and for restoration of mudflats and saltmarshes, to include fixed point photography to show succession of habitats, and biannual flora and fauna surveys to determine colonisation levels;
- Establishment of a community complaints procedure and grievance mechanism for construction workers; and
- Marine water monitoring: both *in situ* and continuous in-situ water sampling to ensure that sedimentation levels do not exceed established thresholds, *ex situ* analysis of water samples and sediment quality monitoring;
- Marine ecology: in addition to the water quality monitoring described above the following will be undertaken:
  - DDV / ROV inspection of seagrass and coral habitat near trenching activities to ensure siltation is contained;
  - Census (DDV / ROV) conducted to ascertain species composition; and
  - Marine Mammal and Reptile Observer (MMRO) personnel on board during construction phase to minimise the potential for vessel collisions with marine fauna.

1.2.6. Residual impacts

Following the implementation of all recommended mitigation and monitoring measures, all impacts including cumulative impacts will be reduced to acceptable significance (negligible to moderate negative). Table 1-1 provides an overview of the impact significance identified for this Project prior and after mitigation and monitoring measures.

Table 1-1: Residual impacts summary

Environmental Component	Impact Significance Prior to Mitigation Measures	Impact Significance After Mitigation (Residual Impacts)
Construction Phase		
Air Quality	Minor to Major negative	Minor negative
Marine Water	Minor to Moderate negative	Minor negative
Waste Management	Negligible to Major negative	Negligible to Minor negative

Environmental Component	Impact Significance Prior to Mitigation Measures	Impact Significance After Mitigation (Residual Impacts)
Soil and Groundwater	Minor to Major negative	Negligible to Minor negative
Marine Ecology	Negligible to Major negative	Negligible to Moderate negative
Terrestrial Ecology	Negligible to Major negative	Negligible to Minor negative
Noise	Negligible to Major negative	Negligible to Minor negative
Traffic and Transportation	Negligible to Minor negative	Negligible
Socio-economic	Negligible to Major Negative	Negligible to Minor negative and Minor positive
Cultural Heritage & Archaeology	Negligible to Major negative	Negligible to Minor negative
Climate Change	Moderate negative	Minor negative
Operation Phase		
Air Quality	Negligible and Major positive	Negligible and Major positive
Marine Water	No Change	No Change
Waste Management	Negligible to Major negative	Negligible to Minor negative
Soil and Groundwater	Moderate to Major negative	Minor negative
Marine Ecology	Moderate negative and Major positive	Minor negative and Major positive
Terrestrial Ecology	No Change	No Change
Noise	Negligible	Negligible
Traffic and Transportation	Negligible	Negligible
Socio-economic	Negligible to Major negative	Negligible and Minor positive
Cultural Heritage & Archaeology	Negligible	Negligible
Climate Change	Moderate negative and Major positive	Minor negative and Major positive

1.2.7. Project Advantages and Disadvantages

1.2.7.1. Project Advantages

Currently all operating companies in the Abu Dhabi offshore area (ADNOC Offshore, ADNOC LNG, BUNDUQ, ADOC and Total ABK) manage their electrical power requirements locally and independently using gas turbine generators (GTGs). The electrical power requirement for sustained production and future development plans will substantially increase. Moreover, the existing GTGs will expire through their duration of use and can raise environmental concerns as well as concerns towards the economic impacts of maintenance.

The Project is therefore being developed by ADNOC to provide an alternative source of power for offshore facilities, which will replace the existing GTG power sources with electricity generated on the mainland, which will include renewable sources, thereby ensuring that operational carbon emissions are reduced and that future operational demand requirements can be met.

This Project is expected to result in both economic and sustainability benefits to Abu Dhabi Emirate in terms of oil and gas activities and capabilities through reducing energy demands and associated maintenance costs, in addition to reducing the existing carbon footprint associated with the electrical power requirements for offshore activities. These objectives strongly align with the demonstrable and ongoing efforts made towards climate change and carbon footprint reduction underway within the UAE.

Given the substantial national focus placed upon addressing climate change drivers and moving the country towards a greener and more sustainable future, the Project can be considered to be contributing to this goal in a positive way, through enabling and facilitating greener electricity sources to be used and creating the opportunity to reduce carbon emissions associated with offshore oil and gas activities.

1.2.7.2. Project Disadvantages

Disadvantages associated with the Project relate to the sensitive nature of the marine environment through which the cable routes will traverse. The expected impacts resulting from construction activities associated with trenching, cable laying and backfilling, prior to the implementation of mitigation measures, may be significant.

2. INTRODUCTION

2.1. Project Title and Project Proponent

Project Name	Project Lightning (referred to as ‘the Project’ throughout this report)
Project Proponent	Abu Dhabi National Oil Company (ADNOC)
Project Developers	Consortium of Electricité de France (EDF), Korea Electric Power Corporation (KEPCO) and Kyuden International Corporation (KIC)
Project Contractors	Consortium of Jan De Nul Dredging Ltd., Abu Dhabi Branch (JDN) and Samsung C&T Corporation (SCT)
Project Type	Infrastructure
EAD DPA Number:	DPA2104081
ro ect roponent’s ain Contact	Abdulla Alhai – Engineer, ADNOC Electrical (Engineering) Team
Address:	ADNOC, PO Box 303, Abu Dhabi, UAE
Email address:	amalhai@adnoc.ae
Tel:	+971 2 6052138

2.2. ESIA Consultants

Environmental Consultancy Company	Anthesis Middle East (appointed by the Consortium)
EAD Registration number	EC-00254/15; ECR-433/17
Contact:	Simon Pickup – Managing Director
Address:	1605 Metropolis Tower, Business Bay, Dubai, P.O. Box 392563, United Arab Emirates
Telephone:	+971 4 277 8007
Fax:	+971 4 277 8006

The individual team members responsible for the preparation of this ESIA are set out within Table 2-1 below.

Table 2-1: ESIA technical team members

Team Member	Company	Role	Scope
Simon Pickup	Anthesis	Project Director	ESIA Review and Site Surveyor
Apolline Boudier	Anthesis	Project Manager	ESIA Review and Reporting
Anna Blackwell	Anthesis	Assistant Project Manager	ESIA Reporting
Adrian Hudson	Anthesis	Principal Terrestrial Ecologist	ESIA Terrestrial Ecology Reporting and Terrestrial Ecology Surveyor
Nesma Othman	Anthesis	Project Team Support	ESIA Reporting
Greg Ashcroft	WKC	Marine Expert	Marine Hydrodynamic Modelling, Marine Ecology and Water Quality Reviewer
Ray Visitacion	WKC	Marine Expert	Marine Surveyor and Marine Ecology Reporting
Ravel Barnard	WKC	Marine Expert	Marine Hydrodynamic Modelling and Marine Water & Sediment Reporting

Additionally, it should be noted that the ESIA includes data that were collected prior the start of the ESIA process. All data included in this ESIA are summarised in Table 2-2 below and further detailed in **Section 2.4.2**.

Table 2-2: Data collection from Others

Company	Role	Scope	Data Period
Fugro	Marine Experts	Marine surveyors	2020
Mott MacDonald	Environmental Consultant	Environmental Scoping and Gap Analysis, Hydrodynamic Modelling,	2020-2021
Nautica	Environmental Consultant	Soil and groundwater sampling, noise monitoring and terrestrial ecology surveys	2021
Dome	Environmental Consultant	EIA Scoping Report Satah & Arzanah Island	2012-2016
Blue Sea	Environmental Consultant	Environmental Baseline Survey	2009

2.3. Project Description and Rationale

2.3.1. Project Description

The Project involves the provision of high voltage sub-sea transmission cables to supply power from the Abu Dhabi utility grid network from Abu Dhabi Transmission and Dispatch Company (TRANSCO) to the Abu Dhabi offshore oil and gas facilities, operated by ADNOC, with connections to Das Island and Al Ghallan Island.

The Project is being developed by ADNOC to provide an alternative source of power for offshore facilities, which will replace the existing offshore power generation sources with electricity generated on the mainland. This development is therefore expected to reduce the carbon footprint of ADNOC's offshore operations by more than 30%, which would be a significant contribution to Abu Dhabi and the UAE's carbon emissions targets.

The power supply will consist of the following cable routes:

- **Route 1 – Mirfa to Al Ghallan Island:** two high voltage direct current (HVDC) sub-sea transmission cables and a fibre-optic (FO) cable (bundled together) will be linking to the supply power via a converter station from the Al Mirfa Power & Water Complex to the Al Ghallan artificial island;
- **Route 2 – Shuweihat to Das Island:** Two HVDC sub-sea transmission cables, two FO cables and one Metallic Return Cable (MRC) will be linking to the supply power via a converter station from Al Shuweihat Power & Water Complex to Das artificial island.

In addition to the cable routes, the Project includes the onshore tie-ins with the TRANSCO networks within existing substations within both Al Mirfa Power & Water Complex and Al Shuweihat Power & Water Complex.

The proposed routes and Project location overview are illustrated below in Figure 2-1.

The Project will be developed on a build, own, operate, transfer ("BOOT") basis. The consortium of EDF, KEPCO and KIC will create a Project Company with ADNOC and Abu Dhabi Power Company (ADPC) where the owners of the future company will consist of ADNOC (30%), ADPC (30%) and the consortium EDF/KEPCO/KIC (40%). The Project Company will start the design of the facilities immediately after financial close with a commercial operation target scheduled from Q4-2024 for Route 2 (Shuweihat to Das Island) and Q1-2025 for Route 1 (Mirfa to Al Ghallan Island).

The appointed Engineering, Procurement and Construction (EPC) Contractor is a consortium between Jan De Nul Dredging Ltd., Abu Dhabi Branch (JDN) and Samsung C&T Corporation (SCT). SCT will be responsible for the construction and installation of converter buildings and equipment, whilst JDN will be responsible for all cable installation, dredging, backfilling and cable protection works, both onshore and offshore.

An overview of the Project cable routes locations are detailed as follows:

- **Route 1 – Mirfa to Al Ghallan Island:** The cables (two HVDC & one FO) will originate at the Mirfa substation within the Al Mirfa Power & Water Complex located approximately 110km south-west of Abu Dhabi city. The surrounding area predominantly features open desert, with residential housing located to the south-east of the Project site and approximately 5km to the east is located Mirfa Hotel and Mirfa Harbour. The cables will reach Al Ghallan Island located within the Zakum Oil Field approximately 80km north of Mirfa; and

- **Route 2 – Shuweihat to Das Island:** The cables (three HVDC & one FO) will connect from the Shuweihat substation within Al Shuweihat Power & Water Complex, located approximately 190km to the south-west of Abu Dhabi city. The surrounding areas are predominantly open desert, with the town of Al Ruwais situated approximately 8km to the south-east. Das Island is located approximately 110km north of Al Shuweihat Power & Water Complex and is inhabited by over 5,000 people working in the oil and gas industry.

Figure 2-1: Project location overview

2.3.2. Project Rationale

Currently all operating companies in the Abu Dhabi offshore area (ADNOC Offshore, ADNOC LNG, BUNDUQ, ADOC and Total ABK) manage their electrical power requirements locally and independently using gas turbine generators (GTGs). The electrical power requirement for sustained production and future development plans will substantially increase. Moreover, the existing GTGs will expire through their duration of use and can raise environmental concerns as well as concerns towards the economic impacts of maintenance.

The Project is therefore being developed by ADNOC to provide an alternative source of power for offshore facilities, which will replace the existing GTG power sources with electricity generated on the mainland, which will include renewable sources, thereby ensuring that operational carbon emissions are reduced and that future operational demand requirements can be met.

This Project is expected to result in both economic and sustainability benefits to Abu Dhabi Emirate in terms of oil and gas activities and capabilities through reducing energy demands and associated maintenance costs, in addition to reducing the existing carbon footprint associated with the electrical power requirements for offshore activities. These objectives strongly align with the demonstrable and ongoing efforts made towards climate change and carbon footprint reduction underway within the UAE, described further in **Section 4.1**.

Given the substantial national focus placed upon addressing climate change drivers and moving the country towards a greener and more sustainable future, the Project can be considered to provide a significant contribution to this goal, through enabling and facilitating greener electricity sources to be used and creating the opportunity to reduce carbon emissions associated with offshore oil and gas activities.

2.4. Justification and Chronology for the Development of the ESIA Report

2.4.1. Overview

Project Lightning has been registered via an Environmental Permit Application (EPA) with the EAD under the following reference: DPA2104081.

At the Project inception, a number of baseline studies were commissioned by ADNOC and undertaken by Mott MacDonald, Fugro and Nautica in support of Project Lightning, which are listed below in **Section 2.4.2.**

Anthesis has undertaken a review of these documents, and specifically the Gap Analysis Report prepared by Mott MacDonald in April 2021 (AD41-90.0/27/26-G-25301, Rev. 02) which identifies the existing and relevant baseline information available and subsequently areas where data is lacking. It is understood that the Gap Analysis Report has been accepted and approved by EAD with comments and is to be considered as the Terms of Reference (ToR) for Project Lightning.

Following Anthesis appointment, a number of tasks were completed which included the following: a review of the Gap Analysis Report, a meeting with EAD held on the 21st September 2021 (Minutes of Meeting (MoM) presented in **Appendix 6.1**) and the submission of a Scoping Letter document issued to EAD on the 27th September 2021 (Ref:210923/EAD/1176/1 – shown in

Appendix 4.**1**). The purpose of the Scoping Letter was to provide responses to EAD comments on the Gap Analysis Report, which are set out below in **Section 2.4.3.1,** and to provide a clear methodology for the ESIA baseline surveys and impact assessment studies.

The Scoping Letter was subsequently reviewed and approved by EAD with comments which were received on the 21st and 24th November 2021 (email exchanges presented in **Appendix 6.2**). Another meeting was held with EAD on the 29th November 2021 (MoM presented in **Appendix 6.3**) to discuss and receive clarifications on the received comments. The responses to EAD comments on the Scoping Letter are presented in **Section 2.4.3.2** below.

On the 16th March 2022, another meeting with EAD (MoM presented in **Appendix 6.4**) was held with the intent for Anthesis to:

- present the positive changes which have been made in relation to the cable routes for the nearshore areas for both routes in order to reduce and/or avoid impacts upon critical and sensitive marine habitats;
- provide an overview of expected offshore construction activities and identify the locations and capacity of the expected offshore disposal areas; and
- present the change in cable routes near Al Ghallan Island.

Following the meeting, EAD issued the following comments on the 8th April 2022 (e-mail copy provided in **Appendix 6.5)**:

A- In reference to slide 11 which discuss the Das route at the nearshore area (Shuwiehat PDP) it is believed that the company can avoid the impacts on fringing coral reef by:

1- applying HDD method with possibility of minor shifting
2- make more detail investigation of the area and define the location of the gaps among coral reef to make it the selected bath.

B- 03 Construction Overview and Disposal Area:

1- the required dredging for the project is massive comparing to the direct footprint especially when we include the sloped sides. This cannot be approved and the project footprint must be limited to the cable itself.
2- no offshore disposal, all disposal areas mut be onshore especially the project is in proximity of the land. Even if offshore disposal area going to be approved but an HDM study must be provided to make sure no impacts on the Mara ah Protected area and the critical habitat in the region.

An initial response was issued to EAD on the 12th April 2022 (Refer to **Appendix 6.6)** and a clarification call with EAD was held on the 13th April 2022 (MoM presented in **Appendix 6.7**). Following the clarification call and further workshop with all relevant stakeholders, a final response was issued to EAD on the 28th April 2022 (Refer to **Appendix 6.8**).

Note that all revised route options identified for the Project are presented in **Chapter 6: Project Alternatives.**

2.4.2. Previous Project Specific Baseline Surveys

As described above, a number of previous environmental baseline studies were completed for the Project.

The baseline studies undertaken by Mott MacDonald are listed as follows:

- Environmental Screening Report (Mott MacDonald, June 2020) (3);
- Gap Analysis Report (Mott MacDonald, March 2021) (4);
- Ecosystem Services Assessment (Mott MacDonald, April 2021) (5);
- Dredging Management Plan Framework (Mott MacDonald, May 2021) (6);
- Hydrodynamic and Sediment Dispersion Modelling (Mott MacDonald, May 2021) (7);
- Critical Habitat Assessment (Mott MacDonald, May 2021) (8);
- Framework Biodiversity Action Plan (Mott MacDonald, May 2021) (9);

- Framework Compensation Plan (Mott MacDonald, May 2020) (10); and
- Marine Impact Assessment (Mott MacDonald, June 2021) (11).

Additionally, Nautica, on behalf of Mott MacDonald, completed baseline studies to identify the terrestrial ecology, soil and groundwater and noise conditions at Mirfa, Shuweihat and Das Island. The baseline studies are listed as follows:

- Mirfa Landfall Terrestrial Ecology Report (Nautica September 2021) (12);
- Shuweihat Landfall Terrestrial Ecology Report (Nautica September 2021) (13); and
- Das Island Landfall Terrestrial Ecology Report (Nautica September 2021) (14).

Furthermore, the following baseline studies have been undertaken by Fugro in relation to metocean, bathymetric and environmental baseline data:

- Environmental Baseline Survey Results Report Route 1 Rev 04 (Fugro, 2020) (15);
- Environmental Baseline Survey Results Report Route 2 Rev 04 (Fugro, 2020) (16);
- Weather Report – Statistical Report Eastern Route (Route 1) Location North (Fugro, 2020) (17);
- Weather Report – Statistical Report Eastern Route (Route 1) Location South (Fugro, 2020) (18);
- Environmental Baseline Survey Results Report – Route 1 E-0395-Document Rev 4 (Fugro, 2020) (19);
- Environmental Baseline Survey Results Report – Route 2 E-0395-Lightning Project Rev 02 (Fugro, 2020a) (20);
- Geophysical Survey Report – Cable Route 1A from Mirfa Landfall to Lower Zakum Island G Rev 02 (Fugro, 2020c) (21);
- Weather Report – Statistical Report Eastern Route (Route 1) Location North A (Fugro, 2020d) (22);
- Weather Report – Statistical Report Eastern Route (Route 1) Location South (Fugro, 2020e) (23);
- Weather Report – Statistical Report Eastern Route (Route 2) Location North (Fugro, 2020f) (24);
- Weather Report – Statistical Report Eastern Route (Route 2) Location South (Fugro, 2020g) (25);
- Geophysical Survey Report – Cable Route 1-A from Mirfa to Landfall to Lower Zakum Island G (Fugro, 2020h) (26)
- Geophysical Survey Report – Cable Route 1B from Mirfa to Landfall to Lower Zakum Island G (Fugro, 2020i) (27);
- Geophysical Survey Report – Cable Route 2 from Shuweihat to Landfall to Das (Fugro, 2020j) (28);
- Geophysical Survey Report – Cable Route 2A from Shuweihat to Landfall to Das (Fugro, 2020k) (Ref: AD41-457-G-24200-01 (MRU093-V06-Route-2B) (29); and
- Geophysical Survey Report – Cable Route 2B from Shuweihat to Landfall to Das (Fugro, 2020l) (30).

Previously, environmental studies have been undertaken in relation to other projects within the vicinity of the Project Lightning area, and whilst now considered to be out of date in terms of data relevance, these have also been considered and reviewed within the preparation process of this ESIA. These studies are as follows:

- Feed Services for Hail and Ghasha Development, Front End Engineering Design – Environmental Impact Assessment (EIA) Offshore, (Bechtel, April 2020) (31);

- Environmental Baseline Study, ADMA-OPCO's Existing Facilities – Zakum Oil Field (Blue Sea Environmental Consultants, February 2011) (32); and
- Das Island Environmental Baseline Survey (Blue sea, 2009) (33).

2.4.3. EAD Approval and Comments on Scoping Documents

2.4.3.1. Mott MacDonald Gap Analysis Report

A Gap Analysis Report was prepared by Mott MacDonald in April 2021 (34). This document was accepted by the EAD as a Terms of Reference for the subsequent ESIA. The EAD provided a series of comments in relation to the Gap Analysis Report. Anthesis provided the following responses below in Table 2-3 within our Scoping Letter.

These comments and responses have been considered and integrated within this ESIA.

Table 2-3: Response to EAD Comments on Mott MacDonald Gap Analysis

EAD Comment	Anthesis Response submitted as part of the Scoping Letter (December 2021)	Anthesis Response as part of this ESIA (June 2022)
The most sensitive path of the Zakum cable *(Route 1)* from Mirfa power plant passes through the MMBR. EIA must address (a) why a deviated route cannot be considered, (b) seasonality, duration etc. of the operational aspect of the Project for the MMBR patch of the route, (c) impact of the Project within and outside of the MMBR.	Noted and agreed. Consultations will be undertaken with ADNOC relating to initial route selection and this will be reviewed following the results of marine modelling and impact assessments and appropriate mitigation measures will be presented.	In regard to point (a), consultations between the Project Proponent (ADNOC), the developers (consortium EDF/KEPCO/KIC), the EPC Contractor (consortium JDN and SCT) and Anthesis were undertaken on a regular basis in order to find solutions to avoid sensitive areas to meet IFC standards requirements and to ensure EAD approval of the cable routes. Due to the Project time constraint, Anthesis proposed to undertake a remote sensing survey completed via processing aerial imagery to determine the location of sensitive and critical marine habitats near the cable routes in advance of the marine surveys. This allowed to re-route the cables to avoid impacts on critical and sensitive habitats. A full description of the options considered and the entire re-routing process is detailed in **Chapter 6** and is also presented in the MoM from the 16th March 2022 meeting with EAD (**Appendix 6.4**). Following the results of the marine surveys and marine modelling exercise presented in **Section 5.2** and **Section 5.5**, it is concluded that the revised routes have reduced significantly impacts upon sensitive receptors and additionally, appropriate mitigation, monitoring and compensation measures have been presented in this ESIA to minimise the residual impacts significance. In regard to point (b) and (c), as mentioned above, **Section 5.2** and **Section 5.5** present a number of mitigation, monitoring and compensation measures to reduce impacts upon sensitive areas, including the Marawah Marine Biosphere Reserve (MMBR).

EAD Comment	Anthesis Response submitted as part of the Scoping Letter (December 2021)	Anthesis Response as part of this ESIA (June 2022)
Please review and follow the EAD TGD for hydrodynamic modelling (EAD-EQ-PR-TG-13) and TGD for Dredging and Reclamation in Abu Dhabi Emirate (EAD-EQ-PR-TG-12). Both TGDs can be found on: https://eservices.ead.ae/en/web/guest/info-center	Noted. WKC are very familiar with undertaking hydrodynamic modelling and associated assessments within Abu Dhabi Emirate and will incorporate all requirements specified within these documents.	Please refer to **Section 5.2** and **Appendix 2.1** which presents in detail the methodology used for the marine modelling exercises.
The bathymetry survey is required to calibrate and validate the HDM and the bathymetry should cover the edge of the maximum potential impacts (worst case scenario(s)) of sediments dispersion during dredging and reclamation.	Noted. This will be included within the bathymetry data collection process.	Please refer to **Section 5.2** and **Appendix 2.1** which presents in detail the methodology used for the marine modelling exercises. It should also be noted that bathymetry surveys were already undertaken by Fugro for the Project inception which were prior to this ESIA process.
2 ADCPs must be installed in parallel for 15 days minimum for each route.	Please note that only one marine model will be developed covering both routes simultaneously. We therefore propose to install one ADCP for each route only (2 in total), for 15 days. It is proposed that it will not be necessary to install two per route since one overarching model will be developed to cover the entire Project area i.e. both cable routes, and as such it is considered that 2 ADCPs to cover the wider Project area will be sufficient. Post submission of the Scoping Letter: EAD requested two ADCPs per route and therefore a total of four ADCPs were deployed for the Project.	As requested by EAD, four ADCPs were deployed for the Project. Results of the ADCPs is presented in **Section 5.2** and **Appendix 2.1.**
Animation videos for the model must be provided	Noted. These will be provided.	The animation videos are submitted to EAD as part of the ESIA submission. Additionally, images from the animation videos have been extracted which are presented in **Appendix 2.1** and **Section 5.2**.

EAD Comment	Anthesis Response submitted as part of the Scoping Letter (December 2021)	Anthesis Response as part of this ESIA (June 2022)
The mesh growth rate should not exceed 10% to make sure it works efficiently.	Agreed. However, please note that mesh growth rate restriction of 10% is not applicable for flexible mesh models. This will be explained within the report. However, please note the below: During initial hydrodynamic simulation testing, the mesh size is varied in order to ensure model stability and accuracy. Once the model is proved to be stable, the mesh size is reduced to conclude if accuracy is improved by reducing the mesh size. WKC generally follows DHI guidelines on limiting scaling between mesh transitions by a factor of 4 to 10[1]. This factor has been recommended to ensure mathematical stability for MIKE software specifically. 'Mesh growth size' is approached differently in different software. These other software (e.g. Delft3D) will require a different approach to mesh generation to ensure stability considering the different mathematics within the software. The EAD guidance specifies 'a maximum growth rate of 10% in the mesh size', however, using MIKE stability can be achieved outside of these bounds. This rate appears to match the default used in Delft[2]. Although, please note that WKC only uses DHI's MIKE modelling suite.	Please refer to **Section 5.2** and **Appendix 2.1** which presents in detail the methodology used for the marine modelling exercises.
The sensitivity test for the mesh size must be provided.	Please see response above.	Please refer to **Section 5.2** and **Appendix 2.1** which presents in detail the methodology used for the marine modelling exercises.

[1] manuals.mikepoweredbydhi.help/2017/General/Mesh_Generator_Step_by_Step.pdf
[2] content.oss.deltares.nl/delft3d/manuals/RGFGRID_User_Manual.pdf

2.4.3.2. Anthesis Scoping Letter

Whilst the Gap Analysis Report defined where additional data need to be collected and which impact assessments will be required, it did not provide detail on the actual approaches to be adopted as part of the ESIA. Anthesis therefore prepared a Scoping Letter document to supplement the Gap Analysis Report with the intention of providing EAD with:

- A detailed methodology for baseline investigations as identified within the Gap Analysis Report; and
- A detailed methodology for impact assessments identified within the Gap Analysis Report.

A meeting between EAD, the Sponsors, Mott MacDonald and Anthesis was held on 21st September 2021 (MoM can be found within **Appendix 6.1**) with the intention of obtaining initial EAD feedback on the methodologies set out within the Scoping Letter to ensure that all parties fully agree with the scope which will ultimately be implemented as part of this ESIA. Following the meeting, Anthesis finalised the Scoping Letter following comments received from EAD and formally issued the document on the 27th September 2021 (Ref:210923/EAD/1176/1). The Scoping Letter was subsequently reviewed and approved by EAD with comments which were received on the 21st and 24th November 2021 (email exchanges presented in **Appendix 6.2**). Another meeting was held with EAD on the 29th November 2021 (MoM presented in **Appendix 6.3**) to discuss and receive clarifications on the received comments.

The Scoping Letter, which is provided in

Appendix 4.**1**, is therefore considered, in conjunction with the Gap Analysis Report prepared by Mott MacDonald (

Appendix 4.**2**), as the approved scoping document which has been used to inform the baseline surveys and subsequent assessments presented within this ESIA.

The EAD comments and Anthesis response are presented in Table 2-4 below.

Table 2-4: Response to EAD Comments on Anthesis Scoping Letter

No.	EAD Comment	Anthesis Response as part of this ESIA (June 2022)
Marine Environment:		
1.	Area where pipeline will be extended is critical habitat mainly for dugong mothers and their calves.	Please refer to **Section 5.5** which presents the results of the marine baseline survey and assess the impacts upon dugongs. Pipeline route has been altered to avoid critical habitat where possible and mitigation is applied to minimise the extent of impact to seagrass habitat. In addition, where practicable, work will be restricted during sensitive months. This is described in **Section 5.5.3.2.1**.
2.	The area includes healthy seagrass which is crucial for dugong and green sea turtles feeding.	Please refer to **Section 5.5** which presents the results of the marine baseline survey and assess the impacts upon seagrass. Pipeline route has been altered to avoid critical habitat were possible, mitigation is applied to minimise the extent of impact to seagrass habitat. In addition, where practicable, work will be restricted during sensitive months. This is described in **Section 5.5.3.2.1**.
3.	Initial Comment: Any works in the region must take in consideration the dugongs, green sea turtles, and the sea grass. So that; any works will be prohibited during the months Jun, July, and August. Revised Comment (Post Meeting Clarification (09/12/21) from EAD): – The months allowed for work are May, June, July, August and September. – Months are completely prohibited to work are December, January, February and March. – The other months (April, October and November) must be avoided as marine mammals might be available there, depending on temperature.	Clarifications of the initial EAD comment was made on the 9th December 2021 as presented in the MoM from the 29th November 2021 meeting with EAD (**Appendix 6.3**) which limits working areas during the months of December to March. Following the results of the marine surveys, mitigation and monitoring measures were presented to ensure reduction of impact upon the sensitive marine fauna. **Section 5.5** presents the results of the marine baseline survey, assess the impacts upon marine fauna and present mitigation, monitoring and compensation measures.
4.	No dredging is the most preferable techniques for laying the cables. Otherwise; the dredging method with minimum impact must be used.	Please refer to **Section 4.3** which details the construction methodology along the Project route. It should be noted that the cables will required to be buried at the Project nearshore areas for technical and safety requirements and therefore dredging and backfilling will be required in these areas. For the rest of the Project, the majority of the cable will be laid on the bottom of the sea and will be protected with rock installations and, where the cable

No.	EAD Comment	Anthesis Response as part of this ESIA (June 2022)
		crosses existing cables and/or assets, the cable will be protected by concrete mattresses. As presented in **Chapter 6** and the MoM from the 16th March 2022 meeting with EAD (**Appendix 6.4**), it should be noted that the revised Route 1 (Mirfa – Al Ghallan) has minimised the need of floatation / dredged channels within the nearshore areas to ensure reduction of impacts.
5.	Surveys are required for Dugongs, Green Sea Turtles, Seagrass species composition and distribution, and marine invertebrates.	<u>Seagrass and fish:</u> As per Item 2 of the MoM from the 29th November 2021 meeting with EAD (**Appendix 6.3**), the methodology to identify seagrass, macroalgae and fish species, composition and distribution was discussed and approved by EAD. <u>Marine Mammals and Reptiles:</u> As per Item 3 of the MoM from the 29th November 2021 meeting with EAD (**Appendix 6.3**), the methodology to identify the presence of marine mammals and reptiles was discussed and approved by EAD. <u>Marine Invertebrates:</u> As per Item 4 of the MoM from the 29th November 2021 meeting with EAD (**Appendix 6.3**), the methodology to identify and analyse the species of marine invertebrates was discussed and approved by EAD. The methodology of the marine surveys is also presented in **Section 5.5** and in **Appendix 2.2** to **Appendix 2.4.**
6.	As we agreed earlier, 2 ADCPs to be installed for each site.	As requested by EAD, four ADCPs were deployed for the Project. Results of the ADCPs is presented in **Section 5.2** and **Appendix 2.1.**
<u>Terrestrial Environment:</u>		
7.	Agreed as it is in the submitted scope of work.	Noted. The terrestrial environment is discussed in **Section 5.6**.

2.5. ESIA Compliance

This ESIA has been prepared in accordance with, and with the aim of obtaining approvals from, the EAD, although consideration has also been taken in terms of ADNOC's HSE Division requirements, which include a number of Codes of Practice procedures, the most pertinent of which are listed within **Section 3.4**.

Clause 3.3 of ADNOC Code of Practice on Environmental Protection: Environmental Impact Assessment (ADNOC COPV2-01) states the following:

> *n certain cases, the A process may need to be conducted ith the involvement of e ternal regulators, such as EAD. This situation arises where an ADNOC Group project is planned at a location that is outside the Concession Area or where a project is a joint one between an ADNOC Group Company and a non-ADNOC Group Company.*
>
> *In either of these cases, the EAD EIA procedure, requirements and process shall be strictly followed. EIA Report shall be prepared in EAD format and submitted to ADNOC GHSE unit for their review and onward submission to AD .*

This ESIA has therefore been prepared in accordance with the requirements set out within EAD Technical Guidance Document for Environmental Impact Assessment (EIA), April 2014 (EAD-EQ-PCE-TG-02).

The ESIA has also been developed to demonstrate compliance with IFC Performance Standards and EHS Guidelines, Equator Principles and other recognised International Best Practice Guidelines, in order to meet with the requirements of:

- Japanese Bank for International Cooperation (JBIC); and
- Korea Export Import Bank (KEXIM).

Finally, the Abu Dhabi Department of Culture and Tourism (DCT) was consulted in relation to determining and considering the potential for presence of archaeological or cultural heritage artefacts which may be impacted as a result of the Project and ensuring that any resources present are protected. A separate NOC will then be submitted independently of the ESIA process by the Project Owner. The results of the NOC will be provided and incorporated within the CESMP, including site-specific mitigation measures which will be required to be implemented accordingly.

3. LEGAL FRAMEWORK AND STANDARDS

3.1. Legislation

3.1.1. Regulatory Framework in the United Arab Emirates

Federal Law No. (24) of 1999, Protection and Development of Environment is the key environmental law within the UAE. This law broadly outlines environmental protection across different environmental aspects (such as marine pollution, chemical materials, hazardous wastes and air pollution) and outlines the requirement for adequate environmental impact assessments of projects. The overall aim of Law No. (24) of 1999 is to protect the natural environment. The primary tools for achieving the objectives outlined by this law are regulations regarding the environmental impact of major projects, environmental monitoring, and protection, natural reserves, hazardous substances and compensation issues in case of environmental damage. The law aims to achieve the following goals:

- Protection and conservation of the quality and natural balance of the environment;
- Control of all forms of pollution and avoidance of any immediate or long-term harmful effects resulting from development;
- Handling of hazardous substances, hazardous wastes and medical waste;
- Development of natural resources and conservation of biological diversity in the region and the exploitation of such resources with consideration of present and future generations;
- Protection of society, human health and the health of other living creatures from activities and acts that are environmentally harmful or impede authorized use of the environmental setting;
- Protection of the UAE environment from the harmful effects of activities undertaken outside the region of the UAE; and
- Compliance with international and regional conventions ratified or approved by the UAE regarding environmental protection, control of pollution and conservation of natural resources.

In addition to the requirements of Federal Law 24, a number of Executive Regulations deal with specific environmental areas, including:

- Regulation for the Environmental Effects of Installations. This regulation requires an ESIA to be carried out for certain projects before an Environmental License to develop and operate the project is issued by the Competent Authority; and
- Regulation for the Protection of the Maritime Environment. This is concerned with the prevention of pollution of the marine environment from vessels, land-based sources and offshore platforms.

Furthermore, the Executive Guidelines for Federal Law No. (24) for 1999, Concerning Environmental Protection and Development, Decree No. (37) of 2001, state the requirement to have a permit for new projects and also states that *hen analysing the e pected environmental reactions, the following elements must be taken into consideration when conducting an ESIA:*

a) Any environmental impact on the ecological system that might be affected by the project / activity; and
b) Any impact on an Area/Place/or building that has an archaeological, amusement, architectural, cultural, historical, scientific, or social values, or has other environmental characteristics that form a value for the e isting or future generations.

Table 3-1 below details additional Federal laws, which are of potential relevance to the Project.

Table 3-1: UAE laws & standards

Legislation	Scope
Federal Law Number 7, 1993 Establishment of FEA and its amendments	Articles establishing the Federal Environmental Agency as a legal entity.
Federal Law Number 23, 1999 Protection and Development of Marine Resources	Governs exploitation, protection and development of marine biological resources.
Federal Law Number 9, 1983 UAE Hunting Law	Law regulating the hunting of birds and animals (mammals and reptiles).
Federal Law Number 11, 2002 Regulation and Control of Trade in Endangered Species and Wild Fauna and Flora and its Executive Order	Controls trade in internationally recognized endangered species and wild flora and fauna.
Law No 1, 2002 and its amendment by the Federal Law No 20, 1996 regarding the Regulation and Control of the use of Radioactive Sources and Protection against their Hazards	This law aims to control the use of radioactive sources in the UAE and control associated hazards. The law stipulates the establishment of the Federal Environment Agency which coordinates, controls and develop emergency plans at a country level for radioactive sources and potential environmental impacts. * Note, no radioactive materials will be used during the construction phase of the project.
Ministerial Order (12) 2006, pertaining to the protection of Air Quality.	Establishes the relevant Ambient Air Quality Standards in the UAE for: Sulphur dioxide, Nitrogen dioxide, Ozone and Particulate matter less than 10m.
UAE standards EMS 477 / 2006	The standard composition of the new diesel has been approved by the Emirates Standardization and Metrology Agency (EMS 477/2006).
Ministerial Order Number 12 and the Federal Environment Agency's Noise Emission limit values.	Establishes limits for noise levels within residential areas with light traffic, residential areas downtown, industrial areas, commercial areas, and residential areas which include some workshops, commercial business or residential areas near the highways.
Ministerial Decision 42 of 2008	This Ministerial Decision is to ensure that any structure that is to undergo demolition must be free of Asbestos Containing Materials prior to demolition.
Ministerial Decision No 32, 1982	This law is concerned with the protection of Health and Safety of workers, it contains provisions to ensure that employers take the

Legislation	Scope
	necessary measures to prevent employees being exposed to risks from work related accidents and diseases.
Law No. (4), 1989	Concerning the establishment of the National Avian Research Centre.
Law No. (2) 1999	Pertaining to the protection of environment against abuse of the use of insecticides, pesticides and chemical fertilisers.

3.1.2. Regulatory Framework in Abu Dhabi

The Competent Authority for environmental affairs in Abu Dhabi Emirate is the Environment Agency – Abu Dhabi (EAD). The EAD was established under Local Law No. 4 of 1996, which was then amended by Local Law No. (16) of 2005 Pertaining to the Reorganisation of the Abu Dhabi Environment Agency.

The following legislation, technical guidance and best practice documents are potentially of relevance to the Project:

- Technical Guidance Note TG-003R Standards and Limits for Pollution to Air and Marine Environments, Occupational Exposure, Pesticides and Chemical Use which provides the standards and limits of the following:
  - Air emission limits;
  - Maximum limits for air pollutants within working areas;
  - Noise emission limits;
  - Recommended ambient air quality limits;
  - Characteristics of treated industrial wastewaters; and
  - Recommended ambient marine water quality standards.
- Local Law No. (21) of 2005 for Waste Management in Abu Dhabi Emirate sets out responsibilities for the Competent Authority, concerned parties and producers of wastes with regards to waste management within the Emirate;
- Permissible Discharge Limits to the Desert (Abu Dhabi National Oil Company), specifies water quality criteria for the discharge of water into the desert;
- Abu Dhabi Specification - Environmental Specification for Soil Contamination (ADS 19/2017);
- The Ambient Marine Water and Sediments Specifications (AMWSS); identifies the maximum allowable concentrations for ambient marine water and sediment samples, which must be analysed on a regular basis by an accredited laboratory and results provided to EAD;
- Law No. (22) 2005, concerning Animal Hunting in the Abu Dhabi Emirate;
- Law No. (13) 2005, concerning the legislation of Grazing in Abu Dhabi;
- Emiri Decree No. (10) of 2001 concerning Declaring Marah as a Protected Marine Area;
- Abu Dhabi Environmental Health & Safety Management System (AD EHSMS). The Abu Dhabi Environment, EHSMS has been developed to achieve excellence in the management and protection of the environment, health and safety, through a partnership between all government and private sectors to ensure activities within Abu Dhabi Emirate are undertaken in a responsible, safe and sustainable manner.

3.2. EAD Technical Guidelines

Technical Guidelines (TGs) and Standard Operating Procedures (SOPs) were revised by the EAD in April 2014; including the Technical Guidance Document for Environmental Impact Assessments (EIA) of April 2014 which has been referred to as part of the development of this ESIA. Further updates were then made with additional guidance documents being published in 2016 and 2018. The following TGs and SOPs documents were referred to prior to and during the preparation of this report:

- Technical Guidance Document for Mangrove Planting Permitting and Management Plan, September 2015 (EAD-TMBS-TG-01);
- Permitting of Development and Infrastructure Projects in Abu Dhabi, April 2014 (EAD-EQ-PCE-SOP-02);
- Technical Guidance Document for Environmental Impact Assessment (EIA), April 2014 (EAD-EQ-PCE-TG-02);
- Technical Guidance Document for Terms of Reference (TOR), April 2014 (EAD-EQ-PCE-TG-04);
- Technical Guidance Document for Construction Environmental Management Plan (CEMP), April 2014 (EAD-EQ-PCE-TG-05);
- Technical Guidance Document for Operational Environmental Management Plan (OEMP), April 2014 (EAD-EQ-PCE-TG-06);
- Technical Guidance Document for Environmental Action Plan (EAP), April 2014 (EAD-EQ-PCE-TG-08);
- Technical Guidance Document for Submission of Environmental Applications and Reports, April 2014 (EAD-EQ-PCE-TG-09);
- Technical Guidance Document for Environmental Audit Reports, April 2014 (EAD-EQ-PCE-TG-10);
- Technical Guidance Document for Wastewater and Marine Water Quality Monitoring, April 2014 (EAD-EQ-PCE-TG-11);
- Technical Guidance Document for Best Environmental Practices for Construction Environmental Management Plans (CEMP BEP), 2018 (EAD-EQ-PR-TG-11);
- Technical Guidance Document for Dredging and Reclamation in Abu Dhabi Emirate, 2016 (EAD-EQ-PR-TG-12);
- Technical Guidance Document for Hydrodynamic Modelling, 2016 (EAD-EQ-PR-TG-13);
- Technical Guidance Document for Monitoring Reports, April 2014 (EAD-EQ-PCE-TG-13); and
- Best Management Practices (BMP) Technical Guidance Document for Discharges from Construction Activities, April 2014 (EAD-EQ-PCE-TG-15).

The SOPs relating to the permitting process and specifically to the Environmental permitting of new development and infrastructure projects and the ESIA submission are presented in Figure 3-1 and Figure 3-2 below.

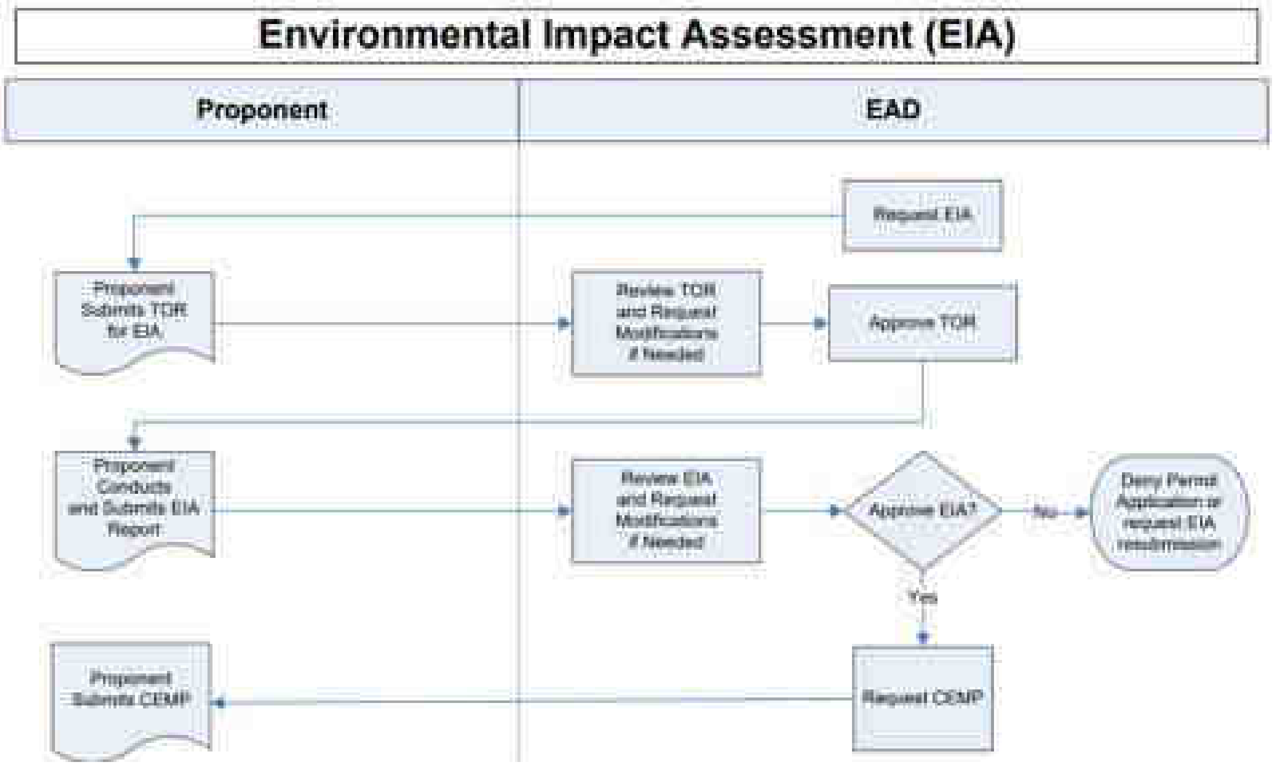


Figure 3-1: EIA Process in Abu Dhabi

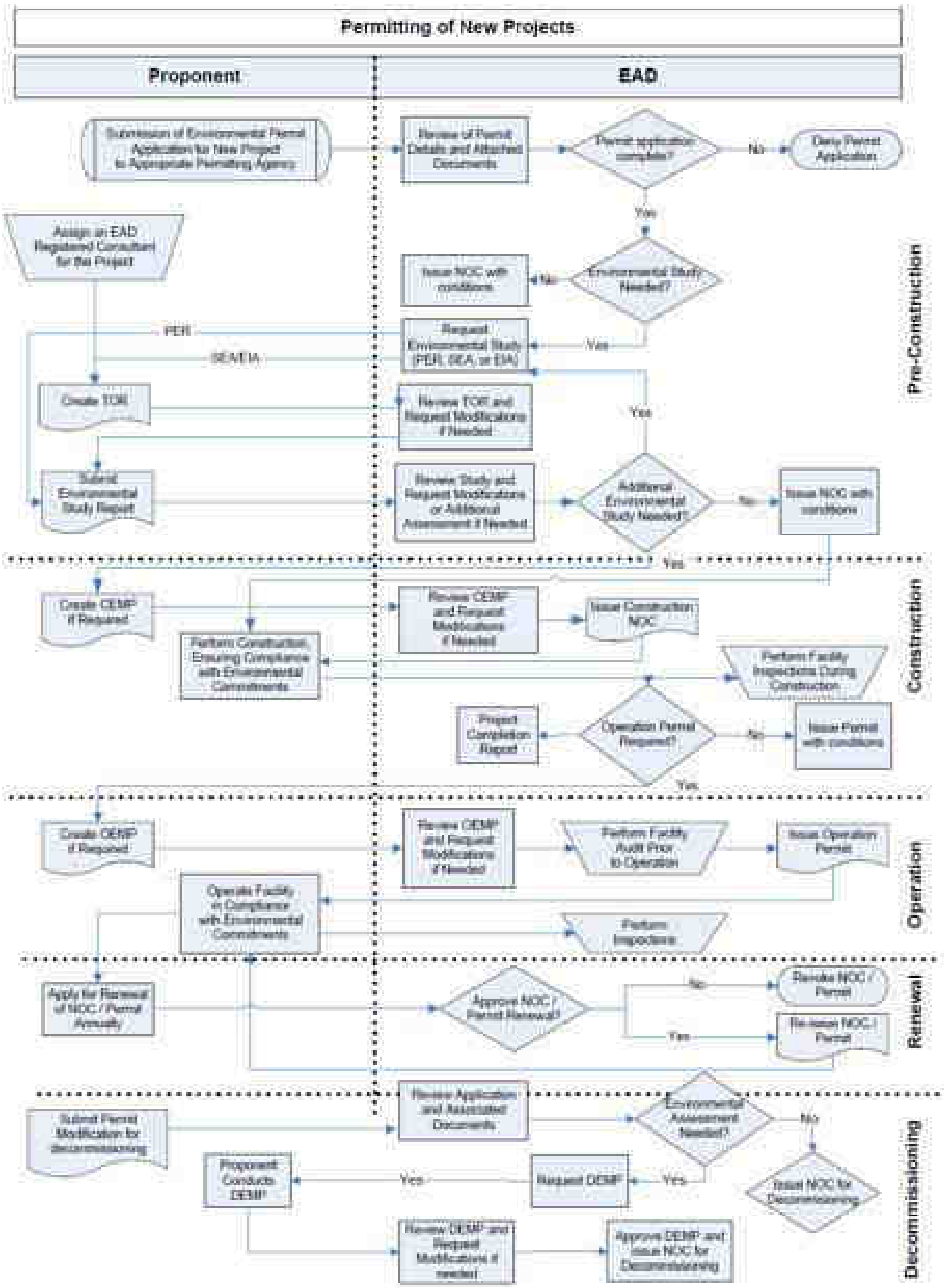


Figure 3-2 Environmental permitting of new development and infrastructure projects in Abu Dhabi

3.3. Environmental Regulations & Standards

This section sets out the environmental standards which apply within Abu Dhabi, as set out within Federal and Emirate laws and guidelines.

3.3.1. Air Quality

Cabinet Decree No 12 of 2006, pertaining to the protection of Air Quality sets out ambient air quality standards which are presented within Table 3-2 below.

Table 3-2: Ambient air quality standards

Air Polluting Parameter	Averaging Period		Maximum Allowable Concentration in the mbient ir ($\mu g/m^3$)
Sulphur Dioxide	1	Hour	350
	24	Hour	150
	1	Year	60
Carbon Monoxide	1	Hour	30,000
	8	Hour	10,000
Nitrogen Dioxide	1	Hour	400
	24	Hour	150
Ozone	1	Hour	200
	8	Hour	120
Total Suspended Particulates	24	Hour	230
	1	Year	90
Particulate Matter <10 micron (PM_{10})	24	Hour	150
Lead	1	Year	1

Table 3-3 below sets out the emissions standards for stationary sources.

Table 3-3: Air emission limits for stationary combustion sources using hydrocarbon fuel

Targeted Emissions	Expressed As	Emissions Limit Values	Units
Visible Emissions (All Sources)	-	250	mg/Nm^3
Total Suspended Particulates	TSP	250	mg/Nm^3
Sulphur Dioxides	SO_2	500	mg/Nm^3
Nitrogen Oxides (expressed as NO_2)	NO_x	Gas Fuel = 350 Liquid Fuel = 500	mg/Nm^3
Fuel Combustion Units			
Turbine Units		Gas Fuel = 70 Liquid Fuel = 150	
Carbon Monoxide	CO	500	mg/Nm^3

3.3.2. Waste Management

3.3.2.1. Federal Legislation

The following key pieces of legislation sets out control measures for waste production, storage, transportation and treatment within the UAE:

- Executive Order of Federal Law No. (24) Regulation for Handling Hazardous Materials, Hazardous Wastes and Medical Wastes and the Federal Law No. 12 of 2018 on the Integration of Waste Management;
- Ministerial Decree No. (98) of 2019 On using Refuse Derived Fuel (RDF) produced from waste treatment procedures in cement plants; and
- Ministerial Resolution No. (21) on the use of recycled aggregates from construction and demolition waste for road construction and infrastructure projects.

Furthermore, the UAE Vision 2021 sets an overall UAE target of 75% of waste generated shall be diverted from landfill.

3.3.2.2. Abu Dhabi Waste Legislation

Waste management, including the means for collection, transportation, treatment, and disposal of all solid wastes produced in Abu Dhabi Emirate is ensured through the implementation of Executive Council Decree (decision Number 21) which was enforced in March 2005. The implementation of this decree has led to the development of the Master Plan for Waste Management in Abu Dhabi.

Law No. 21 (2005) '*Managing Wastes in Abu Dhabi'* identifies EAD as the responsible body for the monitoring and regulation of all wastes generated within the Emirate. EAD are tasked with ensuring that all government and private bodies dealing with waste comply adequately with requirements for collection, transportation, storage, treatment and disposal of waste.

Abu Dhabi Executive Council Decree (Number 11) was issued in May 2007 which served to formulate the Abu Dhabi Higher Committee for Waste Management in Abu Dhabi Emirate to ensure that Law No. 21 is adequately implemented. Under Decree 17 of 2008, the Abu Dhabi Waste Management Centre (CWM) has been tasked with upgrading the waste management framework within the Emirate and has overall responsibility for waste management; including upgrading and enforcing existing waste policies and monitoring. The Abu Dhabi Environment Vision 2030 provides an overall guiding framework to consider and preserve the environment when operating in the Emirate of Abu Dhabi. The vision for the waste sector is to achieve an enhanced value creation through optimised material flows and waste management by 2030. To realise this vision, Abu Dhabi plans to initially increase waste reduction, recycling and reuse to divert waste from landfills. Then, Abu Dhabi plans to change the focus from waste management to resource and material flow.

In addition, Order number BT9G25/2010 issued by the Executive Council Abu Dhabi, dated 26th July 2010 requires the use of a minimum of 40% aggregate (by volume) of recycled construction and demolition waste in infrastructure projects.

EAD has led the development of a five-year Waste Management Strategy for the Emirate of Abu Dhabi in partnership with CWM and the Department of Municipal Affairs (DMA). This strategy refers as *' o ards ntegrated Waste Management in Abu Dhabi'* (35) establishes targets *(Table 4)* and the initiatives required to achieve them. Central to the whole strategy is to divert 85% of municipal solid waste and 90% of construction and demolition waste from landfill.

The UAE has set two strategic targets to be achieved by all Emirates by 2021 as part of the UAE Vision 2021 (36) and EAD Strategic Plan 2016-2020 as follows:

- 1.5kg Municipal Solid Waste (MSW) capita/day; and
- 75% of MSW generated to be treated.

Furthermore, as per Plan Abu Dhabi 2030, Abu Dhabi Emirate has set a target that 60% of total waste generated is to be treated using environmentally and economically sustainable methods, which should be achieved by 2020 (37).

- Waste environmental regulations & standards within Abu Dhabi Emirate include the following:
- Waste Management Policy (EAD-EQ-PR-P-01): Waste Classification;
- Waste Management Policy (EAD-EQ-PR-TGD-01): Waste Classification Technical Guideline;
- Waste Management Policy (EAD-EQ-PR-P-02): Waste Planning;
- Waste Management Policy (EAD-EQ-PR-P-03): Licensing and Enforcement Policy for Waste Sector;
- Waste Management Policy (EAD-EQ-PR-P-04): Waste Collection, Segregation, Transfer and Tracking Policy;
- Waste Management Policy (EAD-EQ-PR-P-05): Waste Reuse, Recycling, Resource Recovery, Treatment and Disposal Policy;
- Waste Management Policy (EAD-EQ-PR-TG-XX): Technical Guideline on Duty of Care in Waste Management in the Emirate of Abu Dhabi;
- Tadweer (Waste Management Center – Abu Dhabi) Standard Operating Procedure (CWM.SOP.PR/07): Management of Construction & Demolition Waste in Abu Dhabi Emirate;

- Tadweer (Waste Management Center – Abu Dhabi) Technical Guidelines (CWM TG # 01): Requirement & Procedure for Disposal of Hazardous Waste;
- Tadweer (Waste Management Center – Abu Dhabi) Technical Guidelines (CWM TG # 02): Requirements for the Transport of Hazardous Waste;
- Tadweer (Center of Waste Management – Abu Dhabi) Technical Guidelines (CWM TG #05): Permitting of Cleaning and Transportation of Oil and Grease from Tanks, Pipelines, etc.;
- Tadweer (Center of Waste Management – Abu Dhabi) Technical Guidelines (CWM TG #06): Requirements and Procedures for Registration of Waste Skips and Container;
- Tadweer (Center of Waste Management – Abu Dhabi) Technical Guidelines (CWM TG #07): Test Requirements for Treated Wastes including Disposal;
- Tadweer (Waste Management Center – Abu Dhabi) Technical Guidelines (CWM TG # 08): Management of Asbestos and Asbestos Containing Material in the Emirate of Abu Dhabi;
- Tadweer (Center of Waste Management – Abu Dhabi) Technical Guidelines (CWM TG #09): Permitting & Licensing Waste Transportation Vehicles & GPS Requirements;
- Tadweer (Waste Management Center – Abu Dhabi) Technical Guidelines (CWM TG # 10): Inspection of Waste Treatment Facilities, Waste Transportation and Pest Control Facilities;
- Tadweer (Waste Management Center – Abu Dhabi) Technical Guidelines (CWM TG # 11): Permits and Licensing Requirements for Transportation, Treatment and Recycling Facility;
- Health Authority - Abu Dhabi, Policy on Medical Waste Management in Health Care Facilities: PPR/HCP/P0002/07 of 2007;
- OSHAD SF CoP 54.0 - Waste Management; and
- OSHAD SF CoP 1.0 - Hazardous Materials.

3.3.2.3. Treated Wastewater Discharge Limits to Land

The EAD Technical report – Recommended Standards for Treated Wastewater reuse and Discharge to Land in Abu Dhabi Emirate (38) sets out the recommended standards for treated wastewater reuse and discharge to land, which are presented below in Table 3-4.

Table 3-4: Recommended standards for treated wastewater reuse and discharge to land

Constituent	Recommended Level	Rationale for the Standard and References for the Selected Standard
Metals		
Al	*5.0 mg/l*	Aluminium can cause non-productiveness in acid soils, but soils at pH 5.5 to 8.0 will precipitate the ion and eliminate toxicity. United State Environmental Protection Agency (US EPA) sets a limit of (5.0 mg/l) for long-term use, and (20 mg/l) for short-term use. Food and Agriculture Organization (FAO) and some European Union (EU) countries in addition to Cyprus, Greece and Korea adopted a maximum concentration of (5.0 mg/l). RSB sets a maximum allowable concentration of (5.0 mg/l). Italy set a more restricted limit of (1.0 mg/l).
As	*0.1 mg/l*	Depending on plant species, nutrient solutions containing 0.5 to 10 mg/L can induce arsenic toxicity. Only a fraction of the total arsenic in soil is available to plants. US EPA sets a limit of (0.1 mg/l) for long-term use, and (2.0 mg/l) for short-term use. FAO and some EU countries adopted a maximum concentration of (0.1 mg/l). RSB sets a maximum allowable concentration of (0.1 mg/l). New Zealand and Canada have set the same limit. However, Italy set a more restricted limit of (0.02 mg/l).
Cd	*0.01 mg/l*	Cadmium is toxic to some crops at low concentrations in nutrient solutions. Most of the international guidelines recommend conservative limits due to its potential for accumulation in plants and soils to concentrations that may be harmful to humans. US EPA sets a limit of (0.01 mg/l) for long-term use, and (0.05 mg/l) for short-term use. FAO, some EU countries in addition to Cyprus, Greece, Korea and RSB adopted a maximum concentration of (0.01 mg/l). However, Italy set a more restricted limit of (0.005 mg/l).
Cr	*0.1 mg/l*	Chromium is not generally recognized as essential growth element. Due to lack of knowledge on toxicity to plants, conservative limits are recommended. US EPA sets a limit of (0.1 mg/l) for long-term use, and (1.0 mg/l) for short-term use. FAO and some EU countries adopted a maximum concentration of (0.1 mg/l). RSB sets a maximum allowable concentration of (0.1 mg/l). Korea adopted a more restricted limit of (0.05 mg/l).
Cu	*0.2 mg/l*	Copper is an essential element for plant growth. Most plants can tolerate concentrations in soils of 20 to 30 mg/kg. Hence Cu concentrations in irrigation water up to (5 mg/l) will not produce any negative impacts to plants and soils. US EPA sets a limit of (0.2 mg/l) for long-term use, and (5.0 mg/l) for short-term use. FAO, some EU countries and RSB adopted a maximum concentration of (0.2 mg/l).
Fe	*5.0 mg/l*	Iron in the presence of oxygen is not harmful to plants because it is readily oxidized to insoluble iron. Therefore, iron in irrigation water precipitates on soils. Concentrations in irrigation water of up to (5 mg/l) are not found to harm plants or soils. US EPA sets a limit of (5 mg/l) for long-term use, and (20 mg/l) for short-term use. FAO and some EU countries adopted a maximum concentration of (5.0 mg/l). RSB sets a maximum allowable concentration of (5 mg/l). Greece and Italy set more restricted limits of (3.0 and 2.0 mg/l) respectively.
Pb	*5.0 mg/l*	Lead can inhibit plant cell growth at very high concentrations. US EPA sets a limit of (5.0 mg/l) for long-term use, and (10.0 mg/l) for short-term use. FAO and some EU countries adopted a maximum concentration of

Constituent	Recommended Level	Rationale for the Standard and References for the Selected Standard
		(5.0 mg/l), while Greece and Italy set a maximum limit of (0.1 mg/l). RSB sets a maximum allowable concentration of (5 mg/l).
Mn	*0.2 mg/l*	Manganese is an essential trace element. Up to (5.0 mg/l) in irrigation water is not expected to cause any harm to plants in alkaline soils. However, it is toxic to a number of crops at few-tenth to a few mg/l in acidic soils. US EPA sets a limit of (0.2 mg/l) for long-term use, and (10.0 mg/l) for short-term use. FAO, some EU countries and RSB adopted a maximum concentration of (0.2 mg/l).
Ni	*0.2 mg/l*	Nickel is toxic to a number of plants at 0.5 to 1.0 mg/l. Toxicity is reduced at neutral or alkaline pH. US EPA sets a limit of (0.2 mg/l) for long-term use, and (2.0 mg/l) for short-term use. FAO and some EU countries adopted a maximum concentration of (0.2 mg/l). RSB sets a maximum allowable concentration of (0.2 mg/l).
Se	*0.02 mg/l*	Selenium is toxic to plants al low concentrations and to livestock if forage is grown in soils with low levels of Selenium. US EPA sets a limit of (0.02 mg/l) for long-term and short-term uses. FAO, some EU countries and RSB adopted a maximum concentration of (0.02 mg/l). Italy set a more restricted limit of (0.01 mg/l).
V	*0.1 mg/l*	Vanadium is toxic to many plants at relatively low concentrations. US EPA sets a limit of (0.1 mg/l) for long-term use, and (1.0 mg/l) for short-term use. FAO, some EU countries and RSB adopted a maximum concentration of (0.1 mg/l).
Zn	*2.0 mg/l*	Zinc is an essential micronutrient. Concentrations in soils may reach a few hundred mg/kg before any negative effect take place. It is toxic to some plants at widely varying concentrations. US EPA sets a limit of (2.0 mg/l) for long-term use, and (10.0 mg/l) for short-term use. FAO and some EU countries adopted a maximum concentration of (2.0 mg/l). RSB sets a maximum allowable concentration of (2.0 mg/l). Italy set a more restricted limit of (0.5 mg/l).
Other Inorganics and General Constituents		
pH	*6.0 – 9.0 unit*	Normal pH value has generally no significant negative impacts on plants or soils. The main pH impact is on nutrient availability for plants and in addition on irrigation equipment, which could corrode or may develop a scale or precipitation of carbonates. Most of the international guidelines, including FAO, set a range of pH value of 6.0-9.0 for irrigation water.
Cl	*50 – 350 mg/l*	Chloride is a major salinity parameter in irrigation water; therefore, its concentration is generally reflected in the EC or TDS value. There is no negative impact of Cl on soil, however, when it exists in high concentrations it will have adverse impacts on fruit crops that are sensitive to Cl. When using sprinkler irrigation, it is highly recommended to have Cl concentration less (105 mg/l), and for surface irrigation the concentration should not exceed (355 mg/l) for crops that have high sensitivity and slight to moderate sensitivity to Cl (as per FAO guidelines). Standard ranges have been set by Australia and New Zealand depending on crop tolerance. Therefore, no one value was chosen as a representative value.

Constituent	Recommended Level	Rationale for the Standard and References for the Selected Standard
Salinity	*Crop-specific (as per FAO guidelines)*	Different types of plants can only tolerate a certain salt content of irrigation water, expressed generally in Electrical Conductivity (EC) units. Plants are classified into 3 categories: sensitive, salt medium tolerant and salt tolerant plants. Generally, exceeding the upper limit of salinity tolerance for crops could probably result in a productivity decline. The FAO has established guidelines for agricultural water primarily based on salinity.
Total Suspended Solids (TSS)	*10 mg/l for landscape irrigation of unlimited public access* *30 mg/l for amenity areas of limited public access*	Turbidity and TSS may reduce the permeability of the surface soil layer or may cause clogging of the micro irrigation systems. All other impacts are related to the composition of the substances causing turbidity or suspension. When using sprinkler irrigation, turbidity and TSS may precipitate on leaves and fruits, which lead to lower product quality. US EPA/ United States Agency for International Development (USAID) guidelines set a Turbidity value of (≤2 NTU) for all types of landscape irrigation and for food crops not commercially processed; and (30 mg/l) of TSS for food crops commercially crops. Cyprus criteria set a maximum limit of (10 mg/l) for amenity areas of unlimited public vegetables eaten cooked; and (30 mg/l) for crops of human consumption, amenity areas of limited public access, and for fodder crops. Greece adopted a maximum TSS limit of (10 mg/l) for unrestricted irrigation, and (35 mg/l) for restricted irrigation. FAO guidelines did not set specific limits for TSS or turbidity.
Na	*50 – 200 mg/l*	Sodium is a major salinity parameter in irrigation water; therefore its concentration is generally reflected in the EC or TDS value. Excessive (Na) in irrigation water promotes soil dispersion and structural breakdown, where the finer soil particles fill many of the smaller pore spaces, sealing the surface and greatly reducing water infiltration rates. The growth of plants is thus affected by an unavailability of soil water. The Sodium Adsorption Ration (SAR) was developed to determine the suitability of water for irrigation. When using sprinkler irrigation, it is highly recommended to have (Na) concentration less than (70 mg/l), and for surface irrigation the concentration should not exceed (200 mg/l) for crops that have high sensitivity and slight to moderate sensitivity to Na (as per FAO guidelines). Standard ranges have been set by Australia and New Zealand depending on crop tolerance. Therefore, no one value was chosen as a representative value.
Sodium Adsorption Ratio (SAR)	*6 unit*	When the SAR value is ≤ 6, no problem is to be expected for soils or plants. SAR of 6-9 may cause some problems to soils, such as decreasing soil permeability. No one value was chosen as a representative value.
B	*0.7 mg/l*	Boron is an essential element for plant growth, but the range of its concentration in irrigation water between nutritional requirements and toxicity is very narrow. The optimum yield of some crops is at few tenth mg/l. Concentrations of (1.0 mg/l) and more are toxic to many sensitive plants. Values in some international guidelines range from (0.5 to 6.0 mg/l). US EPA set a limit of (0.75 mg/l) for long-term use, and (2.0 mg/l) for short-term use. New Zealand set the more stringent value of (0.5 mg/l). FAO guidelines recommended a limit of (0.7 mg/l) for sensitive crops, and (0.7-3.0 mg/l) for slight to moderate sensitive crops. Greece and Italy set the following limits of (2.0 and 1.0 mg/l) respectively.
BOD_5	*10 mg/l*	Oxygen is necessary for plant growth and it should be present in the root zone. Anaerobic conditions will occur only if irrigation water contains high organic matter concentrations and low DO contents. Excessive amounts

Constituent	Recommended Level	Rationale for the Standard and References for the Selected Standard
		of organics (BOD and COD) cause problems, low to moderate concentrations are beneficial. US EPA/USAID guidelines set a BOD_5 value of (10 mg/l) for all types of landscape irrigation and for food crops not commercially processed; and (30 mg/l) for food crops commercially processed and fodder and non-food crops. Cyprus criteria set a maximum limit of BOD_5 of (10 mg/l) for amenity areas of unlimited public access and for vegetables eaten cooked; and (20 mg/l) for crops of human consumption, amenity areas of limited public access, and for fodder crops. Greece adopted a maximum BOD_5 limit of (10 mg/l) for unrestricted irrigation, and (25 mg/l) for restricted irrigation. The Sultanate of Oman adopted a similar approach. FAO guidelines did not set specific limits for BOD_5 or COD.
NO_3	*30 as N*	Nitrogen is the most beneficial nutrient to plant. Treated wastewater usually contains relatively high concentrations of Nitrate. NO_3 serves as a nutrient for plants, but excessive concentrations may cause delayed maturity or poor crop quality. Excessive nitrogen in water can also cause groundwater contamination. FAO recommended a maximum level of (30 mg/l) for irrigation water. Jordan set a limit of (45 mg/l) for industrial crops and forest trees irrigation, Dubai sets a limit of (50 mg/l).
Cl_2	*1.0 mg/l*	Free residual chlorine (Cl_2) at concentrations less than (1.0 mg/l) usually poses no problem to plants. However, some sensitive crops may be damaged at levels much lower than this. Cl_2 at concentrations greater than (5.0 mg/l) causes severe damage to most plants. Most of the guidelines do not set a limit for Cl_2; the US EPA recommended a maximum limit of (1.0 mg/l).
Microbial		
E. coli or thermo-tolerant coliform bacteria	*1000 MPN or FCU/100 ml for restricted irrigation*	Spain, Cyprus and Portugal adopted a limit of (100/100 ml) for unrestricted irrigation, and (1000/100 ml) for restricted irrigation. France adopted a limit of (250/100 ml) for unrestricted irrigation, and (10,000/100 ml) for restricted irrigation. The WHO recommended (1000/100ml) for unrestricted irrigation, and (10,000/100 ml) for restricted irrigation. RSB regulations set a limit of (100/100 ml) for general reuse, and (1000/100 ml) for restricted reuse.
Intestinal Helminth	*1 egg per litre*	Most of the international guidelines set a limit of 1 egg/L.

3.3.3. Soil

Abu Dhabi Quality & Conformity Council (QCC) released in 2017 the new Abu Dhabi Specification (ADS) for Soil Contamination which will be used for the ESIA for soil testing. Table 3-5 below presents the maximum allowable soil contaminants for residential / open space use. This is a worst case and a lower threshold may be appropriate in some areas conforming to limits for industrial uses, which will be determined as part of the ESIA.

Table 3-5: ADS maximum allowable soil contaminants for residential/open space use (Table1))

No.	Parameter	Unit	Screening level	Clean-up level
1	Antimony (Sb)	mg/kg (DW[1])	31	310
2	Arsenic (As)	mg/kg (DW)	6.8	68
3	Beryllium (Be)	mg/kg (DW)	160	1600
4	Cadmium (Cd)	mg/kg (DW)	71	710
5	Chromium (Cr VI)	mg/kg (DW)	3	30
6	Cyanide (CN)	mg/kg (DW)	2.7	27
7	Cobalt (Co)	mg/kg (DW)	23	230
8	Copper (Cu)	g/kg (DW)	3.1	31.0
9	Lead (Pb)	g/kg (DW)	4.0	40.0
10	Manganese (Mn)	g/kg (DW)	1.8	18.0
11	Mercury (Hg)	g/kg (DW)	11	110
12	Molybdenum (Mo)	mg/kg (DW)	390	3900
13	Nickel (Ni)	g/kg (DW)	1.5	15.0
14	Selenium (Se)	mg/kg (DW)	390	3900
15	Asbestos	g/10 kg (DW)	1.0	1.0
16	Benzene	mg/kg (DW)	12	120
17	Toluene	g/kg (DW)	4.9	49
18	Ethylbenzene	mg/kg (DW)	58	580
19	Xylene	mg/kg (DW)	580	5800
20	Polychlorinated Biphenyls	mg/kg (DW)	13.0	130

No.	Parameter	Unit	Screening level	Clean-up level
21	Benzo(a)pyrene (BaP)	mg/kg (DW)	0.16	1.6
22	Trichloroethylene (TCE)	mg/kg (DW)	4.1	41
23	Vinyl Chloride (C2H3Cl)	mg/kg (DW)	0.59	5.9

Note:

[1] **DW:** Dry Weight

[2] **Screening level:** Concentration of a given contaminant for a specific use based on an increased cancer risk of 1 in 100,000 across the population. Further investigation and management actions are required as per requirements of the competent authority in case the soil quality exceeds the screening levels but do not exceed the clean-up levels.

[3] **Clean-up level:** In case the soil quality exceeds the clean-up levels for the designated land use, remediation measures shall be implemented as per requirements of the competent authority. All remediation plans shall be prepared as per the prevailing and proven environmental technologies for site remediation. In addition, all remediation plans and measures shall be approved by the competent authority on a case-by-case basis.

3.3.4. Groundwater

No groundwater standards are currently published for Abu Dhabi Emirate. Therefore, in the absence of regulations, the Dutch Target and Intervention values have been referred to. The Dutch Groundwater Target and Intervention Values across the Project are presented in Table 3-6 below.

Table 3-6: Dutch groundwater target and intervention values (2009)

Parameters	Groundwater (µg/L in solution)	
	Target value for shallow groundwater (<10m bgl)	Intervention value
I - Metals		
Antimony	-	20
Arsenic	10	60
Barium	50	625
Cadmium	0.4	6
Chromium	1	30
Cobalt	20	100
Copper	15	75
Mercury	0.05	0.3
Lead	15	75
Molybdenum	5	300
Nickel	15	75
Zinc	65	800
II - Inorganic compounds		
Cyanides-free	5	1500

Parameters	Groundwater (μg/L in solution)	
	Target value for shallow groundwater (<10m bgl)	Intervention value
Cyanides-complex (pH<5)	10	1500
Cyanides-complex (pH ≥5)	10	1500
Thiocyanates (sum)	-	1500
Bromide (mg Br/l)	0.3 mg/L[2]	-
Chloride (mg Cl/l)	100 mg/L[2]	-
Fluoride (mg F/l)	0.5 mg/L[2]	-
III - Aromatic compounds		
Benzene	0.2	30
Ethyl benzene	4	150
Toluene	7	1000
Xylenes	0.2	70
Styrene (vinyl benzene)	6	300
Phenol	0.2	2000
Cresols (sum)	0.2	200
Catechol(o-dihydroxybenzene)	0.2	1250
Resorcinol(m-dihydroxybenzene)	0.2	600
Hydroquinone(p-dihydroxybenzene)	0.2	800
IV - Polycyclic aromatic hydrocarbons (PAH)		
PAH (sum 10)	-	-
Naphthalene	0.01	70
Anthracene	0.0007	5
Phenatrene	0.003	5
Fluoranthene	0.003	1
Benzo(a)anthracene	0.0001	0.5
Chrysene	0.003	0.2
Benzo(a)pyrene	0.0005	0.05
Benzo(ghi)perylene	0.0003	0.05
Benzo(k)fluoranthene	0.0004	0.05
Indeno(1,2,3-cd)pyrene	0.0004	0.05
V - Chlorinated hydrocarbons		
Vinyl Chloride	0.01	5

Parameters	Groundwater (µg/L in solution)	
	Target value for shallow groundwater (<10m bgl)	Intervention value
Dichloromethane	0.01	1000
1,1-dichloroethane	7	900
1,2-dichloroethane	7	400
1,1-dichloroethene	0.01	10
1,2-dichloroethene (cis and trans)	0.01	20
Dichloropropane	0.8	80
Trichloromethane (chloroform)	6	400
1,1,1-trichloroethane	0.01	300
1,1,2-trichloroethane	0.01	130
Trichloroethene (Tri)	24	500
Tetrachloromethane (Tetra)	0.01	10
Tetrachloroethene (Per)	0.01	40
Chlorobenzenes (sum)	-	-
Monochlorobenzene	7	180
Dichlorobenzenes	3	50
Trichlorobenzenes	0.01	10
Tetrachlorobenzenes	0.01	2.5
Pentachlorobenzene	0.003	1
Hexachlorobenzene	0.00009	0.5
Chlorophenols (sum)	-	-
Monochlorophenols (sum)	0.3	100
Dichlorophenols	0.2	30
Trichlorophenols	0.03	10
Tetrachlorophenols	0.01	10
Pentachlorophenol	0.04	3
Chloronaphthalene	-	6
Monochloroaniline	-	30
Polychlorobiphenyls (sum 7)	0.01	0.01
VI - Pesticides		
dichloro-diphenyl-trichloroethane (DDT) / dichlorodiphenyldichloroethylene (DDE) / dichlorodiphenyldichloroethane (DDD)	0.004 ng/L	0.01

Parameters	Groundwater (µg/L in solution)	
	Target value for shallow groundwater (<10m bgl)	Intervention value
Drins (sum)	-	0.1
Aldrin	0.009 ng/L	
Dieldrin	0.1 ng/L	
Endrin	0.04 ng/L	
Hexachlorocyclohexane (HCH) compounds (sum)	0.05	1
α-HCH	33 ng/L	
β-HCH	8 ng/L	
γ-HCH (lindane)	9 ng/L	
Atrazine	29 ng/L	150
Carbaryl	2 ng/L	50
Carbofuran	9 ng/L	100
Chlorodane	0.02 ng/L	0.2
α-endosulfan	0.2 ng/L	5
Heptachloro	0.005 ng/L	0.3
Heptachloro-epoxide	0.005 ng/L	3
Maneb	0.05 ng/L	0.1
2-methyl-4-chlorophenoxyacetic acid (MCPA)	0.02	50
Organotin compounds	0.05*-16 ng/L	0.7
VII - Other contaminants		
Cyclohexanone	0.5	15000
Phthalates (sum)	0.5	5
Mineral oil	50	600
Pyridine	0.5	30
Tetrahydrofuran	0.5	300
Tetrahydrothiophene	0.5	5000
Tribromomethane	-	630
VIII - Aromatic compounds		
Dodecylbenzene	-	0.02
Aromatic solvents	-	150
IX - Chlorinated hydrocarbons		
Dichloroaniline	-	100

Parameters	Groundwater (µg/L in solution)	
	Target value for shallow groundwater (<10m bgl)	Intervention value
Trichloroaniline	-	10
Tetrachloroaniline	-	10
Pentachloroaniline	-	1
4-chloromethylphenols	-	350
Dioxin	-	0.001 ng/L
X - Pesticides		
Azinphos-methyl	0.1* ng/L	2
XI - Other contaminants		
Acrylonitrile	0.08	5
Butanol	-	5600
1,2-butylacetate	-	6300
Ethylacetate	-	15000
Diethylene glycol	-	13000
Ethylene glycol	-	5500
Formaldehyde	-	50
Isopropanol	-	31000
Methanol	-	24000
Methyl-tetra-butyl ether (MTBE)	-	9200
Methylethylketone	-	6000

3.3.5. Marine Environment

Protection of the marine environment is regulated under the ‘Regulation for the Protection of Maritime Environment’, UAE Cabinet. The principle requirements of Chapter 3 of this regulation, pertaining to this scope of works, are as follows:

- No discharge of plastic materials including but not limited to, synthetic rope, synthetic fishing nets, plastic bags;
- No discharge of garbage including products, ceramics, glass and bottles, wood, lining and packing materials; and
- Food leftovers generated from marine vessels, rigs or barges, if to be disposed of into marine environment the discharge location must be as far as possible from land but not less than 12 nautical miles from the nearest shoreline.

In accordance with the Council of Ministers' Decision No 37 – 2001 – Protection of the Marine Environment, the non-degradable pollutants / Illegal compounds to be discharged into marine environment are presented in Table 3-7 below.

Table 3-7: Prohibited substances for discharge to the marine environment (8)

Type of Prohibited Substances	Prohibited Substances
Organophosphorus Pesticides	Dimethoate
	Malathion
Polychlorinated Biphenyls	Polychlorinated Biphenyls (PCBs)
	Aroclor
	Tetrachlorobiphenyl
	Trichlorobiphenyl
Organochlorine Pesticides	Aldrin
	Dieldrin
	DDT
	Chlordane
	Eldrin
Polynuclear Aromatic Hydrocarbons (PAH)	Benzo (a) pyrene
	Naphthalene

The EAD Technical Guidance Document Standards and Limits for Pollution to Air and Marine Environments includes Recommended Ambient Marine Water Quality Standards as presented in Table 3-8 below.

Table 3-8: Recommended ambient marine water quality objectives (EAD AWQS)

Parameters	Maximum Concentration	Units
Physical Indicators		
Floating Particles / Floatable / Debris	Nil	mg/m^2
Temperature	+/- 3	^oC of background
Turbidity	10	NTU
Transparency	≥10	Meter of Secchi Depth

Parameters	Maximum Concentration	Units
Salinity	≤5	% background concentration
BOD	5	mg/l
Odour	Not objectionable	-
Colour	No change from background	-
Chemical Indicators		
Ammonia	0.004	mg/L
Arsenic	0.005	mg/L
Cadmium	0.001	mg/L
Chorine Residual	0.01	mg/L
Chromium	0.01	mg/L
Copper	0.01	mg/L
Cyanide	0.004	mg/L
Lead	0.01	mg/L
Mercury	Not given	Not given
Oil and grease	Not visible	mg/L
Petroleum Hydrocarbon	5	mg/L
Dissolved Oxygen	≥4	mg/L
Total Suspended Solids	≤33	mg/L
pH	6.5 – 8.5	mg/L
Phenols	0.001	mg/L
Phosphorus Total	0.001	mg/L
Phosphate	34	Microgram/L
Sulphides	0.004	mg/L
Total Organic Carbon	2.5	mg/L
Zinc	0.01	mg/L

Parameters	Maximum Concentration	Units
Nickel	20	Microgram/L
Iron	0.3	mg/L
Vanadium	9.4	Microgram/L
NO_3	95	Microgram/L
NO_2	34	Microgram/L

Furthermore, the Abu Dhabi Specification (ADS) for Ambient Marine Water and Sediments Specifications are presented in Table 3-9 and Table 3-10 below.

Table 3-9: Maximum allowable concentrations for ambient marine water (ADS)

Parameter	Unit	General Use Areas	Marine Protected Use Areas
Cadmium	µg/l	0.7	0.3
Chromium	µg/l	0.2	0.2
Copper	µg/l	3.0	3.0
Lead	µg/l	2.2	2.2
Mercury	µg/l	0.1	0.1
Nickel	µg/l	7.0	3.0
Zinc	µg/l	15.0	15.0
Total Petroleum Hydrocarbons (TPH)	µg/l	7.0	7.0
Total Polychlorinated Biphenyls (PCBs)	µg/l	0.03	0.03
Chlorophyll (a)	µg/l	1.0	0.7
Dissolved Oxygen (DO)*	mg/l	4.0	4.0
Enterococci	CFU or MPN/100 ml	35	35
Note: µg/l: micrograms per liter; mg/l: milligram per liter; CFU: Colony Forming Unit; MPN: Most Probable Number **: minimum allowable concentration*			

Table 3-10: Maximum allowable concentrations for ambient marine sediments (ADS)

Parameter	Unit	General Use Areas	Marine Protected Use Areas
Arsenic (As)	mg/kg	7.0	7.0
Cadmium (Cd)	mg/kg	0.7	0.2
Chromium (Cr)	mg/kg	52	11
Copper (Cu)	mg/kg	20.0	20.0
Lead (Pb)	mg/kg	30.0	5.0
Mercury (Hg)	mg/kg	0.2	0.2
Nickel (Ni)	mg/kg	16.0	7.0
Zinc (Zn)	mg/kg	125.0	70.0
Total Polychlorinated Biphenyls (PCBs)	µg/kg	22.0	22.0
Total Polycyclic Aromatic Hydrocarbons (PAHs)	mg/kg	1.7	1.7
Note: mg/kg: milligram per kilogram; µg/kg: micrograms per kilogram; DW: Dry Weight			

3.3.6. Ecology

3.3.6.1. Federal Laws

The following Federal Laws will apply for the protection of ecological resources:

- Federal Law No. (24) of 1999 Protection and Development of the Environment sets out control measures with respect to the development of natural resources and conservation of biological diversity in the region;
- Federal Law No. (9) of 1983 on regulating the Hunting of Birds and Animals;
- Federal Law number (81) of the year 1974 on the admission of the United Arab Emirates to the International Convention on Trade in Endangered Species of Wild Fauna and Flora;
- Federal Law number (11) of the year 2002 Concerning Regulating and Controlling the International Trade in Endangered Species of Wild Fauna & Flora; and
- Decree No. 224 of 2015 on protecting wild plants species which list Endangered, Vulnerable and Near Threatened species within the UAE.

3.3.6.2. UAE Protected Reserves

3.3.6.2.1. Protected Areas in UAE – Federal Law No. (24), 1999

Federal Law No. (24) for the year 1999 defines reserves as: *land or ater ith special environmental nature birds, animals, fish, plants, or natural phenomena of a cultural, environmental or aesthetic value), determined by a resolution of the Ministers Council, on the proposal of the Environment and Protected Areas Authority or the decision of the competent authority .*

The following are the listed protected areas in accordance with Federal Law No. 24, 1999:

- Abu Dhabi Mangrove and Coastal Wetland Reserve (Abu Dhabi);
- Ain Al Faydah National Park (Abu Dhabi);
- Al Aweer Nature Reserve (Dubai);
- Al Khawanij Nature Reserve (Dubai);
- Al Maha Nature Reserve Dubai);
- Dubai Desert Conservation Reserve National Park (Dubai);
- Hatta Nature Reserve (Dubai);
- Jabal Ali Wildlife Sanctuary (Dubai);
- Khor Kalba Nature Reserve (Sharjah);
- Marawah Marine Biosphere Reserve (MMBR) (Abu Dhabi);
- Mushrif National Park (Dubai);
- Nadd Al Sheba Nature Reserve (Dubai);
- Rams Lagoon Reserve (Dubai);
- Ras Al Khor Wildlife Sanctuary (Dubai);
- Wadi Wurayah National Park (Fujairah); and
- Zirkuh Island Bird Sanctuary (Abu Dhabi).

3.3.6.2.2. Biosphere Reserves

The UNESCO World Network of Biosphere Reserves (WNBR) are designed to cover all major representative natural and semi-natural ecosystems and are nominated by national governments under the Man and Biosphere (MAB) Programme. The MAB Programme establishes a global network of 727 biosphere reserves across 131 countries with the objective of enabling the integration of humans and nature, facilitating productive dialogue and providing a scientific basis for enhancing this relationship between people and their environments. Biosphere Reserves are nominated as 'learning places for sustainable development' whereby each reserve promotes solutions for reconciling the conservation of biodiversity with its sustainable use. The MAB Programme thereby contributes to the 2030 Agenda and the Sustainable Development Goals (SDGs), initiated by the United Nations General Assembly in 2015.

One Biosphere Reserve has been declared in the UAE, the Marawah Marine Biosphere Reserve (MMBR), which falls within the Project site / area of Project influence. Comprising a total area of 425,500ha, the site includes numerous islands and a coastline stretching over 120km, with several important representative habitats of national and regional significance. These habitats include sea grass beds, coral reef communities, macroalgae outcrops and mangrove vegetation. The MMBR is also of global importance as a shelter and feeding ground for the vulnerable Dugong (*Dugong dugon*).

3.3.6.2.3. Ramsar Sites

The Convention on Wetlands of International Importance (Ramsar) entered into force in the United Arab Emirates on 29 December 2007. The UAE currently has seven sites designated as Wetlands of International Importance (Ramsar Sites) as follows:

- Sir Bu Nair Island Protected Area (Sharjah);
- Wadi Wurayah National Park (Fujairah);
- Al Wathba Wetland Reserve (Abu Dhabi);
- Al-Zora Protected Area (Ajman);
- Bul Syayeef (Abu Dhabi);
- Mangrove and Alhafeya Protected Area in Khor Kalba (Sharjah);
- Ras Al Khor Wildlife Sanctuary (Dubai);
- Jebel Ali Wetland Sanctuary (Dubai); and
- Hatta Mountain Reserve (Dubai).

3.3.7. Noise & Vibration

Cabinet Decree No 12 of 2006 for the protection of air quality includes limits for noise emissions which are presented in Table 3-11 below.

Table 3-11: Noise emissions limits

Location	Allowable Limits for Noise Levels in dB	
	Day (7:00 a.m. – 8:00 p.m.)	Night (8:00 p.m. – 7:00 a.m.)
Residential Areas with Light Traffic	40 - 50	30 - 40
Residential Areas in the Downtown	45 - 55	35 - 45
Residential Areas which include some Workshops, Commercial Business or Residential Areas near the Highways	50 - 60	40 - 50
Commercial Areas & Downtown	55 - 65	45 - 55
Industrial Areas (Heavy Industries)	60 - 70	50 - 60

3.3.8. Cultural Heritage

Archaeological and cultural heritage sites are protected by the Federal Law No 11 of 2017 (hereafter referred to as the Antiquities Law). The most relevant and essential articles of the Antiquities Law are discussed.

3.3.8.1. Legal Definition of Antiquities

In article 1 of Federal Law No 11 of 2017, the governmental protection of all cultural heritage is declared. All such cultural heritage is considered governmental property. This includes both tangible and intangible heritage. The term "mobile antiquities" is equal to the archaeological technical term "small finds", while archaeological and cultural heritage sites (traditional villages) are addressed as "immobile antiquities" in the text of the Antiquities Law.

Article 2 of the Federal Law No 11 of 2017 defines the aims to be achieved by the regulations.

It can be translated to the enrichment of the cultural development of the country and suggests the importance of such national heritage to strengthen national identity.

Article 3 of the Antiquities Law limits the application of the law explicitly to antiquities situated geographically inside the territory of the UAE.

Articles 4 to 11 provide regulations on the administration of antiquities within the territory of each union state of the UAE.

Article 12 provides a legal obligation to protect any movable antiquity, discovered accidentally, and to inform a governmental authority about their existence in order to follow up by the responsible authorities.

In Chapter 3, Article 18 to 24, regulations are provided for immovable antiquities, which translates to legal treatment of archaeological and cultural heritage sites according to the definition provided in Article 1. Namely, it is legally prohibited to conduct any work that could potentially harm such sites.

3.3.8.2. Protection, Preservation and Education as Legal Aims

In article 2 of the Antiquities Law, it is the declared aim of the State of UAE is to protect and preserve the national cultural heritage. Furthermore, the promotion of the knowledge about the cultural heritage of the State of UAE is explicitly mentioned.

In Article 2 of the Antiquities Law, education about the national heritage of the UAE is defined as a legal aim. The responsible Authority is tasked with executing both objectives, preservation and education; at present, the legal obligations are transferred to the constituted Emirate Departments of Antiquities. These are the responsible authorities to define, preserve and administer any cultural heritage of the State of UAE.

The research and systematic excavation of archaeological sites in the UAE is subject to the legal regulations provided in Chapter 5 of the Antiquities Law. The potential involvement of scientists or scientific institutions from abroad is explicitly mentioned and sanctioned.

3.3.8.3. Requirement for Development Projects

Article 20 states that the execution of major development or construction projects or infrastructure projects may only be commenced after the competent authority undertakes archaeological surveys, in accordance with the procedures applied by the competent authority. Cooperation between the responsible Authorities and the responsible town planning and development Authorities (e.g. Municipalities and relevant local Ministries) therefore is required to schedule the planning of major infrastructure accordingly.

3.3.8.4. Regulations on the Violation of the Antiquities Law

The non-compliance with the Antiquities Law is subject to penalties defined in Chapter 6. Penalties apply for any damage, removal, deformation or destruction of antiquities, movable or immovable. Penalties include significant fines and imprisonment.

3.4. ADNOC Process and Standards

3.4.1. Process

ADNOC's Health, Safety and Environment (HSE) Division is the regulator for all HSE requirements within ADNOC's jurisdiction. ADNOC requires that for relevant projects (those which exceed thresholds as defined within ADNOC Guidelines for environmental impacts), a Health, Safety and Environmental Impact Assessment (HSEIA) is conducted in accordance with their requirements, primarily set out within ADNOC-COPV2-01 (July 2018).

The output from the ESIA process is the Environmental Impact Assessment Report. The ESIA report will typically contain a number of recommendations for the control and management of environmental impacts during the construction and operational phases of the Project, or decommissioning, as appropriate, including environmental monitoring requirements.

These recommendations must be subsequently documented in appropriate follow-on management documents, including:

- Construction Environmental Management Plans (CEMP);
- Operational Environmental Management Plans (OEMP); and
- Decommissioning Environmental Monitoring Plans (DEMP).

3.4.2. Codes of Practice, Procedures and Guidance Notes

A range of Codes of Practice, Procedures and Guidance Notes have been developed by ADNOC, which provide guidance on for undertaking the ESIA and subsequent environmental management process and procedures. Those which have been identified as being of particular relevance to the Project will be considered during the preparation of the ESIA. However, Clause 3.3 of Code of Practice on Environmental Protection: Environmental Impact Assessment (ADNOC COPV2-01) states the following:

> "In certain cases, the EIA process may need to be conducted with the involvement of external regulators, such as EAD. This situation arises where an ADNOC Group project is planned at a location that is outside the Concession Area or where a project is a joint one between an ADNOC Group Company and a non-ADNOC Group Company.
>
> In either of these cases, the EAD EIA procedure, requirements and process shall be strictly followed. EIA Report shall be prepared in EAD format and submitted to ADNOC GHSE unit for their review and onward submission to EAD".

Therefore, the ESIA has been prepared in accordance with EAD Technical Guidance Document for Environmental Impact Assessment (EIA), April 2014 (EAD-EQ-PCE-TG-02).

Additional ADNOC Code of Practices (COPs) have been considered within the ESIA, including the following:

- Code of Practice on HSE Administration and Management: HSEIA Requirements (ADNOC COPV1-02);
- Code of Practice on HSE Administration and Management: Management of Contractor HSE and Welfare (ADNOC COPV1-04);
- Code of Practice on HSE Administration and Management: ADNOC HSE Management System (ADNOC COPV1-09);
- Code of Practice on Food & Water & Labour Welfare (ADNOC-COPV1-10);
- Code of Practice on HSE Administration and Management: Preparation of Project HSE Plans (ADNOC COPV1-013);
- Code of Practice on Environmental Protection: Pollution Prevention Control (ADNOC-COPV2-02);
- Code of Practice on Environmental Protection: Energy Management Systems (ADNOC-COPV2-03);
- Code of Practice on Environmental Protection: Environmental Management Systems (ADNOC-COPV2-04);
- Code of Practice on Environmental Protection: Waste Management (ADNOC-COPV2-05);
- Code of Practice on Environmental Protection: Environmental Performance Monitoring (ADNOC-COPV2-06);
- Code of Practice on Environmental Protection: Environmental Risk Assessment (ADNOC-COPV2-07);
- Code of Practice on Occupational Health: Occupational Health Risk Management (OHRM) (ADNOC COPV3-01);
- Code of Practice on Safety and Risk Management: Framework of Occupational Safety Risk Management (ADNOC COPV4-01);
- Code of Practice on Control of Major Accidental Hazards (COMAH) (ADNOC-COPV5-01);
- Code of Practice on Safety and Risk Management: HSE Risk Management (ADNOC COPV5-06); and
- ADNOC Offshore Technical Standard (A0-HSE-E-PRO-301 (Rev. 0): Procedure for Environmental Aspects Identification and Impact Assessment (May 2019).

3.5. International Treaties

The UAE is party to a number of regional and international treaties and conventions related to the environment as presented in Table 3-12 below.

Table 3-12: International treaties and conventions related to the environment in the UAE

Convention Name	Status: Approval, Acceptance, Accession, Succession or Ratification	Date of Approval, Acceptance, Accession, Succession or Ratification	Globally Date of Agreement
The International Treaty on Plant Genetic Resources for Food and Agriculture (CGRFA)	Ratified	24/01/2004	Rome, 04/11/2002
Convention on International Trade in Endangered Species of wild Fauna and Flora (CITES)	Ratified	9/05/1990	Washington, D.C, 03/03/1973
Vienna Convention for the Protection of the Ozone Layer	Ratified	29/12/2004	Vienna, 22/03/1985
Montreal Protocol on Substances that Deplete the Ozone Layer	Ratified	29/12/2004	Montreal, 16/09/1987
Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer	Ratified	16/02/2005	London, 29/06/1990
Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer	Ratified	16/02/2005	Copenhagen, 25/11/1992
Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer	Ratified	16/02/2005	Montreal, 17/09/1997
Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer	Ratified	16/02/2005	Beijing, 3/12/1999
The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal	Ratified	3/03/1990	Basel, 22/03/1989
United Nations Convention to Combat Desertification	Ratified	21/10/1998	Paris, 14/10/1994
Convention on Biological Diversity (CBD)	Ratified	24/11/1999	Rio de Janeiro, 05/06/1992
Protocol Nagoya - Kuala Lumpur Supplementary to the Cartagena Protocol on Biosafety on liability and redress	Ratified	23/07/2014	Pyeongchang, 10/10/2010
Cartagena Protocol on Biosafety	Ratified	23/07/2014	Montreal, 29/01/2000
Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their use	Ratified	23/07/2014	Nagoya, 29/10/2010

Convention Name	Status: Approval, Acceptance, Accession, Succession or Ratification	Date of Approval, Acceptance, Accession, Succession or Ratification	Globally Date of Agreement
Intergovernmental Platform on Biodiversity and Ecosystem services	Ratified	11/01/2015	Panama City, 01/04/2012
Stockholm Convention on Persistent Organic Pollutants	Ratified	11/07/ 2002	Stockholm, 22/ May/ 2001
Convention on Wetlands of International Importance - Ramsar	Ratified	29/12/2007	Australia, 08/05/1974
United Nations Framework Convention on Climate Change (UNFCCC)	Ratified	20/11/1995	New York, 09/05/1992
Kyoto Protocol to the United Nations Framework Convention on Climate Change	Ratified	29/12/2004	Kyoto, 11/12/1997
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	Ratified	11/08/2002	Rotterdam, 10/10/1998)
Regional Organization for the Protection of the Marine Environment (ROPME)	Ratified	01/04/1979	Kuwait, 24/04/1978
Protocol Concerning Regional Cooperation In Combating Pollution By Oil And Other Harmful Substances In Cases Of Emergency	Ratified	01/04/1979	Kuwait, 24/April/1978
Protocol Concerning Marine Pollution resulting from Exploration of the Continental Shelf	Ratified	16/07/1990	Kuwait, 1/03/1989
Protocol for the protection of the Marine Environment against Pollution from Land - Based Source	Acceptance	21/02/1990	Kuwait, 1/02/1990
Convention on the sanitary and phytosanitary (SPS)	Accession	10/04/1996)	Kuwait, 1/01/1995
International Plant Protection Convention	Accession	02/10/2005	Rome, 6/12/1951
Minamata Convention on Mercury	Ratified	25/03/2015	Kumamoto, 10/10/2013
Agreement on Agriculture	Accession	10/04/1996	Kuwait, 1/January/1995
Convention on the Conservation of Migratory Species of Wild Animals (CMS)	Ratified	01/05/2016	Bonn, 23/06/1979
Convention on Conservation of Wildlife and its Natural Habitats in the GCC	Ratified	2003	Kuwait, 2001
Paris Agreement on Climate Change	Acceptance	22/04/2016	Paris, 12/12/2015
The International Treaty on Plant Genetic Resources for Food and Agriculture (CGRFA)	Ratified	9/05/1990	Washington, D.C, 3/03/1973

Convention Name	Status: Approval, Acceptance, Accession, Succession or Ratification	Date of Approval, Acceptance, Accession, Succession or Ratification	Globally Date of Agreement
The International Convention for the Prevention of Pollution from Ships (MARPOL)	Accession	2019	2019

3.6. World Bank / International Finance Corporation

3.6.1. Overview

The IFC is part of the World Bank Group and fosters sustainable economic growth in developing countries by financing private sector investment. The IFC have developed their Performance Standards to ensure that their operations are sustainable. The IFC Standards have also been widely adopted by a wide range of groups including Export Credit Agencies through the Common Approaches and financial institutions which have signed up to the Equator Principles (referred to as Equator Principal Financial Institutions (EPFIs)).

3.6.2. Performance Standards

All IFC projects or projects where IFC Performance Standards (updated 2012) are adhered to must meet with the following Performance Standards (PSs) on Social and Environmental Sustainability:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts;
- Performance Standard 2: Labour 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; and
- Performance Standard 8: Cultural Heritage.

It should be noted that all above IFC performance standards apply to the Project with the exception of PS5 (since the land within the Project footprint is uninhabited and therefore no land acquisition or involuntary resettlement will occur) and PS7 (as the Project site and its surrounding do not support indigenous populations).

3.6.3. IFC Environmental Health & Safety Guidelines

The IFC has prepared a series of Environmental Health and Safety Guidelines (EHS), which provide general and sector specific guidance. The EHS Guidelines are indeed technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP) and are referred to in the World Bank's Environmental and Social Framework and in IFC's Performance Standards. These documents provide details of the required levels and considerations when undertaking an ESIA for a project.

In relation to this Project, the following are considered to be relevant:

- World Bank/IFC General EHS Guidelines (2007): The General EHS Guidelines covers four main subjects which include environment, occupational health and safety, community health and safety and construction and decommissioning; and
- World Bank/IFC EHS Guidelines for Electric Power Transmission and Distribution (2007);
- World Bank/IFC EHS Guidelines for Thermal Power Plants (2008);
- World Bank/IFC EHS Guidelines for Electric Power Transmission and Distribution (2007); and
- World Bank/IFC EHS Guidelines for Offshore Oil and Gas Development (2015).

3.6.4. IFC EHS Guidelines Compliance Limits

The IFC EHS Guidelines set out compliance limits in relation to ambient air quality and noise which are described below:

3.6.4.1. Ambient Air Quality

The WHO has provided Air Quality Guidelines (AQGs) designed to offer guidance in reducing the health impacts of air pollution. As part of the AQGs is included ambient air quality limits which are used by IFC as a guidance in the absence of national legislated standards, which are detailed in Table 3-13.

Table 3-13: WHO ambient air quality limits

Pollutant	Averaging Period	Guideline Value	
		µg/m³	Conversion to ppm
$PM_{2.5}$	Annual	10	*N/A*
	24-hour	25	*N/A*
PM_{10}	Annual	20	*N/A*
	24-hour	50	*N/A*
O_3	8-hour	100	0.051
NO_2	Annual	40	0.021
	1-hour	200	0.106
SO_2	24-hour	20	0.008
	10-minute	500	0.191

3.6.4.2. Ambient Noise

The IFC General EHS Guidelines states that noise levels shall not exceed the following:

- 55 L_{Aeq} dB(A) during the daytime and 45 L_{Aeq} dB(A) during the night-time at residential, institutional or educational establishments;

- 70 L_{Aeq} dB(A) at an industrial receptor for daytime and night-time periods; or
- A maximum 3dB(A) increase in background levels at the nearest receptor location off-site.

3.6.5. IFC Project Category

The Project footprint will fall within and adjacent to the MMBR which is both nationally protected by law and internationally registered under the UNESCO Man and Biosphere Programme global network of Biosphere Reserves. Furthermore, the area through which the Project route will pass is considered to support Critical Habitat as per IFC PS6.

Based on the World Bank (WB) / International Finance Corporation (IFC) Standard, the Project is categorised as a "*Category A: Business activities with potential significant adverse environmental or social risks and/or impacts that are diverse, irreversible, or unprecedented*" as the Project construction has the potential to cause irreversible impacts on the marine environment if not mitigated, monitored and compensated correctly.

3.6.6. Equator Principles

3.6.6.1. Overview

The Equator Principles (EPs) present ten key 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 Action Plan;
- Principle 5: Stakeholder Engagement;
- Principle 6: Grievance Mechanism;
- Principle 7: Independent Review;
- Principle 8: Covenants;
- Principle 9: Independent Monitoring and Reporting; and
- Principle 10: Reporting and Transparency.

As part of the EPs, for Projects located in Non-Designated Countries, the Assessment process shall evaluate compliance with the applicable IFC Performance Standards and the World Bank Group EHS Guidelines. The UAE is a non-designated country and therefore the ESIA will evaluate compliance with these requirements, working on the assumption that the Project is a Category A.

3.6.6.2. Equator Principles Versions

The current version of the EPs is Version 4 (referred as 'EPV4'), dated July 2020. The changes in EPV4 in comparison to EP Version 3 (referred as 'EPV3') can be summarised as follows:

- **Scope of applicability of the EPs** – the threshold amount for the application of EPs to project related corporate loans has been reduced and loans for sovereign borrowers are now within the scope of EPV4 for Category A and Category B projects. In addition, the scope has been extended to project related refinancing and project related acquisition;

- **Applicable standards in designated countries vs. non-designated countries** – EPFIs are required to evaluate the specific risks of proposed projects in Designated Countries to determine if IFC Performance Laws are applicable. Furthermore, EPFIs are required to review all Category A and B projects globally to ensure compliance with the EPs;
- **Human rights and social risk** – EPV4 requires obtainment of the Free, Prior and Informed Consent (FPIC) of Indigenous Peoples affected by a project, as per IFC Performance Standard 7. Nonetheless, this will not be applicable since no indigenous populations will be affected by the Project; and
- **Climate change** – EPV4 introduced an element of climate change assessment. A Climate Change Risk Assessment is required:
  - For all Category A and, as appropriate, Category B Projects, will include consideration of relevant physical risks as defined by the Task Force on Climate-related Financial Disclosures (TCFD);
  - For all Projects, in all locations, when combined Scope 1 and Scope 2 Emissions are expected to be more than 100,000 tonnes of CO_2 equivalent annually. Consideration must be given to relevant Climate Transition Risks (as defined by the TCFD) and an alternatives analysis completed which evaluates lower Greenhouse Gas (GHG) intensive alternatives.

Therefore, following the above changes between EPV3 and EPV4, of relevance for this Project, new sections will be included in the ESIA which assessed the physical climate change risk. The Project has no direct GHG emissions (Scope 1) with the exception of limited direct (Scope 1) and indirect (Scope 2) temporary emissions caused by the construction phase which are estimated to produce significantly less than 100,000 tonnes of CO_2 equivalent. Additionally, the installation of the Project will result in a reduction of approximately 30% of existing emission levels by negating the requirement for the use of GTGs for power sources for offshore activities. The replacement of the GTGs with electricity generated from a range of more sustainable and renewable sources will result in a positive impact in terms of reducing greenhouse gas emissions and pollutants. This is further detailed in **Section 5.1.2.3.2** which presents the ADNOC actual and forecasted offshore GHG intensity figures.

3.7. Japanese Bank for International Cooperation

3.7.1. Overview

The Project will require financing from the Japan Bank for International Cooperation (JBIC). In January 2015 JBIC released their Guidelines for the Confirmation of Environmental and Social Considerations, which was adopted in April 2015 and replaced earlier editions of the guidelines.

As part of this JBIC requires that project proponents undertake appropriate environmental and social considerations so as to prevent or minimize the impact on the environment and local communities, and not to bring about unacceptable effects.

In making its funding decisions, JBIC conducts screenings and reviews of environmental and social considerations to confirm that the requirements are duly satisfied. JBIC makes the utmost efforts to ensure that appropriate environmental and social considerations are undertaken, in accordance with the nature of the project for which JBIC provides funding, as stated in the Guidelines, through such means as loan agreements.

JBIC undertakes the following process to ensure that projects are environmentally and socially acceptable:

a) classifies the project into one of three categories, based upon environmental and social sensitivity, referred to as “screening”;
b) conducts a review of environmental and social considerations when making a decision on funding, to confirm that the requirements are duly satisfied (referred to as “environmental review”); and

c) conducts monitoring and follow-up after the decision has been made on funding (referred to as “monitoring”).

JBIC ascertains whether a project complies with environmental laws and standards of the host national and local governments concerned, as well as whether it conforms to their environmental policies and plans. JBIC also ascertains whether a project meets the relevant aspects of World Bank Safeguard Policy regarding environmental and social considerations. On the other hand, for private sector limited or non-recourse project finance cases, or where appropriate, JBIC ascertains whether the project meets the relevant aspects of International Finance Corporation Performance Standards (which are discussed in **Section 3.6.2** above).

3.7.2. Project Categorisation

A proposed project is classified as Category A if it is likely to have significant adverse impacts on the environment. A project with complicated or unprecedented impacts which are difficult to assess is also classified as Category A. The impact of Category A projects may affect an area broader than the sites or facilities subject to physical construction. Category A, in principle, includes projects in sensitive sectors (i.e., sectors that are liable to cause adverse environmental impact) or with sensitive characteristics (i.e., characteristics that are liable to cause adverse environmental impact) and projects located in or near sensitive areas.

An illustrative list of sensitive sectors, characteristics and areas is provided within the Guidelines. Given the fact that the Project could result in significant environmental impacts and that these impacts could extend beyond the sites or facilities subject to physical construction, in addition to the location within and adjacent to a Marine Protected Area, for the purposes of this ESIA it is assumed that the Project would be classified as Category A. On this basis, the ESIA has adopted the conditions set out within the JBIC Guidelines for ESIA Reports for Category A Projects.

3.7.3. ESIA Requirements

Borrowers and related parties must submit an ESIA report and environmental permit certificates issued by the host governments or other appropriate authority for Category A projects.

The environmental review process for both Category A and B projects examines the potential negative and positive environmental impact of projects. JBIC evaluates measures necessary to prevent, minimise, mitigate or compensate for potential negative impact, and measures to promote positive impact if any such measures are available.

3.7.4. Disclosure

Prior to making decisions on funding and depending on the nature of the project, JBIC discloses information in principle as set out below. JBIC endeavours to disclose information in a manner that allows adequate time before decisions are made on funding and realise further information disclosure by working on project proponents to this end through the borrowers and related parties, in compliance with the relevant laws and ordinances in the host country, as follows:

- Upon completion of the screening of a project, JBIC discloses the project name, country, location, outline and sector of the project, and its category classification, as well as the reasons for that classification; and
- In the case of Category A and Category B Projects, JBIC publishes on its website the status of acquirement of the ESIA reports and environmental permit certificates confirming environmental and social considerations.

3.8. KEXIM

3.8.1. Overview

The Project will also be financed by Korea Export Import Bank (KEXIM). KEXIM requires that any Project above 10 million Special Drawing Rights (SDR) or financing for the nuclear sector or for Projects in environmentally sensitive areas are subject to their Environmental and Social Due Diligence Procedures.

3.8.2. Project Categorisation

Once a client submits an Environmental and Social (E&S) Screening Form, the bank estimates the levels of E&S risks involved in the project to be supported, and categorizes the project according to the extent and level of such risks. The categories defined by KEXIM are as follows:

- Category A - Projects with potential significant adverse environmental and/or social impacts which may affect an area broader than the sites;
- Category B - Projects with potential environmental and/or social impacts which are less adverse than those of Category A Projects, and for which mitigation measures are more readily available;
- Category C - Projects with minimal or no potentially adverse environmental and/or social impacts; and
- Category FI - Indirect loan Projects with similar level of environmental and/or social impact of Category A or B.

3.8.3. ESIA Requirements

ESIA's are required for Category A and B projects and must be conducted with reference to the most stringent standards among the host country regulations and internationally recognized standards such as IFC Performance Standards, EHS guidelines, etc.

3.8.4. Disclosure

KEXIM discloses E&S information pertaining to projects on its website before and after a final commitment to grant official support. For Category A projects the Project Information Disclosure period is at least 30 days before a final commitment to grant official support. For Category B projects, Project Information Disclosure occurs after a final commitment.

3.9. ESIA Approach and Methodology

This section presents the approach and methodology which will be adopted as part of the ESIA process for the Project. This includes the approach to determine the existing environmental and socio-economic conditions, including identification of sensitive receptors and the general methodology for the assessment of environmental impacts likely to be associated with the Project.

3.9.1. Methodology

The standard approach to the assessment of impacts for the ESIA is illustrated in Figure 3-3 below.

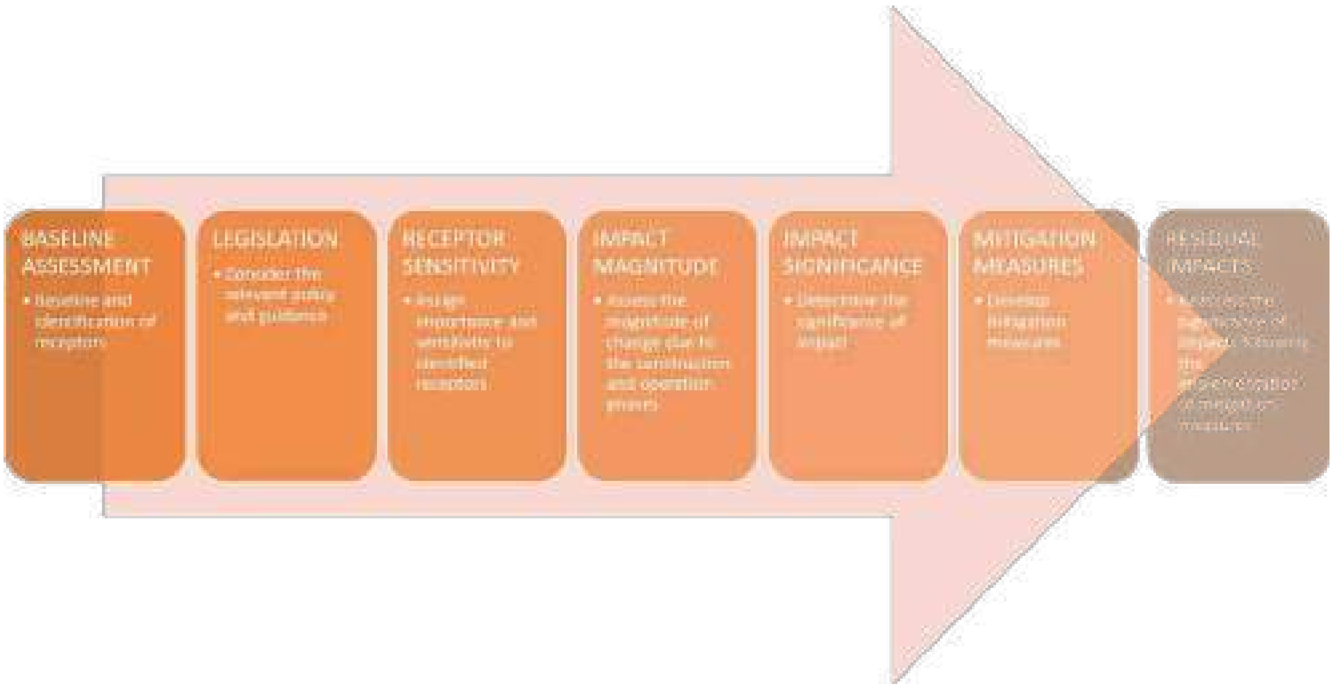


Figure 3-3: ESIA process flow chart

The assessment of the potential impacts of both the construction and operational phases of the Project will be based on a number of criteria, which are used to determine whether or not such effects are 'significant'. These significant criteria will include:

- Local, national and international legislation, regulations and standards;
- Relationship with national planning policies or drivers;
- Sensitivity of the local environment;
- Reversibility or irreversibility and duration of the impact;
- Inter-relationship, if any, between the impacts, otherwise known as cumulative impacts; and
- Outcomes of consultations with relevant stakeholders.

The significance of impacts reflects judgements as to the importance or sensitivity of the affected receptors and the nature, magnitude and duration of the predicted changes.

The approach to identifying required mitigation and management measures has also been identified to ensure that, where significant impacts are identified, these can be reduced to acceptable levels.

3.9.2. Sensitivity and Importance of Receptors

Receptors are defined as the physical resource or user group that would be impacted by a proposed development. In each technical chapter of the ESIA report, the potential sensitive receptors will be identified. The sensitivity of the receptors will be determined within each of the technical chapters using professional judgement, the consideration of existing designations and quantifiable data, where possible. Some examples are as follows:

- A proposed project site which is a protected area in accordance with IUCN criteria, international conventions such as RAMSAR, and supports species listed as Critically Endangered, Endangered or Vulnerable in the 2004 IUCN Red List of Threatened Animals and Critical habitats, would be classified as highly sensitive. In contrast, a site which includes habitats that are severely modified, damaged or degraded, or supporting a generic and common terrestrial habitat, would be classified as less sensitive; and

- Residential areas would generally be considered more sensitive to noise and poorly controlled lighting from a construction site than industrial areas.

3.9.3. Description of Impact

Impacts are defined as the physical changes to the environment as attributed to a project. In each technical chapter of the ESIA Update report, the likely environmental impacts have been identified and taken into consideration in the course of the assessment.

Impacts are defined as either ‘negative’ or ‘positive’ and, depending on the discipline, either ‘direct’ (effects directly attributable to a project action / activity), or ‘indirect’ (effects that are not directly attributed to a project action / activity).

Impacts are also divided into those occurring during the construction phase of a project, and those that occur during the operational phase. Again, dependent on the discipline, the ESIA may refer to such effects as ‘temporary’, generally during the construction phase and demobilisation phase and ‘permanent’ (generally during the operational phase).

3.9.4. Significance of Impacts

Prediction of impacts is essentially an objective exercise to determine what could potentially happen to the environment as a consequence of the Project and its associated activities. Impacts have been categorised according to their various characteristics (e.g. are they detrimental or beneficial? direct or indirect? etc.). The various types of impacts that arise, and the terms used in this assessment are shown and discussed in the following tables and associated text.

When evaluating the severity of environmental impacts, the following factors are taken into consideration:

- **Impact Magnitude:** the magnitude of the change that is induced (i.e. the percentage of a resource that is lost);
- **Impact Duration:** the time period over which the impact will last;
- **Impact Extent:** the geographical extent of the induced change;
- **Likelihood:** the likelihood that the event will occur during the project lifecycle; and
- **Regulations, Standards and Guidelines**: the status of the impact in relation to regulations (e.g. discharge limits), standards (e.g. environmental quality criteria) and guidelines.

Table 3-14 to Table 3-17 below outline the impact criteria used within the assessment of the proposed Project.

Table 3-14: Definition of impact type

Impact Type	Definition
Direct Impact	Impacts that result from a direct interaction between a planned project activity and the receiving environment (e.g. between occupation of a plot of land and the habitats which are lost).
Secondary Impact	Impacts that follow on from the primary interactions between the project and its environment as a result of subsequent interactions within the environment. (e.g. loss of part of a habitat affects the viability of a species population over a wider area).
Indirect Impacts	Impacts that result from other activities that are encouraged to happen as a consequence of the project (e.g. presence of project promotes service industries in the region).
Cumulative impact	Impacts that act together with other impacts to affect the same environmental resource or receptor.:
Residual Impact	Impacts that remain after mitigation measures have been designed into the intended activity.

Table 3-15: Impact assessment terminology

Impact Severity	Definition
Impact Magnitude	
Magnitude	Estimate the size of the impact (e.g. the size of the area damaged or impacted the % of a resource that is lost or affected etc.)
Impact Nature	
Negative impact	An impact that is considered to represent an adverse change from the baseline or introduces a new undesirable factor.
Positive impact	An impact that is considered to represent an improvement on the baseline or introduces a new desirable factor.
Neutral impact	An impact that is considered to represent neither an improvement nor deterioration in baseline conditions.
Impact Duration	
Temporary	Impacts are predicted to be of a short duration and intermittent / occasional in nature.
Short-term	Impacts that are predicted to last only for a limited period but will cease on completion of the activity, or as a result of mitigation / reinstatement measures and natural recovery.

Impact Severity	Definition
Long-term	Impacts that will continue over an extended period but cease when the project stops operating. These will include impacts that may be intermittent or repeated rather than continuous if they occur over an extended period of time.
Permanent	Impacts that occur once on development of the project and cause a permanent change in the affected receptor or resources that endures substantially beyond the project lifetime.
Impact Extent	
Local	Impacts are on a local scale (e.g. restricted to the vicinity of the facility etc).
Regional	Impacts are on a national scale (effects well beyond the immediate vicinity of the project and affect an entire region).
Global	Impacts are on a global scale (e.g. global warming, depletion of the ozone layer).

Table 3-16: Impact severity criteria

Impact Severity	Definition
Slight	Where the development would cause perceptible improvement or deterioration to the existing environment.
Low	Where the development would cause noticeable improvement or deterioration to the existing environment.
Medium	Where the development would cause moderate improvement or deterioration to the existing environment.
High	Where the development would cause significant improvement (or deterioration) to the existing environment.

Table 3-17: Likelihood categories

Impact Likelihood	Definition
Extremely unlikely	The event is very unlikely to occur under normal conditions but may occur in exceptional circumstances, e.g. emergency conditions.
Unlikely	The event is unlikely but may occur under normal conditions.
Low likelihood	The event is likely to occur during normal conditions.
Medium likelihood	The event is very likely to occur during normal conditions.
High likelihood	The event will certainly occur during normal conditions.

3.9.5. Evaluation of Impacts

The significance of each impact (Table 3-19) is determined by comparing the impact severity against the sensitivity of the receptor in the impact significance matrix provided below in Table 3-18.

Table 3-18: Determining the significance of impacts

Impact Severity		Sensitivity of Receptor				
		Low	Low-medium	Medium	Medium High	High
No change / impact will occur	No Change	Negligible	Negligible	Negligible	Negligible	Negligible
Change / impact will occur	Slight	Negligible	Negligible	Negligible	Minor	Minor
	Low	Negligible	Negligible	Minor	Minor	Moderate
	Medium	Negligible	Minor	Minor	Moderate	Major [1]
	High	Minor	Moderate	Moderate	Major [3]	Major [1]

Table 3-19: Definition of each impact significance

Significance	Definition
Negligible	Magnitude of change comparable to natural variation.
Minor	Detectable but not significant.
Moderate	Significant; amenable to mitigation and should be mitigated where practicable.
Major	Significant; amenable to mitigation; and shall be mitigated.
Critical	Intolerable; corresponds to a major impact, but not amenable to mitigation; alternatives must be identified – Project Stopper.

The Critical Impact designation indicated in Table 3-19 above will be allocated in place of a Major Impact when mitigation for the Major Impact is not possible and the impact takes on a Critical Impact status where alternatives must then be considered.

[3] Note: Major impacts would be accorded a 'Critical' impact status if no or very limited mitigation is possible. Critical impacts would require the identification of alternatives or compensation measures.

3.9.6. Mitigation, Enhancement and Assessment of Residual Impacts

Where significant impacts are identified, from moderate levels of significance and above, mitigation and enhancement measures will be identified to prevent, reduce or remedy any potentially significant environmental impacts which cannot be avoided or effectively reduced through changes to the construction or operational methodology.

Such measures will need to be implemented during the construction phase or the operational phases or the Project by adopting the control hierarchy principles as illustrated by Figure 3-4.

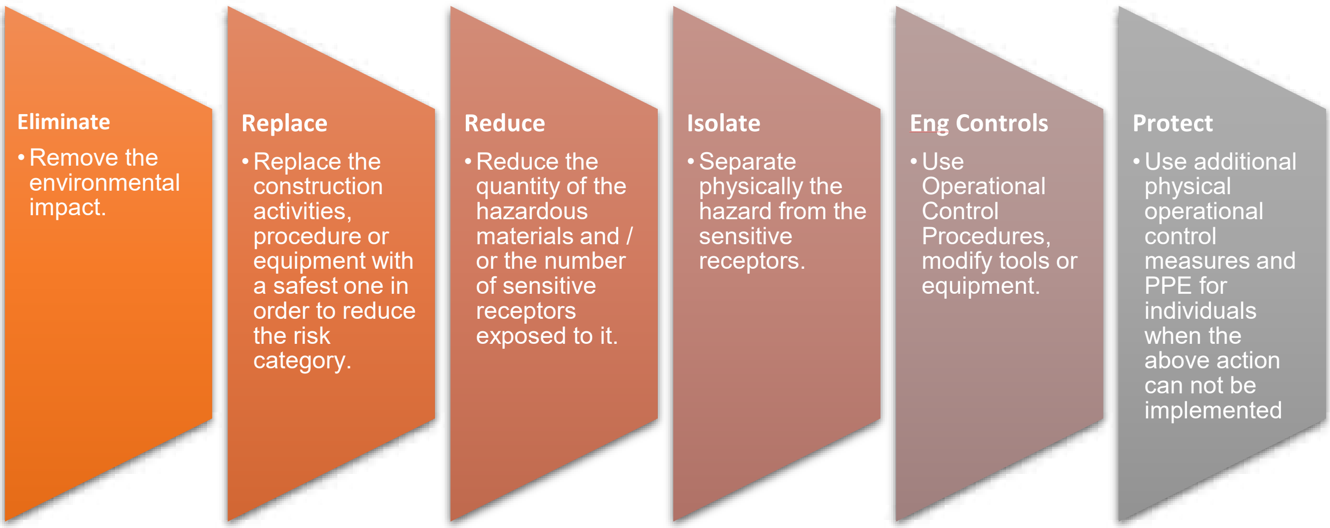


Figure 3-4: Control hierarchy principles

Each technical chapter of the ESIA report will detail the measures recommended to mitigate any identified significant effects and any measures which may provide positive environmental effects.

3.9.7. Cumulative Impacts

Cumulative impacts are those that occur in combination with other developments or impacts taking place at the same time. The potential for cumulative environmental impacts to arise will also be considered. Two types of cumulative effects will be included in the ESIA:

- **Type 1 Cumulative Impact**: the combined effects of different environmental factors from a single development on a particular receptor, e.g. one residential property may experience a degradation in local air quality and an increase in noise levels as a result of a single development; and
- **Type 2 Cumulative Impact**: the combined effects of all developments within the area, e.g. impacts on air quality from one development may not be significant when considered alone but may be significant in combination with other proposed developments. Type 2 cumulative impacts could occur within the Project site and interrelated facilities, which may be under construction and/or operation in conjunction with other future proposed developments, such as residential, other infrastructure.

3.9.8. Mitigation Measures

Following the impact assessment, avoidance, mitigation, compensation or enhancement measures will be identified to prevent, reduce or compensate for any potentially significant environmental impacts.

Each technical chapter of the ESIA Report will detail the measures recommended to mitigate any identified significant effects and any measures which may provide positive environmental effects. An assessment of the significance of any residual impacts remaining following the implementation of mitigation measures will then be undertaken.

3.9.9. Environmental Management and Monitoring

Detailed control measures have been developed as part of this ESIA, where potentially significant impacts have been identified.

The Project represents an infrastructure development which will traverse through MMBR and the majority of the impacts are expected to occur during the construction phase, whilst operational phase impacts will be limited. It is recommended that a Construction Environmental and Social Management Plan (CESMP) is developed as part of the Project EMP process. However, due to the sensitivity of the surrounding environment, particularly the marine environment and associated habitats, it is also considered prudent to prepare an Operational Environmental and Social Management Plan (OESMP) to ensure the effective management of all Project components. The ongoing monitoring of compensatory terrestrial ecology measures proposed within this ESIA also require continued assessment for determining their success. Full details of the CESMP and OESMP framework is presented in **Section 5.14**.

The CESMP and OESMP will ensure the following:

- Provision of a clear framework for the implementation of environmental management plans;
- Responsibilities for implementation are defined;
- Clear environmental management actions are defined;
- Requirements for monitoring including methods and frequency are defined; and
- Mechanisms for feedback, management plan updates and reporting are in place to ensure that the plans remain relevant.

4. PROJECT DESCRIPTION

4.1. Statement of Need

In consideration of the rapid population growth and economic development within the UAE, the associated increases in water and power demand and the vulnerability of the country due to the low-lying coastal areas and hot arid climate, the UAE Government has recognised and is addressing the pressures and threats posed to the country by climate change. Over the past two decades, the UAE has been consistently and strongly committed to reducing environmental and climate impacts by reducing carbon emissions and moving towards a green and sustainable economy. For example, the UAE was one of the first major oil producing countries to become a signatory to the Kyoto Protocol to the UN Convention on Climate Change in 2005. A number of policies and frameworks and Government entities have been created, prepared and refined within the country and at Abu Dhabi Emirate level to guide the transition to a greener economy through the reduction of carbon emissions (1) (2).

In 1995, the UAE ratified the United Nations Framework Convention on Climate Change (UNFCCC) which focuses on the objective to '*stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference ith the climate system*'. Since this ratification, the UAE and Abu Dhabi have continued to make commitments and policies to address climate change issues, increase adaptability and reduce their carbon footprint. The UAE is listed as a non-Annex 1 country within the UNFCCC and therefore is not obligated to make reductions to emissions; despite this, the UAE is constantly striving to reduce emissions and adopt a greener and more sustainable economy.

The Ministry of Climate Change and Environment (MoCCaE) in collaboration with the EAD has developed the Abu Dhabi Greenhouse Gas (GHG) Emissions Inventory (1) (2), in conjunction with a number of government entities and companies, including ADNOC. The inventories identify baseline emissions levels and provide future projections to 2030 of emissions data, both direct and indirect, from a range of sources including waste, land use, industrial and energy sectors (1). The initial inventory was produced in 2010 (base year), followed by an updated inventory in 2012 which also identified emissions projections for 2030. The latest emissions inventory provided data for 2014-2016 plus updates to the emissions projections for 2030 (2).

The GHG Emissions Inventory will assist in and promote the reduction of carbon emissions and therefore will contribute in assisting the UAE and the Emirate of Abu Dhabi in meeting its commitment to the following policies and agreements, all of which share the same ultimate goal of reducing climate change impacts:

- Abu Dhabi Vision 2030;
- UAE Green Growth Strategy;
- UAE Energy Strategy (which aims to achieve 50% clean energy contributions by 2050);
- National Climate Change Plan of the UAE;
- The Paris Agreement (2016); and
- United Nations Framework Convention on Climate Change (UNFCCC) (1).

Currently all operating companies in the Abu Dhabi offshore area (ADNOC Offshore, ADNOC LNG, BUNDUQ, ADOC and Total ABK) manage their electrical power requirement locally and independently using gas turbine generators (GTGs). The electrical power requirement for sustained production and future development plans will substantially increase over time. Moreover, the existing GTGs currently being used will expire through their duration of use and can raise environmental concerns as well as concerns towards the economic impacts of maintenance.

The Project is therefore being developed by ADNOC to provide an alternative source of power for offshore facilities, which will replace the existing GTG power sources with electricity generated on the mainland. This development is therefore expected to reduce the carbon footprint of ADNOC's offshore operations by more than 30%, replacing existing offshore GTGs with more sustainable power sources available on the Abu Dhabi onshore power network, thereby ensuring that operational carbon emissions are reduced and that future operational demand requirements can be met. This progressive and collaborative approach will also drive operational efficiencies and improve system reliability of energy supply, while offering the potential for power supply cost optimisation. Full details on the reduction of GHG emissions from the ADNOC offshore facilities is presented in **Section 5.1.2.3.2.**

This Project is therefore expected to result in both economic and sustainability benefits to Abu Dhabi Emirate and the UAE in terms of oil and gas activities and capabilities through reducing energy demands and associated maintenance costs, in addition to reducing the existing carbon footprint associated with the electrical power requirements for offshore activities. These objectives strongly align with the demonstrable and ongoing efforts made towards climate change and carbon footprint reduction described above.

Given the substantial focus placed upon addressing climate change drivers and moving the country towards a greener and more sustainable future, the Project can be considered to provide a significant contribution to this goal, through enabling and facilitating greener electricity sources to be used and creating the opportunity to reduce carbon emissions associated with offshore oil and gas activities.

4.2. Project Location and Scale

4.2.1. Sites Location

4.2.1.1. Overview

The Project is separated into two distinctive areas which are located within the Al Dhafra Region within the Emirate of Abu Dhabi as illustrated in Figure 4-1 and Figure 4-2 below.

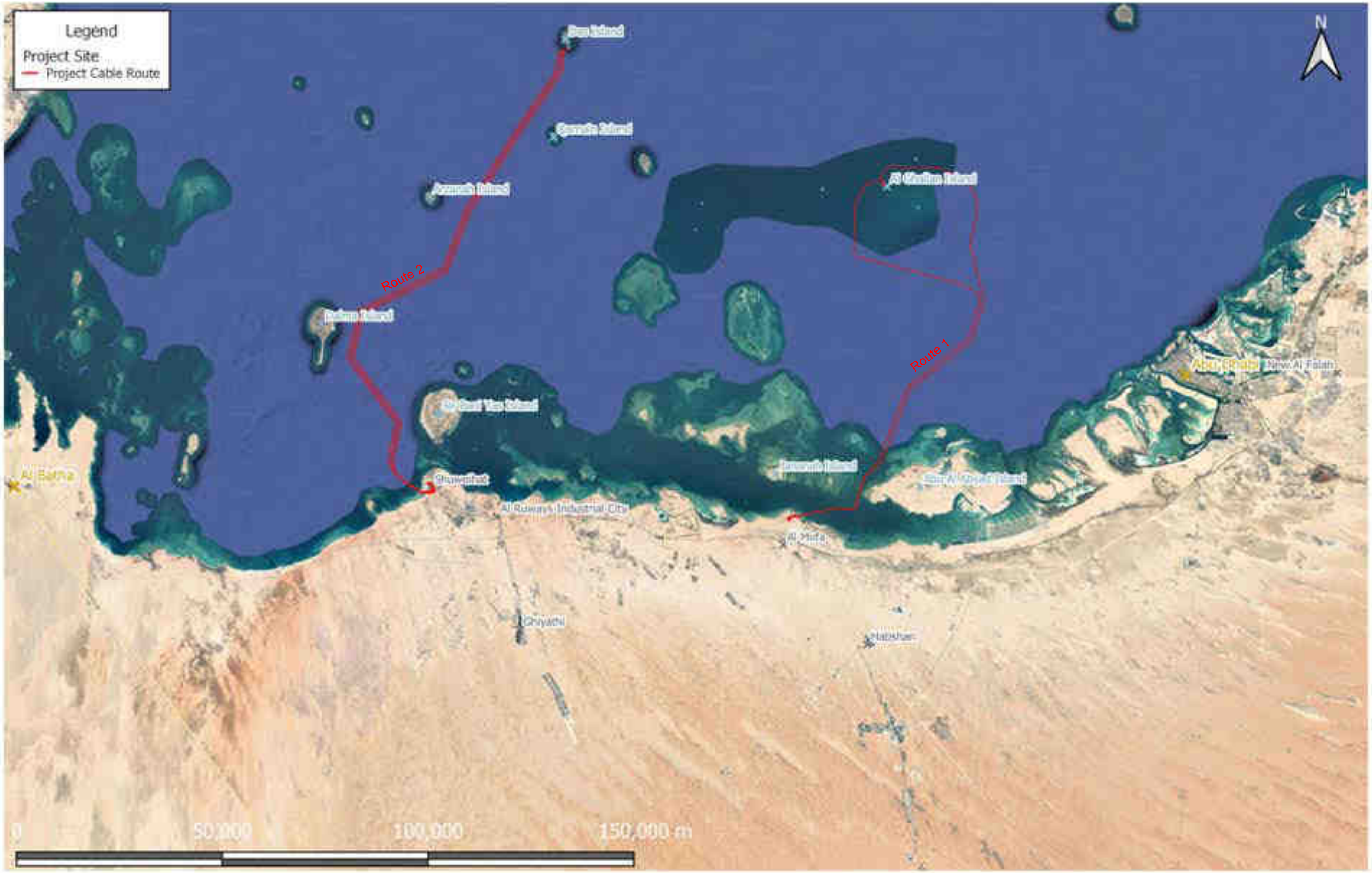
The Project site crosses through coastal areas, shallow coastal waterways, coastal islands and deep offshore areas with some of those containing sensitive and critical habitats. Furthermore, and as illustrated in Figure 4-3 below, the Project site crosses part of and then follows the border of the MMBR which is nationally protected by law and internationally registered under the UNESCO Man and Biosphere Programme global network of biosphere reserves. Finally, the Project also crosses through a number of oil and gas fields as illustrated in Figure 4-4 below.

The proposed sub-sea cable corridors will originate from two separate onshore power supply station locations and are separated into two main routes, namely:

- Route 1 – Mirfa to Al Ghallan Island; and
- Route 2 – Shuweihat to Das Island.

The below figures illustrate each route and provide an illustration of the Project scale and the proposed sub-sea cable routes.

Figure 4-1: Location of Project sites and areas within the UAE context

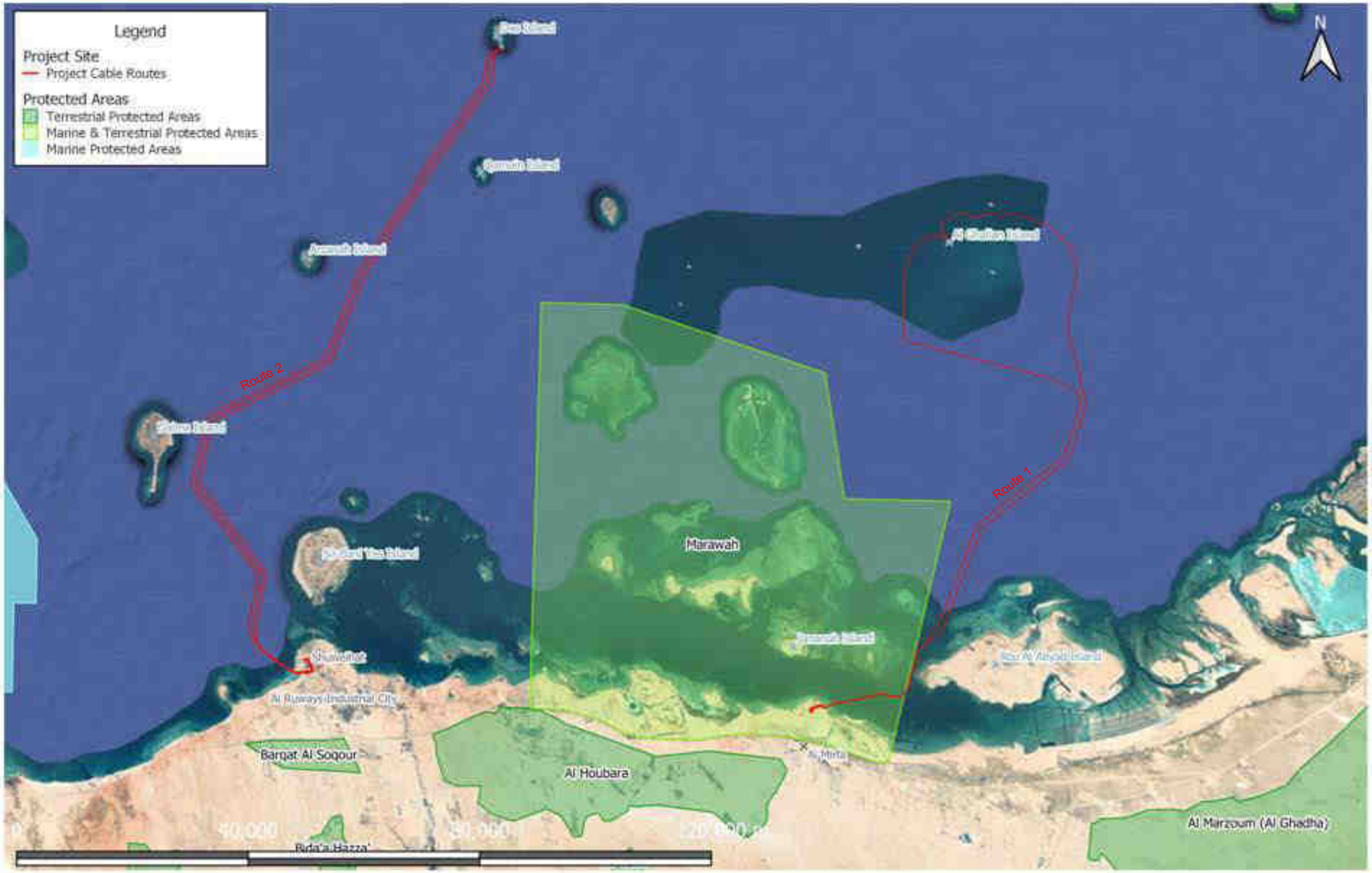


Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:1140430
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 08/05/22

Anthesis

Figure 4-2: Location of Project sites and areas within Abu Dhabi Emirate



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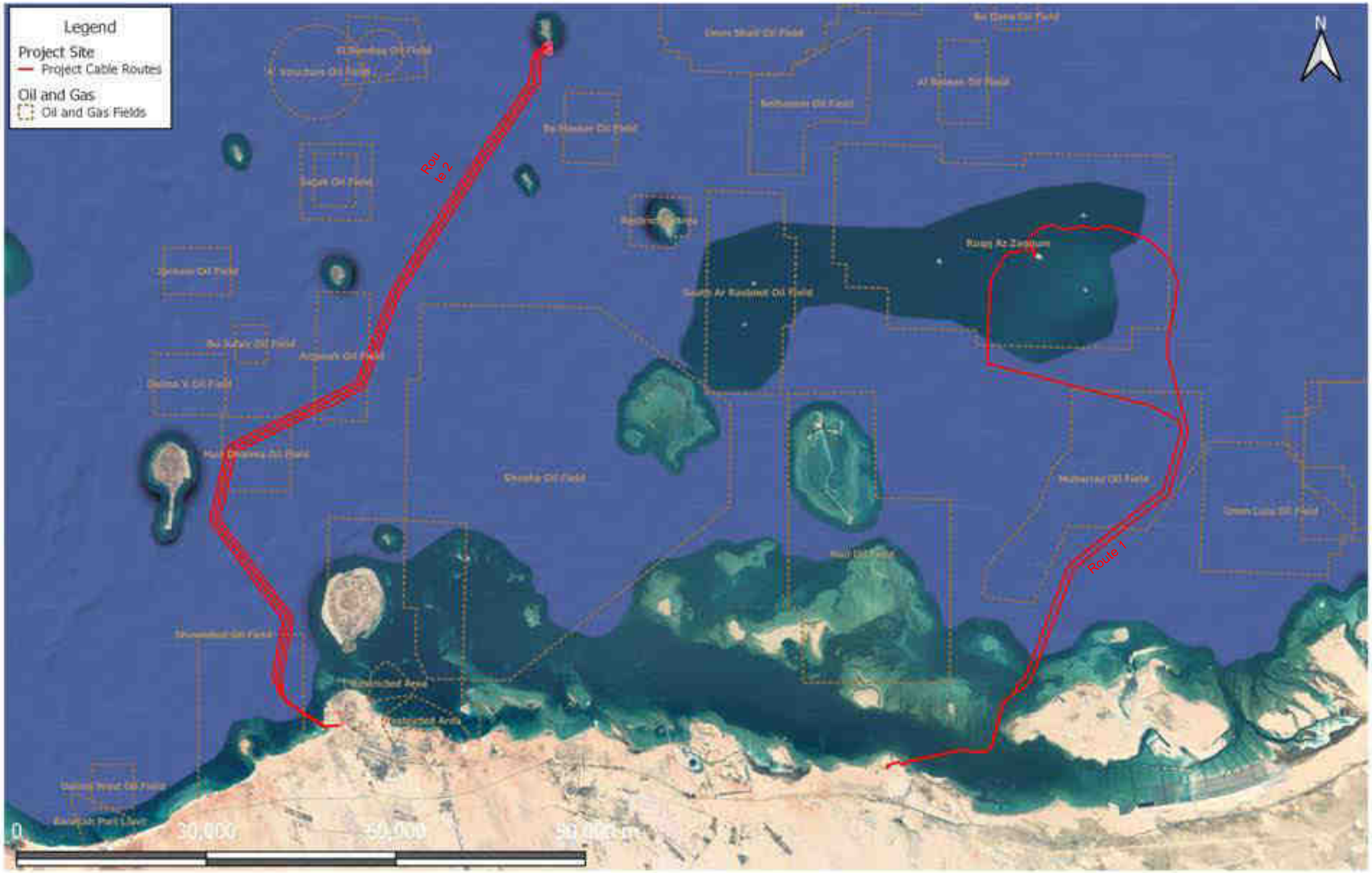
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:810482
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 08/05/22

Figure 4-3: Location of Project sites and areas in relation to nearby protected areas



Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:742511
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 08/05/22

Figure 4-4: Location of Project sites and areas in relation to nearby oil fields

Figure 4-5: Location of Project Route 1 sites and areas

Project Number: 1176
Project Name: Project Lightning
Data Sources: Various
Compiled By: AB

Scale: 1:457252
Coordinate System: World Mercator System
Datum: WGS84
Units: meters
Date: 08/05/22

Anthesis

Figure 4-6: Location of Project Route 2 sites and areas

4.2.1.2. Project Coordinates, Geographic Boundaries and Scale

Table 4-1 below provides details regarding the scale and length of the each of the proposed cable routes.

Table 4-1: Overview and scale of proposed cable Routes 1 and 2

Cable Section	Onshore End		Offshore End		Total Length (km)	No. of crossings
	Location	Type	Location	Type		
Route 1						
1A	Mirfa	Onshore	Al Ghallan	Artificial Island	132	73
1B	Mirfa	Onshore	Al Ghallan	Artificial Island	132	56
Route 2						
2	Shuweihat	Onshore	Das	Artificial Island	137	39
2A	Shuweihat	Onshore	Das	Artificial Island	136	33
2B	Shuweihat	Onshore	Das	Artificial Island	137	39

The grid reference coordinates for the boundary of the Project sites and alignments are provided below in Table 4-2 and Table 4-3. Additionally, Figure 4-7 to Figure 4-21 illustrate each coordinate points.

Additionally, Kilometre Points (KP) are illustrated for each route in Figure 4-22 and Figure 4-23 below.

Table 4-2: Route 1 - Project Coordinates (UTM)

Route Number	Easting	Northing
Onshore Boundary – Route 1		
O1	748222.76	2668150.69
O2	748049.58	2668079.96
O3	748054.71	2668334.48
O4	747947.81	2668589.25
O5	748053.85	2668635.70
O6	748018.08	2668718.68
O7	749688.71	2669409.43
O8	750366.44	2668978.82
O9	750370.33	2668990.97
O10	750442.93	2668850.78
O11	750384.95	2668907.73
O12	749735.02	2669320.95
O13	748262.54	2668691.37
O14	748264.30	2668688.42
Cable 1A		
1A-1	748059.39	2668430.02
1A-2	748069.45	2668407.57
1A-3	748239.36	2668479.52
1A-4	748243.77	2668540.73
1A-5	748255.13	2668546.30
1A-6	748265.82	2668689.62
1A-7	748246.68	2668736.95
1A-8	749712.31	2669364.21
1A-9	750398.47	2668927.87
1A-10	750429.18	2668876.89
1A-11	751411.75	2669422.13
1A-12	760030.67	2671706.05
1A-13	761146.92	2671451.76
1A-14	763139.00	2671417.97
1A-15	763270.64	2671447.38
1A-16	763397.99	2671478.95
1A-17	763760.31	2671646.56
1A-18	764227.49	2672121.52
1A-19	764345.89	2672302.10
1A-20	764535.72	2672727.50
1A-21	764612.14	2672952.11
1A-22	765921.76	2679052.61
1A-23	765977.92	2679155.55
1A-24	767858.88	2681233.49
1A-25	767970.84	2681301.31
1A-26	768741.50	2681574.42
1A-27	768824.43	2681629.24
1A-28	770202.09	2683154.74
1A-29	776268.50	2701094.05
1A-30	790738.35	2713652.75
1A-31	793379.63	2723571.85
1A-32	789627.01	2735673.92
1A-33	789548.71	2738468.42
1A-34	790534.40	2744366.39
1A-35	790689.56	2747577.17
1A-36	789001.13	2750792.39
1A-37	785814.26	2753752.30
1A-38	780794.33	2755315.30
1A-39	778510.74	2755592.91
1A-40	777281.05	2755001.48
1A-41	775942.47	2755330.18
1A-42	774917.23	2755410.58
1A-43	774636.00	2755329.00
1A-44	774221.00	2755123.00
1A-45	773597.00	2755065.00
1A-46	773164.14	2754847.86
1A-47	772422.33	2754707.35
1A-48	770536.93	2755420.35
1A-49	770359.24	2755423.02
1A-50	768568.12	2754815.79
1A-51	766951.19	2753238.29
1A-52	766803.81	2752343.36
1A-53	766890.71	2752081.80
1A-54	767741.17	2751392.31
1A-55	767819.92	2751197.44
1A-56	767907.55	2750904.62
1A-57	767902.07	2750840.02
1A-58	767878.07	2750771.15
Landfall Al Ghallan Island – Cable 1A		
1A-59	767892.17	2750715.00
1A-60	767908.31	2750649.39
1A-61	767909.73	2750640.42
1A-62	767795.05	2750449.73
1A-63	767816.10	2750439.78
1A-64	767828.59	2750465.32
Cable 1B		
1B-1	748170.93	2668477.29
1B-2	748180.23	2668456.54
1B-3	748237.23	2668480.30
1B-4	748241.91	2668541.75
1B-5	748253.37	2668547.64
1B-6	748263.96	2668689.45
1B-7	748244.14	2668737.23
1B-8	749712.49	2669366.60
1B-9	750360.16	2668954.68
1B-10	751385.60	2669518.72
1B-11	760030.99	2671809.26
1B-12	761153.15	2671552.12
1B-13	763113.48	2671517.68
1B-14	763373.13	2671577.18
1B-15	763685.43	2671717.30
1B-16	764164.16	2672212.03
1B-17	764271.15	2672384.02
1B-18	764436.59	2672762.15
1B-19	764523.08	2673014.38
1B-20	765826.36	2679084.44
1B-21	765913.10	2679233.10
1B-22	767815.51	2681342.55
1B-23	768034.69	2682203.56
1B-24	768110.56	2682330.35
1B-25	769323.50	2683675.03
1B-26	775404.86	2701665.78
1B-27	789860.51	2714220.78
1B-28	792338.90	2723530.73
1B-29	791801.16	2725249.46
1B-30	787175.90	2727472.57
1B-31	761507.64	2732915.70
1B-32	761117.24	2733288.10
1B-33	761027.75	2745907.37
1B-34	761105.73	2746183.53
1B-35	763135.79	2750039.26
1B-36	763645.13	2750574.68
1B-37	764184.17	2750756.72
1B-38	764384.26	2750759.94
1B-39	764638.00	2750685.45
1B-40	764963.99	2750792.62
1B-41	765245.67	2751047.27
1B-42	765745.28	2751178.56
1B-43	766714.56	2751119.41
1B-44	767244.18	2751379.40
1B-45	767368.33	2751401.68
1B-46	767530.92	2751347.27
1B-47	767725.87	2751205.78
1B-48	767780.50	2751126.16
1B-49	767868.51	2750875.20
1B-50	767872.32	2750769.96
Landfall Al Ghallan Island		
1B-51	767889.72	2750714.24
1B-52	767902.89	2750648.58
1B-53	767903.71	2750637.51
1B-54	767791.83	2750449.32
1B-55	767904.69	2750396.71
1B-56	767917.61	2750423.63

Table 4-3: Route 2 – Project Coordinates (UTM)

Route Number	Easting	Northing
Onshore Boundary – Route 2		
O1	660089.00	2673402.00
O2	660796.74	2673502.20
O3	661854.74	2671529.61
O4	661388.98	2671291.27
O5	660954.22	2671261.38
O6	660953.32	2671105.57
O7	660703.87	2671106.73
O8	660703.46	2671268.37
O9	658853.12	2671032.48
O10	658708.40	2670930.33
O11	658786.20	2671182.60
O12	658874.15	2671106.05
O13	660703.88	2671339.36
O14	660704.05	2671505.86
O15	660954.21	2671505.93
O16	660954.20	2671331.61
O17	661371.09	2671359.21
O18	661759.38	2671560.08
O19	660758.70	2673425.63
O20	660097.64	2673333.80
Cable 2		
2-1	660854.68	2671309.12
2-2	660854.28	2671277.49
2-3	660695.18	2671276.88
2-4	660679.54	2671301.24
2-5	658752.33	2671054.59
2-6	658747.32	2671055.02
2-7	654387.50	2673605.37
2-8	653965.79	2674032.83
2-9	652493.14	2674997.26
2-10	651816.78	2676036.07
2-11	650944.04	2678556.78
2-12	650929.44	2678672.33
2-13	652312.50	2687446.00
2-14	652332.70	2687710.41
2-15	652202.16	2687956.02
2-16	640135.29	2702831.58
2-17	640060.67	2703034.53
2-18	640104.00	2703337.00
2-19	642180.22	2714135.95
2-20	642359.34	2714372.49
2-21	659393.83	2723773.39
2-22	659558.93	2723793.55
2-23	659723.53	2723864.26
2-24	662003.46	2725162.36
2-25	662161.81	2725360.04
2-26	666861.83	2739740.88
2-27	686784.68	2773121.61
2-28	686799.42	2773213.01
2-29	686807.49	2773341.76
2-30	686868.37	2773464.16
2-31	687355.83	2773809.08
2-32	687406.50	2773869.41
2-33	687439.45	2773961.11
2-34	687830.29	2778855.70
2-35	687879.79	2779032.29
2-36	688041.66	2779192.13
2-37	688389.72	2779347.97
2-38	688511.73	2779456.52
2-39	688813.60	2779999.67
2-40	688840.20	2780024.31
2-41	688871.47	2780037.41
2-42	688910.69	2780038.35
2-43	688942.39	2780027.00
2-44	689079.07	2779949.12
2-45	689121.98	2779941.05
2-46	689276.90	2779914.54
2-47	689278.10	2779914.58
2-48	689279.39	2779915.94
2-49	689284.58	2779946.01
Cable 2A		
2A-1	660828.87	2671310.96
2A-2	660828.28	2671277.88
2A-3	660695.57	2671277.32
2A-4	660679.84	2671302.23
2A-5	658911.04	2671075.35
2A-6	654029.61	2674079.21
2A-7	652523.79	2675140.22
2A-8	651941.41	2676092.13
2A-9	651995.15	2676443.78
2A-10	651984.15	2676606.32
2A-11	651632.38	2678637.30
2A-12	653057.24	2687680.00
2A-13	653075.25	2687890.70
2A-14	652980.82	2688105.14
2A-15	642926.11	2700377.35
2A-16	642914.50	2700507.93
2A-17	642891.71	2700677.87
2A-18	640872.07	2703036.32
2A-19	640810.06	2703212.37
2A-20	640822.05	2703364.45
2A-21	642789.49	2713618.15
2A-22	642968.94	2713907.81
2A-23	656767.56	2721485.14
2A-24	657297.95	2721598.43
2A-25	658593.34	2722308.53
2A-26	658968.51	2722691.59
2A-27	662521.46	2724649.77
2A-28	662737.32	2724869.98
2A-29	667504.02	2739453.60
2A-30	688248.69	2774126.52
2A-31	688305.95	2774333.19
2A-32	688484.93	2778947.79
2A-33	688813.47	2779915.82
2A-34	688847.13	2779955.45
2A-35	688910.45	2779972.67
2A-36	689078.35	2779945.27
2A-37	689121.88	2779940.41
2A-38	689301.27	2779909.60
2A-39	689302.99	2779909.49
2A-40	689304.05	2779910.46
2A-41	689309.80	2779943.14
Cable 2B		
2B-1	660879.86	2671310.51
2B-2	660879.43	2671276.45
2B-3	660695.00	2671276.00
2B-4	660679.19	2671300.68
2B-5	658911.22	2671074.25
2B-6	658727.17	2670955.70
2B-7	658717.48	2670956.41
2B-8	654384.42	2673484.27
2B-9	653930.70	2673966.01
2B-10	652493.68	2674820.90
2B-11	651696.27	2676017.42
2B-12	651395.85	2676275.44
2B-13	650285.79	2678479.52
2B-14	650225.50	2678706.08
2B-15	651589.70	2687361.98
2B-16	651475.79	2687740.42
2B-17	639390.88	2702638.32
2B-18	639325.70	2702994.61
2B-19	641544.44	2714559.48
2B-20	641815.94	2714874.33
2B-21	661419.17	2725643.14
2B-22	661604.10	2725905.80
2B-23	666209.14	2740001.38
2B-24	686476.92	2773955.53
2B-25	686605.98	2774773.46
2B-26	686823.25	2775178.60
2B-27	686833.56	2775277.52
2B-28	686833.42	2776166.39
2B-29	686876.95	2776296.68
2B-30	686972.59	2776443.16
2B-31	687254.49	2778721.60
2B-32	687296.73	2778827.89
2B-33	687679.62	2779294.92
2B-34	687795.64	2779359.94
2B-35	688504.95	2779678.85
2B-36	688576.91	2779748.22
2B-37	688826.55	2780078.18
2B-38	688849.86	2780096.99
2B-39	688891.74	2780110.05
2B-40	688941.11	2780101.62
2B-41	688974.49	2780077.12
2B-42	689079.85	2779952.85
2B-43	689122.24	2779941.45
2B-44	689252.48	2779919.16
2B-45	689254.22	2779920.69
2B-46	689259.58	2779951.84

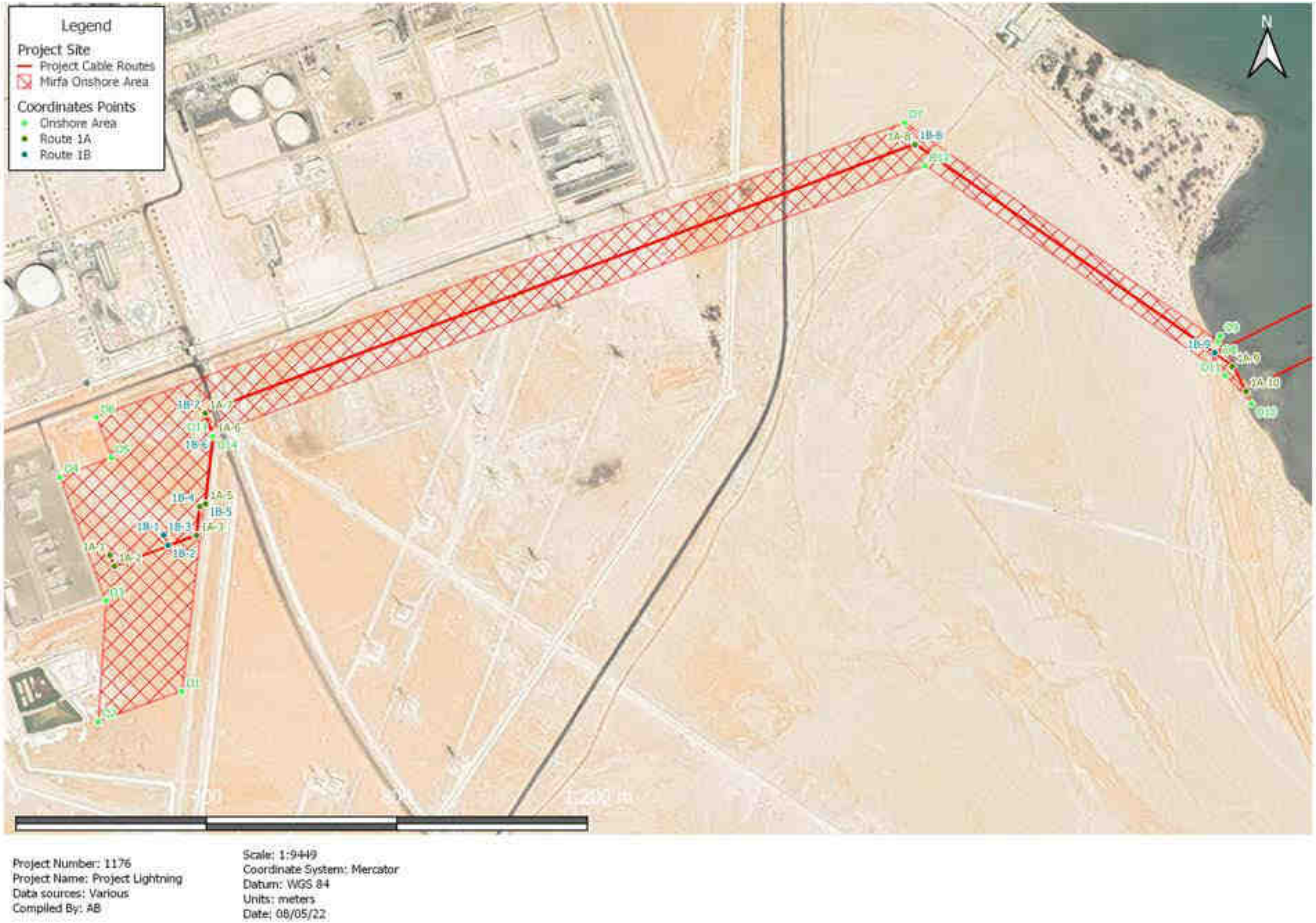


Figure 4-7: Route 1 Coordinates Points on the onshore area

Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

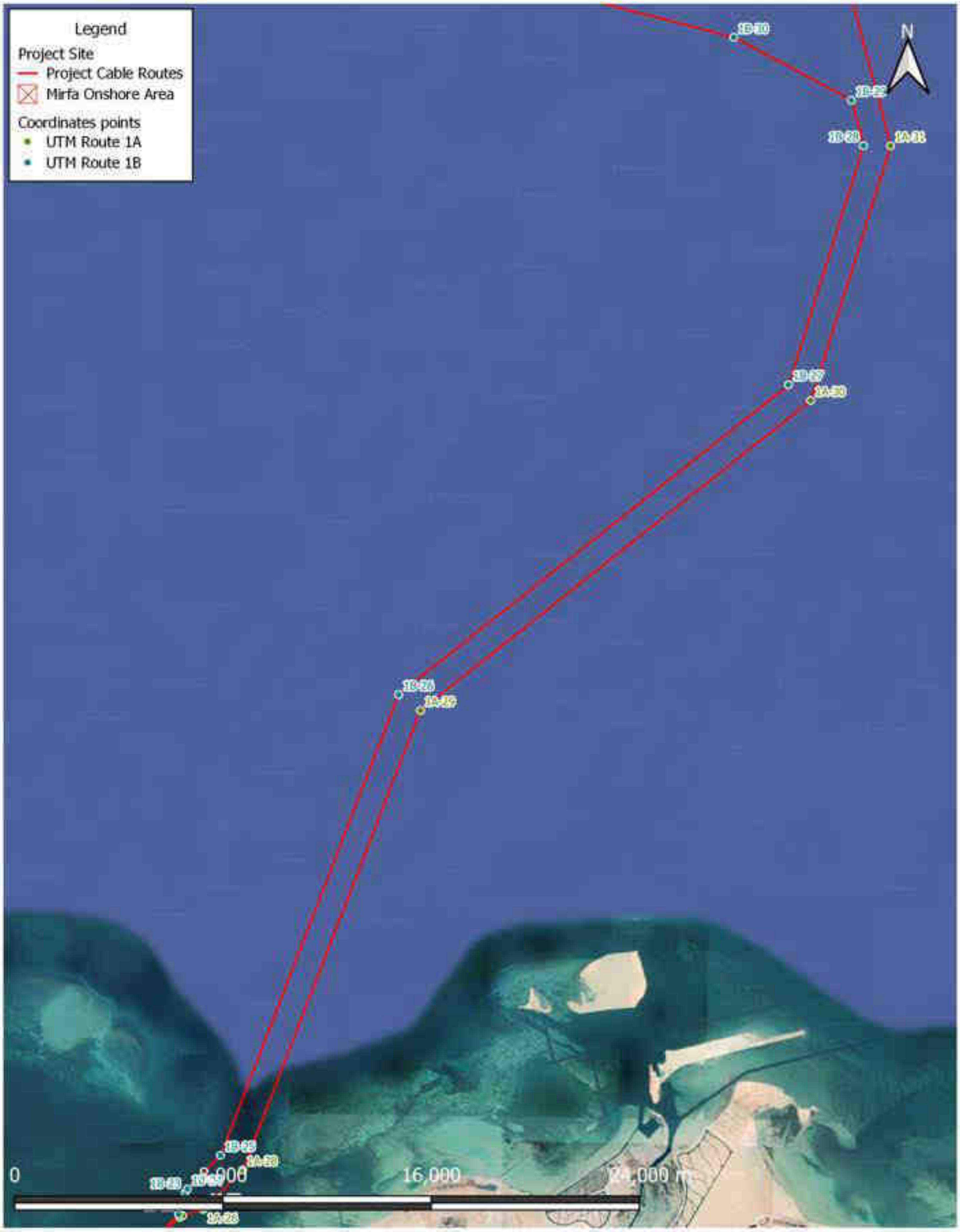
Scale: 1:51169
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 08/05/22

Figure 4-8: Route 1 Coordinates Points (KP 0.000 to KP 17.000)

Project Number: 1176
Project Name: Project Lightning
Data Sources: Various
Compiled By: AB

Scale: 1:49874
Coordinate System: World Mercator System
Datum: WGS84
Units: meters
Date: 08/05/22

Figure 4-9: Route 1 Coordinates Points (KP 15.000 to KP 28.000)



Project Number: 1176
Project Name: Project Lightning
Data Sources: Various
Compiled By: AB

Scale: 1:179133
Coordinate System: World Mercator System
Datum: WGS84
Units: meters
Date: 08/05/22

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Figure 4-10: Route 1 Coordinates Points (KP 24.000 to KP 81.500 (Route 1A) & KP 85.000 (Route 1B)

Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:160369
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 08/05/22

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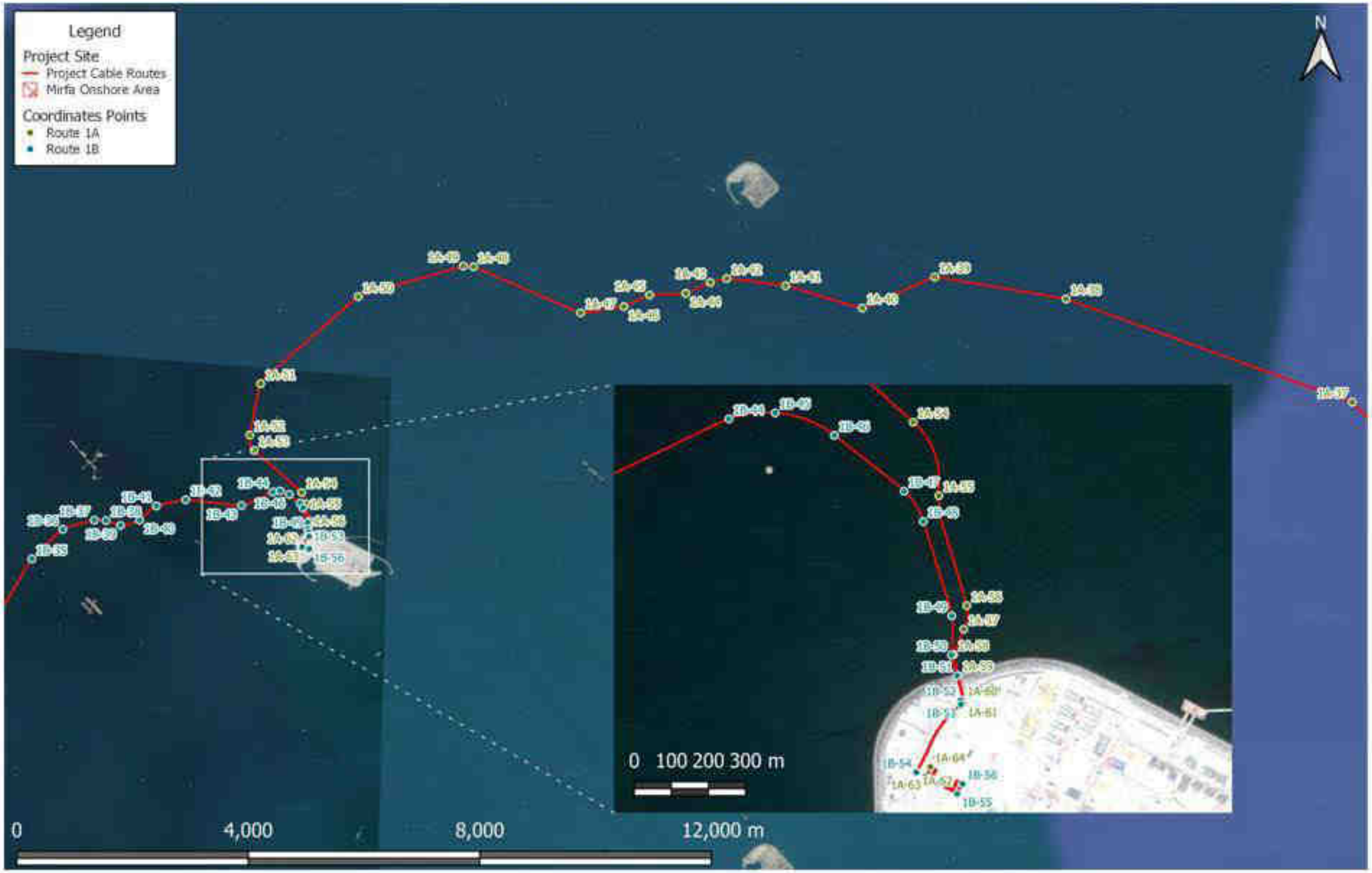
Figure 4-11: Route 1 Coordinates Points (KP 73.000 to KP 104.500 (Route 1A) & KP 126.000 (Route 1B)



Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:80997
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 08/05/22

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Figure 4-12: Route 1 Coordinates Points (KP 104.500 (Route 1A) & KP 126.000 (Route 1B) to KP 132.000)

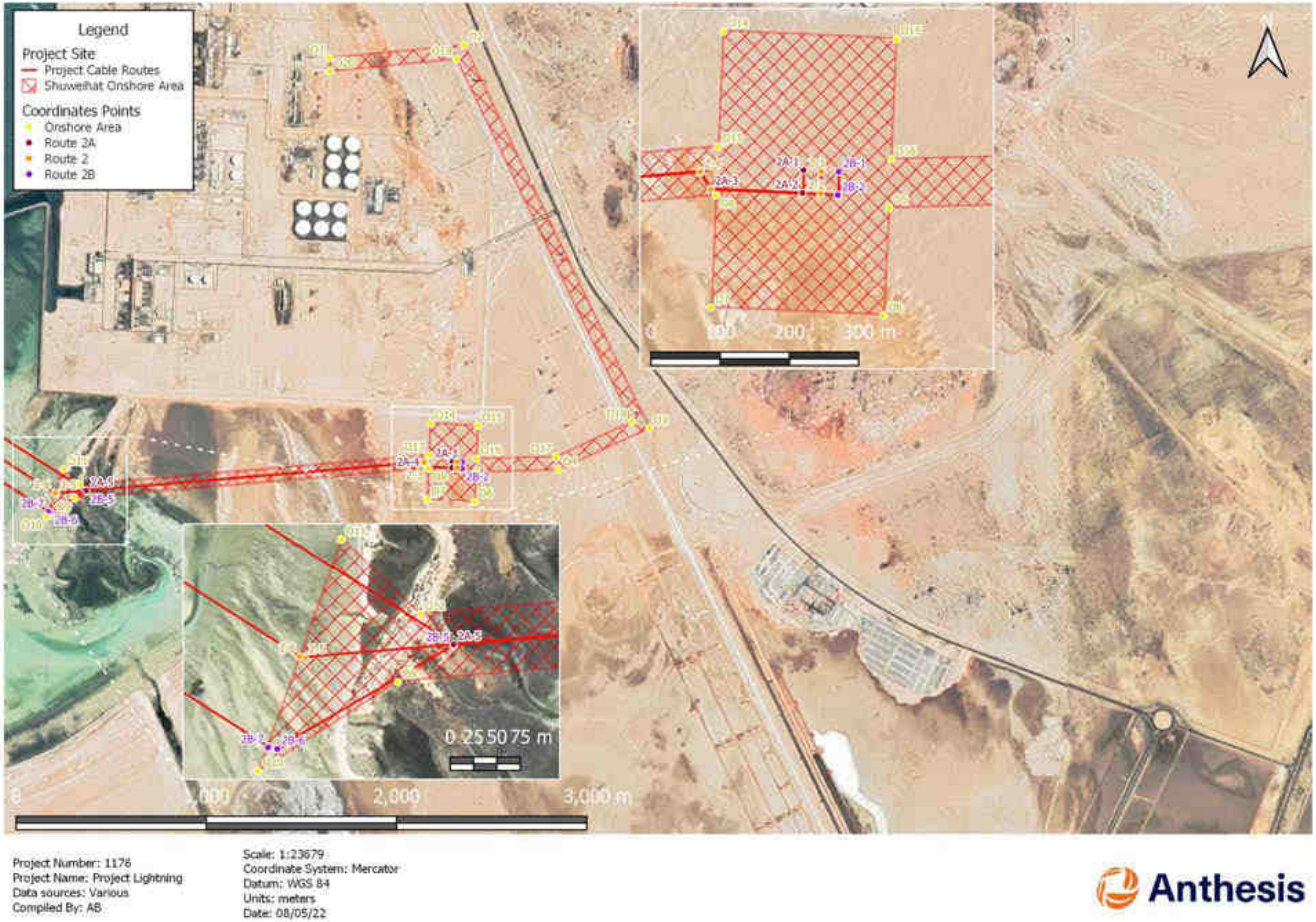
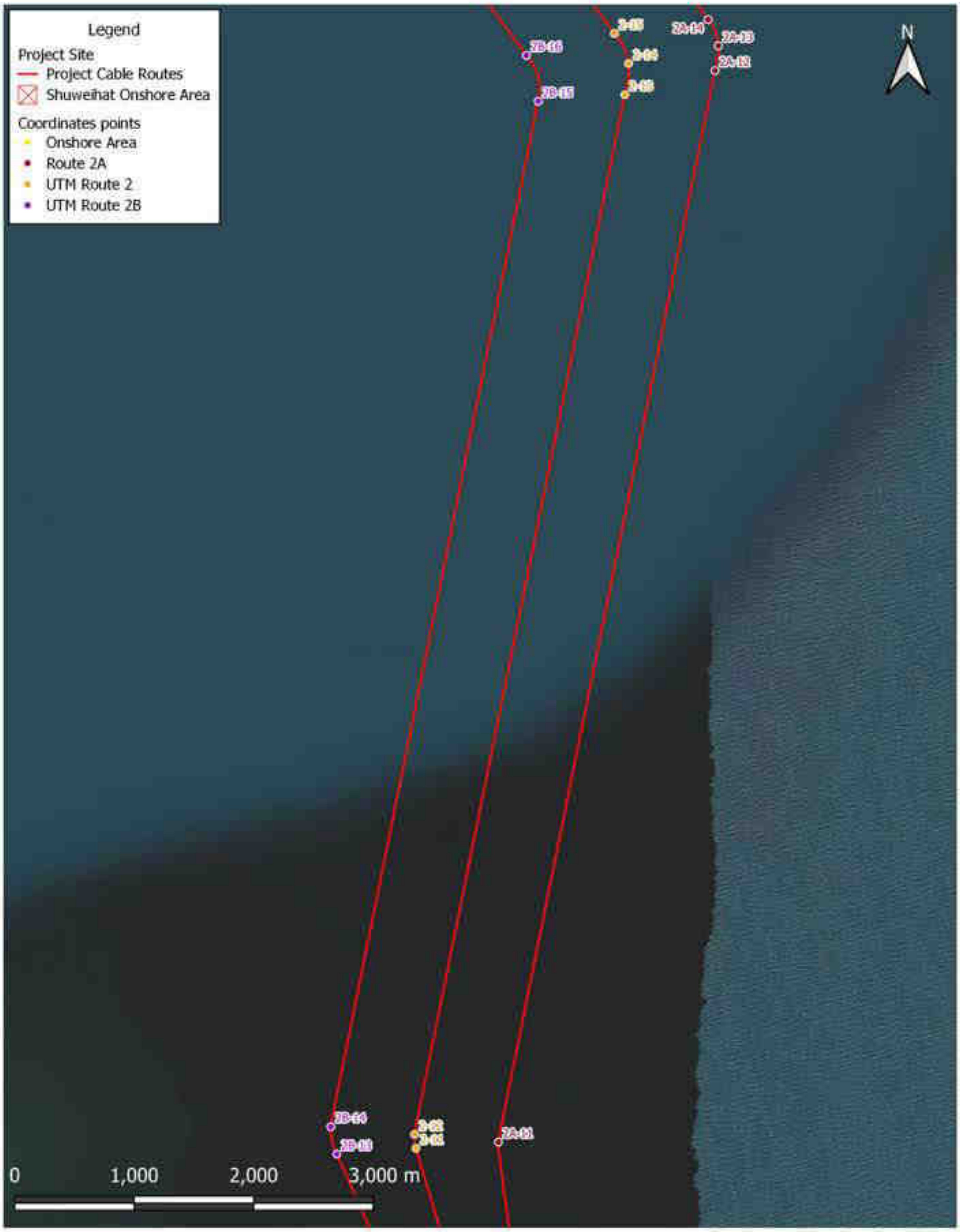


Figure 4-13: Route 2 Coordinates Points on the onshore area

Figure 4-14: Route 2 Coordinates Points (KP 0.000 to KP 12.000)



Project Number: 1176
Project Name: Project Lightning
Data Sources: Various
Compiled By: AB

Scale: 1:39078
Coordinate System: World Mercator System
Datum: WGS84
Units: meters
Date: 08/05/22

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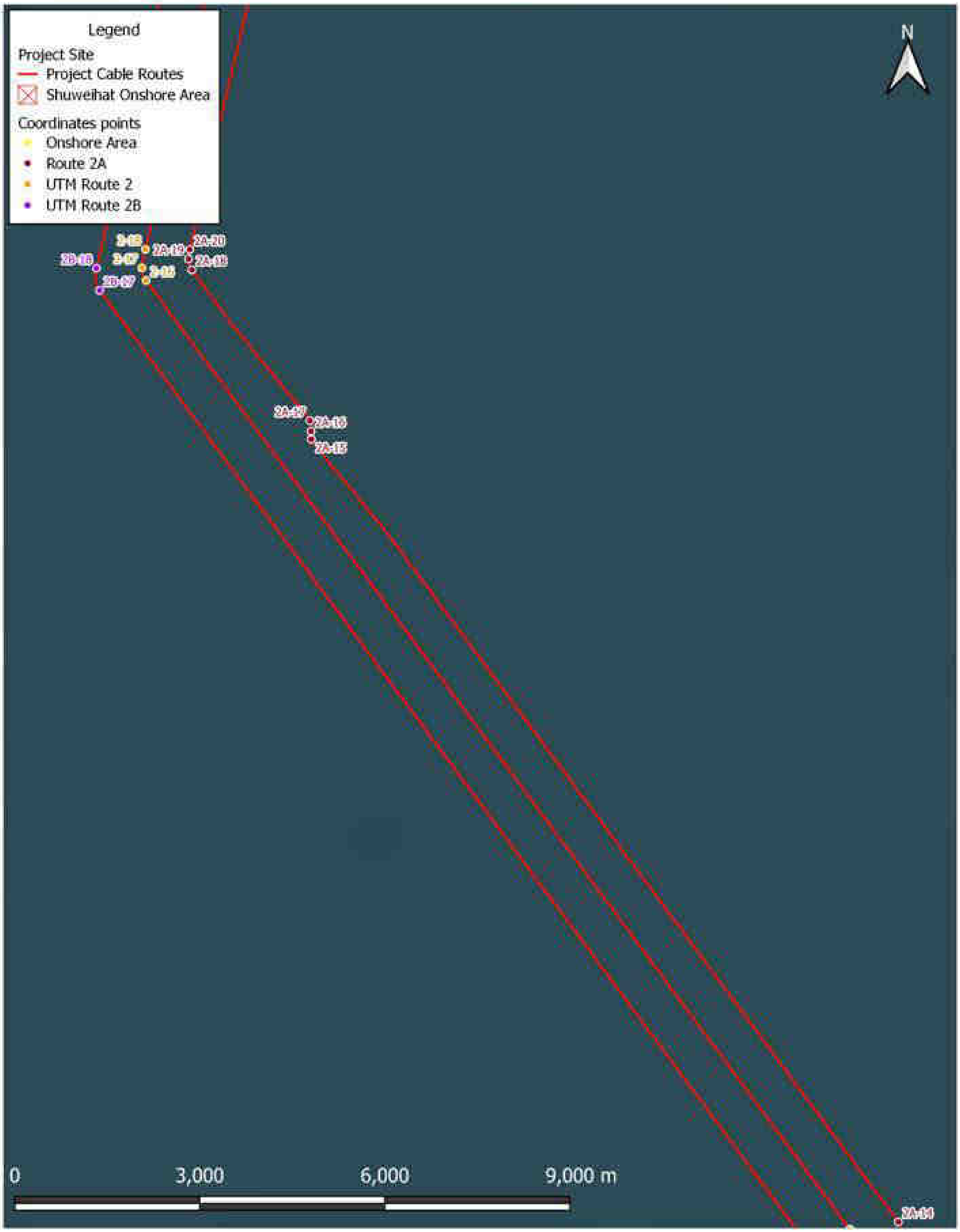
Figure 4-15: Route 2 Coordinates Points (KP 11.500 to KP 21.000)



Project Number: 1176
Project Name: Project Lightning
Data Sources: Various
Compiled By: AB

Scale: 1:75687
Coordinate System: World Mercator System
Datum: WGS84
Units: meters
Date: 08/05/22

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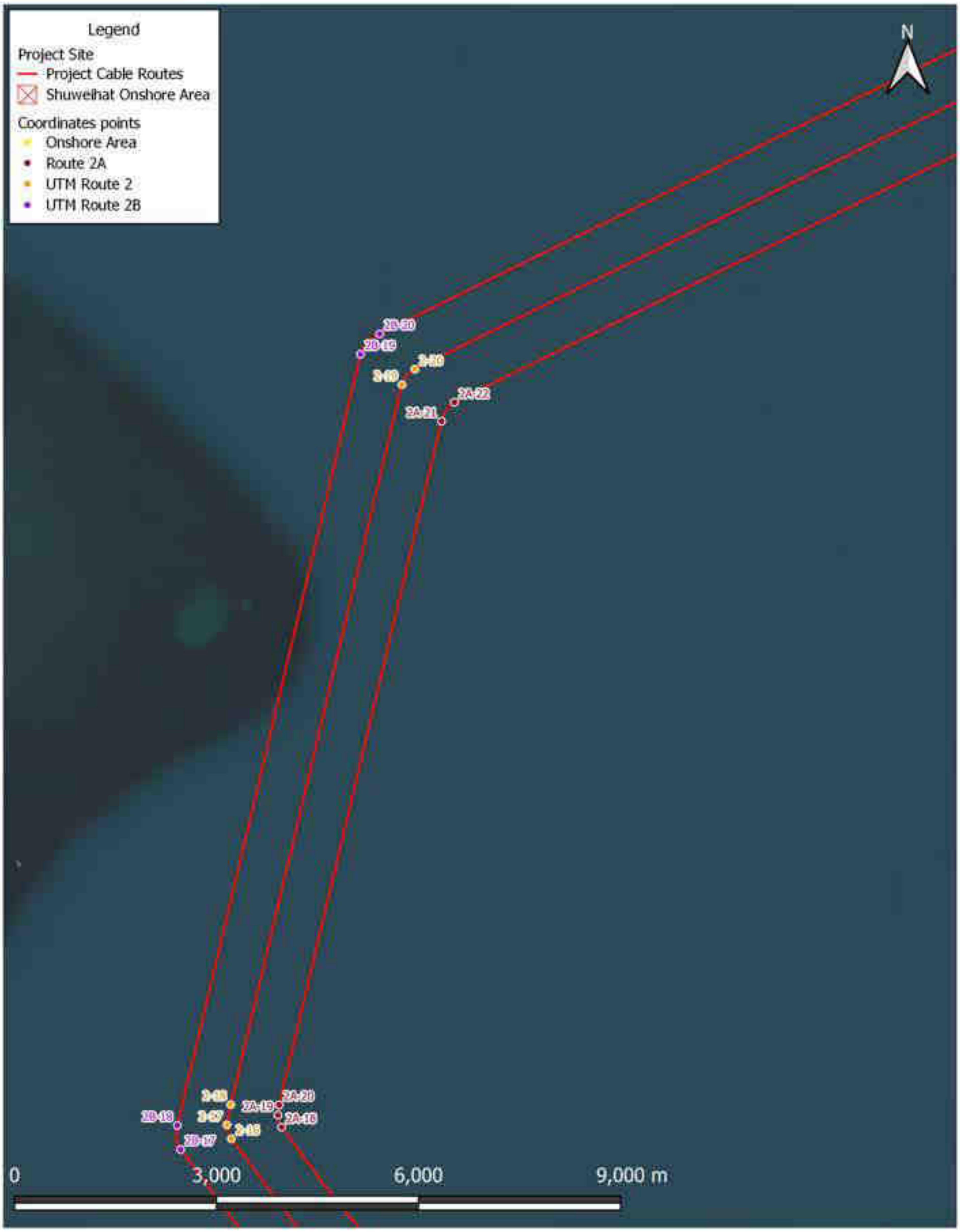
Figure 4-16: Route 2 Coordinates Points (KP 21.000 to KP 41.000)



Project Number: 1176
Project Name: Project Lightning
Data Sources: Various
Compiled By: AB

Scale: 1:69346
Coordinate System: World Mercator System
Datum: WGS84
Units: meters
Date: 08/05/22

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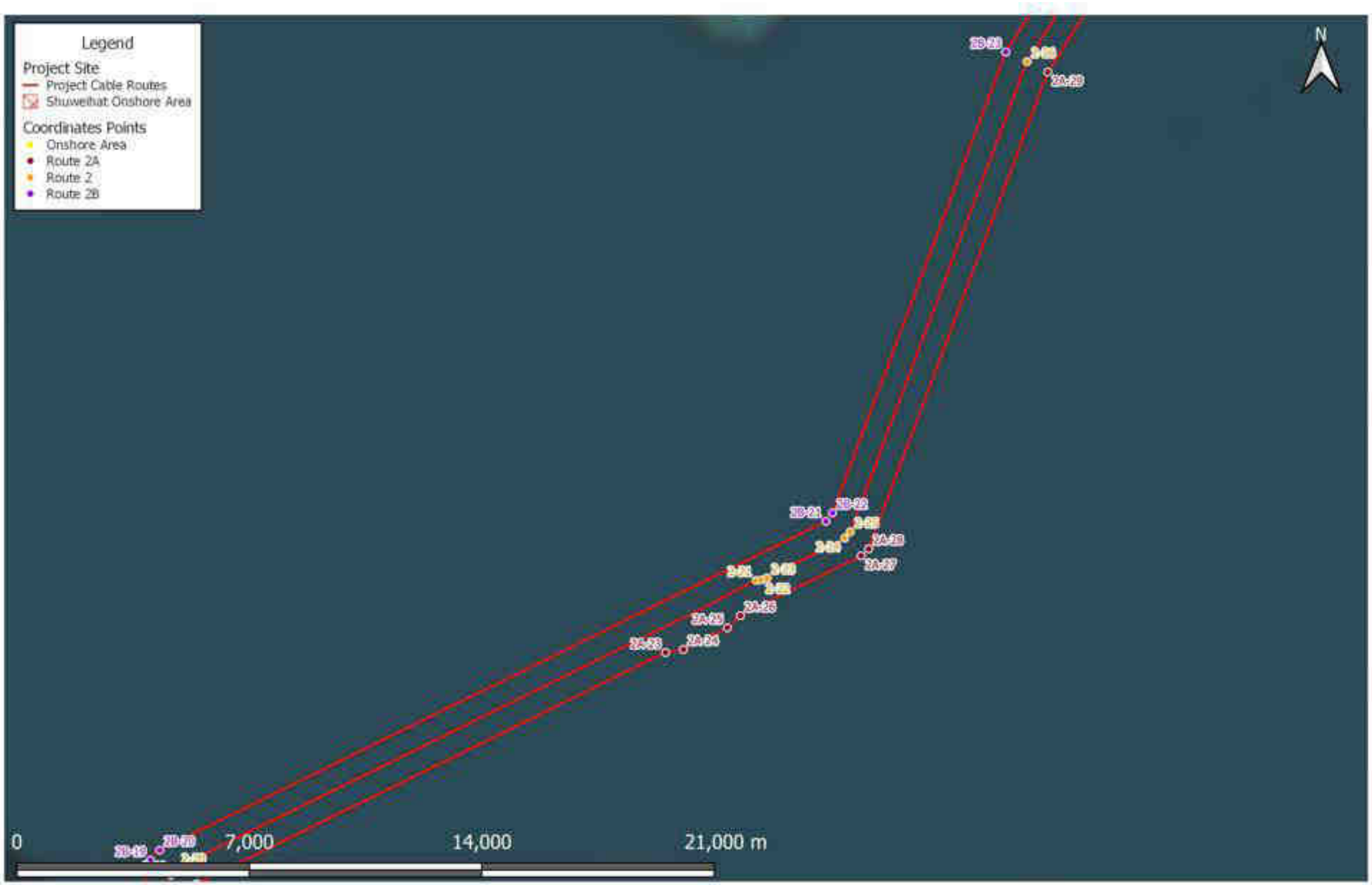
Figure 4-17: Route 2 Coordinates Points (KP 39.000 to KP 60.000)



Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:141357
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 08/05/22

Anthesis

Figure 4-18: Route 2 Coordinates Points (KP 51.000 to KP 91.000)

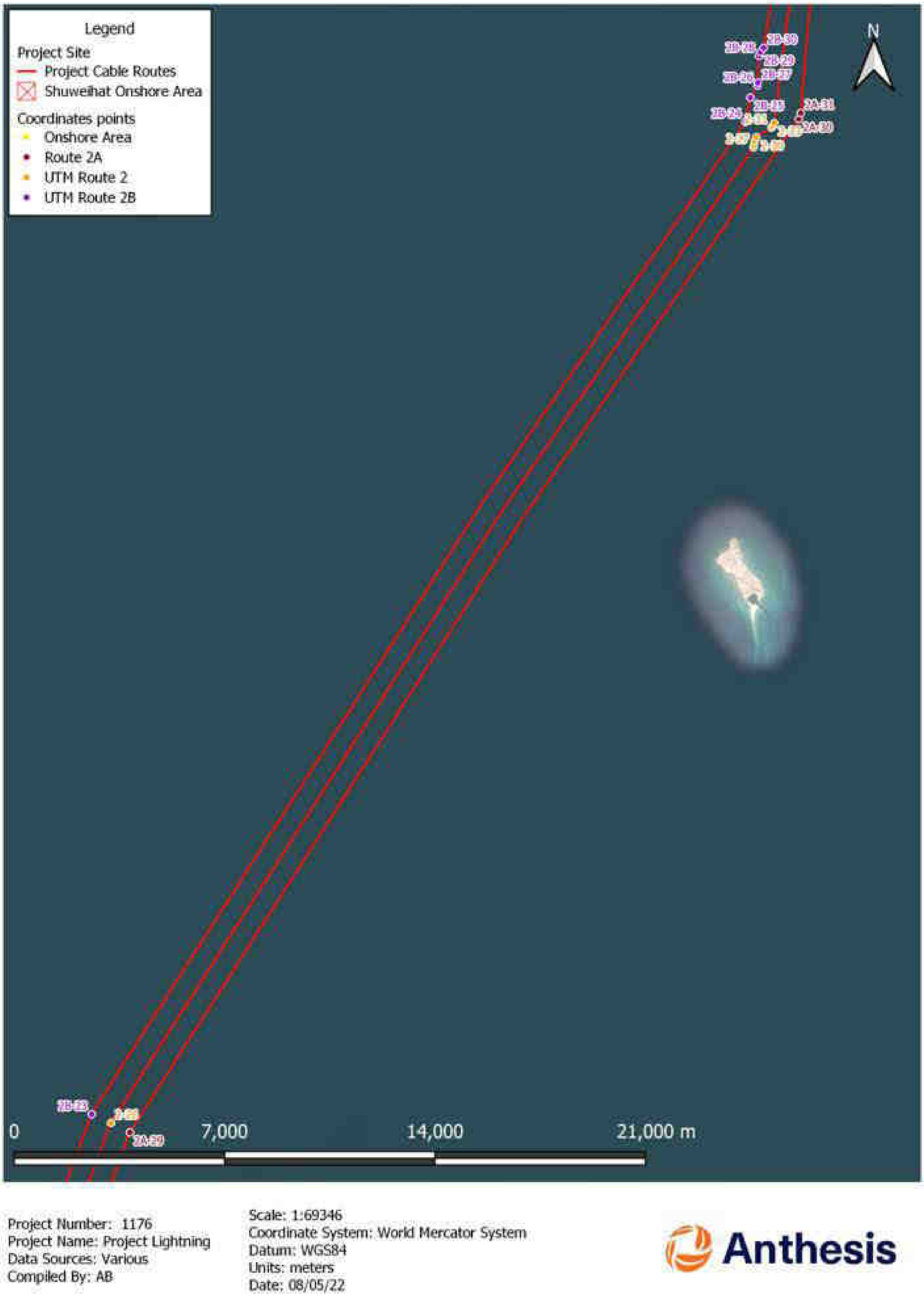


Figure 4-19: Route 2 Coordinates Points (KP 88.000 to KP 133.000)

Figure 4-20: Route 2 Coordinates Points (KP 128.000 to KP 135.000)

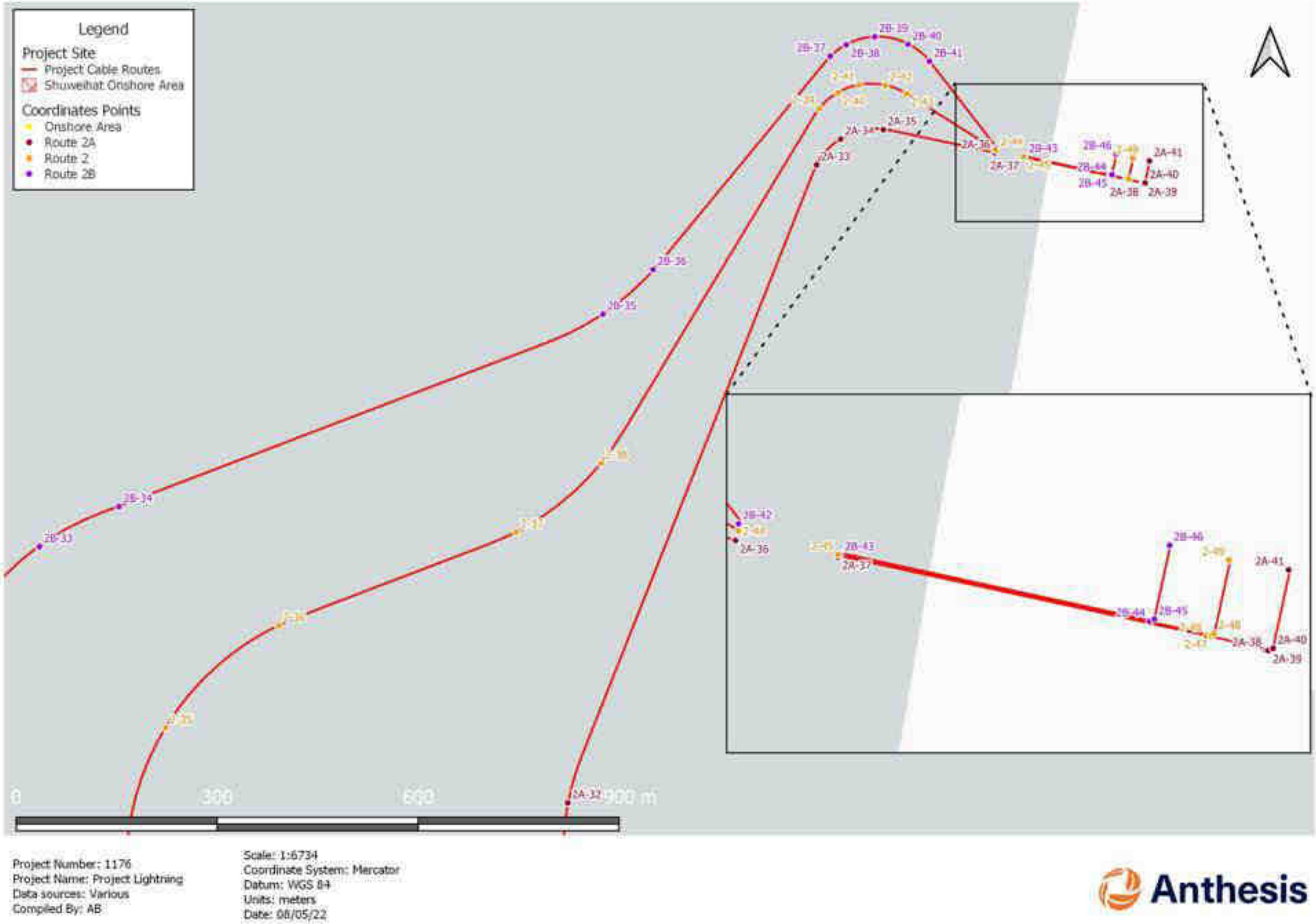


Figure 4-21: Route 2 Coordinates Points (KP 135.000 to KP 137.000)

Project Number: 1176
Project Name: Project Lightning
Data Sources: Various
Compiled By: AB

Scale: 1:394991
Coordinate System: World Mercator System
Datum: WGS84
Units: meters
Date: 08/05/22

Figure 4-22: Route 1 KPs

Project Number: 1176
Project Name: Project Lightning
Data Sources: Various
Compiled By: AB

Scale: 1:394991
Coordinate System: World Mercator System
Datum: WGS84
Units: meters
Date: 08/05/22

Figure 4-23: Route 2 KPs

4.2.2. Sites Surroundings

4.2.2.1. Overview

The Project routes will cross a number of areas. An overview is provided as follows:

- **Route 1 – Mirfa to Al Ghallan Island:** Al Ghallan Island sub-sea transmission cables (two cables plus one FO cable) will originate at Al Mirfa Power and Water Complex located approximately 110km south-west of Abu Dhabi city. The surrounding land use is predominantly open desert areas, with a small area of residential housing (referred as 'Residential Area (2)) located approximately 200m to the north of the Project site. Other receptors are generally located more than 1.5km away from the Project site, largely within the coastal town of Mirfa, with an estimated population of 29,000. The cables will then extend for 132km passing first throughout the MMBR for 14.5km then within close proximity to the MMBR boundary for 7.5km. The route then continues north passing near Abu Al Abyad Island to then further connect to Al Ghallan Island situated within the Zakum Oil Field located approximately 80km north of Mirfa. Al Ghallan Island is an artificial island constructed for the purpose of housing drilling rigs and associated ADNOC infrastructure. The population is unknown, but it is expected that ADNOC operational workers inhabit the island on a rotational basis; and
- **Route 2 – Shuweihat to Das Island**: Das Cluster sub-sea transmission cables (three cables plus one FO cable) will originate at Al Shuweihat Power and Water Complex located approximately 190km to the south-west of Abu Dhabi city. The surrounding land use is predominantly undeveloped coastal habitats and disturbed industrial areas with accommodation camps located approximately 600m to the north. The town of Al Ruwais is situated approximately 10km to the east, with an estimated population of 25,000. The cables will extend for 136 - 137km, passing nearby islands (Sir Baniyas, Dalma, Arzanah and Qarnain Islands) to then connect with Das Island situated approximately 110km to the north of the mainland. Das Island is inhabited by over 5,000 people on a rotational basis, working in various sectors and departments of ADNOC.

4.2.2.2. Protected Areas

The location of the Project site in relation to all UAE Protected Areas and the closest, MMBR is shown in Figure 4-3 above.

MMBR is protected under both UAE and international law following designation in 2007 as the first marine biosphere reserve in the UAE and region by UNESCO, on the basis of the natural diversity found within the intertidal and marine habitats within the area, including mangroves, seagrass, coral reefs, sabkha and sandy and rocky seashores. A large number of species are found within the MMBR, both terrestrial and marine, many of which are considered to be of conservation concern, perhaps most notably of which being the Dugong (*Dugong dugon*) (39). MMBR is recognised as being of global importance in terms of providing feeding and shelter for dugongs, whilst also providing spawning and nursery habitats for fish species and foraging grounds for green turtles (*Chelonia mydas*) and Hawksbill turtles (*Eretmochelys imbricata*), in addition to a variety of migratory bird species (39).

Figure 4-24 and Figure 4-25 below illustrates the various zones of the MMBR, including the core, transition and buffer zones. These zones are described below:

- **Core zone** – includes protected areas that act as reference points on the natural state of the ecosystems represented by the biosphere reserves. Activities should be limited to monitoring minimally disturbed ecosystems, non-destructive research and other low impact uses (such as education);
- **Buffer zone** – surrounds or is contiguous to the core zone. The buffer zone may be an area for experimental research, or may involve ways to manage natural vegetation, agricultural land, forests, fisheries or ranch land to enhance overall quality of production while conserving natural processes and biodiversity. This zone may also accommodate education, training, ecotourism, and recreation facilities. In many biosphere reserves, the buffer zone is regarded as an area in which human use is less intensive than what might be found in the transition zone; and
- **Transition zone** – is a large outer area of a reserve where people may live and work, contain towns, farms, fisheries, and other human activities and are the areas where stakeholders work together to manage and sustainably develop the area's resources.

As illustrated in Figure 4-24 and Figure 4-25 below, the following is identified:

- Route 1 first 14.5km (KP 0.000 to KP 14.500) traverses through the MMBR Buffer Zone;
- From KP 14.500 to KP 42.500, Route 1 crosses through the MMBR Transition Zone. However, the following should be noted:
  - From KP 14.500 to KP 20.500, Route 1 runs along the MMBR Buffer Zone with an approximate distance of 280m to its closest point;
  - From KP 20.500 to KP 22.000, Route 1 runs along the MMBR Core Zone with an approximate distance of 280m to its closest point; and
  - From KP 22.000 to KP 34.000, Route 1 moves further away from the MMBR Core Zone with an initial distance of 500m at KP 22.000 to a distance of 3.8km at KP 34.000.

Therefore, one of the key aims of this ESIA is to ensure that no significant and long-lasting impacts upon the features for which the reserve has been designated would occur to ensure the Project feasibility.

Two terrestrial protected areas are also present within the local area, Al Houbara and Barqat Al Suqoor, as shown in Figure 4-3 above, which are 12km and 15km respectively from the Project site and are not expected to be impacted as a result.

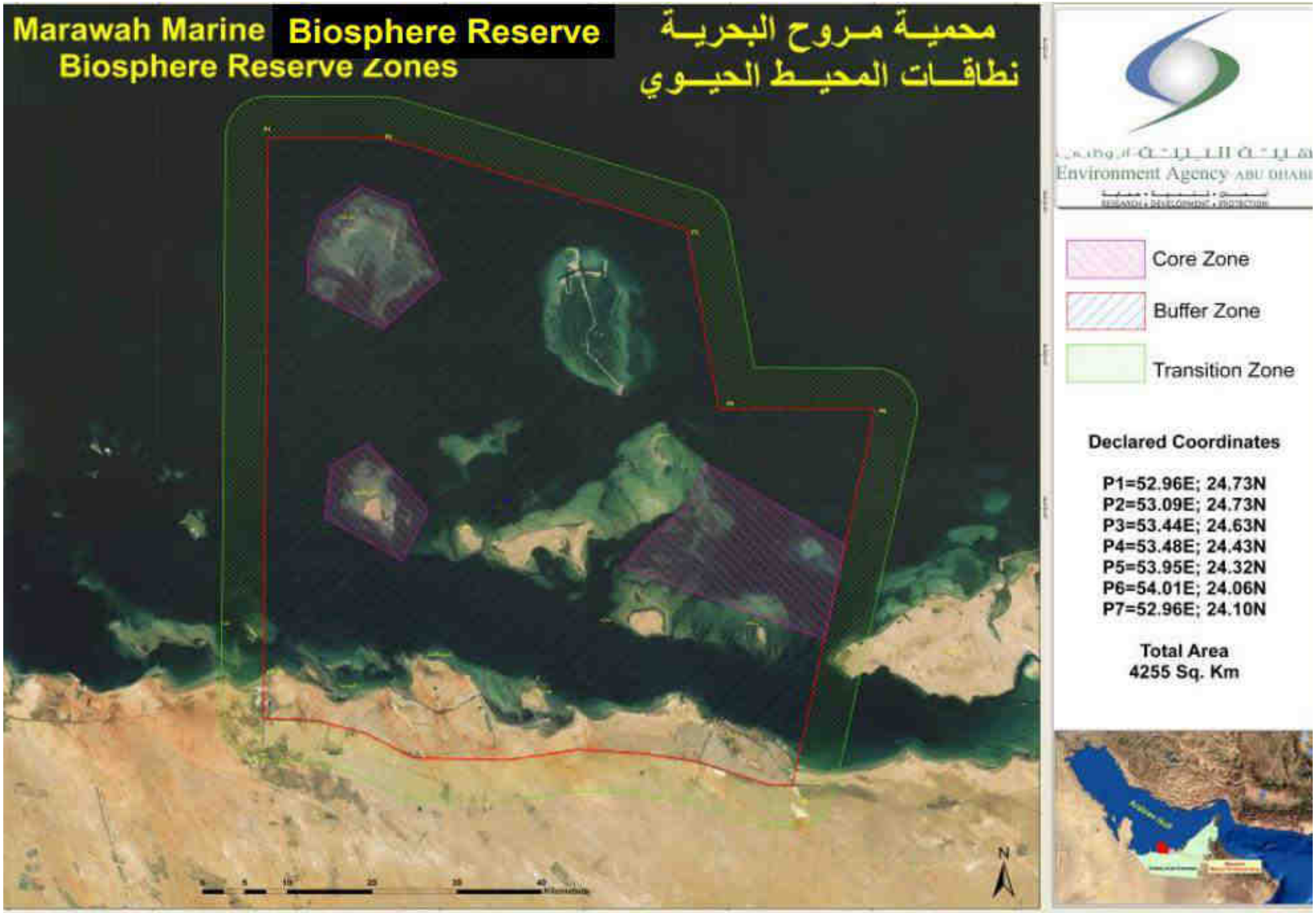


Figure 4-24: MMBR Zoning (40)

Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:223751
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 16/05/22

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Figure 4-25: Overview of the Project location in regard to the MMBR Core, Buffer and Transition Zones

4.2.2.3. Landuse

4.2.2.3.1. Route 1 – Mirfa Area

As illustrated below in Figure 4-26, the landuses in the surrounding area within 2km of the Project site are limited to the following:

- Two residential areas to the east and north-west of the Project site;
- Industrial area (adjacent Al Mirfa Power and Water Complex); and
- Commercial area (EAD Cultured Pearl Farm).

Additionally and as shown in Figure 4-27 and Figure 4-28, the landuses within 2km of the expected construction routes contain a variety of landuses within Mirfa including the following:

- Residential areas;
- Commercial and government/public buildings;
- Hospitals / clinics;
- Park / camping / beach / other recreational areas;
- Farmland;
- Plantations; and
- Industrial / port / utilities.

Further detailed descriptions of landuses and sensitive receptors within the vicinity of the Project sites are provided below in **Section 4.2.3** and **Section 4.2.4**

4.2.2.3.2. Route 2 – Shuweihat

At Shuweihat, land use is limited to industrial and residential areas, with the residential buildings limited to labour accommodation camps to the north of the Project site. Land use within the vicinity of the Project site and wider area is shown in Figure 4-29 below.

Landuses within 2km of the expected construction route are illustrated below in Figure 4-30 and Figure 4-31 and are likely to be limited to small areas of residential properties, in addition to Al Dhanna Golf Club.

4.2.2.3.3. Future Developments

Known proposed future developments expected within the vicinity of the Project are detailed below in Table 4-4 and are illustrated in Figure 4-26 to Figure 4-31.

Table 4-4: Future Developments

Development Name	Location to the Project site	Expected Construction date	Operation date	Description
Route 1 – Mirfa				
Project Wave	Approximately 2km south-west of Project site at Mirfa	Q1 2023	Q1 2026	Project that will include a desalination plant, intake pump station, intake pipeline and transportation pipeline. The Project construction is expected to take approximately 37 months.
Route 2 – Shuweihat				
Mugharraq Port	Approximately 730m north of the Project site at Shuweihat	Masterplan Phase 1: December 2020	2023	Redevelopment of the existing port, archaeological site and provision of offices for general business services.
		Masterplan Phase 2: December 2020- December 2021		Development of industrial area of the port including storehouses and warehouses, manufacturing and processing plots, commercial properties and community facilities.
		Masterplan Phase 3: December 2021 – December 2022		Development of remaining land for industrial storehouses and warehouses, manufacturing
Dalma Sea Cage Aquaculture Project	Approximate location to the east of Dalma Island, approximately 1.3km distant from Route 2 cable corridor	*Not known*	*Not known*	EAD is proposing to establish a sea cage to cultivate finfish, most likely grouper, to provide sustainable food sources and reduce pressure on marine fish stocks.

Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

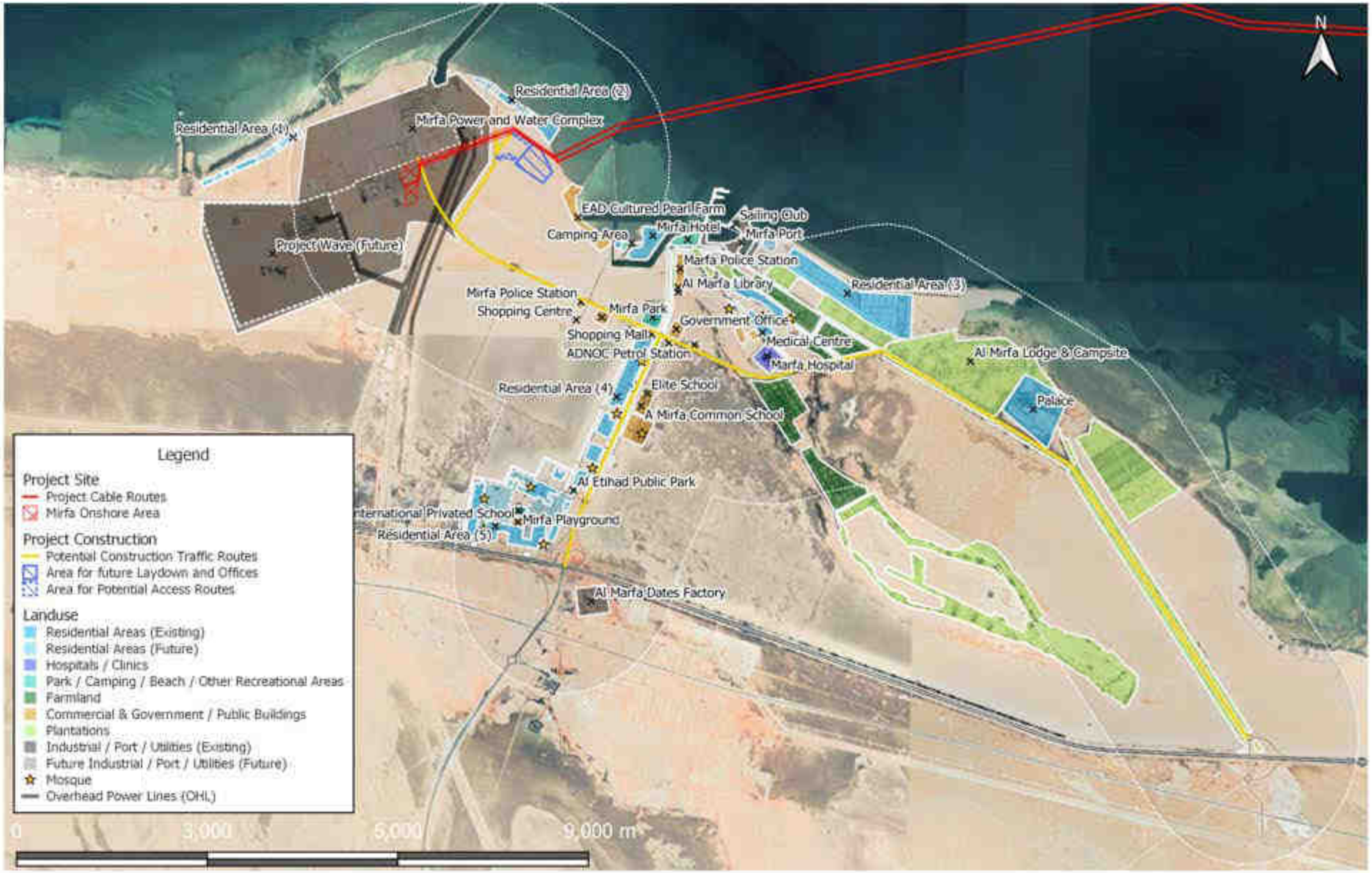
Scale: 1:30372
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 08/05/22

Figure 4-26: Landuse within 2km of the Project Route 1 onshore area

Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:73835
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 08/05/22

Figure 4-27: Landuse within 2km of the Project Route 1 onshore area and expected construction routes



Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:73835
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 08/05/22

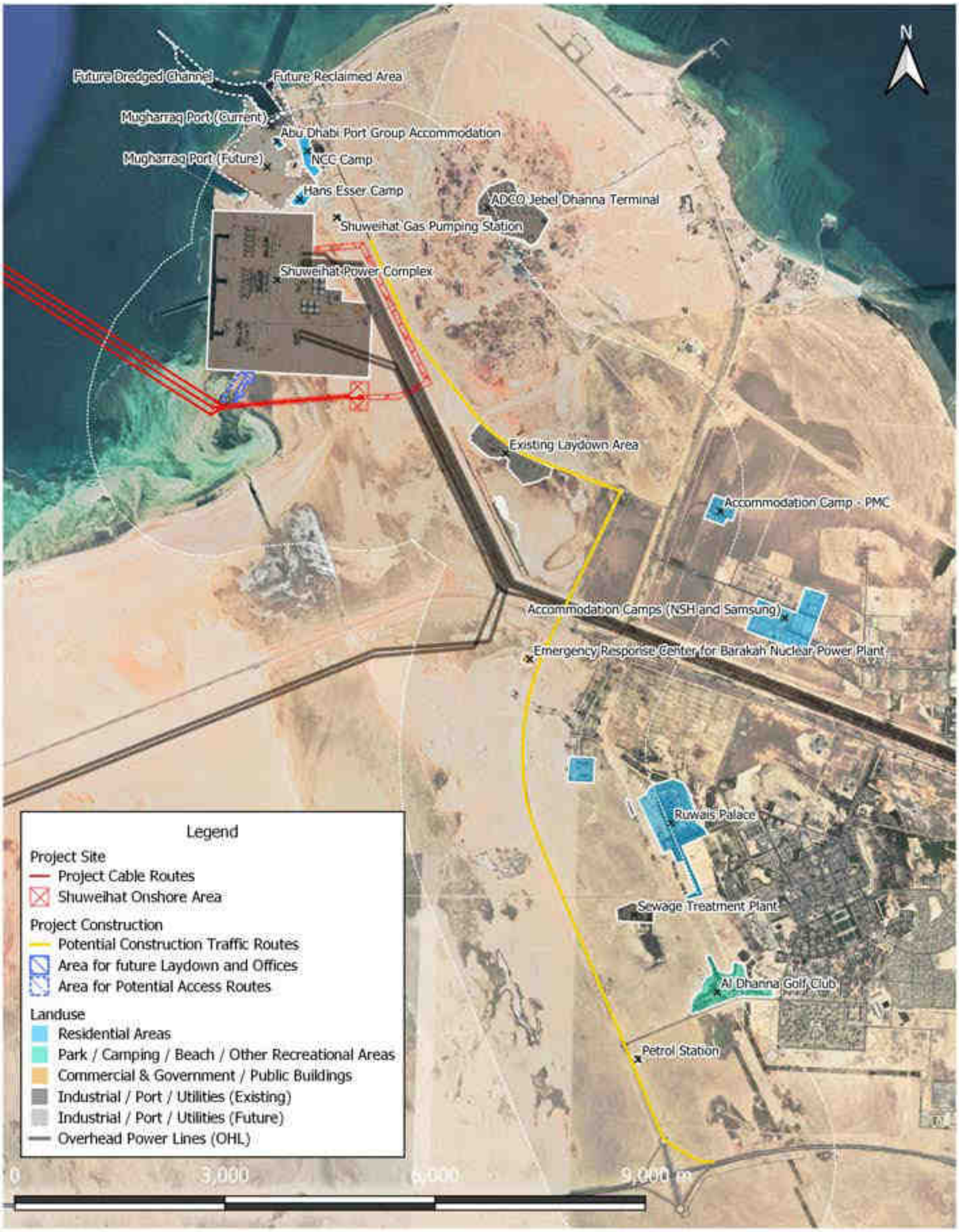
Figure 4-28: Landuse within 2km of the Project Route 1 onshore area and expected construction routes (with labels)

Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:39643
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 08/05/22

Figure 4-29: Landuse within 2km of the Project Route 2 onshore

Figure 4-30: Landuse within 2km of the Project Route 2 onshore area and expected construction routes



Project Number: 1176
Project Name: Project Lightning
Data Sources: Various
Compiled By: AB

Scale: 1:66536
Coordinate System: World Mercator System
Datum: WGS84
Units: meters
Date: 08/05/22

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Figure 4-31: Landuse within 2km of the Project Route 1 onshore area and expected construction routes (with labels)

4.2.3. Sites Description

4.2.3.1. Site Visits and Baseline Methodology

In addition to specific technical baseline surveys where the methodologies are presented in detail in each technical environmental section within **Chapter 5**, a general Project site visit was undertaken on the 18th – 19th January 2022 and on the 26th – 28th April 2022 in order to provide an assessment of the Project site components and surroundings at both the Mirfa and Shuweihat areas.

Information relating to Das Island and Al Ghallan Island has been obtained from previous studies undertaken by Nautica (41) and via satellite imagery, respectively.

4.2.3.2. Site Description Overview

4.2.3.2.1. Route 1 – Mirfa to Al Ghallan Island

Onshore – Mirfa Area

The Project site is located immediately adjacent to and will be incorporated within the Al Mirfa Power and Water Complex, located approximately 4km north-west of Mirfa, a mixed-use coastal town with an estimated population of approximately 29,000. A large proportion of Mirfa's population work as fishermen and the rest are predominantly employed by various governmental agencies, including municipality plantations, industries and tourism.

The land immediately surrounding the onshore Project area is predominantly undeveloped although an area along the shoreline to the east contains a number of residential properties which are understood to be holiday / weekend residences. Some of these properties are fully developed whilst some are currently under construction, in addition to undeveloped plots which will presumably be developed in the future.

Further along the coastline to the south-east are areas of mangroves and beyond the proposed landfall area, a hooked causeway which extends approximately 1.6km. Approximately 900m to the south of the point where the cable makes landfall is a cultured pearl farm operated by EAD. The surrounding habitat is largely sabkha within this area. Mirfa Hotel and Mirfa Harbour are located further to the south-east, approximately 1.5km from the Project site.

The Project site is also largely undeveloped although in parts, is significantly disturbed, being situated adjacent to an existing industrial area. The Project alignment will make landfall within an area of intertidal mudflats exposed at low tide at the point of landfall, before travelling north and east across coastal sand sheets and low dunes before transitioning to coastal plains on well drained sandy ground and areas of sabkha. These areas are the predominant habitat within close proximity to the main area of the Project site, much of which has been disturbed, graded and demarcated for future development and is interspersed by *ad hoc* and paved tracks and access roads. Overhead lines (OHL) originate from Al Mirfa Power and Water Complex traversing south-west across the Project site.

Figure 4-32 to Figure 4-39 below provide an overview of the existing conditions within the vicinity of the Al Mirfa Power and Water Complex, Project site area and existing sensitive receptors present.

Figure 4-32: Residential properties to the east of Al Mirfa Power and Water Complex

Figure 4-33: Undeveloped areas of coastal sand sheets in between residential plots at Mirfa

Figure 4-34: View looking north and east from Mirfa from intertidal mud flats and mangrove areas

Figure 4-35: Rocky outcrops along coastline looking south-east to Mirfa adjacent to residential properties

Figure 4-36: View east across the bay where cable route will reach land, with Mirfa visible in the distance

Figure 4-37: General view of the Mirfa Project coast with fly tipping evident and hadrah fishing fences visible to the south-east

Figure 4-38: Sabkha habitat present at the EAD Cultured Pearl Farm

Figure 4-39: View east towards Mirfa Hotel

Offshore – Al Ghallan Island Area

The Route 1 cable will terminate at the tie-in location on Al Ghallan Island, which is a fully operational ADNOC facility. As such, access to Al Ghallan Island is highly restricted and therefore no site surveys were undertaken on the island for the purposes of this ESIA.

Satellite imagery indicates that Al Ghallan Island is encircled by breakwater structures and is otherwise comprised of reclaimed land containing heavily developed areas of an industrial nature, with its primary purpose being an ADNOC facility.

Marine Areas

Of the two proposed routes for the cables, Route 1 will traverse through the more sensitive habitat areas present within the Project area since the cable route will be partially located within the MMBR, which is both nationally protected by law and internationally registered under the UNESCO Man and Biosphere Programme global network of Biosphere Reserves.

Furthermore, the shallow coastal areas are of particular sensitivity and support critical habitats, including patch and fringing corals and seagrass meadows, together with species of conservation concern such as dugong and various turtle species.

The MMBR is significant in terms of biological diversity conservation since most of the marine and terrestrial species are present in the area. The total area of the MMBR also represents approximately 4% of the total area of the country. The habitats within the MMBR are considered to be of national and regional importance.

These habitats include seagrasses, mangrove, coral reefs, coastal sabkhas, rocky seashores, sandy seashores and rocky ridges. The MMBR is of global importance as a shelter and feeding ground for dugongs. The area also provides crucial nursery and spawning grounds for a wide variety of fish species and is regionally important as a foraging habitat for hawksbill and green turtles.

Furthermore, the islands inside the protected area provide important nesting sites for hawksbill sea turtles and a number of migratory birds, including about 5% of the world population of the vulnerable Socotra Cormorant.

Most of the islands are inhibited with a very low density of local population. In addition to these inhibited Islands, the coastal area is also target of low-density population concentrated in four aggregations, namely Tareef, Radeem, Mirfaa and Themeiria.

4.2.3.2.2. Route 2 – Shuweihat to Das Island

Onshore – Shuweihat Area

The Project site will be located immediately adjacent to and will be incorporated within the Al Shuweihat Power and Water Complex, located approximately 10km west of Ruwais, an industrial coastal town with an estimated population of approximately 25,000.

Ruwais has expanded considerably since the 1970s when it was formally a small fishing village. It is now a successful industrial and housing complex that has largely been developed by ADNOC as a major contributor to the national economy and represents a series of multimillion-dollar investments by the company. Ruwais has several major industries including an oil refinery, fertilizer plant, marine terminal and a sulphur handling terminal. The town has several schools, a hospital and shopping and entertainment facilities housing and supporting workers within the industrial facilities.

The Project site and surrounding areas consist of disturbed and partially developed industrial areas including areas of coastal sabkha and coastal plains on well-drained sandy ground, saltmarshes and mudflats. Areas of mangroves are present immediately adjacent to the south of the proposed landfall location for the cable corridor.

To the north are located several accommodation camps, including Abu Dhabi Port Group accommodation, Hans Esser Camp and NCC Village, associated with the Shuweihat Complex and ADNOC facilities which are situated approximately between 600m and 1km north of the Project site, respectively. An ADNOC port facility (Mugharraq Port) is situated approximately 1.4km to the north of the Project site.

Approximately 2.2km to the east of the Project site is the Jebel Dhanna Abu Dhabi Company for Onshore Oil Operations (ADCO), an oil storage facility.

Figure 4-40 to Figure 4-43 below provide an overview of the existing conditions present within the Project site and surrounding areas at Al Shuweihat Power and Water Complex.

Offshore - Das Island Area

Das Island is located in the Arabian Gulf, approximately 165km north-west of Abu Dhabi City and 25km west of Umm Shaif oil field. Das Island is fully operational as an ADNOC facility and provides a comprehensive range of facilities for uploading and moving construction materials. As such, access to Das Island is highly restricted and therefore no site surveys were undertaken on the island for the purposes of this ESIA.

Nevertheless, previous baseline surveys undertaken by Nautica in 2021 (41) describe Das Island as comprising a salt plug, within the rocky northern section. The prevailing northwest (shamal) winds have resulted in the deposition of coral sand and eroded detritus adjacent to low rocky hills, which forms the more natural part of the island (42). The island is approximately 3km in length and 1km wide, featuring largely flat sandy beaches in the south and more elevated areas in the north with exposed rocks considered to be some of the oldest to be found in the UAE (41). The heavy industrialisation of the island means that there is little natural vegetation. Landscaping trees and shrubs have been introduced within the flat southern area and there are no natural freshwater sources (41).

Marine Areas

The marine environment adjacent to the Shuweihat Project site, whilst not located within a marine protected area, contains a number of valuable habitats. These are located within the shallow coastal areas which are of particular sensitivity; critical habitats present include patch and fringing corals and seagrass meadows, together with species of conservation concern such as dugong and various turtle species.

Figure 4-40: Mangroves at Shuweihat to the west of the cable route corridor

Figure 4-41: Evidence of tidal coastal deposition of flotsam adjacent to Project site at Shuweihat

Figure 4-42: View north away from Shuweihat Project site and cable corridor

Figure 4-43: Shuweihat Project site area view across bay where cable corridor will traverse

4.2.3.3. Existing Local Road and Transportation Network

4.2.3.3.1. Route 1

Mirfa Area

The Project site and Mirfa town are accessed from the main E11 Highway – Sheikh Khalifa Bin Zayed Al Nahyan International Road via two possible access routes:

- E11 to an interchange with Qassar Al Mighayra Street; or
- E11 to an interchange with Al Shaheed Ahmed Khamis Al Hammadi Street.

Both routes then lead to Al Khor Street which is a local road leading to Al Mirfa Power and Water Complex. The Al Khor Street is an existing paved access roads currently serving the operational Al Mirfa Power and Water Complex.

Table 4-5 below identifies the local site area constraints and local and national transport connections available to the Project Route 1 development.

Table 4-5: Local transportation and constraints for Route 1

Constraints	Route 1	
	Mirfa	Al Ghallan Island
Area constraints for HVDC stations (including temporary laydown areas)	400m x 250m	No data available
Local and long-distance roads / condition / type of road network	Multi-laned asphalted type suitable for transporting heavy goods	Concrete suitable for transporting medium goods
Ports and ship cargo (nearest commercial port location)	Zayed or Khalifa Port or other ports under Petroleum Port Authority	Zayed or Khalifa Port or other ports under Petroleum Port Authority
Air cargo (nearest commercial cargo location)	Abu Dhabi International Airport	Abu Dhabi International Airport

Al Ghallan Island Area

The offshore tie in locations Al Ghallan Island fall within ADNOC jurisdiction and access is therefore restricted to ADNOC personnel.

4.2.3.3.2. Route 2

Shuweihat Area

The Project site is located within a remote coastal area in the Eastern Region of Abu Dhabi, adjacent to Al Ruwais Industrial City. The E11 Highway – Sheikh Khalifa Bin Zayed Al Nahyan International Road traverses parallel to the coast and diverts into Al Rubban Street, the main access road to Ruwais. From the local road network within Ruwais, the Project site can be accessed via two main routes:

- E11 to Al Rubban Street then Al Yash Street; or
- E11 to an interchange with Al Yash Street.

Both routes then lead to Qarn Mugharraq Street which is a local road leading to Shuweihat Power Complex. The Qarn Mugharraq Street is an existing paved access roads currently serving the operational Shuweihat Power Complex.

Table 4-6 below identifies the local site area constraints and local and national transport connections available to the Project Route 2 development.

Table 4-6: Local transportation and constraints for Route 2

Constraints	Route 2	
	Shuweihat	Das Island
Area constraints for HVDC stations (including temporary laydown areas)	400m x 250m	400m x 190m
Local and long distance roads/condition/type of road network	Multi-laned asphalted type suitable for transporting heavy goods	Concrete suitable for transporting medium goods
Ports and ship cargo (nearest commercial port location)	Zayed or Khalifa Port or other ports under Petroleum Port Authority	Zayed or Khalifa Port or other ports under Petroleum Port Authority
Air cargo (nearest commercial cargo location)	Abu Dhabi International Airport	Abu Dhabi International Airport

Das Island Area

The offshore tie in locations Das Island fall within ADNOC jurisdiction and access is therefore restricted to ADNOC personnel.

Figure 4-44: Project Route 1 Mirfa local road network

Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:134624
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 08/05/22

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Figure 4-45: Project Route 2 Shuweihat / Ruwais local road network

4.2.3.4. Existing Marine Access and Transportation Network

As shown in Figure 4-46 below, a significant number of anchoring areas and ports are present within the marine environment surrounding the Project area, although there appear to be no direct conflicts between these and the Project alignment for Route 1 or Route 2.

4.2.3.4.1. Route 1

At the nearest point onshore, the Project alignment is located approximately 2.4km west of Mirfa Port. Within the marine environment, the cable route passes within 1.2km of the entrance to the port. Mirfa Port was one of the first ports provided to support the local fishing industry. Port infrastructure includes a breakwater for protection from currents, berths for fishing and leisure vessels and retail and business areas, including restaurant, administration building etc (43).

Approximately 100km north-east in Abu Dhabi City is located Port Mina Zayed, Port Shahama and further east, Port Khalifa.

4.2.3.4.2. Route 2

Mugharraq Port faces Sir Baniyas Island and is located approximately 1.7km to the north of the Project site. The port provides cargo facilities and support and logistics for Dalma Island and Sir Baniyas Island. The port is currently undergoing upgrade works further to the development of a new masterplan which includes further slipways, revetment for protection, deepening of the port basin and construction of an additional quay wall (43). Additionally, limits of the Port along with its anchoring areas are shown in Figure 4-47 below.

Dalma Port is situated on the eastern edge of Dalma Island, approximately 5km from Route 2 and provides support to passenger ferries, fishing vessels and cargo vessels (43). CICPA facilities are also provided with a 300-metre berth for cargo vessels. A large marina provides fishing and recreational vessels with support, in addition to providing a fish market, restaurant, sheltered storage area and an ADNOC marine fueling facility (43).

Approximately 77km east of Route 2 alignment is located Al Sila Port which is the largest public marina in Abu Dhabi, which provides local fishing support, cargo facilities and recreational activities.

Figure 4-46: Location of Ports and anchoring locations near the Project Routes (44)

Figure 4-47: Mugharraq Port limits and anchorage areas

4.2.3.5. Site History

4.2.3.5.1. Route 1 – Mirfa to Al Ghallan Island

The previously undeveloped site at Mirfa was first developed in 1995 as a power and water plant which has been upgraded and expanded into a significant complex over the past two decades in response to increasing demands for electricity and water (45). Of most recent note was the construction of Mirfa Independent Water and Power Project (IWPP) with a net power capacity of 1600MW, which became operational in October 2017. The Mirfa complex contains sufficient space for future expansions and additions to the current plants.

No information is available regarding Al Ghallan Island history.

4.2.3.5.2. Route 2 – Shuweihat to Das Island

The Shuweihat site was previously an undeveloped area, with Shuweihat S1 IWPP being constructed and operational in 2004, providing a power generation capacity of 1,600MW and 100 million gallons of water per day (MGD). S2 IWPP became operational in October 2011 and provides 1,600MW of power and 100 MGD (46). In July 2014, a third power plant, S3, became operational, providing an additional 1.6 GW from gas-fired facilities (46) (47).

Das Island is fully operational as an ADNOC facility and provides a comprehensive range of facilities for uploading and moving construction materials. Das Island has a long history in the UAE's oil and gas exploration journey and was the location of Abu Dhabi's first global oil shipment in the 1960's.

Das Island was largely underdeveloped prior to oil and gas activities but it is believed to have been previously inhabited due to the presence of a small cemetery. Das Island was known as a turtle breeding ground, and it is understood that turtles still frequent the area. It is also understood to be an important landing ground for a number of migratory bird species (41).

4.2.3.6. Site Topography

Since the Project tie-in locations on the Abu Dhabi mainland will be to existing power and water complexes, both of which have been operational for between 15-25 years, the topography of the Project sites is largely graded and levelled prior to construction. Undeveloped areas closer to the coastline along the cable route are also largely flat with some undulating areas of sand sheets closer to the coastline. Overall, the Project area topography can be described as homogenous.

Topographical surveys are currently ongoing on behalf of the EPC Contractor prior to the commencement of construction activities, in order to inform site preparation requirements.

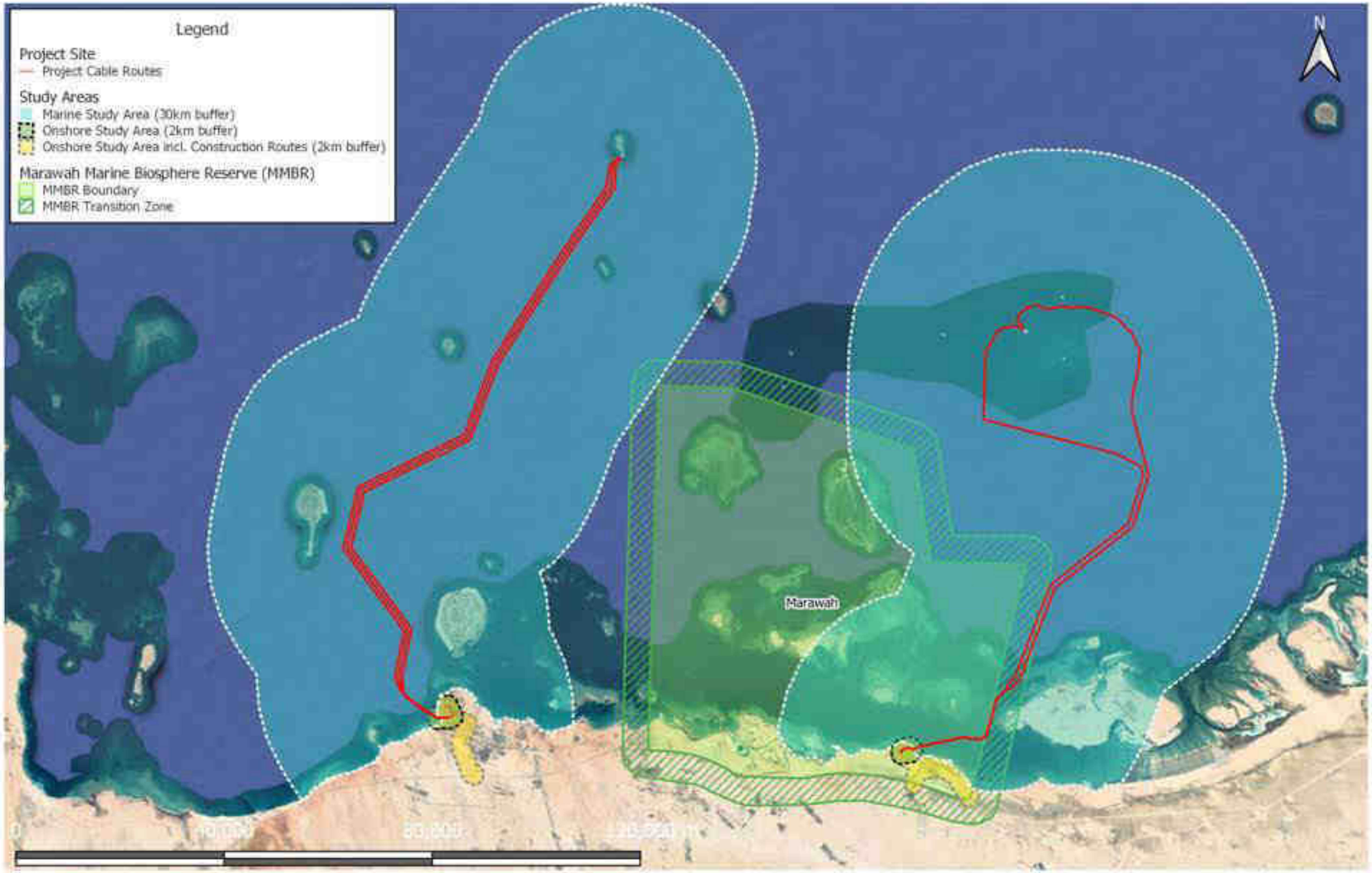
4.2.4. Sensitive Receptors

4.2.4.1. Study Areas

Figure 4-48 below provides an overview of the extent of the entire Project area including both cable corridors (Route 1 and Route 2) proposed onshore and offshore study areas and protected areas within the surrounding areas. Study areas have been defined for both terrestrial and marine components of the Project, as follows:

- 30km within the marine environment – this area has been selected as there is the potential for widespread transport of sediments from marine construction activities and longer-range marine noise impacts (illustrated in Figure 4-48 below); and
- 2km for onshore areas – this area has been selected as construction impacts such as noise, dust etc. would not be expected beyond this distance (illustrated in Figure 4-26 to Figure 4-31 above for Mirfa and Shuweihat, respectively).

These study areas have been refined and amended where necessary within each specific chapter based upon the initial results of impact assessments (for example sediment transport within the marine model).



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Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:901584
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 06/06/22

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Figure 4-48: Project study area overview and MMBR

4.2.4.2. Key Sensitive Receptors

In order to provide a detailed list of potential sensitive receptors, the following was undertaken:

- A review of online information with satellite imagery has enabled an overview of key land-use throughout the Project sites. This also allowed to prepare the in-depth site visits in order to compare the online data with the real time data;
- A review and verification of existing information presented within the Project Lightning Gap Analysis (34) and Environmental Screening Report (48), both prepared by Mott MacDonald;
- Site visits by Anthesis to confirm the presence of sensitive receptors.

The location of the Project sites within areas already containing significant industrial activity designated predominantly for power and water generation and little other development means that onshore sensitive receptors are largely limited to operational staff of adjacent industrial facilities, construction workers associated with the Project activities, accommodation camps at Shuweihat and a small number of residential properties at Mirfa.

In addition, the intertidal and marine environments contain a number of highly sensitive habitats and species, particularly within the vicinity of the Route 1 nearshore areas which are situated within and adjacent to the MMBR. The MMBR is significant in terms of biological diversity conservation since most of the marine and terrestrial species are present in the area. The total area of the MMBR also represents approximately 4% of the total area of the country. The habitats within the MMBR are considered to be of national and regional importance. These habitats include seagrasses, mangrove, coral reefs, coastal sabkhas, rocky seashores, sandy seashores and rocky ridges. The MMBR is of global importance as a shelter and feeding ground for dugongs. The area also provides crucial nursery and spawning grounds for a wide variety of fish species and is regionally important as a foraging habitat for hawksbill and green turtles.

The key sensitive receptors associated with the proposed Project are largely expected to be impacted during the construction phase as it is expected that the construction activities will create the greatest disturbances and impacts. During the operational phase, no significant sensitive receptors are likely to be affected, with only negligible or positive impacts predicted during this phase.

The list of key sensitive receptors has been identified in the below sub-sections.

4.2.4.2.1. Marine Sensitive Receptors

- Marine habitats, specifically:
  - MMBR (Route 1 only);
  - Critical habitats, including:
    - Coral reef;
    - Fringing reef;
    - Seagrass beds;
- Species of conservation concern, including but not limited to a species that have been identified through sureys and identified in the literature review, including:
  - Dugong (*Dugong dugon*);
  - Hawksbill turtle (*Eretmochelys imbricata*);
  - Green sea turtle (*Chelonia mydas*);
  - Olive ridley turtle (*Lepidochelys olivacea*);
  - Loggerhead turtle (*Caretta caretta*);
  - Indian ocean humpback dolphin (*Sousa plumea*);
  - Whale shark (*Rhincodon typus*);

- Indo-pacific finless porpoise (*Neophocaena phocaenoides*);
- Whitecheek shark (*Carcharhinus dussumieri*);
- Smoothtooth blacktip shark (*Carcharhinus leiodon*);
- Longhorned pygmy devil ray (*Mobula eregoodoo*);
- Ocellate eagle ray (*Aetomylaeus milvus*);
- Reticulate whipray or Coach whipray (*Himantura uarnak*);
- Sharpnose guitarfish (*Glaucostegus granulatus*);
- Halavi guitarfish (*Glaucostegus halavi*);
- Daisy parrotfish (*Chlorurus sordidus*);
- Green sawfish (*Pristis zijsron*);
- Reticulate goby (*Gobiodon reticulatus*);
- Thinstripe wrasee (*Halichoeres leptotaenia*); and
- Other marine species.

- Numerous bird species including Socotra cormorant (*Phalacrocorax nigrogularis*), Sociable lapwing (*Vanellus gregarius)* and Great Knot (*Calidris tenuirostris*); and
- Marine water and sediment quality.

4.2.4.2.2. Terrestrial Sensitive Receptors

An overview of terrestrial sensitive receptors is as follows:

- Terrestrial and intertidal habitats, specifically:
  - Critical habitats:
    - Mudflats and sand / tidal flats;
    - Saltmarsh;
    - Mangrove habitats; and
    - Sand sheets and dunes;
  - Nationally environmentally sensitive habitats, including:
    - Sheltered tidal flat with cyanobacterial mats;
    - Storm ridge beaches;
    - Coastal cliffs, headlands, rocky slopes and wadis in coastal situations;
    - Coastal sand sheets and low dunes;
    - Coastal sabkha, including sabkha matti; and
    - Beach rock and gravelly beaches.
- Species of conservation concern, including but not limited to:
  - Osprey (*Pandion haliaetus*);
  - Socotra Cormorant (*Phalacrocorax nigrogularis*);
  - Western Marsh Harrier (*Circus aeruginosus*);
  - Eurasian Curlew (*Numenius arquata*); and
  - Bar-tailed Godwit (*Limosa lapponica*).
- Soil and groundwater quality;
- Waste facilities;
- Cultural heritage sites;
- Coastal viewsheds valuable to recreational and touristic locations in the Western Region coastline;
- Socio-Economic receptors:
  - Local residents and fishermen (including Hadrah fishermen) of coastal towns and individual dwellings throughout the Project area;
  - Workers onshore at adjacent facilities and workers at oil and gas offshore islands / facilities; and

- Construction workers employed by the Project.

4.2.4.3. Detailed List of Onshore Sensitive Receptors

4.2.4.3.1. Route 1

The following specific sensitive receptors have been identified at the onshore Project areas at Mirfa as illustrated in Figure 4-49 and Figure 4-50 below:

- Private residences along the shoreline to the east and west of the Project site, ranging from 90m to >500m to the east;
- Archaeological feature located approximately 2.2km south;
- Terrestrial and intertidal habitats;
- EAD Cultured Pearl Farm, located approximately 2.6km south east;
- Camping area to the south of EAD Cultured Pearl Farm;
- Mirfa Town, located approximately 4km south-east, and includes a number of receptors including:
  - Mirfa Hotel;
  - Mirfa Date Factory;
  - Mirfa International Private School;
  - Al Mirfa Common School;
  - Al Shumoukh School;
  - Al Mirfa Police Station;
  - Mirfa Library;
  - Government offices;
  - A Palace;
  - Small groceries stores and restaurants/cafes;
  - Mirfa Park;
  - Al Etihad Public Park;
  - Al Mirfa Lodge and Campsite;
  - Mirfa Harbour and Port;
  - Mirfa Hospital;
  - Medical Centre;
  - Numerous mosques; and
  - Shopping centres and malls.

4.2.4.3.2. Route 2

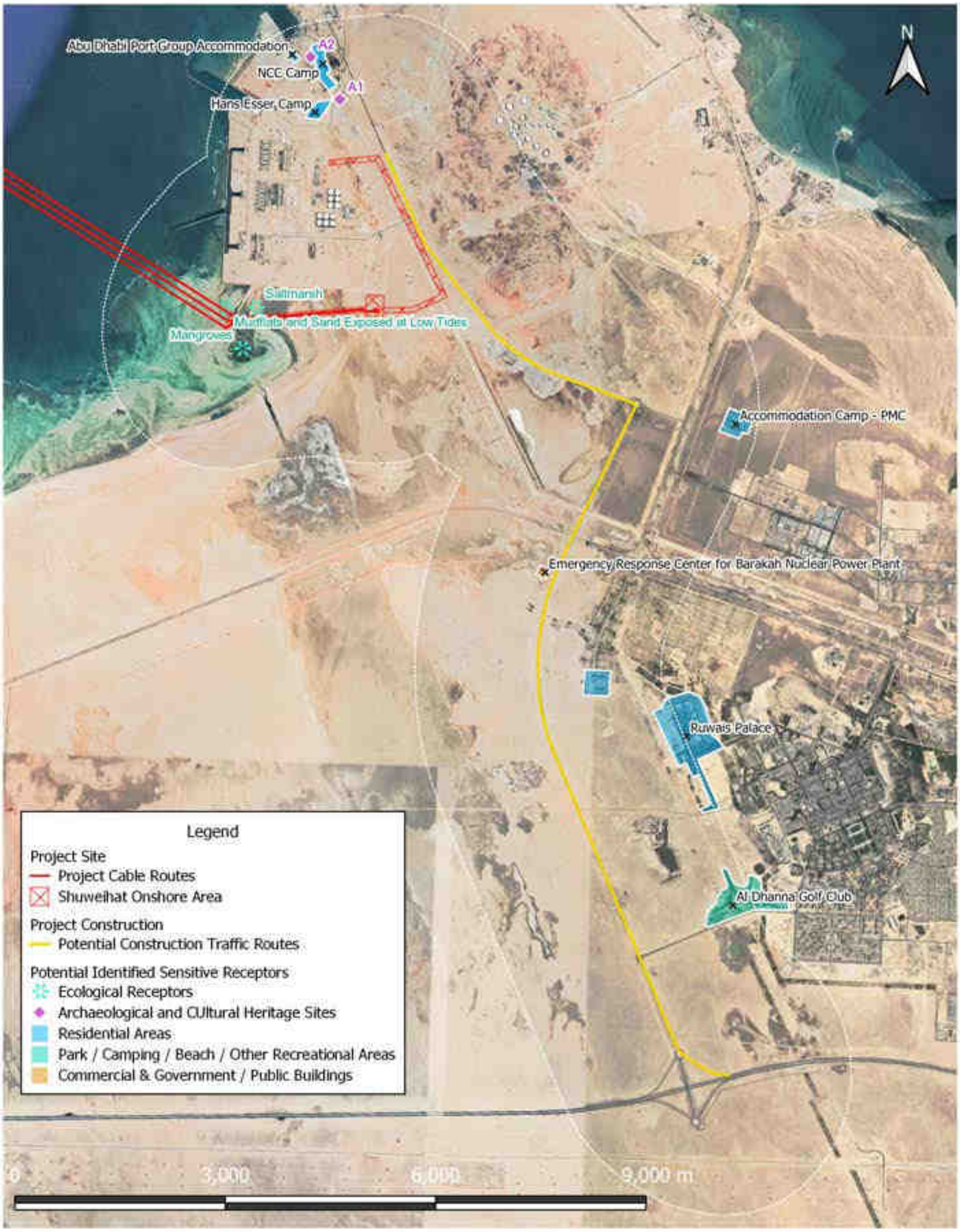
The landfall location of the cable route at Shuweihat contains fewer potential sensitive receptors which are listed below and are illustrated in Figure 4-51 and Figure 4-52 below:

- Mangrove/creek areas within the cable route landfall area;
- Archaeological feature located approximately 870m north;
- ADCO Jebel Dhanna Terminal, located approximately 2km east.
- Mugharraq Port, located approximately 1.6km north; and
- Worker's accommodation to the north of Shuweihat Power and Water Complex, including:
  - Hans Esser Camp, located approximately 600m north;
  - Abu Dhabi Port Group Accommodation, located approximately 1.4km north; and
  - NCC Village Accommodation, located approximately 1km north.

Figure 4-49: Potential Sensitive Receptors located within 2km of the Project area (Route 1 – Mirfa)

Figure 4-50: Potential Sensitive Receptors located within 2km of the Project area and expected construction traffic routes (Route 1 – Mirfa)

Figure 4-51: **Potential Sensitive Receptors located within 2km of the Project area (Route 2 – Shuweihat)**



Project Number: 1176
Project Name: Project Lightning
Data Sources: Various
Compiled By: AB

Scale: 1:66536
Coordinate System: World Mercator System
Datum: WGS84
Units: meters
Date: 09/05/22

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Figure 4-52: Potential Sensitive Receptors located within 2km of the Project area and expected construction traffic routes (Route 2 – Shuweihat)

4.3. Project and Activity Descriptions

The information provided below is sourced from available information at the time of preparing this ESIA, as provided by the Consortium and includes documents provided to bidders including the RFP documents and minimum functional specifications, in addition to information presented within method statements and documents prepared by the EPC Contractor.

It should be noted that the actual design of certain Project components is not yet available and will be determined and refined by the Consortium at a later date.

4.3.1. Description of Project Components

A description of the proposed Project activities is provided below. The Project owner will be responsible for the design, engineering, procurement, supply, construction, testing and installation activities, commissioning, operation and maintenance of the entire system from the onshore tie-in locations throughout the cable corridors to the offshore island termination points in two separate clusters.

It is understood that the new HVDC cabling system will be integrated into the existing onshore power station network and will work in synchronization with the existing power system network both with existing and planned generators, in addition to future Alternating Current (AC) supplies when installed in the future.

The Project will consist of the following main elements:

- HVDC Converter stations (onshore and offshore);
- HVDC and FO cables and associated marine works and equipment;
- Electrical requirements and connectivity;
- Structural and civil requirements;
- Mechanical requirements; and
- Additional pipelines and installations.

The HVDC and FO cables and return conductor cables forming a single HVDC link will be bundled either at the factory or during installation.

The method of bundling shall be robust enough to withstand wear during handling, installation, retrieval and from the operational environment without the composite cables separating for the operating life of the cable.

An overview of the cable installation locations, capacity and cable type and configuration is provided in Table 4-7 below.

Table 4-7: Overview of cable installation location, capacity, cable length and configuration

Location	Capacity (MW)	Cable Type	Kilovolts (kV)	Configuration
Route 1: Mirfa – Al Ghallan Island	2 x 1000	Monopolar	320	2 x (2 HVDC + 1 FOC)
Route 2: Shuweihat – Das Island	2 x 600	Bipolar	400	2 x (1 HVDC + 1 FOC) + 1 metallic return cable (MRC)

4.3.1.1. Overview of Installation Activities

The following installation and construction works are expected to be required and are briefly summarised below in Table 4-8.

Table 4-8: Summary of installation works

Location of works	Installation Activities Required
Nearshore works involving the transition of cable from sea to land and all required tie in locations	– All activities will be informed by and in accordance with the findings within site surveys and studies undertaken and listed within **Chapter 5** e.g. geophysical, environmental and geotechnical; – Pre-laying surveys of cable routes and clearance activities, if required; – Trenching within shallow nearshore areas, intertidal and beach locations, installing the cable and jointing with offshore sections, followed by backfilling of trenches; – Installation and securing of cable protections in required areas; – Tie-in works at both Mirfa and Shuweihat, including, civils and mechanical electrical works, in addition to transition joint bay installation at Mirfa and Shuweihat landfall sites; – Reinstatement works; and – Constructing the converter stations at Mirfa and Shuweihat;
Offshore construction works	– Overall management prior to, during and after the operations; – Pre-engineering bathymetry surveys; – Route engineering and installation engineering, including review of available information and preparation of procedures; – Manufacturing and installation of offshore riser platforms for cables at both islands, including bridges to the converter stations; – Excavation of trenches for cable installation; – Installation of Direct Current (DC) land cables in trench between converter station and riser platform (on islands) or transition joint bay (at shore landings); – Preparation of platform and shore ends; – Cable transport from cable supplier to Project site; – Installation of onshore and offshore HVDC cables and FO cables; – Cable protection works (soil backfilling, rock protection, crossings, platform approach, landing etc.); and – As-built surveys.
Offshore connections	– All activities will be informed by and in accordance with the findings within site surveys and studies undertaken and listed within Chapter 5 e.g. geophysical, environmental and geotechnical; – Installing riser platforms; – Tie-in works at Das and Al Ghallan Island to include mechanical electrical and civil works and construction of converter buildings; and – Post construction surveys.

Project layout drawings for the converter stations and associated elements for each location (i.e. Mirfa, Shuweihat, Das Island and Al Ghallan Island) are illustrated below in Figure 4-53 to Figure 4-56 below.

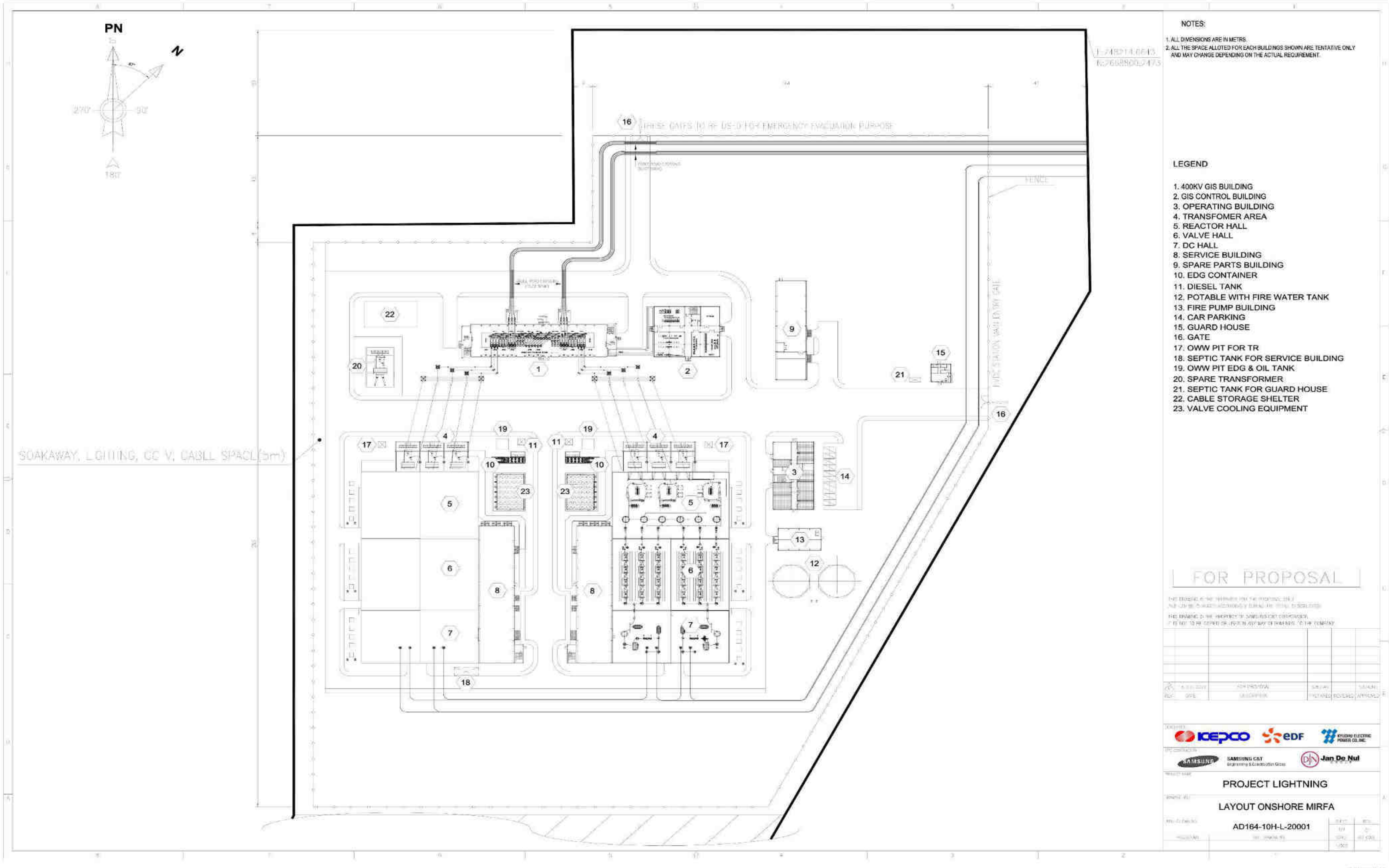


Figure 4-53: Proposed onshore elements layout at Mirfa (Route 1)

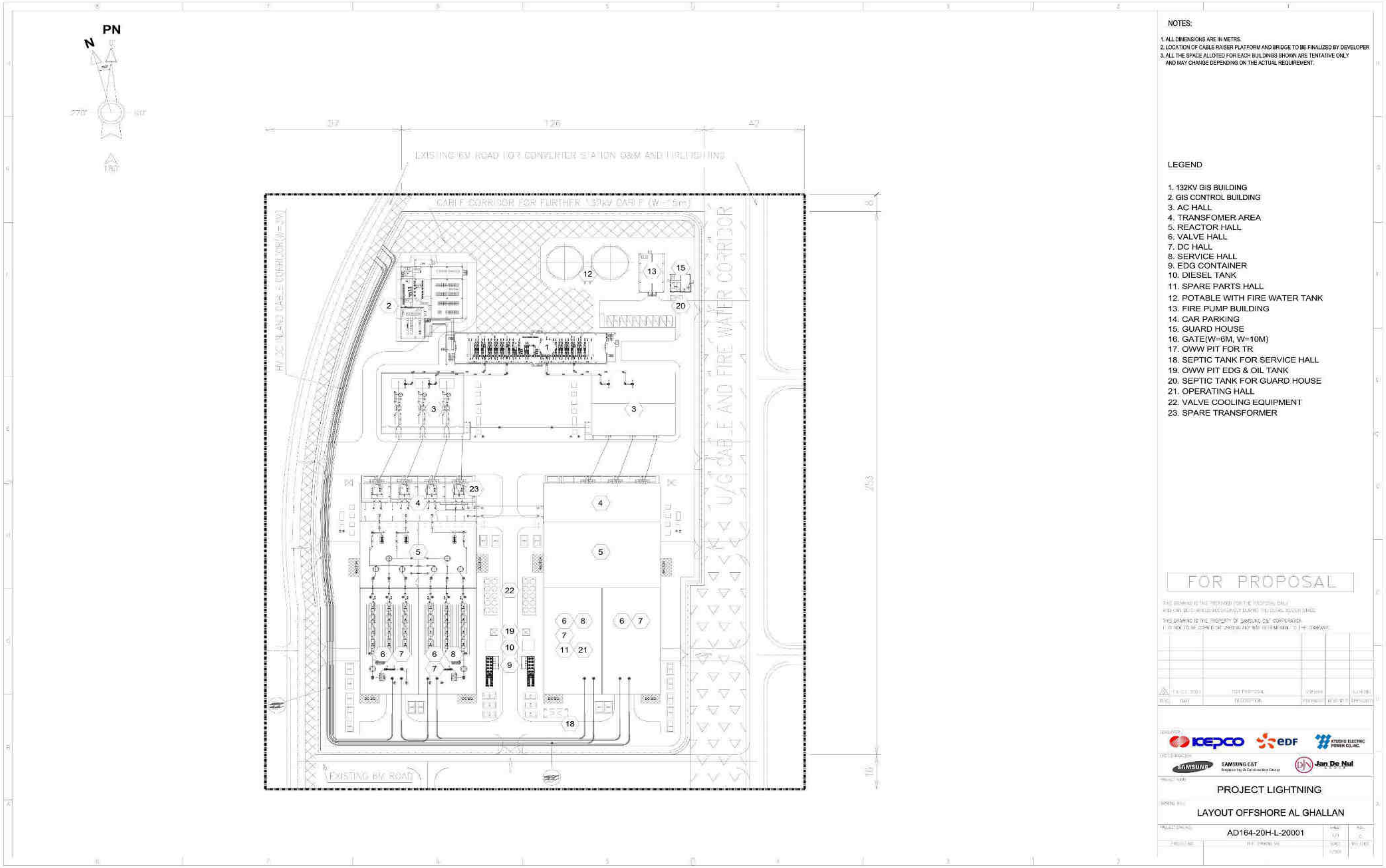


Figure 4-54: Proposed onshore elements layout at Al Ghallan Island (Route 1)

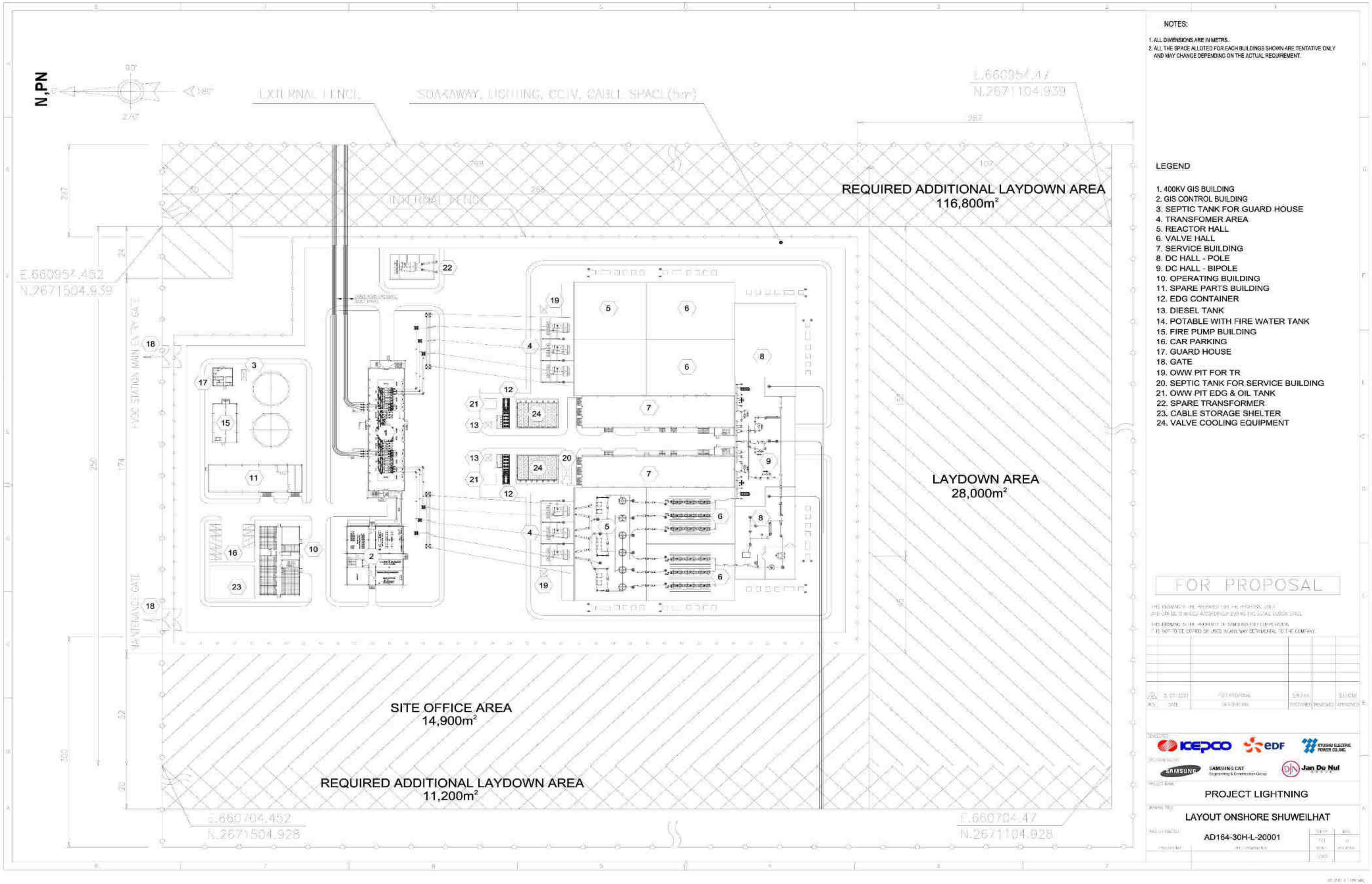


Figure 4-55: Proposed onshore elements layout at Shuweihat (Route 2)

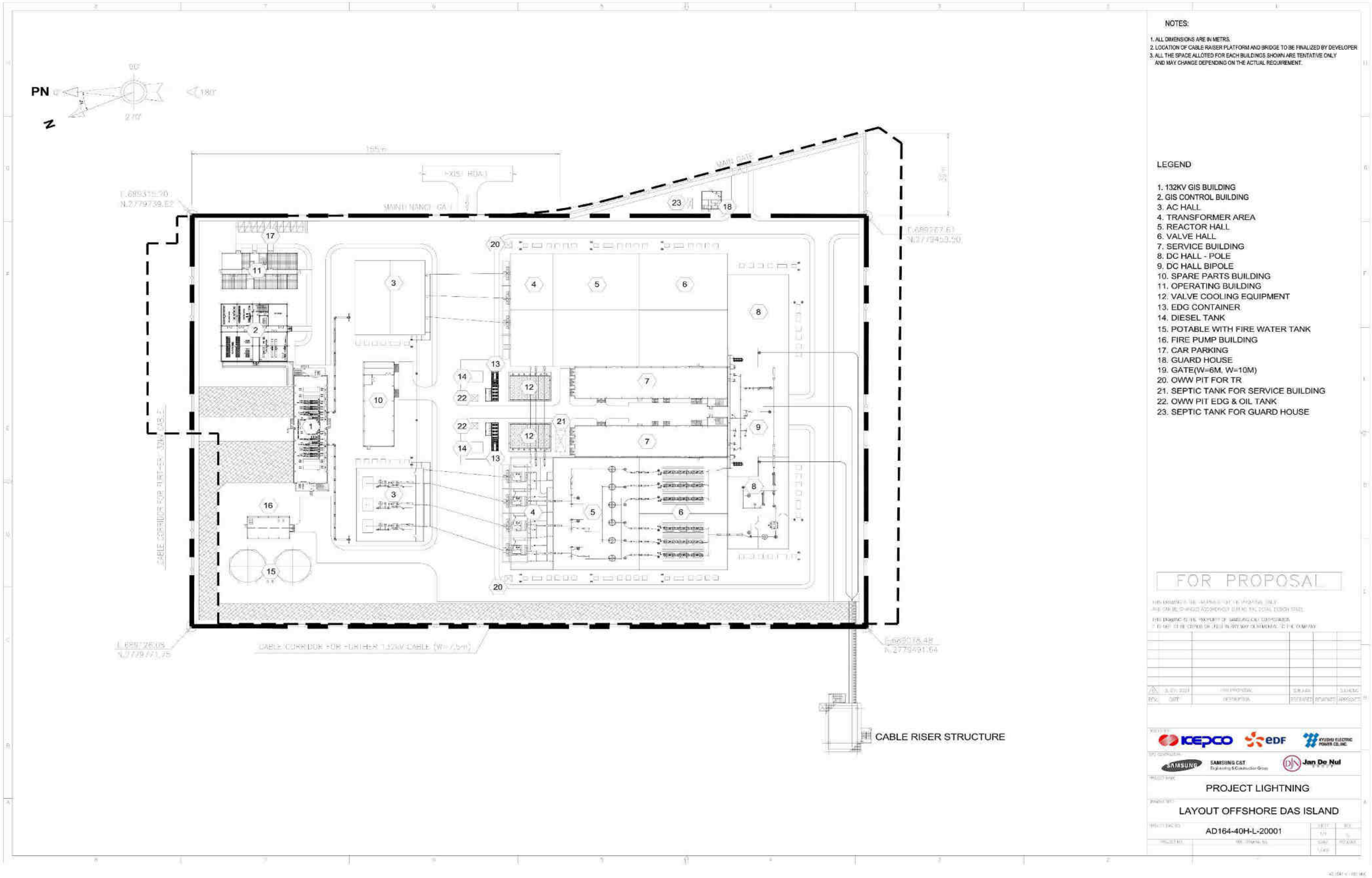


Figure 4-56: Proposed onshore elements layout at Das Island (Route 2)

The required components expected to be installed in relation to each element of the Project are summarised in the below sections.

4.3.1.2. Civil and Structural Components

Both Route 1 and Route 2 will include the following civil and structural components:

- Converter station buildings;
- 400KV GIS substation buildings;
- Gas Insulated Switchgear (GIS) control building;
- Service building, to include a control and protection room, battery room, auxiliary Low Voltage (LV) supply room, heating, ventilation and air conditioning (HVAC) room, converter valve cooling plant room, workshops, office rooms, telecommunication room, stairways, interface equipment rooms, kitchen, washroom and toilets facilities;
- Fire pumphouses;
- Fire water tanks foundations;
- Transformer foundation with oil/water containment bund/pit and surrounded by reinforced concrete blast walls. These oil retention systems will comprise two components, namely an oil catch basin around interface transformers and a common remote collection and separation tank of appropriate volume;
- Pressurised transformer rooms for offshore location;
- Foundations for converter stations, GIS substations, air/water fin/fan coolers, pumps, emergency diesel generator, water tanks, fire pump-house;
- External fencing with access gates;
- Internal access road with car parking;
- External access road from nearby public main access road both onshore and offshore to the converter stations, suitable for transportation of largest and heaviest equipment;
- Stone chippings for remainder of surface areas;
- Sewage collection system with septic tank;
- Common oil/firewater containment pits;
- Site drainage system with local soakaway for onshore components and connecting to nearest offshore network for Das Island and Al Ghallan Island;
- Raising plot and slope protection by stone pitching or concrete apron;
- Concrete cable trenches, duct-banks, pipe trenches, road crossings;
- Landscaping, interlock tile paving, surfacing and gravelling;
- Offshore riser / cable / landing platform for offshore locations. Specific design and/or alternatives to be confirmed at a later date;
- Noise treatment of building and noise attenuation enclosures;
- Piling as required;
- Interface room within TRANSCO sub-station;
- Supports for cable trays, piping, HSE, electrical/instrumentation/telecom installations;
- Tie-ins to existing facilities including roads, drainage, trenches etc. as applicable;

- Crossovers, operating and access platforms, shelters and sunshades as required; and
- Any other civil and structural works required to support and / or facilitate other discipline scope of work.

4.3.1.3. HVDC Converter Stations

The planned requirements for offshore and onshore converter stations are set out below in Table 4-9 below.

Table 4-9: Project HVDC converter station designs

HVDC Route	Converter station requirements
Route 1 – Mirfa (onshore) and Al Ghallan Island (offshore) Route 2 – Shuweihat (onshore) and Das Island (offshore)	– Two valve halls equipped with converter valves and other equipment; – Related control and operation buildings equipped with associated cubicles fully populated with control, protection and telecommunication equipment; – Related AC filter halls including AC filter equipment, if required; – Two AC side as well as DC side primary equipment buildings equipped with all necessary equipment; – One spare parts' building equipped with recommended spare equipment and parts; – Two sets of all other related auxiliary/ancillary equipment buildings equipped with auxiliary system kits or equipment including Uninterruptible Power Supply (UPS), Low Voltage (LV) & Medium Voltage (MV) switchgears, battery system, HVACP system, cooling system, fire protection systems, sockets & lighting; – Lightning protection masts or wires; and – Necessary roadways, foundations, auxiliary cabling, fencing, earthing mats or grids and other civil works.

4.3.1.4. TRANSCO Interfaces

At each onshore tie-in location the following interconnection specifications will be applied:

- 400kV XLPE cables will be installed from the Converter Stations to the TRANSCO tie-in substations with all necessary accessories including cable supports and raisers, cable terminations, cable protections, civil works including trenches, as required. High voltage (HV) cable from TRANSCO tie-in to Converter Stations will be installed within a concrete trough, which is in accordance with the requirements set out by TRANSCO;
- Cable differentiation protection will be provided in accordance with TRANSCO Standards;
- Interface panels will be installed for signal exchange via FO cables;
- The new interface panels between the HVDC cables and the substation will be installed at both Mirfa and Shuweihat substations within purpose-built building structures with independent entrances as there is no space within the existing substation buildings to accommodate the additional interface panels required. The buildings will be constructed in accordance with TRANSCO Standards within the existing boundary of the substations. These are subject to confirmation and agreement with TRANSCO;
- At each interconnection point, the following will be installed: interconnections for protection panels, telecommunication panels, metering panels, SCMS panels, all related civil work and rerouting of any existing cabling;
- The additional interface panel buildings will be powered from the existing substation distribution system, which will require a check for adequacy and potential upgrade; and

- At the converter stations, cables will be connected to a new indoor 400kV Gas Insulated Switchgear in accordance with the requirements of TRANSCO Standards. The GIS and converter transformers will be by cable or alternative solution.

4.3.1.5. High Voltage Interface – Interconnections from Landfall to Converter to Substation

Interface locations will be situated at the cable termination enclosures at the 400kV gas insulated switchgear of each TRANSCO substation. Indicative locations and layouts for the proposed cable and interface locations and converter stations for each route are set out above in Figure 4-5 to Figure 4-21.

4.3.1.5.1. Route 1 – Mirfa

At Mirfa, the cable is proposed to make landfall at an undeveloped area of beach to the east of the Project site. The proposed cable will then traverse approximately 2.5km to an area approximately 250m x 400m which will house two AC/DC converter stations. The cable will then traverse approximately 500m to the main TRANSCO Mirfa 400kV substation, as illustrated above in Figure 4-7. The connection to the TRANSCO Substation will be via two existing spare bays (CO7 and C14) which are designed and equipped for overhead line (OHL) connections.

4.3.1.5.2. Route 1 – Al Ghallan Island

At Al Ghallan Island, the distance from the riser bridge to the Converter Station area will be 520m.

4.3.1.5.3. Route 2 – Shuweihat

Two AC/DC Converter Stations will be installed within proximity to the TRANSCO Shuweihat 400kV substation as shown above in Figure 4-13. The connection from the Converter Stations will be via two existing spare bays (C21 and C32), as at Mirfa, which are currently only partially equipped and will therefore require conversion and adapting. New protection panels will be installed at this location to ensure that the equipment is in accordance with TRANSCO Standards, for two spare feeds of 400kV.

The required cable route from the point of landfall at the transition joint bay (TJB) to the TRANSCO tie-in to the proposed Converter Stations will be 1.3km at Shuweihat.

4.3.1.5.4. Route 2 – Das Island

At Das Island, the distance from the riser bridge to the Converter Station will be 250m.

4.3.1.6. Marine Cables and Marine Works

The subsea cable system scope of work shall include the following:

- Subsea cable protection, trenching and backfilling;
- Installation of HVDC cables and FO cables, bundled together. FO cables will enable communications and signalling;
- Installation of adequate means of cable protection for cables and pipe crossings, onshore landing and approach, offshore landing or riser platform approach;
- Subsea cable additional stabilisation;
- Subsea cable shore approach installation and protections;
- Installation of new riser platform and connecting bridge at each of the island locations. Final design of riser platform or alternative is not yet confirmed;
- J-tubes design and installation, where subsea cables are terminating at Riser Platforms; and

- Conducting all necessary metocean, geotechnical and geophysical surveys at each riser location.

All subsea cable mechanical design and installation requirements will be in accordance with ADNOC OFFHSORE AO-ENG-L-SP-002, Specification for Mechanical Design and Installation of Subsea Cables.

4.3.1.7. Electrical Requirements and Connectivity

Each HVDC transmission cluster will include the following, at a minimum:

- 400kV incoming cable for each onshore substation from the tie-in location in existing TRANSCO substation, until the GIS equipment installed at the converter stations, including associated protections to be installed at each end.
- Any necessary modifications at TRANSCO substations (feeders, protections, control, telecommunication, auxiliary systems). If necessary, new battery and UPS systems shall be provided in TRANSCO substations for the new loads;
- Interface panels, protection cabinets, telecom cabinets, relays and current transformers (CTs) and voltage transformers (VTs), tariff metering at each tie-in TRANSCO substation and all converter stations as necessary. All interface panels in TRANSCO premises shall be installed in a dedicated room which shall be built as a new and separate building inside a TRANSCO substation area, subject to TRANSCO approval;
- GIS equipment installed at the converter stations, onshore and offshore;
- Main transformers at the converter stations, both onshore and offshore;
- Interface panels, protection cabinets, telecom cabinets, relays and CTs and VTs at each converter station;
- Appropriate provisions, as necessary at each location for auxiliary systems such as lighting (internal and external including streetlights, small power), HVACP, fire protection, water systems, emergency diesel generators, AC and DC UPS; and
- Grounding and lightning protection for each converter station.

4.3.1.8. Process, Piping and Pipelines

Route 1 and Route 2 will both feature the following:

- Converter cooling systems – primary;
- Converter cooling systems – secondary;
- Demineralised water supply / make-up;
- Raw water supply / make-up;
- Sanitary, plumbing and waste disposal;
- Nitrogen purging; and
- Diesel oil supply, storage and handling system.

4.3.1.9. Water Supply

During the initial period following commissioning, it is envisaged that offshore components will be provided with water by potable water tankers, for closed cooling water systems, fire protection and service/domestic water requirements. It is then assumed that these components will be connected to the island wide water distribution system.

Fire protection make up water for closed cooling water system and for the service/domestic consumption for onshore elements, ether potable water tankers will be used or the local Abu Dhabi Distribution Company (ADDC) network may be utilised under a separate service agreement.

Raw / potable water will be utilised for make-up water requirements in addition to fire protection supplies and will be stored in duplicate 100% capacity vertical cylindrical steel tanks to provide at a minimum, sufficient water for a four-hour period. Make up and domestic water requirements will need to cover a 160-hour period. Hydraulic connections to the outlet will be by a common outlet header pipe.

4.3.1.10. Wastewater, Oily Water and Sewage Discharge

Wastewater will be approximately collected, handled and treated/disposed of as follows:

- Sanitary wastewater will be collected within septic tanks at each Project location (for both service building and guard house) for disposal by tanker to an offsite facility. It is currently estimated that approximately 3 m^3/day of sanitary wastewater will be generated per location;
- Industrial and process wastewater collection, treatment and transfer systems with neutralization, flocculation and detoxification for all chemicals containing wastewater streams (e.g. areas of chemical storage, boiler blow-down water, chemical cleaning effluents etc.) in addition to sludge dewatering equipment;
- Oily wastewater will be collected at remote common oil retention tanks (7.7 m x 16 m x 5.5 m / station) at each Project site location for collection by tanker and disposal at an offsite facility;
- Stormwater collection (capacity for 1.363 m^3/hr) and transfer facilities; and
- Installation of continuous monitoring systems for monitoring treated effluents.

4.3.1.11. Demineralised Water Supply Pumps and Pipework

Two 100% duty 316L SS centrifugal pumps will be provided to deliver approximately 18m^3/station of demineralized water to the Converter Stations primary cooling systems at Mirfa and Shuweihat.

4.3.1.12. Domestic and Service Water Supply and Water System

Two 100% duty centrifugal pumps will be provided to deliver domestic/service water to the plant at Mirfa and Shuweihat. The system will include the following:

- Battery room: including cold water sink, eye bath and shower;
- Kitchen: Sink with hot/cold water supply and electric immersion heater;
- External coolers: Water washing facilities for radiator tubes; and
- A buried ring main to be provided to enable general washing down activities.

4.3.1.13. Internal and External Access Roads and Surfacing

Both internal and external roads will be installed to serve the Projects requirements. These will enable access to the Project sites from the local road network, facilitating the movement of regular traffic and abnormal loads to transformer locations and other areas where abnormal load delivery or removal is required.

Secondary roads shall also be installed to enable regular maintenance vehicles e.g. forklifts and man lifts to access all areas within the Project site boundary. All other areas of the Project sites which require access will be via appropriately prepared surfaces with adequate support to prevent surface damage or rutting.

A total of ten parking spaces will be provided for regular vehicles as part of the service building. Roads and parking areas will be appropriately demarcated using plastic poly posts to ensure traffic remains within the designated areas. Appropriate gravelling and grading will be applied throughout the Project sites.

4.3.1.14. Site Security and Fencing

Perimeter fencing, access gates, security cameras and motion detectors and appropriate locks will be provided throughout the Project site. Perimeter fencing will also be installed within the main perimeter fence to provide safety distances e.g. around transformers and shunt capacitator banks.

Fences will comprise of electric/manual control from local control rooms, or using external intercom, keypads or card sensor control boxes. Access gates will be wide enough to enable large abnormal loads to access the site without dismantling the gates and/or fencing.

4.3.2. Details of Construction, Operation and Decommissioning Activities and Processes

4.3.2.1. Construction Overview

The appointed EPC Contractor is Samsung C&T Corporation (Samsung) and Jan De Nul Consortium (JDN) (Contractor's Consortium), whereby Samsung will be responsible for the converter stations and equipment and JDN will be responsible for the installation of all cable installation works, both onshore and offshore. A summary of the key construction activities and processes is provided below.

Details relating to the marine trenching and backfilling works to be undertaken in addition to marine cable laying activities and rock installation activities are provided below in **Section 4.3.2.2.2.**

Details relating to onshore civil works including cable laying activities and associated components are provided below within **Section 4.3.2.2.3**.

The following method statements have been referred to:

- Work Method Statement Trenching and Backfilling Works (TSHD Methodology Update), Samsung C&T Corporation & Jan De Nul Consortium, April 2022 (49);
- Method Statement – Submarine Cable Installation, Prysmian Group, April 2022 (50);
- Rock Installation Method Statement, JDN Group, April 2022 (51);
- Lay – CLV (Cable Laying Vessel) – Isaac Newton, JDN Group, April 2019 (52);
- Post-Lay Jet Trenching – UTV1200, JDN Group, November 2020 (53); and
- Civil Works Scope Overview, JDN Group, March 2022.

4.3.2.2. Construction Activities Methodology

4.3.2.2.1. Mobilisation Activities

The EPC Contractor will mobilise to the Project site and the main expected activities will include:

- Site survey and setting out;
- Site fencing;
- Establishment of site access and haulage roads;
- Establishment of temporary offices and welfare facilities;
- Mobilisation of toilet and other sanitary facilities (chemical toilets will be used at each of the locations);
- Establishment of electricity and water sources presumed to include mobile generators and tankered water;

- Establishment of site drainage, including stormwater management systems;
- Establishment of laydown and storage areas for both onshore and offshore equipment;
- Mobilisation of equipment, plants and boats to the sites; and
- Site preparation and levelling (if required).

The construction site areas at the onshore and offshore island locations will be cleared of any debris, obstructions and vegetation.

Details about Laydown Areas, Offices & Welfare Facilities are further discussed in **Section 4.3.2.2.5.**

4.3.2.2.2. Intertidal and Marine Works

Overview

The EPC Contractor's scope includes a number of marine activities including trenching, dredging, laying the cables, backfilling and cable protection activities within the nearshore and offshore at both Route 1 and Route 2.

Route 1 will include the installation of two cables (Cable 1A and Cable 1B) plus FO cable and Route 2 will include the installation of three cables (Cable 2, Cable 2A and Cable 2B) plus FO cable.

Key Activities

Key activities required associated with marine works are as follows:

- Within the intertidal and nearshore areas:
  - Trenching in intertidal, nearshore and offshore zones up to -8 m water depth for all routes;
  - Dredging of rest areas and floatation / dredged channel(s) at Route 1A & 1B required for the access of the cable installation barge. Dredged material is then loaded in a split hopper barge (SHB) and disposed at a temporarily marine disposal area(s);
  - Cable laying / installation;
  - Backfilling of trenches with side cast native material for above trenches within all routes;
  - Backfilling of the cable trenches located within the rest areas and floatation / dredged channel(s) with the temporarily disposed materials at the marine disposal area(s) via barge loading for Route 1A & 1B;
  - Rest areas and floatation channels will not be backfilled completely, only the trenches (located in the rest area/floatation channels) wherein the cable will be installed.

- Within the offshore marine areas (>-8m depth):
  - Cable laying / installation;
  - Post-lay trenching where soft subsea substrate is encountered; and
  - Subsea Rock Installation (SRI) where hard subsea substrate is encountered.

ADNOC specifies that a minimum separation distance of 50m between two cables is needed due to repair and maintenance requirements.

Figure 4-57 illustrates the locations of offshore construction requirements for both Route 1 (Al Ghallan, 1A and 1B) and Route 2 (Das – cable route 2, 2A and 2B). It can be seen that dredging, cable installation and backfilling is required in the nearshore areas of both routes whereas minimal post-lay trenching (for soft subsea substrate) and rock installation (for hard subsea substrate) after cable installation are required in deeper waters.

Full details relating to the marine equipment to be used for these works is provided in the below sections.

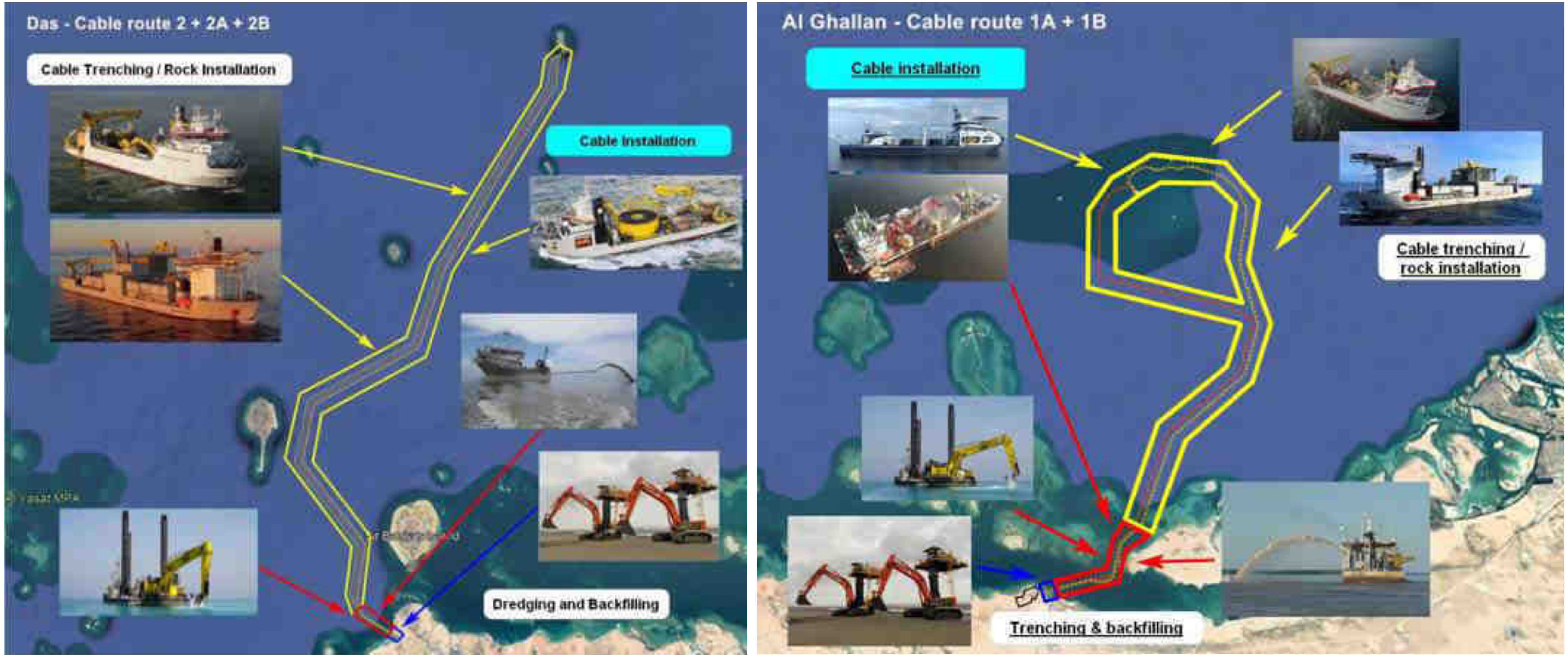


Figure 4-57: Overview of offshore cable construction along both routes

Intertidal and Marine Construction Footprint

Nearshore Areas

General Trenching, Cable Laying and Backfilling (Route 1 & 2)

- Side-casting materials on both sides of trench:
  - Zones trenched by the Starfish equipment will be of approximately 33m in width (expected 10m from one side of the equipment and 23m on the other side but this will depend on local site conditions);
  - Zones trenched by the Back Hoe Dredger (BHD) equipment will be of approximately 40m in width (expected 10m from one side of the equipment and 30m on the other side but this will depend on local site conditions);
  - Zones trenched by the Trailing Suction Hopper Dredger (TSHD)) equipment will be of approximately 80m in width (expected 40m both sides but this will depend on local site conditions); and
  - Floatation/rest areas with material to be disposed of within allocated disposal areas.
- Side-casted materials will be re-used to backfill the trench and provide protection for the cables.

Cross-section illustrations of the various trench designs (with the exception of the floatation / dredged channels) are shown in Figure 4-58 to Figure 4-60 below.

Dredging for Floatation / Dredged Channels, Cable Laying, Trenching and Backfilling (Route 1)

Route 1 requires the installation of floatation / dredged channels of approximately 60m width (at the bottom slope) at shallow areas to allow Cable Laying Vessel (CLV) Ulisse to work. The width of the floatation / dredged channels was defined by the width of the CLV. Further details on the selection of the CLV and the dredging channels is provided in **Chapter 6**. A cross-section illustration of the floatation / dredged channels and trenches required is provided below in Figure 4-61 to Figure 4-62. Further information is provided in the below sections detailing the methodology of trenching and backfilling for each route.

The floatation / dredged channels will be required approximately between KP 18.5 and KP 21.000 which is illustrated in Figure 4-63 below. As mentioned in **Chapter 6**, the original Route 1 near KP 10.000 to KP 15.500 required floatation / dredging channels whereas the revised Route 1 (located in a deeper area) is not expected to require floatation / dredged channels. This is illustrated in Figure 4-64 below. **Note however that this can only be fully confirmed at the CESMP stage once detailed bathymetry survey results of this new route are made available.**

Whilst the trenches will be backfilled, the material generated through dredging of the floatation / dredged channels cannot be reused for backfill as it will put additional stress on cables and therefore offshore marine disposal areas have been identified which are discussed further in the below section.

Dredged material will be loaded into non self-propelled barges (type DN117 or similar which require assistance from tugs) or self-propelled barges which do not require a tug. Material will be removed to the identified disposal areas (refer to Figure 4-65 in the below sections). Dredging works will be undertaken by a BHD but hydraulic hammering may be required in areas containing rocky/harder materials.

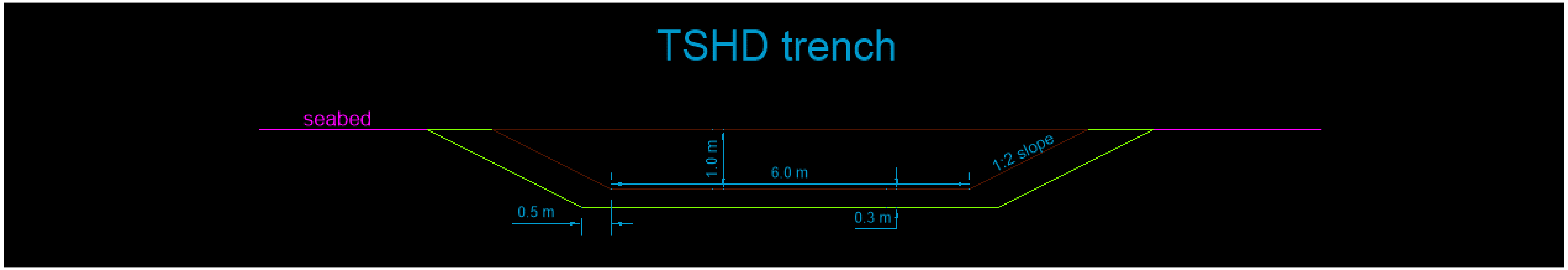


Figure 4-58: Cross section of trench design TSHD – Type 1

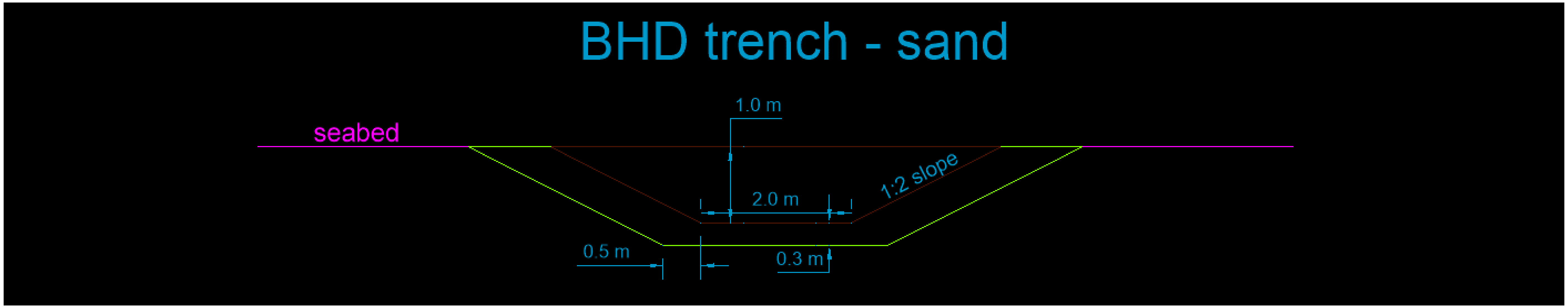


Figure 4-59: Cross section of trench design BHD – Type 1

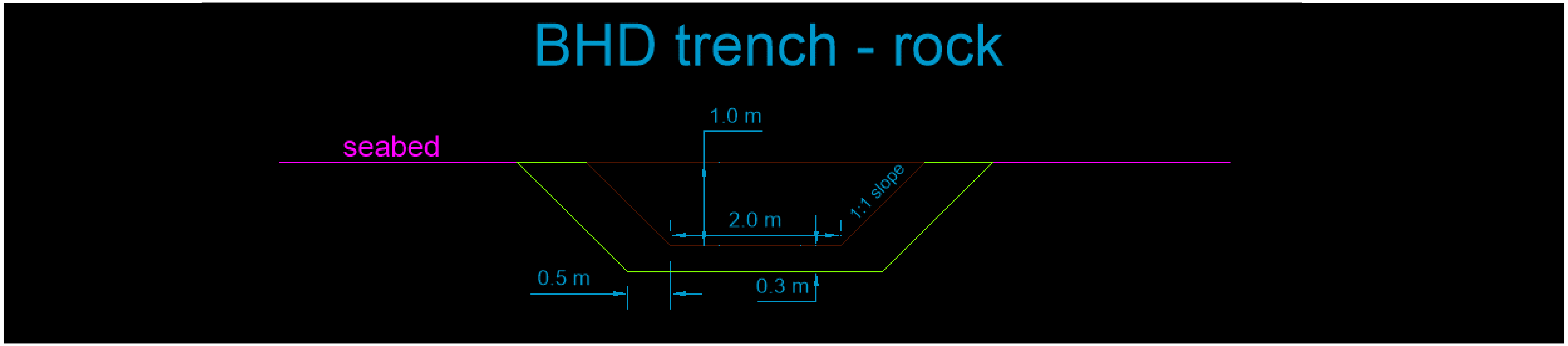


Figure 4-60: Cross section of trench design BHD – Type 2

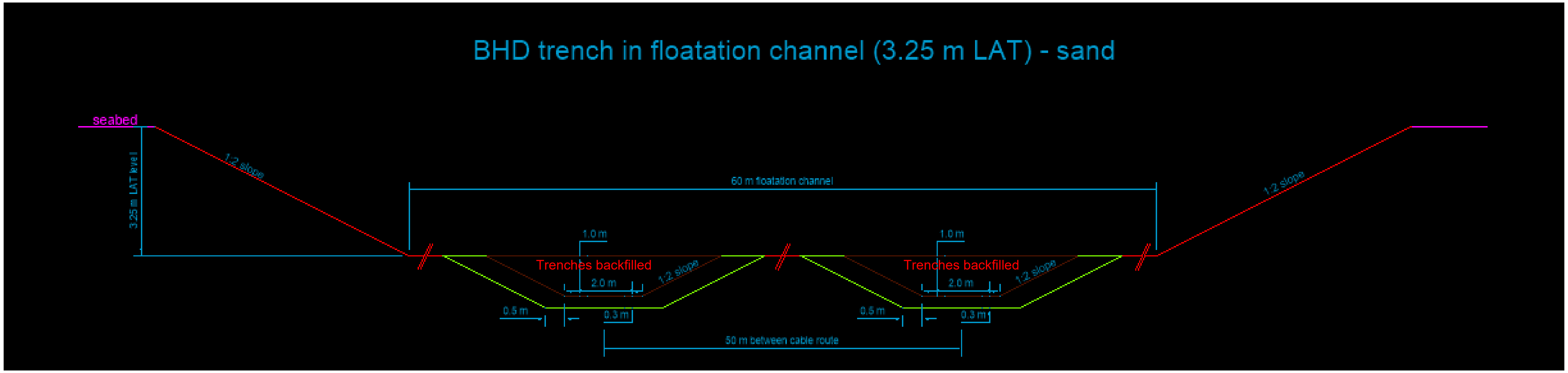


Figure 4-61: Cross section of trench design BHD – Type 3 (floatation channel level = 3.25 m LAT / in case of resting area = 4.75 m LAT)

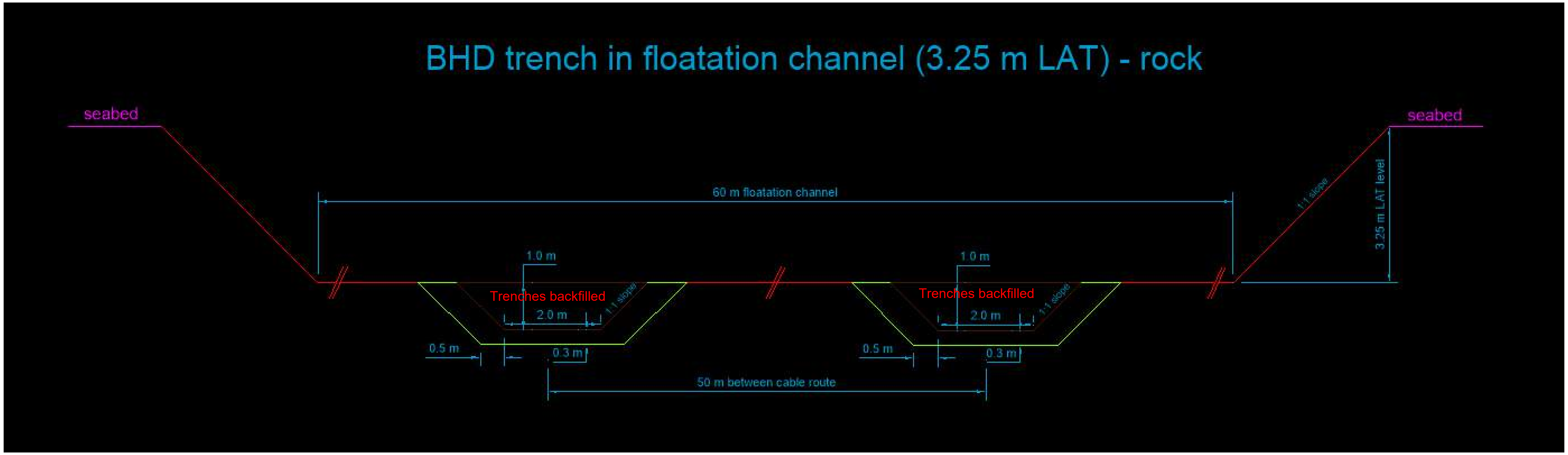


Figure 4-62: Cross section of trench design BHD – Type 4 (floatation channel level = 3.25 m LAT / in case of resting area = 4.75 m LAT)

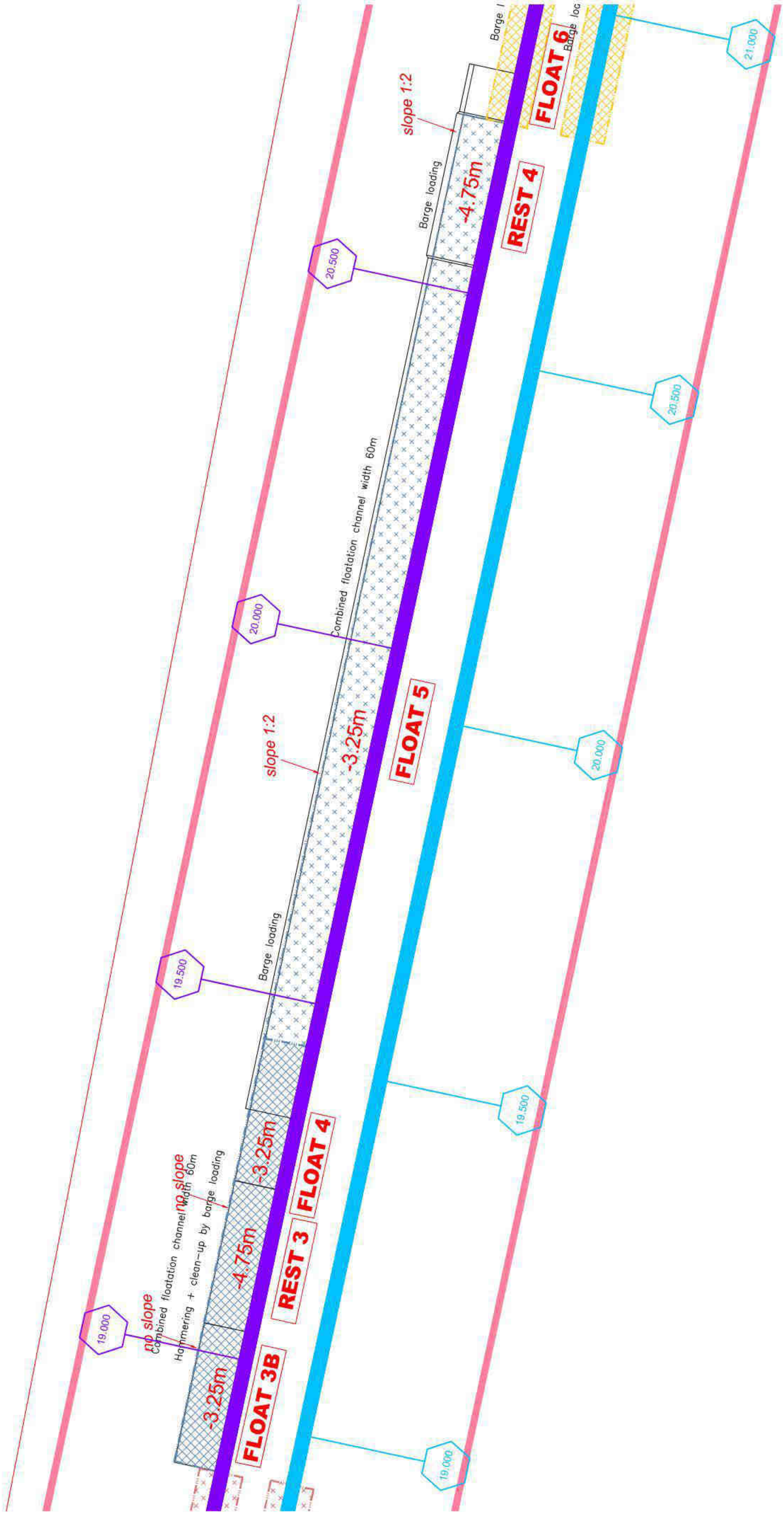


Figure 4-63: Floatation / dredged channel locations (near KP 19.000 to KP 21.000)

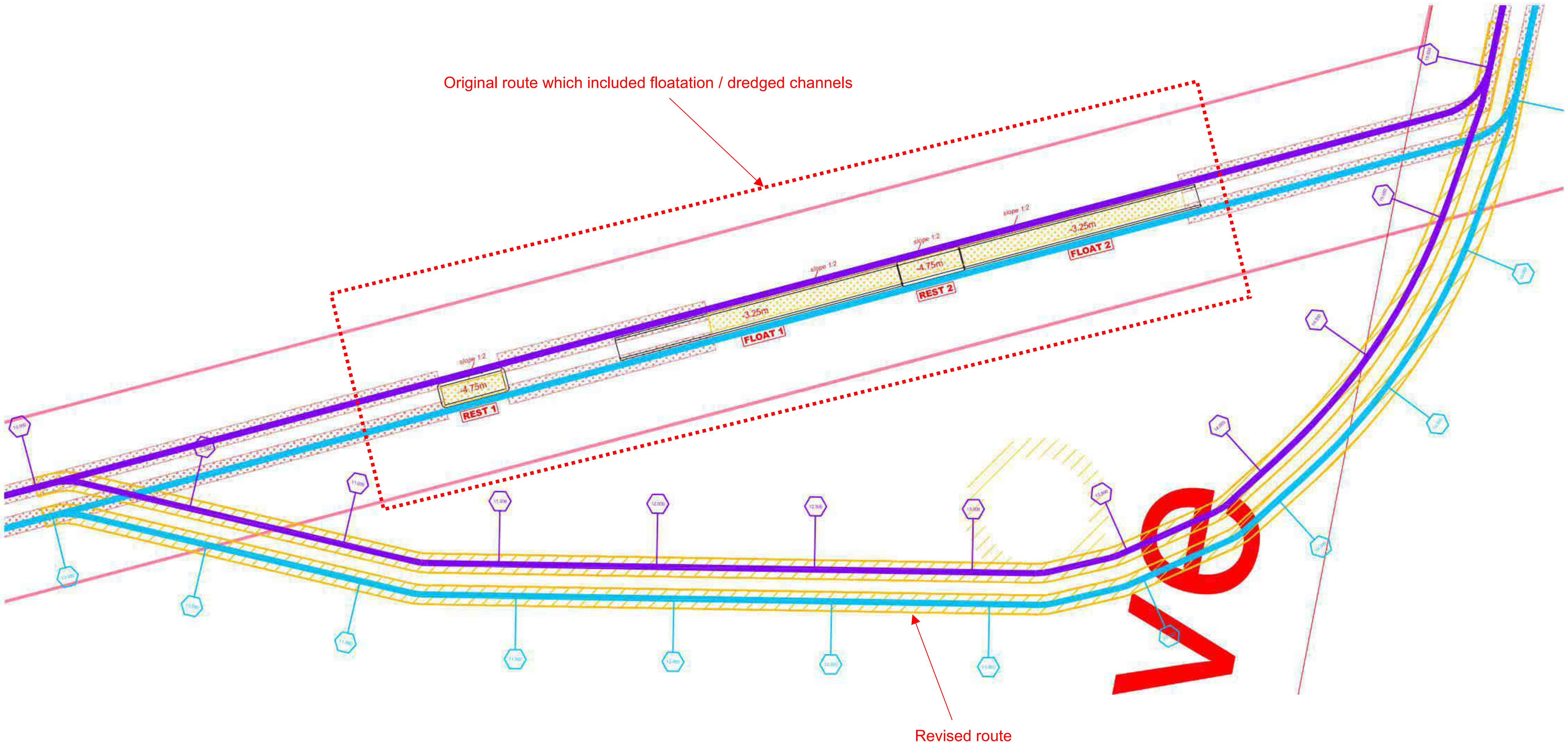


Figure 4-64: Original route with floatation / dredged channel and new route diversion expected to avoid the requirements of floatation / dredged channels (near KP 10.000 to KP 15.500)

Disposal Locations (Route 1)

Due to the requirement of floatation / dredged channels, excess materials will be generated which cannot be reused for backfill as it will put additional stress on cables. Therefore, it has been necessary to identify spaces where marine disposal areas can be used for this excess material. It has been determined that no existing disposal areas are present within the Project area and therefore two Project specific locations have been identified away from marine sensitive receptors (refer to **Chapter 6):**

- one to the north of the floatation / dredged areas at KP 18.5 to KP 21.000 (refer to Figure 4-63); and
- one to the south (only if floatation / dredged areas are required in the area of KP 10.000 to KP 15.500 (refer to Figure 4-64)).

As such, it is currently considered that only the disposal area to the north is likely to be required, however both possible locations are assessed in this ESIA as worst-case scenario. Identified spaces for the future marine disposal areas are illustrated below in Figure 4-65.

The north disposal location was selected due to sufficient depth being identified (-6.0m to -7.8m), a maximum capacity of 3M m^3 that can be deposited and its location as it is in an adequate distance from critical and sensitive habitats (approximately 160m away at the nearest point).

As identified above, it is not confirmed whether the southern disposal area will be required. However, it has been considered within this ESIA, including within hydrodynamic modelling to ensure that a worst-case scenario is assumed and any potential impacts are appropriately considered and mitigated, where necessary. The southern disposal area was selected due to its capacity of 1M m^3 between -4.0m and -5.9m, providing an adequate separation away from critical or sensitive receptors. The area is identified as being generally shallow and disposing materials will be possible if the material is spread out on a large surface to limit layer thickness.

An assessment of expected quantities of material to be disposed and the required depths for disposal are set out below in Table 4-10. These calculations have been based on previously defined floatation / dredged channels required and are worst case quantities.

Table 4-10: Disposal area volume capacity and depth requirements

Disposal Area	Required Volume Capacity (m^3)	Minimum Depth Required at Disposal Areas
North	240,000	7.0 m LAT
South **(if required*)**	590,000	7.0 M LAT
Total =	**830,000**	**-**
Note: * Not expected to be required for the Project but kept in this ESIA as worst-case scenario		

The available spaces for the future disposal areas are shown in Figure 4-65 below with the coordinates presented in Table 4-11 below.

Table 4-11: Coordinates (UTM) of available space for future disposal areas (Route 1)

Route Number	Easting	Northing
Available Space for Future Southern Disposal (Worst case scenario*)		
SD1	764815.34	2672390.60
SD2	765532.18	2672556.27
SD3	766231.30	2672616.24
SD4	767097.89	2671999.24
SD5	768843.79	2671792.55
SD6	769255.81	2672100.87
SD7	768559.63	2668595.00
SD8	768209.19	2668547.32
SD9	765990.73	2668601.25
SD10	764104.88	2669597.64
SD11	764368.00	2671492.25
Available Space for Future Northern Disposal (required)		
ND1	765960.45	2682606.79
ND2	767566.52	2682349.71
ND3	767385.67	2681482.95
ND4	765817.65	2681899.96
Note: * Not expected to be required for the Project but kept in this ESIA as worst-case scenario		

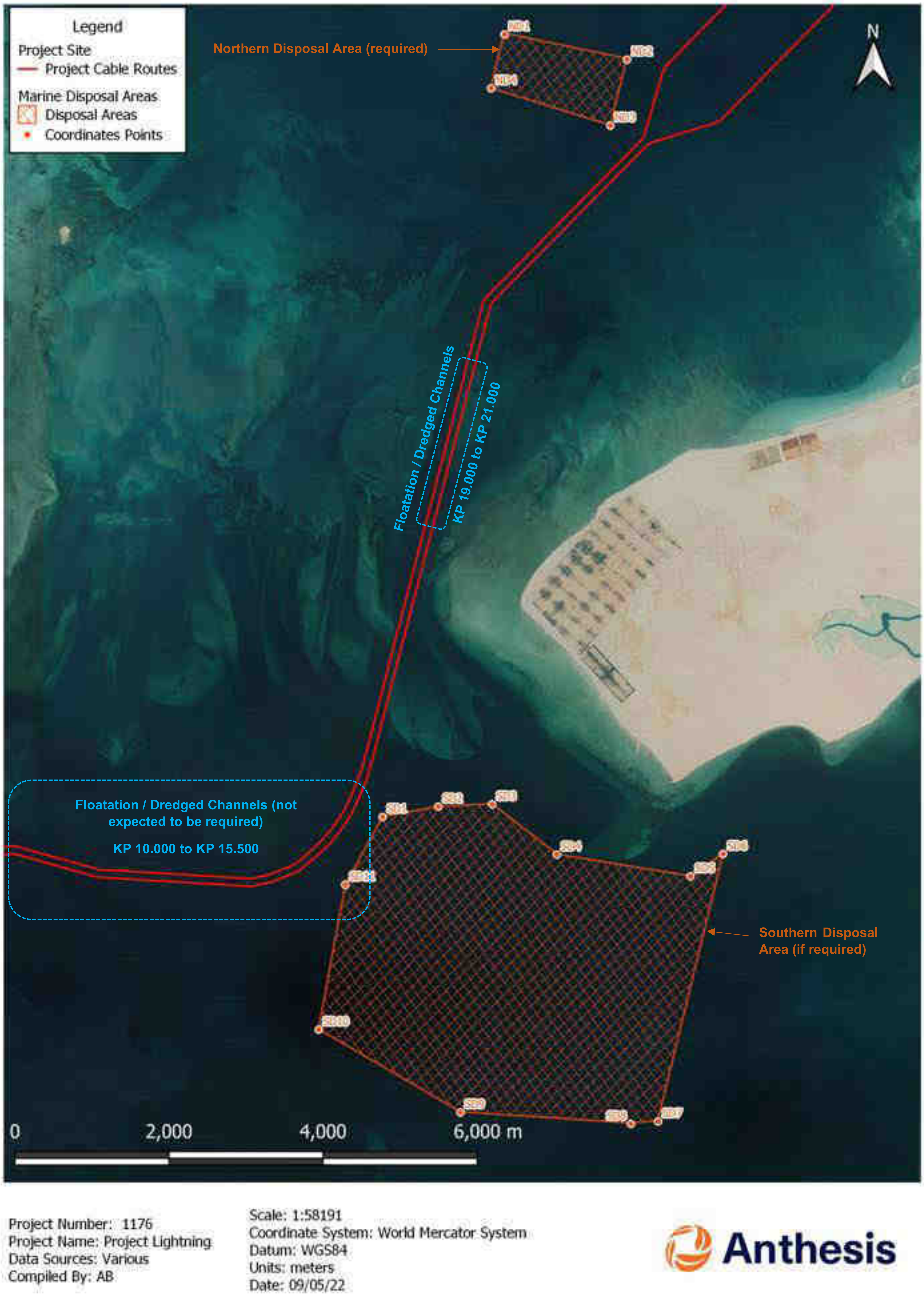


Figure 4-65: Available locations for future marine disposal areas in relation to floatation / dredged channels (KP 10.000 to KP 27.500)

Summary (Route 1 & 2)

Figure 4-66 to Figure 4-73 below illustrate the construction footprint at the nearshore areas for Route 1 & 2. Additionally, Table 4-12 and Table 4-13 below details the calculated and estimated areas that will be disturbed for each equipment.

Table 4-12: Intertidal and marine construction footprint for Route 1

Activities Footprint	Cable Routes	Area	
		m^2	ha
Construction Footprint			
Starfish Equipment within intertidal areas	-	78,555	8
Starfish Equipment within marine areas	1A	25,476	3
	1B	32,870	3
BHD Equipment	1A	384,973	38
	1B	279,208	28
TSHD Equipment	1A	1,194,235	119
	1B	1,252,611	125
Total =	-	**3,247,928**	**325**
Available Space for Future Marine Disposal Areas			
North Disposal Area	1A & 1B	1,319,987	132
South Disposal Area **(if required)**	1A & 1B	15,789,466	1,579
Total =	-	**17,109,453**	**1,711**

Table 4-13: Intertidal and marine construction footprint for Route 2

Activities Footprint	Cable Routes	Area	
		m^2	ha
Starfish Equipment within intertidal areas	2, 2A, 2B	111,924	11
Starfish Equipment within marine areas	2A	31,939	3
	2	32,390	3
	2B	40,092	4
BHD Equipment	2A	48,004	5
	2	52,421	5
	2B	52,383	5
TSHD Equipment	2A	181,114	18
	2	180,727	18
	2B	180,871	18
Total =	-	**799,941**	**80**

Figure 4-66: Overview of the marine construction footprint for Mirfa nearshore area (Route 1) (with the disposal areas) (KP 0.000 to KP 26.000)

Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:5399
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 09/05/22

Anthesis

Figure 4-67: Detailed marine construction footprint for Mirfa nearshore area (Route 1) (KP 0.000 to KP 1.500)

Figure 4-68: Detailed marine construction footprint for Mirfa nearshore area (Route 1) (KP 1.500 to KP 10.000)

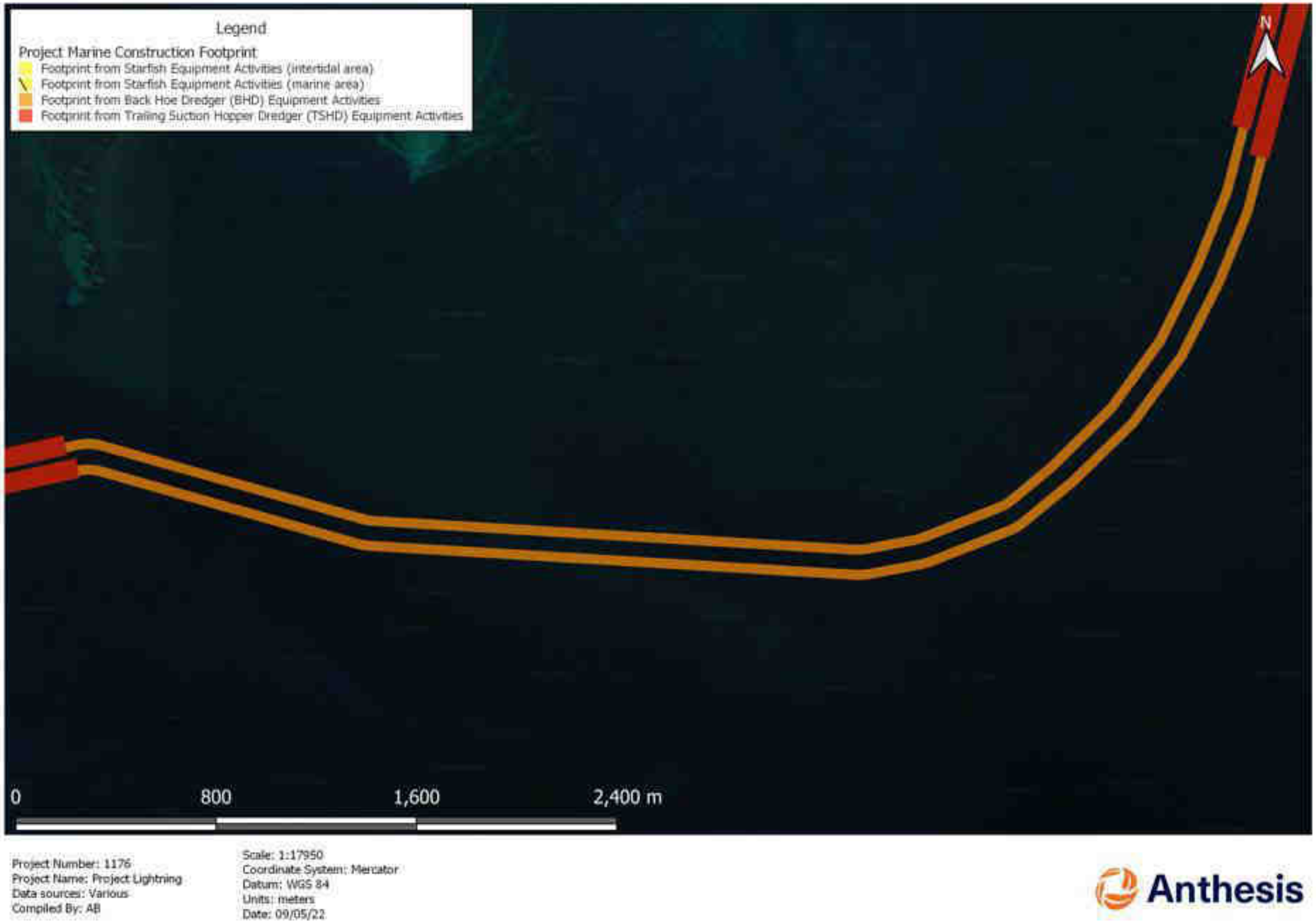


Figure 4-69: Detailed marine construction footprint for Mirfa nearshore area (Route 1) (KP 10.000 to KP 16.000)

Figure 4-70: Detailed marine construction footprint for Mirfa nearshore area (Route 1) (KP 15.500 to KP 21.000)

Figure 4-71: Detailed marine construction footprint for Mirfa nearshore area (Route 1) (KP 20.500 to KP 22.000)

Figure 4-72: Detailed marine construction footprint for Mirfa nearshore area (Route 1) (KP 21.500 to KP 26.000)

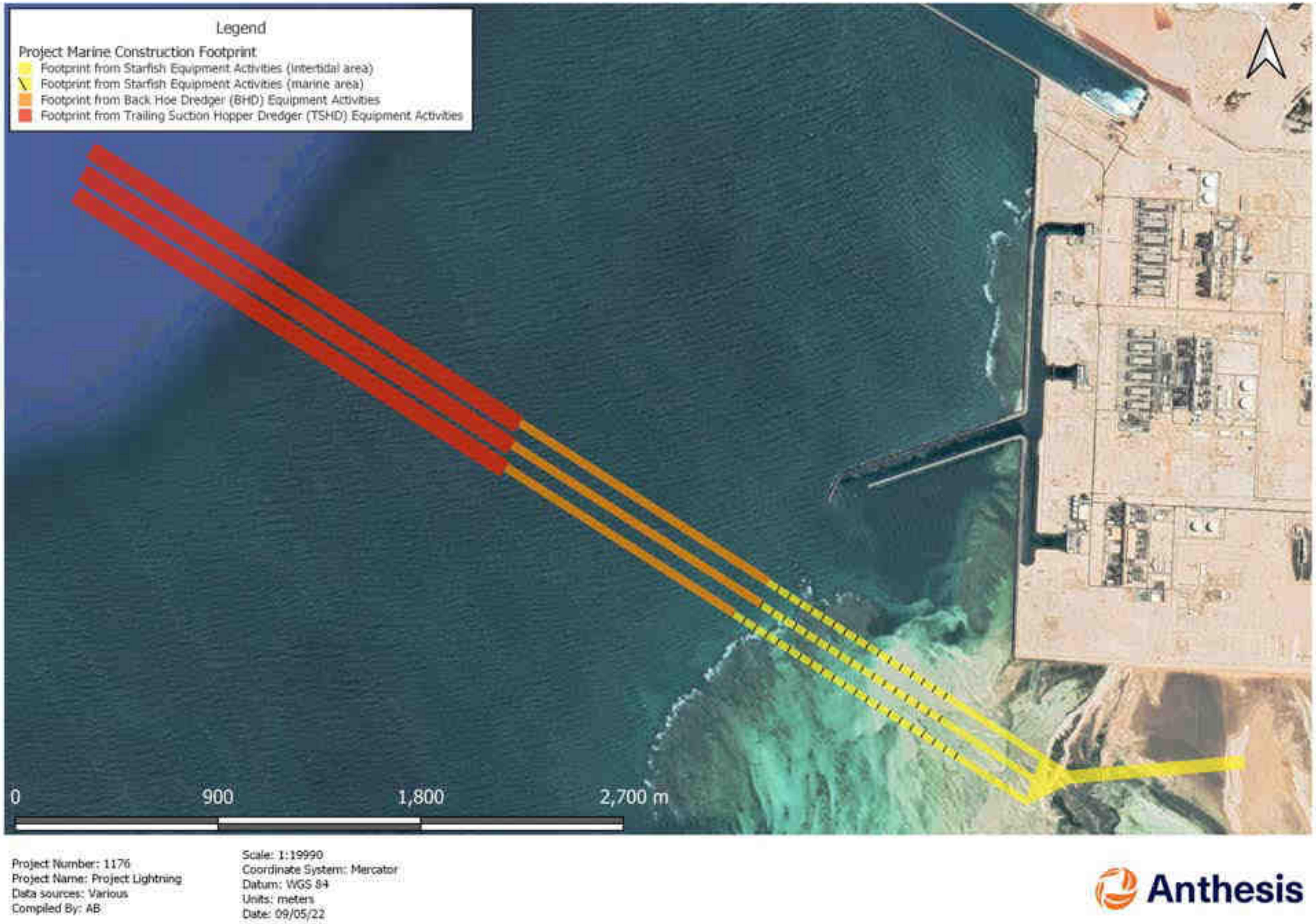


Figure 4-73: Detailed marine construction footprint for Shuweihat nearshore area (Route 2) (KP 0.000 to KP 5.000)

Offshore Areas

Cable Laying, Post-lay Trenching, Rock Installations and Concrete Mattresses (Route 1 & 2)

The remaining areas of the route within deeper water will require cable installation followed by rock installation, post lay trenching and mattresses installation depending on underlying substrate and presence of other subsea assets. At locations where the cable route crosses existing cables, pipelines or other assets the cable will be protected by concrete mattresses.

Trenching Methodology

Starfish (SF) Trenching

Starfish will be utilised at shoreline and intertidal areas to undertaken trench excavation and backfilling. Starfish are elevated excavators which are expected to operate in water depths up to 4.6m at Route 1 and up to 3.1m at Route 2. Following excavation of the trench profile, the material will be temporarily stored along the trench, occasionally forming a bund where materials raise above sea level in shallower areas.

Figure 4-74 below shows an example of a starfish excavating pre-trench design and disposing spoil material on stockpile next to travel path. Hydraulic hammers may be required to be installed on the Starfish in areas of harder bottom material.

Figure 4-74: Starfish excavating pre-trench design

Backhoe Dredgers (BHD) Trenching

Part of the trenching activities within Route 1 and Route 2 will be undertaken by BHD 'Gian Lorenzo Bernini' and BHD "Jerommeke'. Dredged materials will be temporarily stored alongside (sidecast) for reuse as backfill following completion of cable installation.

During the first dredging campaign (refer to **Section 4.3.2.2.4**), within Route 1, excavated materials from the floatation / dredged channels will be loaded into split hopper barges (SHB) and dredged materials transported to the disposal areas.

The BHD dredging methodology can be divided into two steps as follows:

- Bulk dredging – the BHD will focus on bulk volume in trench; and
- Clean-up dredging – the remaining layer of material is removed separately to enable an accurate trench design to be achieved.

Bulk dredging and clean up dredging examples are illustrated in Figure 4-75 and Figure 4-76 below. In areas where the material is stronger than 3-5MPa, a hydraulic hammer will be mounted on the BHDs, as illustrated in Figure 4-77.

Figure 4-75: Bulk dredging

Figure 4-76: Clean up dredging

Figure 4-77: BHD fitted with hydraulic hammer

Split Hopper Barge (SHB) Disposal

Following loading of the SHBs by BHDs, they will travel to the disposal areas. Once the materials have arrived at the disposal areas, the SHB will be split longitudinally, opening up to disperse the load whilst traveling at minimum speed. This is enabled by heavy hinges connecting the two sections of the barge, portside and starboard side as illustrated in Figure 4-78.

Figure 4-78: Split Hopper Barge (SHB)

Trailing Suction Hope Dredger (TSHD) Trenching

At sections of the routes where soils are suitable for dredging by use of a TSHD, the shallow draught TSHD ‘Sebastiano Caboto’ will be used. These sections are located in both shallow and deeper sections of the trench route.

During the trenching works, the dredged materials will be discharged through the side-casting nozzle (located at the side of the vessel) simultaneously during the dredging operations, which will spray the materials over a distance of roughly 40m from centre trench. The area where the dredged material is sprayed, at a distance of approximately 25m next to the trench, will then be the future dredge area for the TSHD during the backfilling works. An example of this is shown below in Figure 4-79.

Figure 4-79: **TSHD using sidecasting nozzle**

Backfilling Methodology

SF Backfilling

Once the cables have been laid, the Starfish will work backwards to reinstate the seabed with the excavated materials in the nearshore areas at Mirfa and Shuweihat, to ensure adequate protection for the installed cable. Spoil material within the Starfish path will usually be used first to clear the path for the machine, before backfilling the side-cast materials. The Starfish operator will continue to test the ground bearing capacity during backfilling, particularly in previously disturbed areas. An example of the Starfish methodology for backfilling is shown in Figure 4-80.

Figure 4-80: Starfish performing backfilling works while standing at the travel path next to the stockpile

BHD Backfilling

In deeper waters, and following cable installation, it is important to backfill as rapidly as possible to ensure that the integrity of the cable is maintained, in accordance with the installation design specifications.

Within rest areas and flotation areas, the BHD will not be able to access side-cast materials and therefore the materials will be delivered to DN39 to fill the trenches remaining via a SHB to be loaded at the disposal area by the BHD 'Jerommeke', an example this is provided in Figure 4-81.

DN39 will be used for backfilling the trench within floatation/rest areas. Jerommeke will load barges in the disposal area which will then sail to DN39. DN39 will discharge the barges to backfill the trench.

Figure 4-81: HD 'Jerommeke' bac filling material from a pontoon

TSHD Backfilling

For the backfilling works, the sprayed materials will be re-dredged along the trench route or at a suitable borrow area/disposal site. The re-dredged materials will then be used for the backfilling of the trench limits to provide sufficient cover to the cable. As mentioned before, the area where the material has to be re-dredged is the area at a distance of 25m next to the trench where the sprayed material is located.

Backfilling works by a TSHD can be undertaken via two methodologies. Firstly, a TSHD can backfill material via a draghead. Following dredging of material into the hopper, the TSHD can sail back to the backfill location (i.e. the trench). Backfilling is the undertaken via pumping of material from the hopper through the discharge line into the loading line and to the suction pipe, in a reverse action of the trenching activities. Figure 4-82 illustrates a TSHD backfilling via suction pipe.

Constant monitoring will be undertaken of mixture velocity, concentration and pressure to ensure discharging can commence in the most efficient way.

Figure 4-82: TSHD backfilling through suction pipe

The second possible methodology for backfilling via the TSHD is similar to the trenching works, in which dredged materials will be discharged through the side-casting nozzle, located at the side of the vessel, which would occur simultaneously during dredging operations. The spray would distribute the materials approximately 25m from the dredged area. The target area where the dredged material is sprayed will then be the trench with the cable installed. Figure 4-83 below illustrates a TSHD backfilling via spraying method.

Figure 4-83: TSHD backfilling via spraying

Trenching and Backfilling Volumes, Production & Spill Rates

Trenching & Backfilling Volume Estimates

A summary is provided below Table 4-14 identifying the total expected trenching and backfilling volumes associated with all cables for both routes. It should be noted that the backfilling volumes are higher than the trenching volume as the sidecast materials will be exposed to the marine environment and during the TSHD activities, due to the nature of the hydraulic process, there is a certain amount of material losses expected. This may lead to a requirement to dredge additional materials to completely backfill the trench, hence the additional backfilling volume.

Table 4-14: Trenching and backfilling volume requirements

Route Section	Trenching Volume (m^3)	Backfilling Volume (m^3)
Route 1		
Route 1A	267,403	404,693
Route 1B	254,150	383,535
Total =	**521,553**	**788,229**

Route Section	Trenching Volume (m^3)	Backfilling Volume (m^3)
Route 2		
Route 2	52,953	75,040
Route 2A	52,953	74,447
Route 2B	53,175	74,437
Total =	**159,081**	**223,923**

Expected Production Rates for Trenching and Backfilling

The trenching and backfilling described in the previous sections will generate the following expected production rates, set out within Table 4-15 below.

Table 4-15: Average production rates of equipment used for trenching and backfilling

Route 1			Route 2		
Equipment	Materials Type	m^3/day	Equipment	Materials Type	m^3/day
Trenching					
Starfish	Sand	760	Starfish	Rock	583
Sebastiano Caboto	Sand	18,749	Sebastiano Caboto	Sand	18,749
Gian Lorenzo Bernini	Sand	2,304	-	-	-
Gian Lorenzo Bernini	Rock	573	Gian Lorenzo Bernini	Rock	573
Jerommeke	Sand	1,078	-	-	-
Jerommeke	Rock	483	Jerommeke	Rock	483
Floatation / Dredged Channels					
Jerommeke	Sand	2,454	-	-	-
Jerommeke	Rock	496	-	-	-
Gian Lorenzo Bernini	Rock	759	-	-	-
Gian Lorenzo Bernini	Sand	3,191	-	-	-
Backfilling					
Starfish	Sand	760	Starfish	Rock	760
Jerommeke	Sand	1,615	-	-	-
Jerommeke	Rock	1,615	Jerommeke	Rock	1,615
Jerommeke + D39	Sand	821	-	-	-
Jerommeke + D39	Rock	821	-	-	-
Sebastiano Caboto	-Sand	6,763	Sebastiano Caboto	Sand	6,763

Submarine Cable Installation Methodology

Overview

It is understood that three vessels will be utilised for subsea cable laying activities, as follows:

- Cable laying barge (CLV) – Ulisse (for nearshore works on Route 1);
- Cable laying vessel (CLV) – Leonardo da Vinci (LDV) (for offshore works on Route 1); and
- Cable laying vessel (CLV) – Isaac Newton (for nearshore and offshore works on Route 2).

The cable bundles for Route 1 will be produced at the Prysmian factory in Arco Felice, Italy. The cables will be loaded at the designated Prysmian cable factory and will be transported to site by the lay vessel. Installations will be performed in free-lay with FO cables to be installed in bundle. Figure 4-84 below illustrates a cross section through of the cables for Route 1.

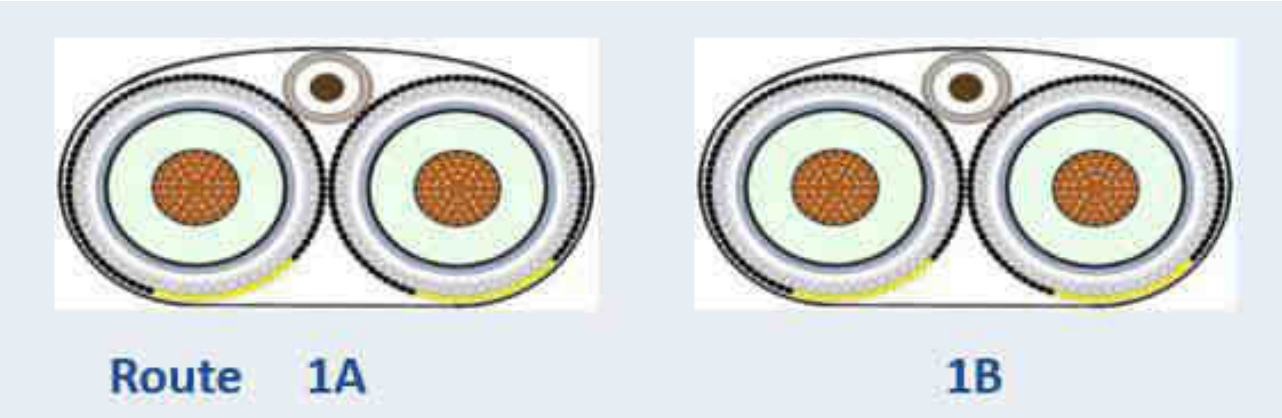


Figure 4-84: Route 1A and 1B cable cross section

The cable bundles for Route 2 will be produced by Sumitomo in Osaka or Kobe in Japan, and Hudiksvall in Sweden. The cables will be loaded at the designated Sumitomo factories and transported to the Project site either by the cable laying vessel or via a dedicated transport vessel. Unlike Route 1, the cables for Route 2 will not be laid in bundled configuration. Figure 4-85 below illustrates a cross section of the cables for Route 2.

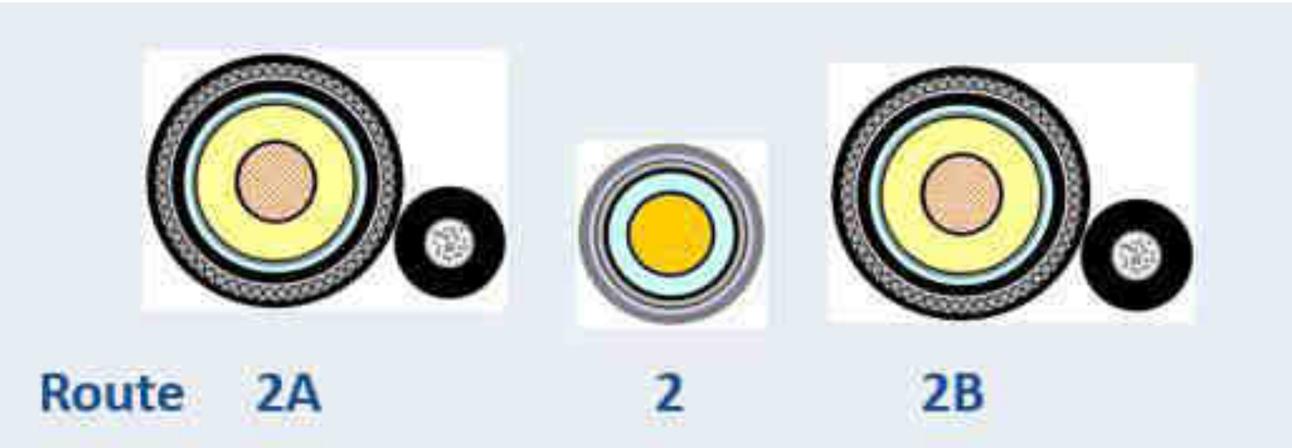


Figure 4-85: Route 2A, 2 and 2B cable cross section

Cable Loading on Vessels

In order to load the cables, the vessel is moored at the Prysmian factory which is appropriately fitted with necessary equipment at a purpose-built pier. The cables will be loaded onto the CLV LDV for transportation to the Project sites. Then, prior to installation activities, transpooling will take place to transfer the necessary cables to the Ulisse within approximately 10m water depth.

Cable Installation Methodology

The functionality of the vessel and cables and associated system will be tested prior to commencing laying activities, to include the following tests:

- Dynamic positioning systems;
- Survey navigation system;
- Hydroacoustic positioning system; and
- Cable laying equipment.

CLV Leonardo da Vinci

The cable lay vessel LDV will be the primary vessel for installation of marine cables and features two carousels of 10,000 tons and 7,000 tons load capacity. The vessel is equipped to conduct the deepest power cable lay up to 3000m water depth. The vessel is designed with an operation endurance of 90 days and max speed above 14 knots.

The vessel is fitted with a Touch Down Monitoring (TDM) Remote Operated Vehicle (ROV) which has its own separate launch and recovery system along with control cabin. TDM is required during field joint deployment and deep-water installation cable crossings.

The draft of the vessel is as follows:

- 8.5m maximum draft assuming that the LDV is fully loaded with cables on both platforms including also FOC platform full, and full of fuel, water etc.; and
- 6.3m draft when empty vessel approaching the platform.

An illustration of the LDV is provided below in Figure 4-86 below.

Figure 4-86: Leonardo da Vinci Cable Lay Vessel

CLV Isaac Newton

The Isaac Newton is illustrated below in Figure 4-87 and will perform deep cable laying activities alongside the CLV Leonardo Da Vinci.

Figure 4-87: CLV Isaac Newton

CLV Ulisse

The Ulisse, is a Prysmian owned dedicated cable installation vessel with experience of installation of export cables and will be utilised for cable laying activities within the nearshore areas, as illustrated in Figure 4-88.

The Ulisse was converted to a cable lay vessel in 2016 and is fitted with an 8-point mooring anchor system (plus one pull ahead anchor) making the Ulisse an ideal vessel to operate safely in shallow waters and is also able to ground out. The Ulisse is permanently equipped with a large 7000Te carousel and therefore can store a large quantity of cable on-board. For the Project, Ulisse will be equipped with two tanks in order to perform the bundle installation.

During operations, the anchors are deployed, recovered and positioned using dedicated Anchor Handler Tugs to allow the vessel to move along the route. During longer transits, the vessel is towed using a Tow Tug with maximum speeds of approximately 7.5 knots.

Accommodation is presently available for a total of approximately 57 berths.

The minimum water depths and widths required for the CLV Ulisse to operate are as shown in Table 4-16.

Table 4-16: CLV Ulisse dimensions and water depth requirements

Parameter	Length/depth (m)
Length overall	122
Breadth	33.5
Depth of water required	7.6
Summer draught	5.41

Figure 4-88: CLV Ulisse

Surface Lay – Ulisse

Following transpooling, CLV Ulisse will lay cables in the shallow water areas near Mirfa in trenches created for purpose. At a certain position, Ulisse will commence pulling activities, within approximately 1km of landfall. Internally developed software will be used for cable laying control. Main lay and burial control parameters and key features will be as follows:

- Ship movement along the route, which will be ensured via Differential Global Position System (DGPS);
- Positioning data will be via WGS84 Spheroid/Datum;
- Length of cable laid will be measured by a meter counter wheel which will be relayed to the laying control computer for comparison against ship movement along the route;
- The outlet cable vertical angle will be monitored by camera and a measuring system at the laying sheave;

- Water depth will be measures by ship echosounder systems to be sent to the lay control computer to be recorded;
- Cable tensions will be measured by a dynamometer system; and
- Cable ship speed will be calculated by the laying control computer.

As the CLV Ulisse approaches land, the final pull-in operation will commence, including fencing of landfall site to limit access. Facilities, WC's and power generators will be mobilised for the duration of these operations.

Prior to the arrival of the installation vessel at landfall site, a winch is set up onshore near the submarine cable final position. The winch is suitably anchored to provide hold back force. The vessel approaches the final landing point while laying the submarine cable. Close to the landing point, the vessel slowly turns around and stops as close as possible to the landing point. The final pull-in using Ulisse follows the same scheme used for a typical CLV.

From this point, the key objective is ensuring that the cable is pulled to the termination point with assistance from the support vessel. Floats attached to the cable will then be removed by divers until the correct position is achieved on seabed.

Surface Lay – LDV

Simultaneously with the nearshore cable laying activities, the LDV will continue to lay the cable, sailing along the cable route whilst the cable is paid out and laid on the seabed. The cable is paid out under control, while the speed is adjusted accordingly.

As the vessel approaches the riser at the offshore platforms at both Das Island and Al Ghallan Island, the same activities already described relating to the nearshore pull-in activities onshore are undertaken and the pulling is completed.

Once the pull-in activities have been completed a joint on the platform between the submarine cable and the mainland cable will be installed. The cables will be pulled in J-tubes and each cable will be pulled in a dedicated J-tube, including the FO cables that will have their J-tubes.

Cable Protection Methodology

Post-Lay Trenching

Post-lay jet trenching operations will be undertaken within certain sections of the route following laying the cables to bury the cable sufficiently deep under the soil. Post-lay trenching is anticipated to be required in areas with soft soil. The exact extent of post-lay trenching will need to be confirmed following completion of the soil investigation campaign and is also subject to variation depending upon the encountered local conditions during the construction.

The post-lay jet trencher UTV 1200 will be utilised, which features the following general specifications and is illustrated in Figure 4-89 below:

- 9.5m x 8.8m x 5.7m;
- Ground pressure 18kPa;
- Maximum soil strength: 80 kPa;
- Maximum operational depth 500m;
- Tractive force 20Te;
- Minimum turning radius 25m;
- Maximum pitch 20 degrees;
- Maximum roll 15 degrees;
- Biodegradable hydraulic oil in trencher and A-frame;

- Burial speed 100m/hr to 600m/hr; and
- Maximum soil strength.

Figure 4-89: UTV 1200 post-lay trencher

The UTV 1200 will be equipped with two pairs of jet swords, 2m and 3m long. Two hydraulic pumps are also installed which will create water flow through the two jet swords. Pump speed will remain constant and water pressure and flow rate remain constant.

The UTV1200 is deployed and lowered on the seabed adjacent to the cable from the MPV Adhémar de Saint Venant or Daniel Bernoulli. The vehicle is then aligned over the product and the trench initiation commences with the swords stowed and fully wide (5.5m). One of the pumps in then activated and water is supplied to both swords. Whilst slowly progressing forward the jet swords are gradually lowered to the target trench depth. The second jet is then started and both pumps and swards are then employed and the vehicle moves forward along the cable route, with operators and trenching superintendent to closely monitor the operational parameters.

When transitioning out of the trenching position, the forward progress is reduced and one pump is shut off and the swords raised. The vehicle is travelled to a suitable recovery position. Upon completion of trenching operations, both swords are stowed and the water pumps are shut down.

Rock Installation

In areas along the route where harder subsea substrate is encountered, post-lay trenching is not possible and therefore rock installations will be required to provide cable protection. This will involve laying rocks on top of the laid cables to provide protection. The following rock type is proposed to be used as illustrated in Table 4-17, which will be sourced from a quarry. It is estimated that 2.6 million tons of rock will be required. It is assumed that the material will be sourced from an existing quarry and additional environmental assessments as part of this EIA are not required.

Table 4-17: Rock material parameters

Rock parameters	
Type	Freshly crushed rock
Grading	Expected 1-5”
Specific density	Approx. 2.65 ton/m^3
Bulk density	Approx. 1.56 ton/m^3

In order to install the rocks, two types of vessels will be utilised, as follows:

- Fall pipe vessel (the ‘Joseph Plateau’) for use in deeper waters; and
- Subsea rock installation vessel (SRIV) for use in shallower areas (The’ Adhémar de Saint-Venant’ and sister vessel ‘Daniel Bernoulli’); and
- Subsea rock installation vessel (SRIV) for use in shallower areas (The 'La Boudeuse') (if required).

A summary of the rock installation process is as follows:

- Preparations on board;
- Load rock at the quarry;
- Sail to the Project site;
- Define the Subsea Rock Installation (SRI) plan (sequence of the in-survey, rock installation and out-survey operations);
- Upon arrival in the field, enter dynamic positioning (DP) mode, do position checks & remove sea fastening of the inclined fall pipe (IFP);
- Deploy the multibeam for the in-survey and make a digital terrain mode (DTM) (of the section);
- Install rocks, including progress surveys until design requirements are met;
- Deploy the multibeam for the out-survey; and
- Sail back to the quarry/ port for reloading.

Joseph Plateau

The fall pipe vessel, the ‘Joseph Plateau’ has a large net carrying capacity of 32,500 tonnes (summer) combined with shallow draught and is shown below in Figure 4-90.

Using the vertical fall pipe, the vessel is able to install rocks with a size up to 400 mm in water depths of up to 2,000 m. The fall pipe end is positioned by a powerful Remotely Operated underwater Vehicle (ROV) and allows for accurate rock installation on the seabed. For shallow water rock installation, the vessel is equipped with an inclined fall pipe which can install rocks at depths 50m at the side of the vessel.

Figure 4-90: Joseph Plateau fall pipe vessel

The 'Joseph Plateau' features the following specifications, as identified within Table 4-18.

Table 4-18: Joseph Plateau vessel specifications

Joseph Plateau vessel specifications	
Length overall	191.5m
Beam	40m
Draught, loaded	9.25m
Service speed	15kn
Vertical fallpipe diameter	1,000mm
Inclined fallpipe diameter	1,000mm
Accommodation	80 persons
Client's office	1

The vessel equipment includes:

- Two hoppers with a total maximum capacity of 22,000 m³ or 32,500 tonnes (Summer);
- Two large hydraulic excavators, capable of handling 1,000 T/hr positioned in the middle of each hopper;
- Two frequency variable vibrator type shakers (feeders);

- A conveyor belt system which transports the rock material from the two feeders into one centralized conveyor belt which flows either to the vertical fallpipe in the centre of the vessel or the inclined fallpipe at the side of the vessel;
- The vertical fallpipe which consists of several fall pipe pieces which are stacked on top of each other;
- The inclined fallpipe (IFP) which is deployed from the starboard side of the vessel;
- The fallpipe ROV (FPROV) at the bottom of the vertical fallpipe

Two large hydraulic excavators are mounted in the middle of each bunker. During loading of the vessel at the quarry, these excavators are used to level out the material, so as to optimise the loading of the bunkers. During rock installation these excavators are used to feed the conveyor belt system to feeders.

In order to load the vessel, the empty vessel will mobilize to the quarry and when the vessel is positioned alongside, the vessel will be moored before loading operations commence. Material will be loaded by conveyor belt into hoppers directly and on-board excavators are then used to redistribute this.

The vessel complies with all Company's, UAE and SOLAS' regulations.

Adhemar de Saint-Venant and Daniel Bernoulli

The SRIV 'Adhémar de Saint-Venant' and 'Daniel Bernoulli' are sister vessels which are constructed in accordance with the most stringent requirements for offshore industry and feature a net carrying capacity of 4,750 tonnes combined with a shallow draught. These vessels are therefore ideal for operating in shallower waters and in addition to rock installations, are also intended for use as support vessels for post-lay trenching and will also perform concrete mattress installation. Images of these two vessels are provided below in Figure 4-91 and Figure 4-92.

Figure 4-91: SRIV Adhémar de Saint-Venant

Figure 4-92: SRIV Daniel Bernoulli

The 'Adhémar de Saint-Venant' and 'Daniel Bernoulli' feature the following specifications, as identified within Table 4-19 below.

Table 4-19: SRIV specifications

Adhémar de Saint- enant' and Daniel erno lli' vessel specifications	
Length overall	95m
Beam	22m
Draught, loaded	6.5m
Service speed	11kn
Large inclined fallpipe diameter	1,800mm
Small inclined fallpipe diameter	1,000mm
Accommodation	60 persons
Client's office	1

The vessels include the following equipment:

- One excavator, capable of handling 1,000T/hr;
- One stone feeder which facilitates about 50T;
- Frequency variable vibrator type shaker; and
- Inclined fallpipe structure.

In order to load the vessels, the empty vessels will mobilize to the quarry and when the vessel is positioned alongside, the vessel will be moored before loading operations commence. Rock material will be placed alongside the vessel and using a large excavator onboard, the vessel will collect the rock material from a loading bin and distribute the material in the hopper onboard.

The vessels comply with all Company's, UAE and SOLAS' regulations.

Subsea Rock Installation Plan

A SRI plan will be prepared prior to installation to specify the dimensions of rock layers, quantities to be installed, vessel positioning and expected time of operation.

The sequence of the survey and rock installation will include the following considerations:

- Local sea/weather conditions;
- Site constraints;
- Road load;
- Construction drawing and survey results;
- Bulk density of material.

Subsea Rock Installation

SRI will be carried out in parallel installation tracks, covering the entire section. Based on pre-survey results, the following parameters will be defined and adhered to, to enable rock installation:

- Width and height of the desired rock installation.

Subsequently the following will be determined prior to commencing laying activities:

- Speed of the vessel and feeder frequency (to control layer thickness);
- Vertical distance between FP/IFP and sea bottom;
- Total SRI length and corresponding expected time; and
- Vessels maneuvering direction.

Following this, installation can begin and involves the fall pipes to be deployed and lowered to the pre-fixed depths above the safe handling zone. Excavators then ensure that the feeders are full of rocks. The feeders control rock material provided to the conveyor belts and the fall pipe and inclined fall pipe; vessel dependent. Rock installation by inclined fall pipe and fall pipe are illustrated below in Figure 4-93 and Figure 4-94, respectively. Rock installation by the 'Joseph Plateau' would be via fall pipe and ROV, whilst the Adhémar de Saint-Venant' and 'Daniel Bernoulli' both are equipped with inclined fall pipes, the latter of which are adjustable to allow installation of large diameter rocks.

Figure 4-93: Rock installation with inclined fall pipe

Figure 4-94: Rock installation via fall pipe with FPROV

Survey Activities

A survey will be undertaken by the FPROV or the moonpool multibeam. The survey activities will include, but not be limited to the following activities:

- Pre-Rock Installation survey;
- Intermediate survey; and
- Post-Rock Installation survey.

An online 3D visualization package will be provided which will visualize terrain models and other information supplied by Company and all changes to the seabed as the Project progresses.

Concrete Mattress Installation

Concrete mattresses will be utilised to provide cable protection at crossing points with existing cables, pipelines and other assets. These specific locations are not yet available. However, it is proposed that these concrete mattresses are deployed via a frame by a vessel crane, an example of which is provided below in Figure 4-95. Matresses are planned to be installed with MPV Adhémar de Saint Venant.

Figure 4-95: Example of concrete mattress for cable protection

4.3.2.2.3. Intertidal and Marine Equipment

Further details on the intertidal and marine equipment are provided in this section. It is anticipated that the following marine equipment will be utilised to undertake the required dredging, cable installation, backfilling and cable protection works.

Construction activities will be undertaken continuously 24 hours a day, 7 days a week including local holidays. A description is provided below in Table 4-20 of the expected key marine equipment types, vessels, and proposed methodologies for each, in addition to a summary of the expected quantities required of each vessel and subsequently cumulative fuel consumption estimates.

Table 4-20: Expected offshore plant and equipment

Vessel name	Vessel / Equipment type	Activity for which the vessel is to be used	Number of Vessels to be used	Installed Power [kW]	Fuel Consumption Working [ton/day]	Fuel Consumption Sailing [ton/day]	Fuel Type	Duration [days] (cumulative for all vessels of this type)
Starfish	Raised excavator	Dredging & backfilling	4	397	0.83		MGO	202
BHD 'Jerommeke'	Backhoe Dredger	Dredging & backfilling	1	775	2.15		MGO	216
BHD 'Gian Lorenzo Bernini'	Backhoe Dredger	Dredging & backfilling	1	1,750	4.89		MGO	106
BHD 'DN39'	Backhoe Dredger	Dredging & backfilling	1		0.57		MGO	43
TSHD 'Sebastiano Caboto'	Trailing Suction Hopper Dredger	Dredging & backfilling	1	4,272	8.18		MGO	167
SHB *(name to be confirmed)*	Split Hopper Barge	Dredging & backfilling	2	2,400	3.51		MGO	367
Tugboat *(name to be confirmed)*	Auxiliary floating equipment	Marine support services	3	1,100	2.32		MGO	438
Multicat *(name to be confirmed)*	Auxiliary floating equipment	Marine support services	1	2,000	3.81		MGO	349
Survey catamaran *(name to be confirmed)*	Auxiliary floating equipment	Marine support services	4	100	0.51		MGO	700
Crew transfer vessel *(name to be confirmed)*	Auxiliary floating equipment	Marine support services	2	100	1.87		MGO	330
Accommodation Barge *(name to be confirmed)*	Auxiliary floating equipment	Marine support services	1	5,000	1.54		MGO	365
Guard vessel *(name to be confirmed)*	Auxiliary floating equipment	Marine support services	15	500	2.32		MGO	2,400
Ulisse	Cable Laying Barge	Cable Laying	1				MGO	50
Leonardo Da Vinci	Cable Laying Vessel	Cable Laying	1				MGO	50
Isaac Newton	Cable Laying Vessel	Cable Laying	1	12,330	10.00	27.00	MGO	69
RHIB *(name to be confirmed)*	RHIB	Beach pull-in	4	150	0.10	0.50	Diesel	49
Diving Support Vessel (DSV) *(name to be confirmed)*	Diving Support Vessel (DSV)	Beach pull-in	1	1,000	3.00	6.00	MGO	49
Multicat *(name to be confirmed)*	Multicat	Beach pull-in	1	2,000	6.00	9.00	MGO	49
Anchor handling tug *(name to be confirmed)*	Anchor handling tug	Anchor handling of CLV	2	4,000	6.00	9.00	MGO	40
PLGR *(name to be confirmed)*	PLGR	Pre-lay grapnel run	1	4,000	6.00	9.00	MGO	18
SRIV 'Adhemar de Saint-Venant'	Subsea Rock Installation Vessel	Cable Protection	1	-	7.50	13.50	MGO	
SRIV 'La Boudeuse'	Subsea Rock Installation Vessel	Cable Protection	1	-	6.50	13.50	MGO	
SRIV 'Joseph Plateau'	Subsea Rock Installation Vessel	Cable Protection	1	-	24.00	66.20	MGO	
Excavator type HITACHI 210	Land based equipment	Civil works	6		0.36	-	Diesel	
Tipper truck	Land based equipment	Civil works	2		0.61	-	Diesel	
Boom truck	Land based equipment	Civil works			0.54	-	Diesel	
Mobile crane	Land based equipment	Civil works			0.52	-	Diesel	
Dozer D6	Land based equipment	Civil works			0.55	-	Diesel	
Fuel truck or fuel tank	Land based equipment	Civil works			0.54	-	Diesel	
Fresh water truck	Land based equipment	Civil works			0.54	-	Diesel	

Trenching Equipment and Machinery

Starfish (SF) Elevated Excavators

The Elevated Excavator type 'Starfish' is specifically designed to work in shallow waters in intertidal areas. Starfish excavators are able to dredge any type of soil and rock up to a certain strength and can be equipped with a hydraulic hammer to tackle harder rocky soils.

Four Elevated Excavators type 'Starfish' are scheduled to be deployed on the project: two are foreseen to work at the Mirfa landfall, while the other two Starfishes are foreseen to work at the Shuweihat landfall. Specifications are provided below for the starfish in Table 4-21 and illustrated below in Figure 4-96.

Table 4-21: Elevated excavator starfish specifications

Vessel	Length Boom (m)	Length Stick (m)	Bukcet Size (m3)
Elevated Excavator Starfish	8.4	5.4	3.0 SAE

Figure 4-96: Starfish elevated excavator

Backhoe Dredgers (BHD)

BHD equipment will be located on one side of the trench and material will be disposed of the same side, either to the north or south of the cable, depending upon local conditions e.g. direction of waves, wind and current at the time.

The Backhoe Dredger (BHD) 'Gian Lorenzo Bernini' (GB) is a larger size backhoe dredger, equipped with a Liebherr P995 excavator.

The Backhoe Dredger 'Jerommeke' (JR) is a smaller size backhoe dredger, equipped with a Hitachi EX1900 excavator and able to work in shallow areas due to its limited vessel draught.

Specifications for the BHDs are provided below in Table 4-22 and illustrated in Figure 4-97 and Figure 4-98 below.

Table 4-22: BHD specifications

Vessel	Length Boom (m)	Length Stick (m)	Bucket Size (m3)	Draught (m)
BHD Gian Lorenzo Bernini	16	6.5	5.80 SAE	3.1
Jerommeke	15	5.5	4.50 SAE	2.8

Figure 4-97: HD ‘ eromme e’

Figure 4-98: HD “ ian Lorenzo ernini’

The Backhoe Dredger ‘DN39’ is a pontoon on which an excavator can be positioned to perform trenching works. Specifications are set out below in Table 4-23 and an illustration of BHD ‘DN39’ is shown in Figure 4-99. The pontoon is equipped with four anchors that are positioned in such a way that the pontoon can move in the desired direction. The movement of the pontoon over the trench will be caused by pulling on the anchors. Further, the deck layout of the pontoon will also be reviewed in order to secure enough working space for the equipment involved in the operations. ‘DN39’ will thus be equipped with an excavator that excavates the material that, on their part, is loaded in barges.

Table 4-23: HD ‘D ’ specifications

Vessel	Length Boom (m)	Width (m)	Deckload (ton/m2)	Draught (m)
BHD DN39	54.86	15.24	7.5	2.92

Figure 4-99: HD ‘D ’

Trailing Suction Hopper Dredger (TSHD)

The ‘Sebastiano Caboto’ is a TSHD is a shallow draught vessel with a hopper capacity of 3,400m^3 and is illustrated below in Figure 4-100.

Figure 4-100: SHD 'Sebastiano Caboto'

The suction pipe configuration of the TSHD 'Sebastiano Caboto' allows dredging up to water depths of 27m. The main characteristics of the proposed TSHD are given in the below table. The vessel will be equipped with a spraying nozzle at the side of the vessel, in order to spray the dredged materials alongside each side of the trench route. The TSHD will excavate the materials from the trench and side-cast them parallel to cable route. Table 4-24 sets out key specifications for the vessel.

Table 4-24: SHD 'Sebastiano Caboto' specifications

Vessel	Length (m)	Breadth (m)	Hopper Capacity (m^3)	Empty/Loaded Draught (m)
TSHD 'Sebastiano Caboto'	93.3	19.8	3,400	2.6/5

Barge Equipment

Auxiliary Barges

Various non-self-propelled split hopper barges will be mobilised to site and may be used to transport dredged materials from the dredge locations to dedicated disposal areas. The split hopper barges will be loaded by the backhoe dredgers.

Auxiliary Floating Equipment

Auxiliary floating equipment will be mobilised to site for assisting the dredging and backfilling spread. The exact quantity of auxiliary marine equipment still has to be confirmed, although the following equipment is expected to be necessary:

- Crew launch(es) for conducting crew changes for marine equipment;
- Survey vessel(s) for follow-up of the works through bathymetric survey;
- Multi-cat for logistics of floating auxiliary equipment and BHD's; and
- Multiple tugs for mobilizing the BHD's; the tugs will be used on site for assisting and shifting of equipment.

Accommodation Barges

The crew of the BHD's and auxiliary floating equipment will be accommodated in accommodation barge(s). These accommodation barges are foreseen to be situated nearby the landfall location of both Route 1 and Route 2. The preferred installation location is still subject to change and the EPC Contractor for marine works, JDN, reserves the right to install the barges somewhere closer to the work locations. The pontoon can only be used moored and in sheltered conditions.

4.3.2.2.4. Trenching & Dredging Campaigns

Route 1 Mirfa to Al Ghallan Island

The proposed dredging campaigns will be undertaken in two stages, as follows:

- **First campaign**: to be undertaken between August 2023 – October 2023 and will involve the dredging of floatation / dredged channels and rest areas along Route 1. All floatation / dredged channels and rest areas will be 60m in width, with a distance of 50m separating each cable. Dredged material will be loaded in to two barges (DN117) which are non-propelled and require a tug, or self-propelled barges. Material will be removed to the identified disposal areas. Works will be undertaken by BHD but hydraulic hammering may be required in areas containing rocky/harder material; and
- **Second campaign**: to be undertaken: to be undertaken between January 2024 – April 2024 which will include trenches at Route 1A and 1B in the nearshore areas from KP 0.00 to end KP 1A: 25.93 and end KP 1B: 24.80. Trenching will include side-casting material and backfilling and equipment required will include the SF, BHD and TSHD.

Route 2 Shuweihat to Das Island

Trenching and backfilling along Route 2 is proposed to take place between May 2024 – November 2024. TSHD, BHD and SF will be utilised and are expected to operate 24 hours a day, 7 days a week. Trenching will be undertaken initially for an estimated period of 4-5 weeks followed by backfilling as soon as possible after cable laying to prevent cable exposure. This methodology will apply for all three cables. Cable 2 will be installed August 2024, Cable 2A in September 2024 and Cable 2B October 2024.

A detailed construction schedule is presented in **Section 4.4** and in **Appendix 7.1.**

4.3.2.2.5. Onshore Works

Overview

The following onshore works are expected to be undertaken are summarised in Table 4-25 below.

Table 4-25: Overview of onshore work activities

Discipline	Items	Work Description	Work Volume
Civil	Stone Column	– Stone column work is one of ground improvement techniques which involves the following works: ▪ Penetration of ground ▪ Stone Feeding ▪ Compaction ▪ Finishing	– For each Island Site - 1,881 (28,000 M, 23,000 ton)
	Earth Work + Mics. Civil	– General Earthwork involves the following works: ▪ Site Stripping ▪ Excavation ▪ Backfill ▪ Compaction ▪ Levelling	– Mirfa: 170,000 m^3 – Shuweihat: 100,000 m^3
	Reinforced Concrete Work	– Reinforced/Precast concrete work which involves the following works: ▪ Reinforcing Bar installation ▪ Formwork Installation ▪ Staging & Scaffolding Installation ▪ Concrete Pouring ▪ Curing & Finishing ▪ Erection and Assembly of PC Members (PC Work)	– 20,000 m^3 per each Site – PC: 20% ~ 50% of total Reinforced Concrete (RC)
	Precast Concrete (PC) Work		
Buildings	Steel Structure + Cladding	– Steel Structure and Cladding installation work: ▪ Anchor bolt installation ▪ Steel Structure erection ▪ Bolting & Grouting ▪ Cladding installation	For steel structure, 3,000 ton per each Site
Mechanical and Electrical	HVAC	– HVAC System installation in: ▪ GIS ▪ Converter Station	18,000 m^2 per each Site (Total 74,000 m^2)
	Electrical Equipment Installation	– Electrical equipment installation at converter station include the followings ▪ Converter Valve ▪ Converter Transformer ▪ Circuit Breaker, Disconnector, Earth Switch ▪ Voltage Transformer (VT), Current Transformer (CT), Reactor, Resister, Capacitor, filter	Converter System (Valve, TR, AC/DC Equip.) at each Site

Discipline	Items	Work Description	Work Volume
		▪ Switchgear and Motor Control Centre (MCC); ▪ Protection and control panel; ▪ DC and UPS; and ▪ Emergency diesel generators (EDG).	
	GIS Installation	– 400kV GIS installation – GIS and Local Control Cabinet (LCC) – Control and protection – Telecom	Each Site
	Balance of Plant (BOP) Mech. (Tank, Piping and etc)	– Fire water tank erection – Fire water piping installation	9,420 DI (U/G 8320) per each Site, 2 small Water Tank
	BOP E&I	– Bulk Material installation – Cable laying and termination – Cable Tray, Conduit, Electrical Distribution Board (EDB); – Earthing and Lightning Protection – Lighting system – Communication and special system	80,000 m LV Cable per each Site
	Firefighting	– Firefighting system installations in GIS – Converter station	1 set per site
	400kV AC Cable Installation	– 400kV AC cable installation from existing GIS to New GIS	For onshore site, 5 km / 1 km respectively
	Existing GIS (Tie-in)	– Existing GIS modification work to connect 400kV New GIS	For onshore Sites
Cable Installation	Cable Installation in cable trench at Mirfa and Shuweihat	– trench excavation – cable installation – supply and installation of concrete troughs (where needed) and foundation layer (both where required), top slabs, cable route markers, warning tape, concrete tiles – supply of trench backfill materials as specified – trench backfilling – TJB construction	For onshore sites
	Cable Installation in cable trench at Das Island and Al Ghallan Island	– trench excavation – cable installation on riser bridge or any alternative method selected – supply and installation of concrete troughs (where needed) and foundation layer (both where required), top slabs, cable route markers, warning tape, concrete tiles	For onshore (island) sites

Discipline	Items	Work Description	Work Volume
		– supply of trench backfill materials as specified – trench backfilling	

Onshore Construction Footprint

Onshore Cable Construction Area

The construction activities required onshore will fall within the project onshore footprint shown previously in **Section 4.2.1.2** (Table 4-2 and Figure 4-7).

Figure 4-101 to Figure 4-103 illustrate the onshore construction footprint on Route 1 Mirfa area and Route 2 Shuweihat area. Detailed methodology is further provided in the below sections.

Temporary Laydown Areas, Offices & Welfare Facilities

As mentioned in **Section 4.3.2.2.1**, temporary laydown areas, offices & welfare facilities will be required to be installed for the construction duration. These are illustrated in Figure 4-104 to Figure 4-111 below. Some of the offices, laydown, workshop etc. will fall within the dedicated onshore cable construction area mentioned in the above section. It should be noted that at this stage the exact locations of all laydown areas, offices, facilities etc. have not yet been finalised. However, selected zones where the future laydown areas, offices & welfare facilities can be installed have been identified between the EPC and Anthesis to limit environmental impacts as detailed in **Chapter 6**.

These selected zones for the future temporary laydown areas, offices & welfare facilities are shown in Figure 4-101 to Figure 4-103 illustrates below with the coordinates presented in Table 4-26 and Table 4-27 below.

Table 4-26: Coordinates (UTM) of available space for temporary laydown areas and access routes, offices & welfare facilities (Route 1)

Route Number	Easting	Northing
Available Space for Future Temporary Laydown Areas, Offices & Welfare Facilities		
LA1-1	750014.94	2669143.98
LA1-2	750178.27	2669040.01
LA1-3	750302.53	2668821.36
LA1-4	750314.71	2668767.38
LA1-5	750346.87	2668715.48
LA1-6	750210.07	2668537.73
LA1-7	749758.31	2668815.89
Available Space for Temporary Laydown Access Routes (Option 1)		
AR1-1	749457.43	2668926.85

Route Number	Easting	Northing
Available Space for Future Temporary Laydown Areas, Offices & Welfare Facilities		
AR1-2	749550.40	2668931.10
AR1-3	749660.11	2668965.34
AR1-4	749812.29	2668883.73
AR1-5	749781.39	2668845.26
AR1-6	749658.53	2668913.23
AR1-7	749557.59	2668883.23
AR1-8	749453.57	2668877.81
Available Space for Temporary Laydown Access Routes (Option 2)		
AR2-1	749692.72	2669289.51
AR2-2	749710.44	2669310.52
AR2-3	749735.05	2669319.82
AR2-4	750014.94	2669143.98
AR2-5	749984.08	2669103.19

Table 4-27: Coordinates (UTM) of available space for temporary laydown areas and access routes, offices & welfare facilities (Route 2)

Route Number	Easting	Northing
Available Space for Future Temporary Laydown Areas, Offices & Welfare Facilities		
LA2-1	659195.68	2671578.63
LA2-2	659316.61	2671575.15
LA2-3	659301.06	2671458.32
LA2-4	659291.40	2671433.54
LA2-5	659280.30	2671420.22
LA2-6	659256.97	2671421.50
LA2-7	659235.31	2671455.54
LA2-8	659225.61	2671455.43
LA2-9	659154.50	2671311.36

Route Number	Easting	Northing
LA2-10	659157.83	2671291.94
LA2-11	659173.53	2671282.54
LA2-12	659192.76	2671262.60
LA2-13	659165.47	2671228.27
LA2-14	659114.88	2671234.22
LA2-15	659105.55	2671223.64
LA2-16	659098.03	2671205.77
LA2-17	659096.59	2671195.17
LA2-18	659083.50	2671174.60
LA2-19	659076.02	2671145.33
LA2-20	659056.81	2671150.51
LA2-21	659056.77	2671194.71
LA2-22	659070.07	2671203.44
LA2-23	659076.06	2671211.59
LA2-24	659085.59	2671236.60
LA2-25	659081.12	2671252.87
LA2-26	659079.69	2671266.64
LA2-27	659084.02	2671292.78
LA2-28	659084.93	2671315.13
LA2-29	659089.26	2671327.88
LA2-30	659099.50	2671341.96
LA2-31	659114.36	2671378.91
LA2-32	659160.86	2671451.71
LA2-33	659177.94	2671488.95
LA2-34	659192.02	2671525.62
LA2-35	659196.71	2671560.26
Available Space for Temporary Laydown Access Routes (Option 1)		

Route Number	Easting	Northing
AR1-1	659056.81	2671150.51
AR1-2	659076.02	2671145.33
AR1-3	659069.64	2671123.22
AR1-4	659041.73	2671120.16
AR1-5	659051.89	2671138.48
Available Space for Temporary Laydown Access Routes (Option 2)		
AR2-1	659102.81	2671579.77
AR2-2	659195.68	2671578.63
AR2-3	659196.71	2671560.26
AR2-4	659116.62	2671559.97
AR2-5	659011.54	2671401.37
AR2-6	658997.91	2671388.44
AR2-7	658986.00	2671370.23
AR2-8	658983.05	2671354.31
AR2-9	658900.09	2671203.85
AR2-10	658904.92	2671182.18
AR2-11	658904.90	2671168.12
AR2-12	658887.85	2671116.07
AR2-13	658865.13	2671128.60
AR2-14	658869.89	2671146.18
AR2-15	658883.46	2671164.41
AR2-16	658889.81	2671177.60
AR2-17	658888.55	2671186.49
AR2-18	658879.06	2671205.01
AR2-19	658895.50	2671231.74
AR2-20	658925.77	2671283.02
AR2-21	658934.96	2671291.20

Route Number	Easting	Northing
AR2-22	658936.66	2671301.93
AR2-23	658963.72	2671343.62
AR2-24	658973.25	2671380.49
AR2-25	658999.73	2671414.41

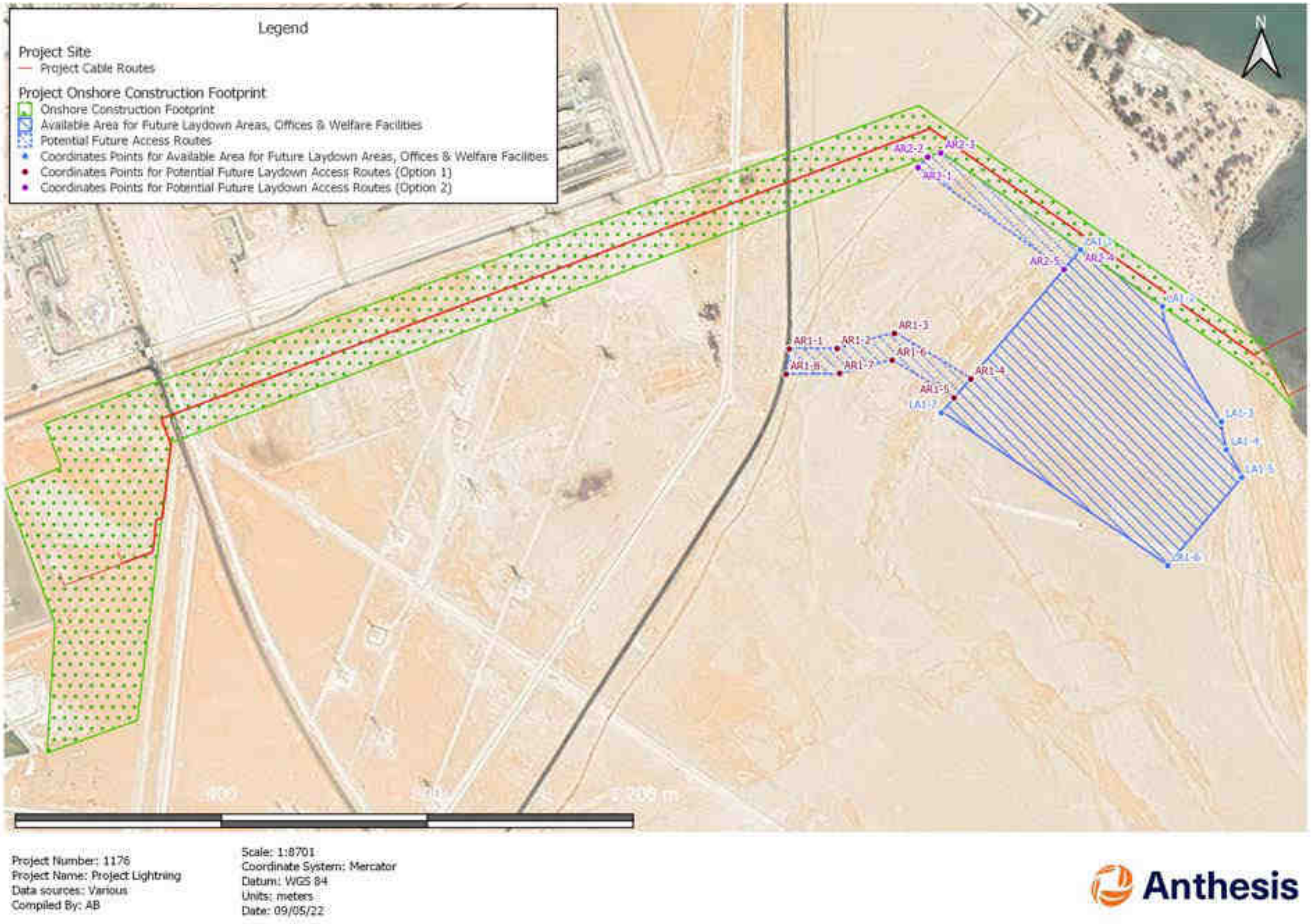


Figure 4-101: Onshore footprint including available locations for future temporary laydown areas and access routes, offices & welfare facilities (Route 1 - Mirfa)

Figure 4-102: Onshore footprint including available locations for future temporary laydown areas and access routes, offices & welfare facilities (Route 2 - Shuweihat)

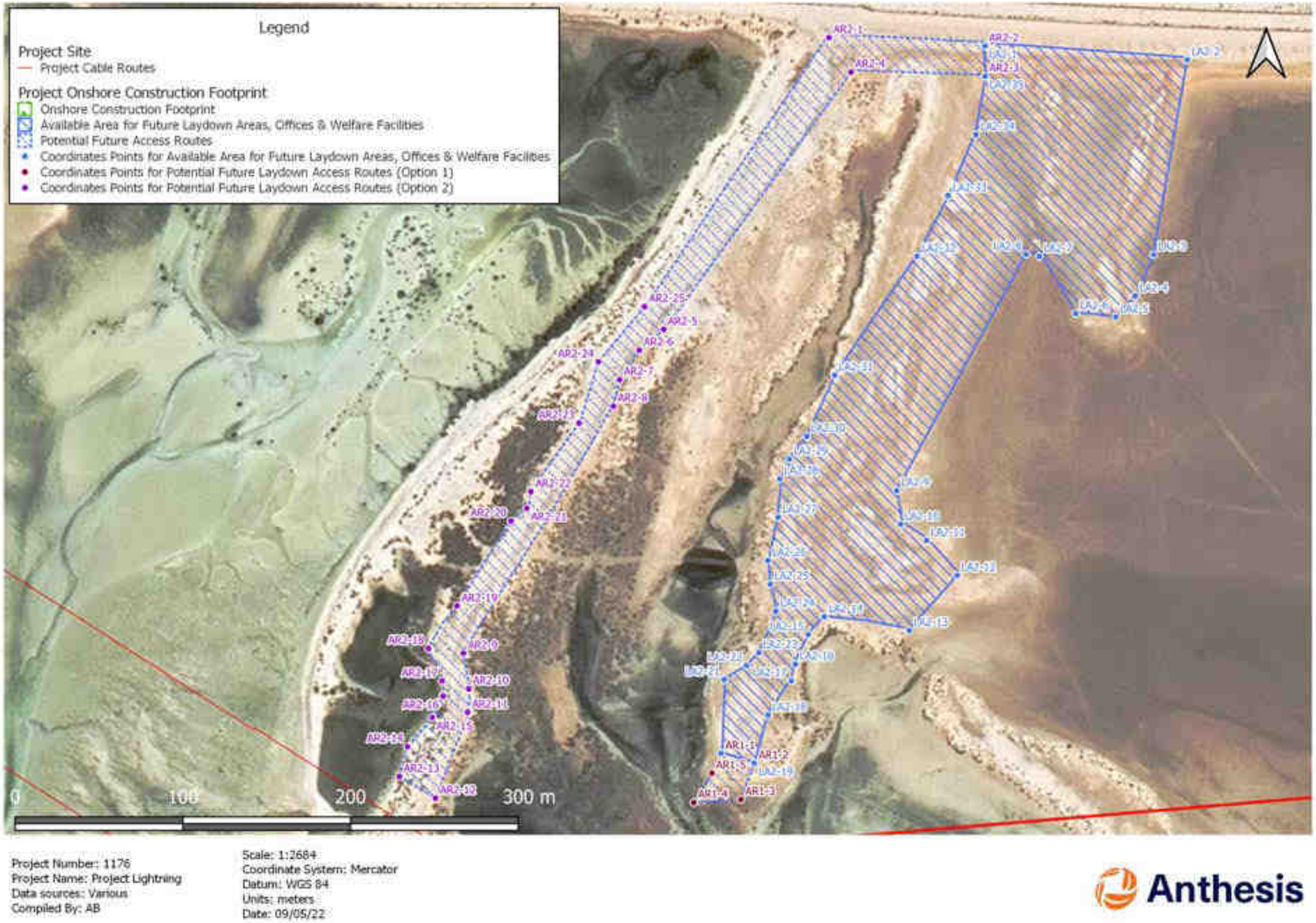


Figure 4-103: Available locations for future temporary laydown areas and access routes, offices & welfare facilities (Route 2 - Shuweihat)

Office WL-01 - Beach

Scale: 1/75

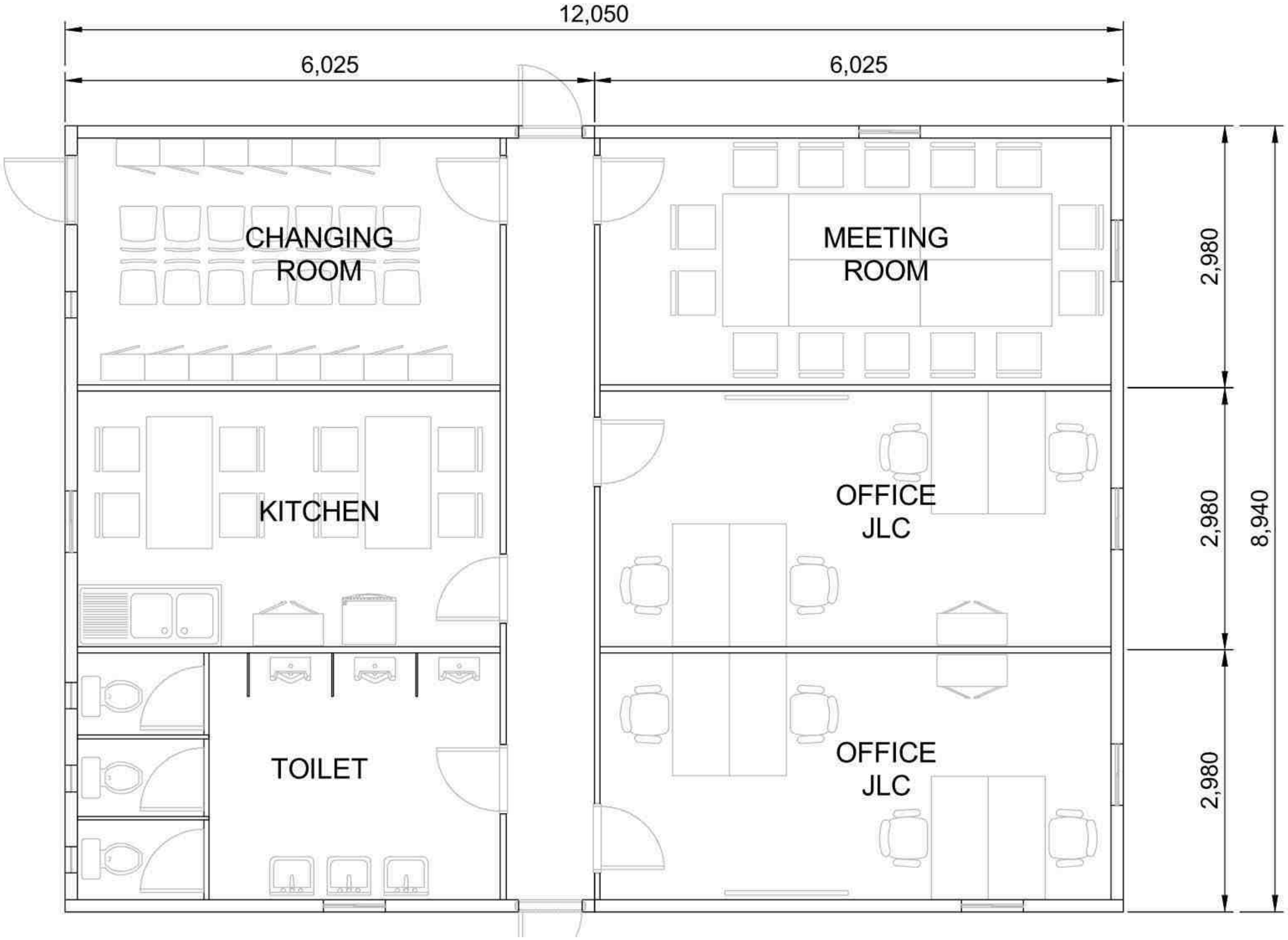
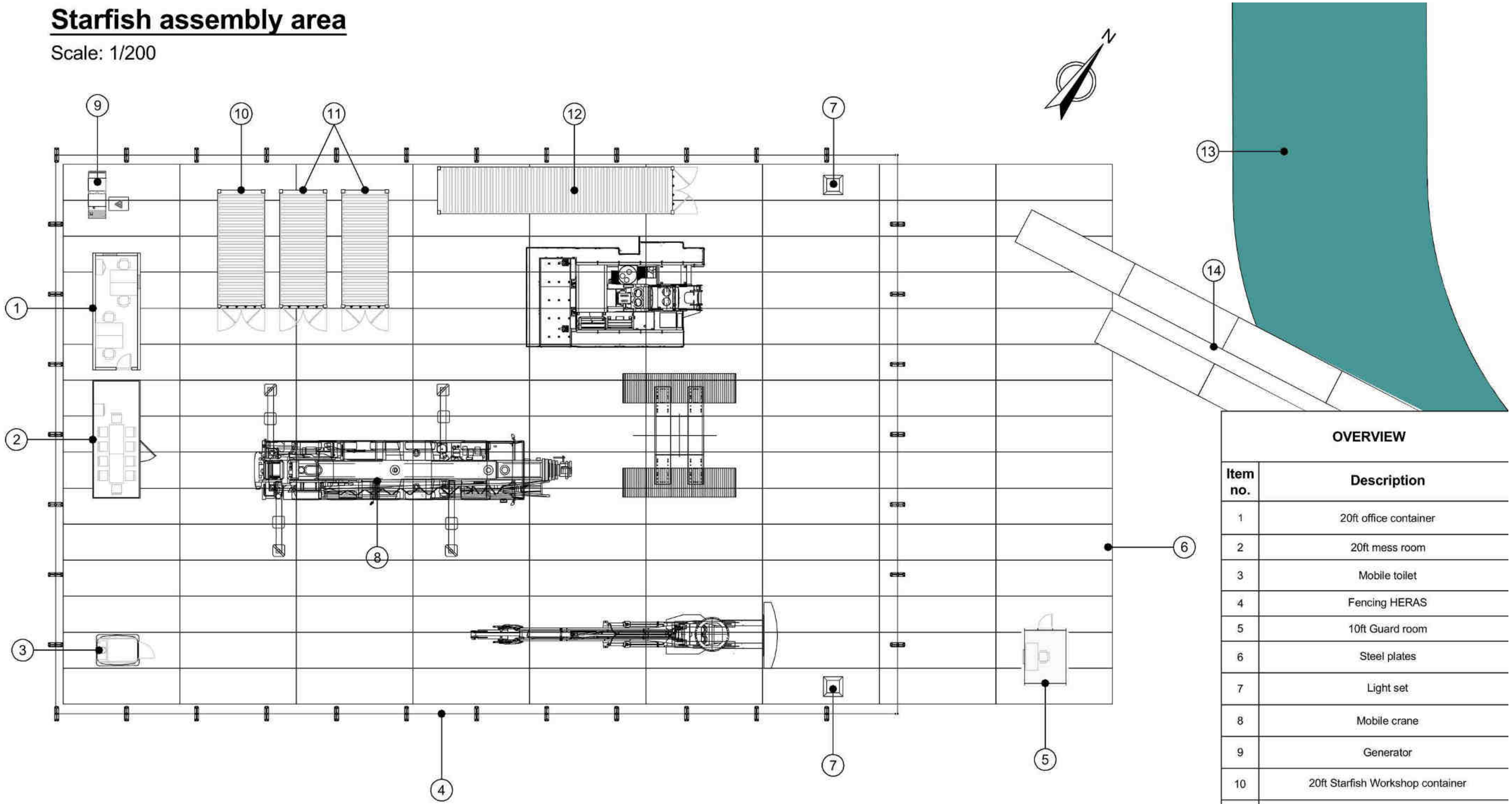


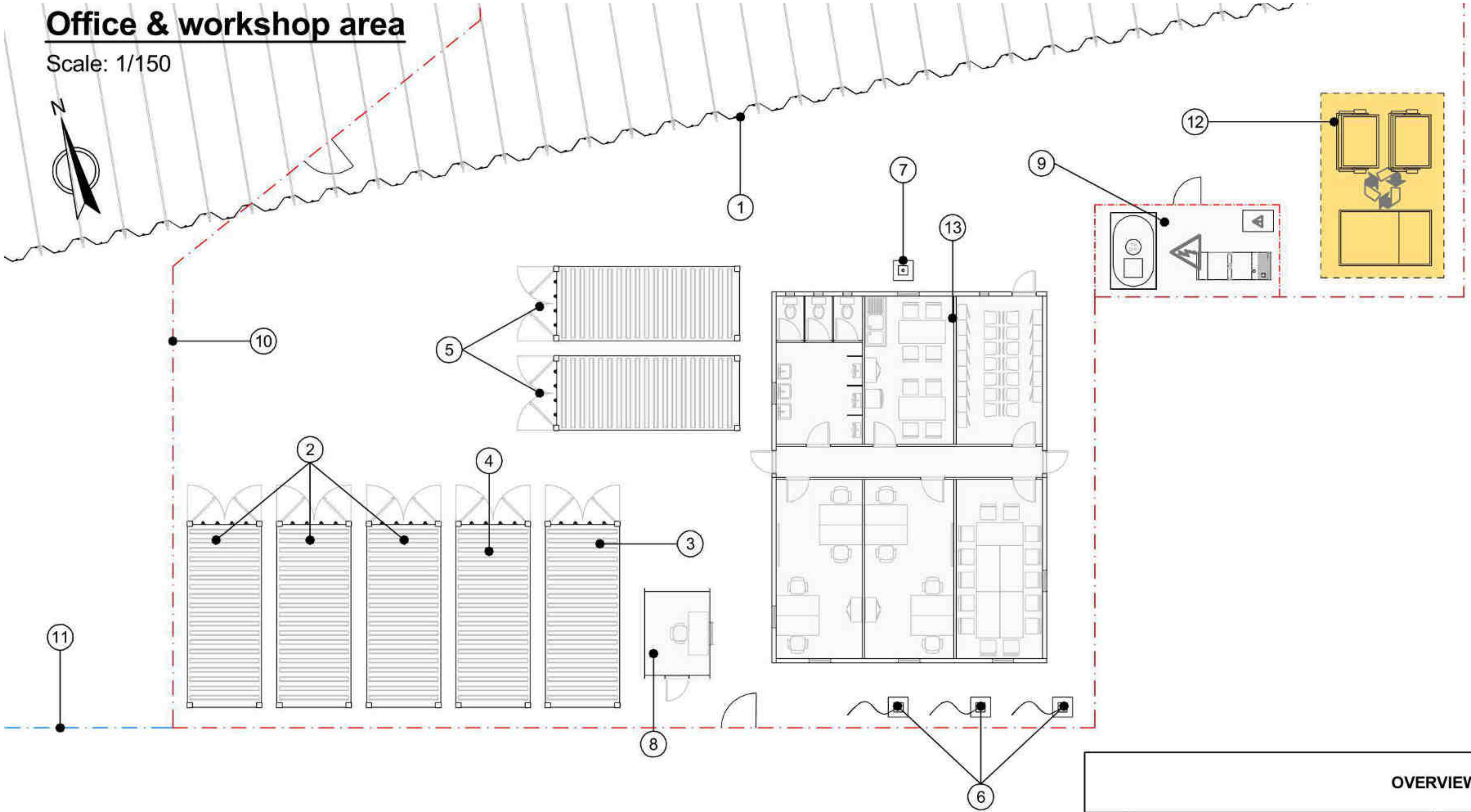
Figure 4-104: Il stration of D ffice “ L-01 – each



OVERVIEW

Item no.	Description
1	20ft office container
2	20ft mess room
3	Mobile toilet
4	Fencing HERAS
5	10ft Guard room
6	Steel plates
7	Light set
8	Mobile crane
9	Generator
10	20ft Starfish Workshop container
11	20ft Starfish spare parts container
12	40ft Starfish parts container
13	Transport route to WL-01 Beach area
14	Access to Parking area

Figure 4-105: Illustration of JDN Starfish Assembly Area



OVERVIEW

Item no.	Description	Item no.	Description
1		8	Security cabin
2	Workshop containers	9	Energy & fuel centre
3	Storage container HSE	10	Fixed fencing Heras type
4	Beach pull container	11	Mobile fencing
5	Workshop containers Starfishes	12	Waste & recycling area
6	Flag poles	13	Beach office
7	Video camera position		

Figure 4-106: Illustration of JDN office & workshop areas within Route 1 Mirfa onshore construction area

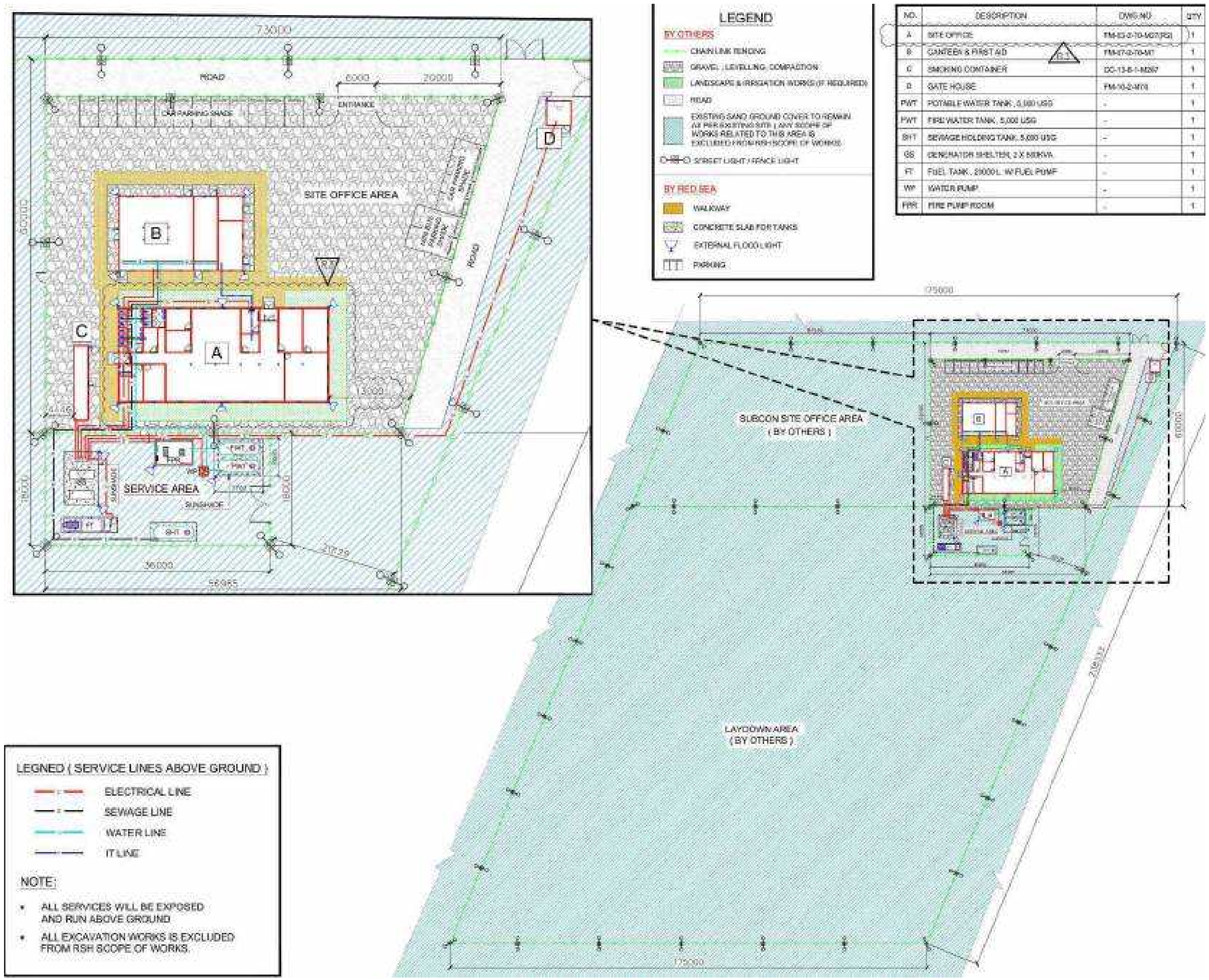


Figure 4-107: Illustration of SCT Site within Route 1 Mirfa area

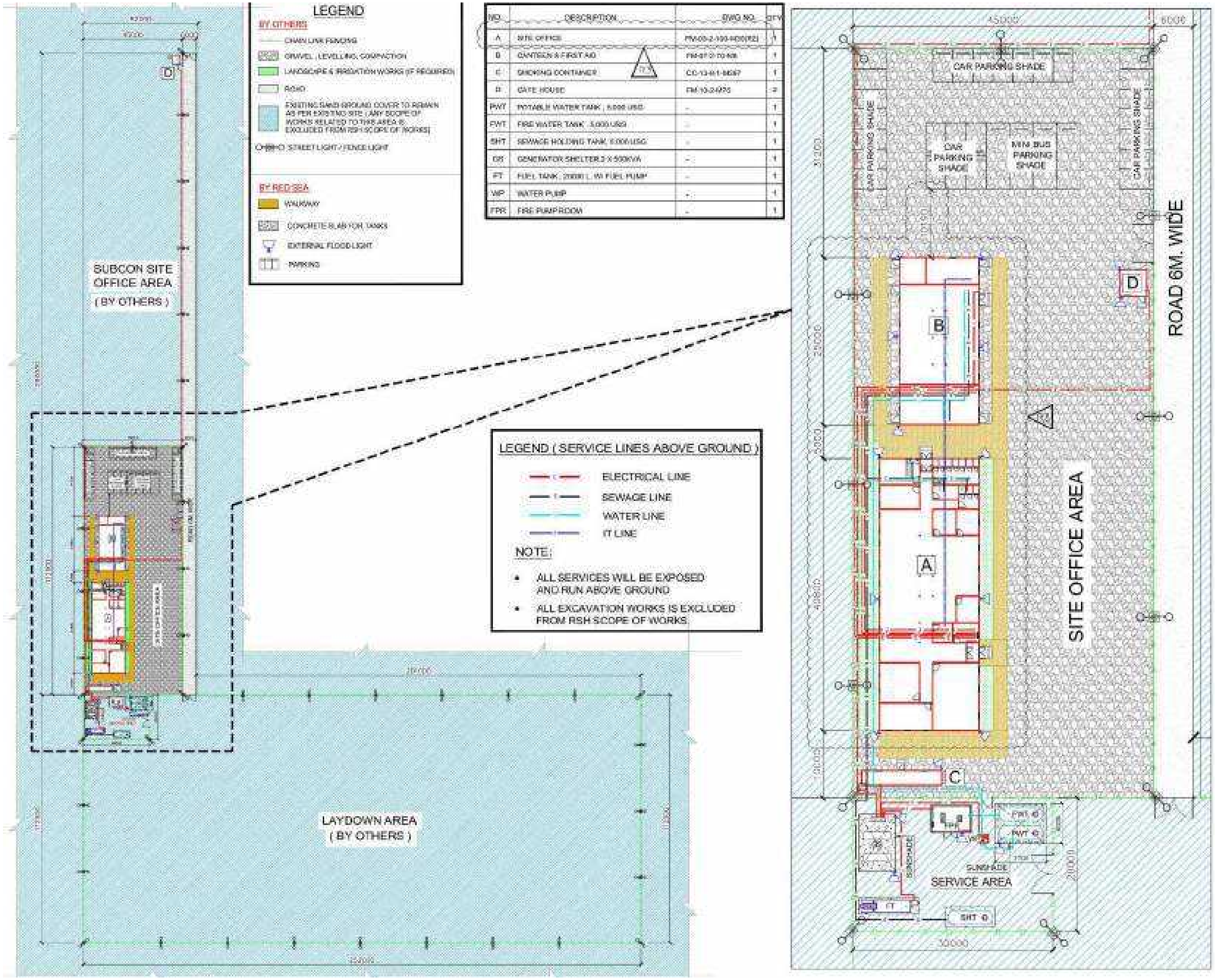


Figure 4-108: Illustration of SCT Site within Route 2 Shuweihat area

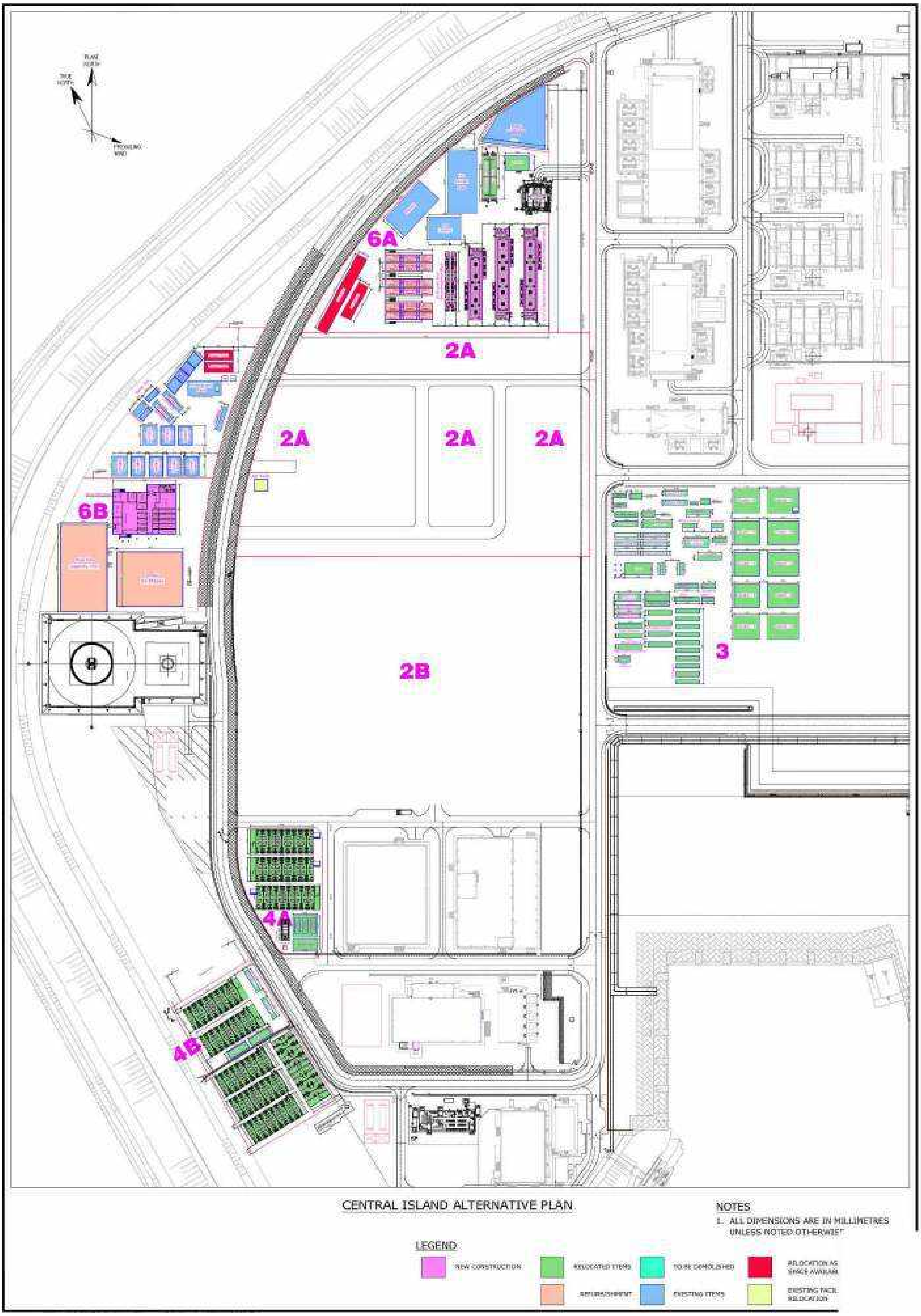


Figure 4-109: Illustration of SCT Site Office and Camp Area within Route 1 Al Ghallan Island area

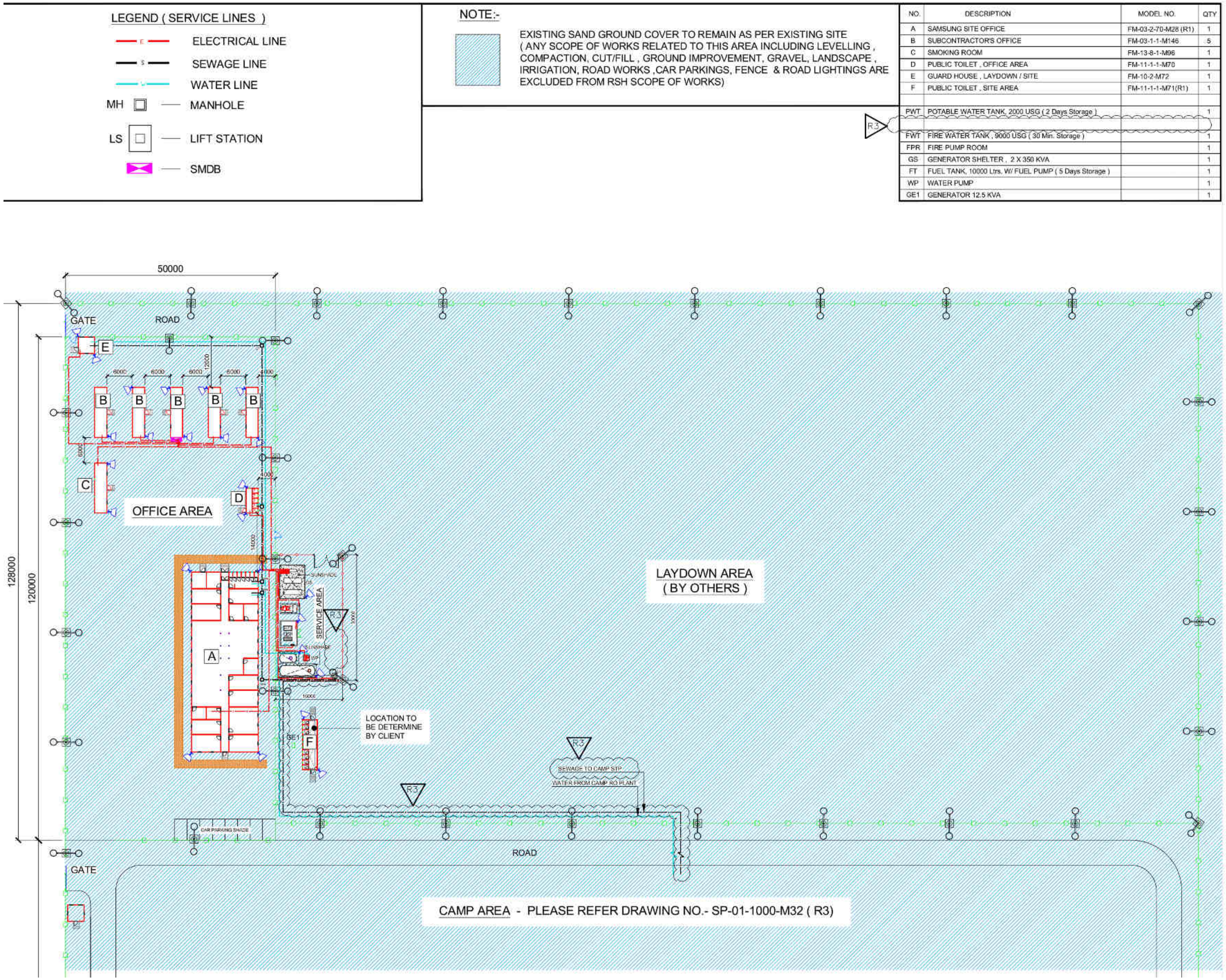


Figure 4-110: Illustration of SCT Site Office within Route 2 Das Island area

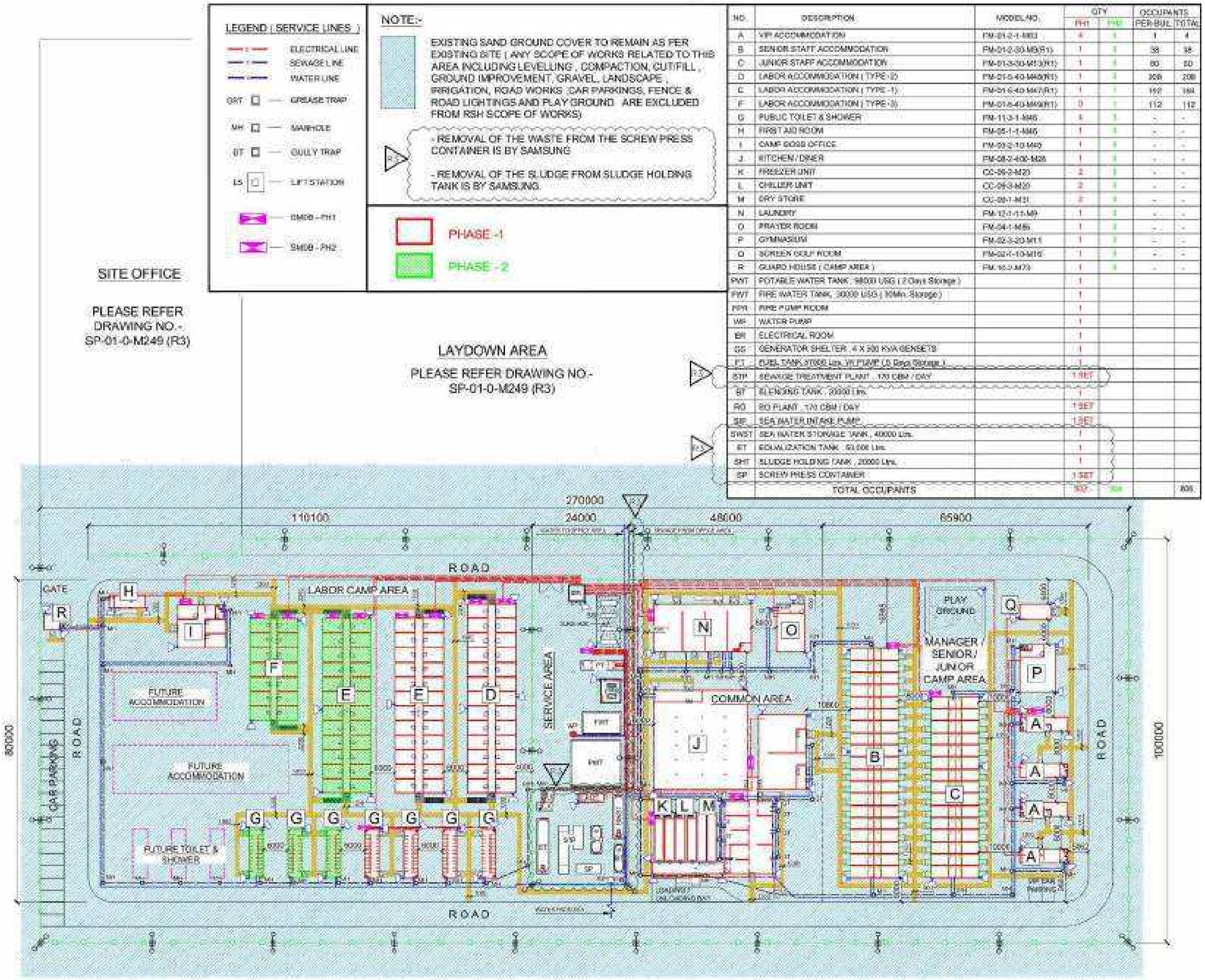


Figure 4-111: Illustration of SCT Camp Area within Route 2 Das Island area

Summary (Route 1 & 2)

Figure 4-101 to Figure 4-103 above illustrate the onshore construction footprint for Route 1 & 2. Additionally, Table 4-28 and Table 4-29 below details the calculated and estimated areas that are expected to be disturbed during the construction work.

Table 4-28: Onshore construction footprint for Route 1

Activities Footprint	Cable Routes	Area	
		m^2	ha
Construction Footprint			
Onshore Construction Footprint (excluding intertidal areas)	-	357,440	36
Total =	-	**357,440**	**36**
Available Space for Future Temporary Laydown Areas, Access Routes, Offices & Welfare Facilities			
Available Space for Laydown Access Routes	Option 1	18,026	2
	Option 2	17,037	2
Available Space for Future Laydown Areas, Offices & Welfare Facilities	-	383,556	38
Total =	-	**418,619**	**42**

Table 4-29: Onshore construction footprint for Route 2

Activities Footprint	Cable Routes	Area	
		m^2	ha
Construction Footprint			
Onshore Construction Footprint (excluding intertidal areas)	-	435,442	44
Total =	-	**435,442**	**44**
Available Space for Future Temporary Laydown Areas, Access Routes, Offices & Welfare Facilities			
Available Space for Laydown Access Routes	Option 1	625	0
	Option 2	11,331	1
Available Space for Future Laydown Areas, Offices & Welfare Facilities	-	363,35	4
Total =	-	**48,291**	**5**

Onshore Cable Installation in Cable Trench

Overview

The onshore works involving cable installations within the cable trenches will include the trench excavation, cable installation, supply of installation of concrete troughs (where required) and foundation layer (if required), top slabs, cable route markers, warning tape, concrete tiles, trench backfill materials according to cross sections. Site accessibility will also be ensured.

Each cable route will feature unique design features in terms of trench depth etc. However, Figure 4-112 below illustrates a typical on land and submarine HVDC cable trench section.

At each location, the cable will be marked and protected in accordance with Figure 4-112 and should include concrete tiles, warning tape, and cable route markers at 50m spacing.

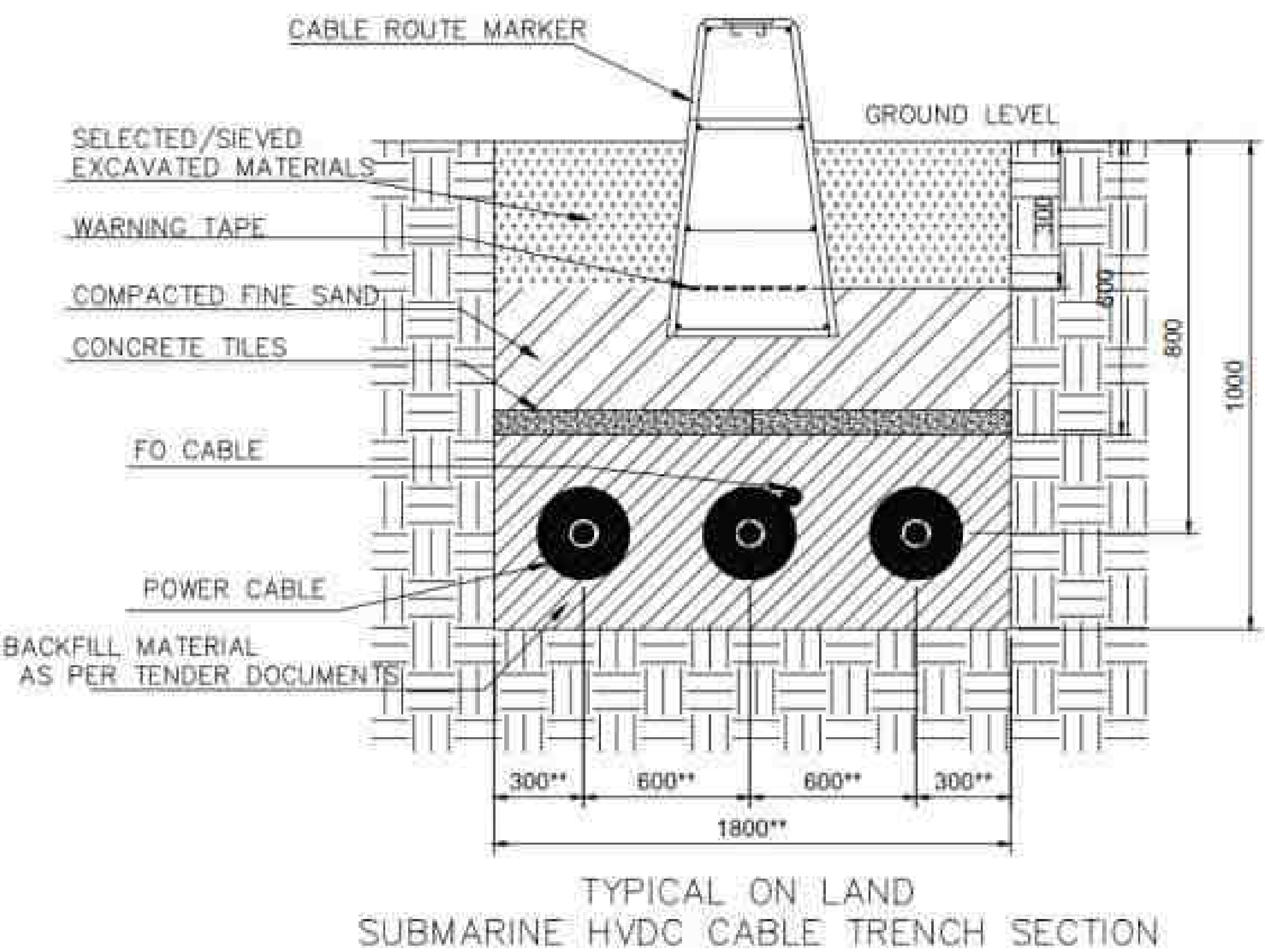


Figure 4-112: Typical cross section of cable trench

Trench Design: Shuweihat Cable

The cable trench section from the Transition Joint Bay (TJB) to Converter Station border at Shuweihat will be as follows, and in accordance with the design shown in Figure 4-113:

- Trench depth: 1m;
- Length: 1.3km;
- Cable spacing: 2.5m; and
- Backfill material: excavated soil (free from rocks).

Cable trench sections on the Converter Station Area will be an accordance with the design shown in Figure 4-114 below.

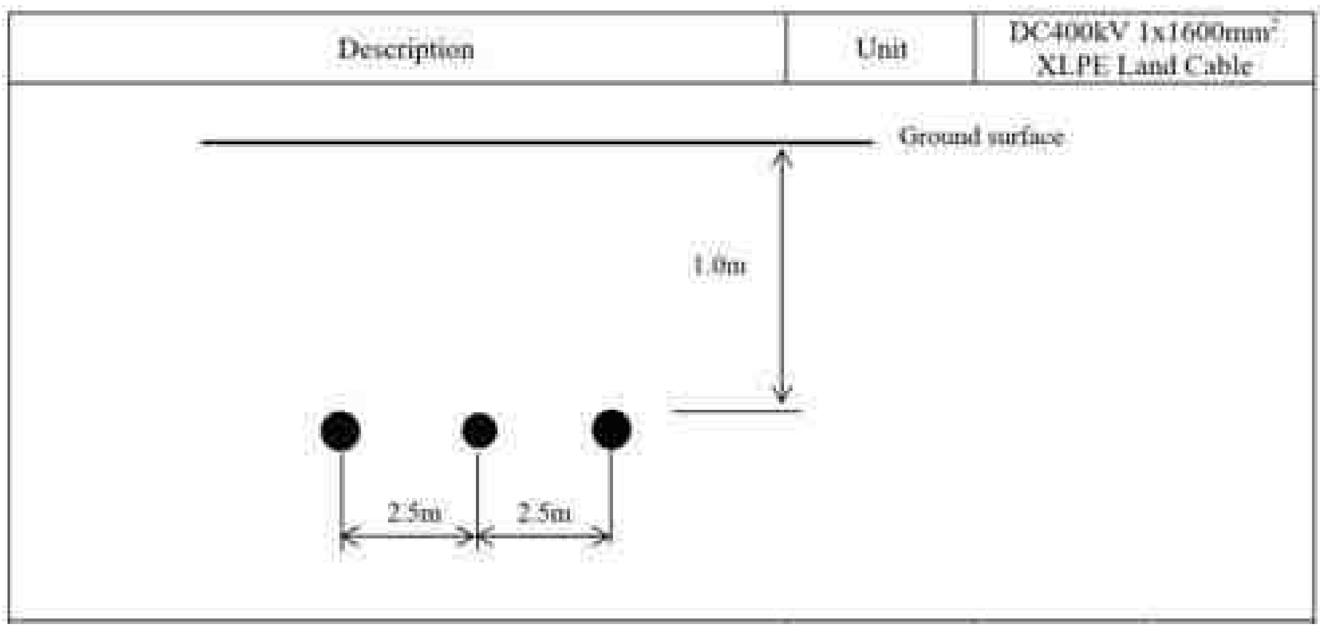


Figure 4-113: Shuweihat cable trench design

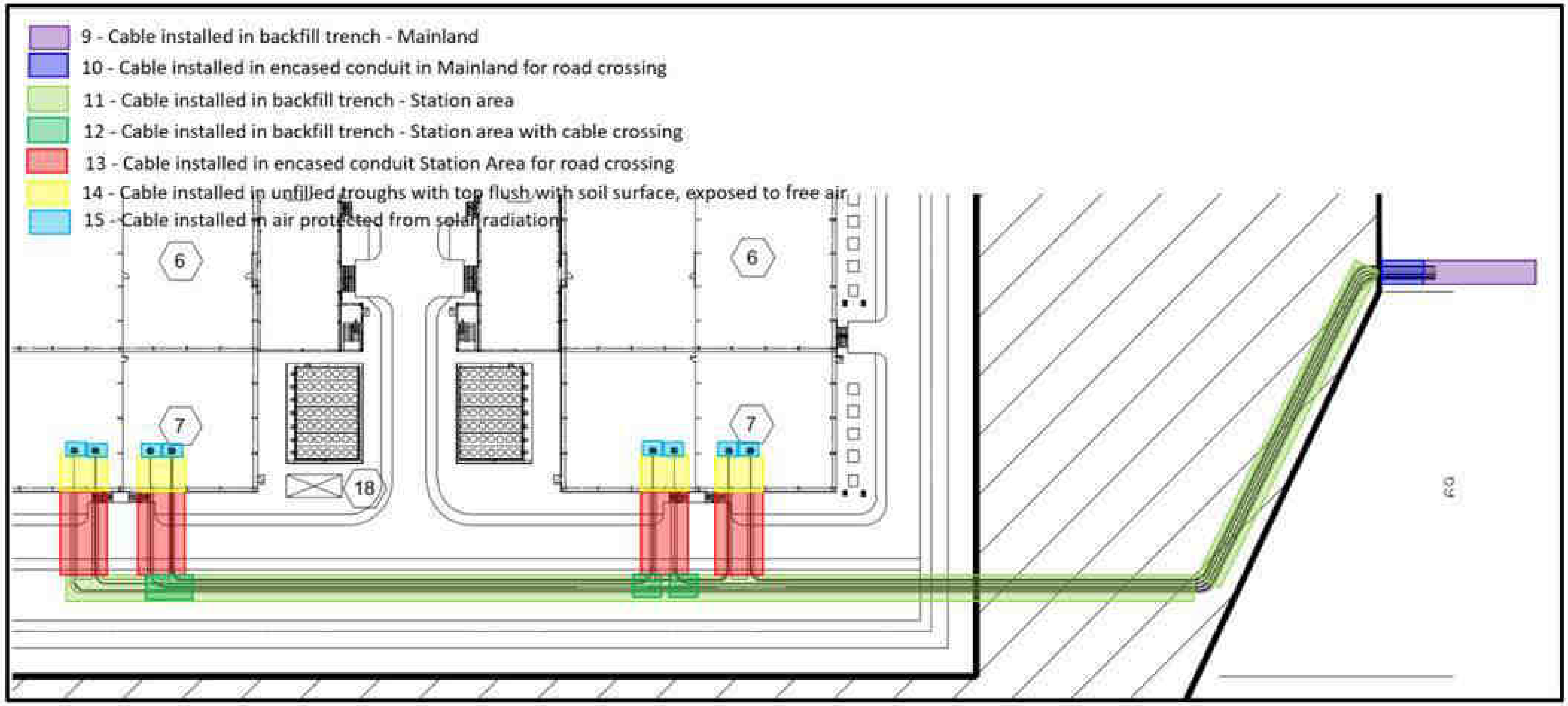


Figure 4-114: Overview of cable trench sections on converter station areas

Trench Design: Route 2 Das Island Cable

Cable installation will be on the riser bridge or any alternative method selected. The length of cable trench sections on the Converter Station Area will be 0.25km.

The cable trench details will be as described for the Al Ghallan Island cable trench design illustrated in Figure 4-115 below.

Trench Design: Mirfa Cable

The cable trench section from TJB (at KP 0+000) to the Converter Station border at Mirfa will be similar to that shown in Figure 4-113 although with 1 extra cable. The following design details will apply:

- Trench depth: 1 m;
- Length: 2.75 km;
- Cable spacing: 2.5 m; and
- Backfill material: excavated soil (free from rocks).

Cable trench sections at the Converter Station Area will be the same design as at Shuweihat as shown in Figure 4-114 above.

Trench Design: Al Ghallan Island Cable

Cable installation will be on the riser bridge or any alternative method selected. The length of cable trench sections on the Converter Station Area will be 0.52km with cables installed in cable troughs, with the top of the trough at ground level.

A cross section of the proposed trough cross section is provided below in Figure 4-115.

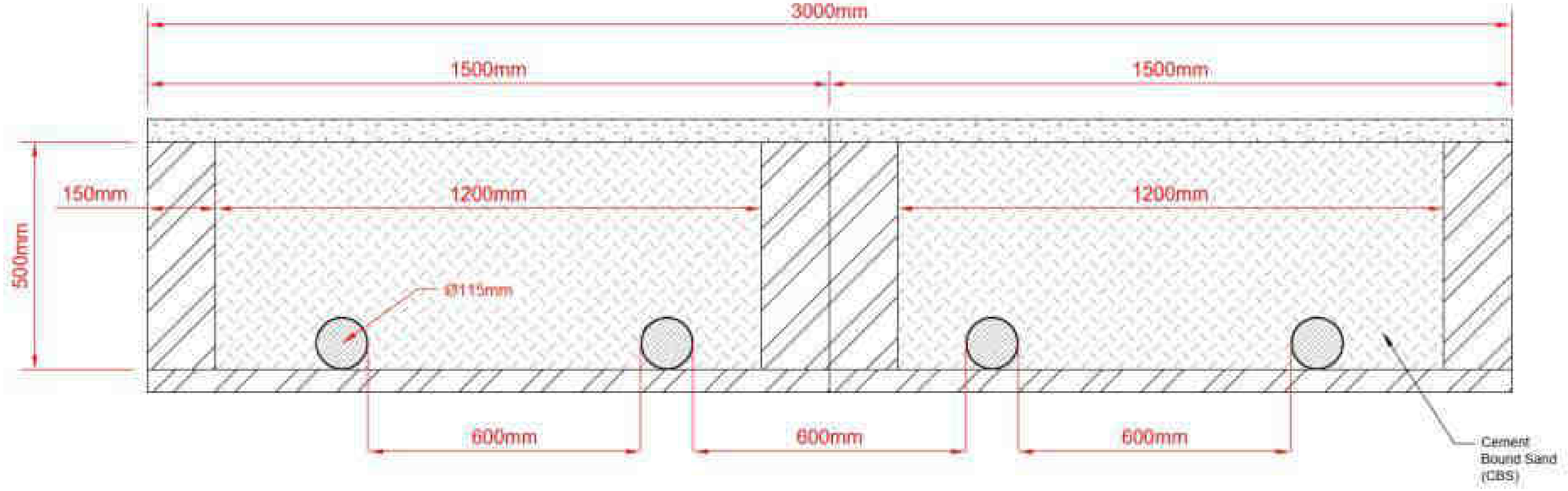


Figure 4-115: Al Ghallan cable trough cross section

Transition Joint Bay Construction

The TJB construction works will include excavation, the TJB construction including adjoining pits and footings and backfilling as required. At both Mirfa and Shuweihat, TJB markers will be utilised as shown below in Figure 4-116.

Figure 4-116: Example of TJB markers to be used at Shuweihat and Mirfa

Shuweihat

At Shuweihat the TJB will be located 850m from the water line towards the converter station and the layout will be as shown below in Figure 4-117.

Mirfa

At Mirfa the TJB will be located directly at water line towards the converter station and the layout will be as at Shuweihat as shown above in Figure 4-117.

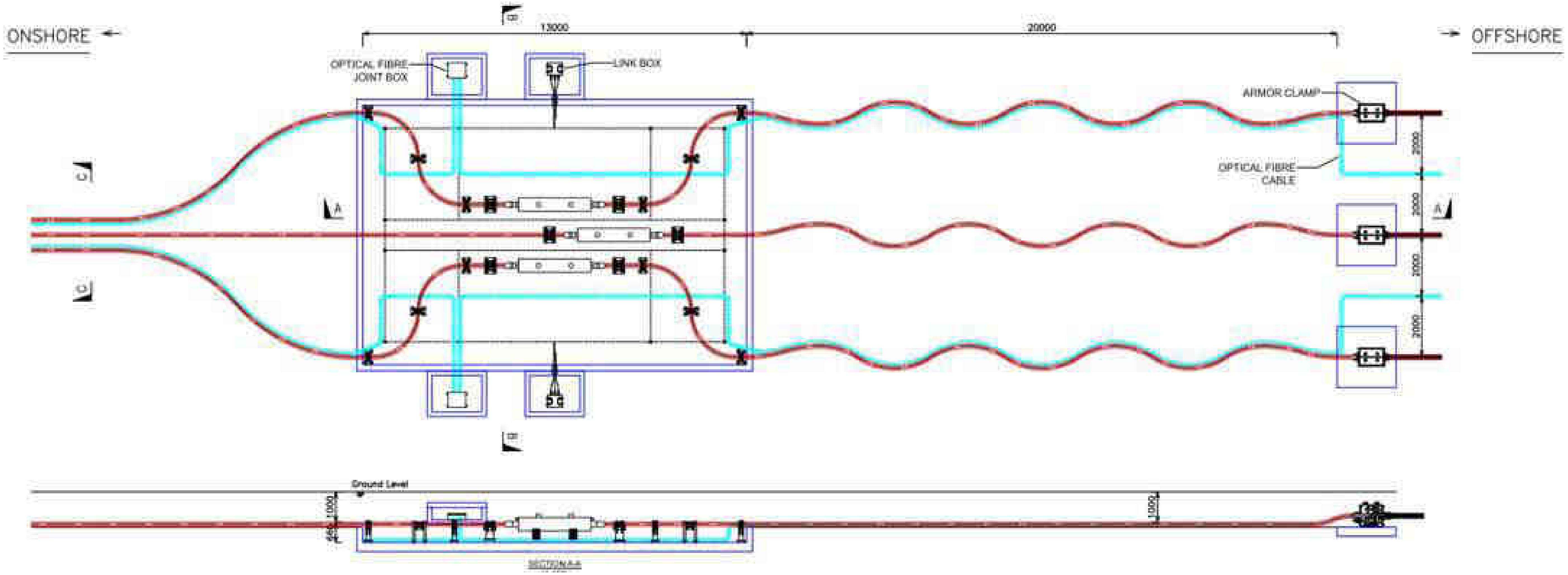


Figure 4-117: Shuweihat TJB details

4.3.2.3. Expected Manpower Requirements

4.3.2.3.1. Construction Phase

During the construction phase, manpower requirements will vary considerably depending upon the construction stage and activities underway.

Expected numbers for both onshore and offshore civil construction works undertaken by SCT are set out below in Figure 4-118 to Figure 4-121.

Expected numbers for marine and onshore cable installation works by JDN are set out below in Figure 4-122.

Figure 4-118: Estimated onshore manpower requirements at Mirfa (Route 1)

	Total Man Months	2021					2022												2023												2024												2025						
		Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Subcontractors-																																																	
Concrete	**5,706**	-	-	-	-	-	-	-	-	-	52	61	61	55	207	212	207	361	329	567	629	704	644	427	308	195	189	195	175	71	50	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Steel Structure	**885**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19	114	179	230	221	118	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cladding	**226**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	46	55	57	55	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HVAC	**1,287**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	86	108	180	433	85	395	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cable	**1,035**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	27	40	139	144	209	158	188	83	45	-	-	-	-	-	-	-	-	-	-	-	-	-
Main Equipment	**267**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26	31	32	31	41	42	39	12	9	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GIS	**1,179**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	68	71	147	170	163	172	150	98	78	29	25	-	-	-	-	-	-	-	-	-	-	-
Commissioning	**326**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	24	25	47	47	42	40	20	20	60	-	-	-	-
Mechanical, Tank Work	**242**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	57	78	78	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Piping	**452**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	33	45	52	52	52	52	52	52	40	-	-	-	-	-	-	-	-	-	-
Firefighting	**982**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	47	72	97	113	113	113	113	113	113	88	-	-	-	-	-	-	-	-	-	-
Stone column	**-**																																																
Subtotal (Subcon)	**12,587**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**52**	**61**	**61**	**55**	**207**	**212**	**207**	**361**	**329**	**567**	**648**	**818**	**917**	**811**	**764**	**829**	**372**	**725**	**317**	**467**	**512**	**616**	**585**	**590**	**379**	**289**	**217**	**215**	**175**	**47**	**42**	**40**	**20**	**20**	**60**	**-**	**-**	**-**	**-**
SCT																																																	
Korean Staff	**346**	-	-		-	-	-	2	4	7	8	8	8	8	8	8	8	8	9	10	11	11	11	11	11	12	12	12	12	12	10	10	10	9	9	9	9	8	8	8	8	8	7	7	5	5	3	1	1
Foreign Staff	**-**	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Local Staff	**156**	-	-		-	-	-	-	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	3	2	2	2	2	2	2	2	2	-	-
TCN Staff	**810**	-	-		-	-	-	-	-	3	10	14	15	15	18	22	25	27	31	31	34	34	34	34	34	31	29	30	29	29	27	26	26	23	23	23	23	22	19	13	13	13	10	10	6	2	2	-	-
Indirect Labour	**458**	-	-		-	-	-	-	-	11	11	11	11	11	11	11	11	11	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	11	11	11	11	11	11	11	11	11	-	-
Subtotal (SCT)	**1,770**	-	-	-	-	-	-	2	9	26	34	38	39	39	42	46	49	51	58	59	63	63	63	63	63	60	58	59	58	58	54	53	53	49	49	49	49	47	41	34	34	34	30	30	24	20	18	1	1
OEM	**160**	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	16	16	16	16	16	16	-	-	-
OE	**494**	-	-		-	-	-	-	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	-	-	-
Total	**15,011**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**22**	**39**	**99**	**112**	**113**	**107**	**262**	**271**	**269**	**425**	**400**	**639**	**724**	**894**	**993**	**887**	**840**	**902**	**443**	**797**	**388**	**538**	**579**	**682**	**659**	**660**	**449**	**359**	**287**	**283**	**237**	**102**	**105**	**103**	**79**	**79**	**113**	**49**	**18**	**1**	**1**

Figure 4-119: Estimated offshore manpower requirements at Al Ghallan Island (Route 1)

	Total Man Months	2023											2024												2025				
		Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Subcontractors																													
Concrete	**5,108**	-	-	-	178	587	586	618	669	711	701	433	311	220	94	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Steel structure	**673**	-	-	-	-	-	-	-	-	-	-	93	140	136	139	140	25	-	-	-	-	-	-	-	-	-	-	-	-
Cladding	**192**	-	-	-	-	-	-	-	-	-	-	-	60	60	31	25	15	1	-	-	-	-	-	-	-	-	-	-	-
HVAC	**988**	-	-	-	-	-	-	-	-	-	-	170	185	202	207	167	48	9	-	-	-	-	-	-	-	-	-	-	-
Cables	**541**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	76	142	132	122	69	-	-	-	-	-	-	-	-
Main Equipment	**887**	-	-	-	-	-	-	-	-	-	-	-	-	20	65	99	115	129	155	121	85	69	30	-	-	-	-	-	-
GIS	**736**	-	-	-	-	-	-	-	-	-	-	-	-	-	65	75	75	75	89	89	89	89	59	19	9	-	-	-	-
Commissioning	**266**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	30	66	60	29	33	47	-
Mechanical, Tank Work	**206**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	47	65	65	29	-	-	-	-	-	-	-	-	-	-
Piping	**416**	-	-	-	-	-	-	-	-	-	-	-	-	18	27	37	43	43	52	52	52	52	40	-	-	-	-	-	-
Firefighting	**1,121**	-	-	-	-	-	-	-	-	-	-	-	-	39	60	94	119	119	143	143	143	143	118	-	-	-	-	-	-
Stone column	**288**			15	31	62	77	64	39	-	-	-	-	-	-	-	-	-											
Subtotal (Subcon)	**11,421**	**-**	**-**	**15**	**209**	**649**	**663**	**682**	**708**	**711**	**701**	**696**	**696**	**695**	**688**	**684**	**581**	**583**	**600**	**527**	**438**	**355**	**277**	**85**	**70**	**29**	**33**	**47**	**-**
SCT																													
Korean Staff	**124**	4	6	6	6	6	6	3	3	3	5	7	7	7	7	7	7	6	6	4	4	3	3	3	1	1	1	1	1
Foreign Staff	**-**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Local Staff	**68**	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	1	1	1	1	1	1	1
TCN Staff	**678**	16	18	19	19	19	19	20	21	24	28	31	33	34	34	33	32	32	32	31	30	26	22	22	22	17	17	17	10
In-direct Labor	**364**	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
Subtotal (SCT)	**1,234**	36	40	41	41	41	41	39	40	43	49	54	56	57	57	56	55	54	54	51	49	44	39	39	37	32	32	32	25
OEM	**160**	-	-	-	-	-	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	16	16	16	16	16	16	-
OE	**189**	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Total	**13,004**	**36**	**47**	**63**	**257**	**697**	**711**	**728**	**755**	**761**	**757**	**757**	**759**	**759**	**760**	**755**	**651**	**652**	**669**	**593**	**502**	**414**	**339**	**147**	**130**	**84**	**88**	**102**	**32**

Figure 4-120: Estimated Onshore Manpower Requirements at Shuweihat (Route 2)

	Total MM	2021					2022												2023												2024												2025						
		Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Subcontractor																																																	
Concrete	**6,936**	-	-	-	-	-	-	-	-	-	-	235	252	252	472	514	767	832	610	501	484	534	388	338	338	136	126	117	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Steel structure	**1,066**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	72	223	306	212	51	84	110	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cladding	**270**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17	64	88	42	14	30	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HVAC	**1,224**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	74	100	267	387	98	155	144	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cable	**1,680**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	43	195	240	278	289	259	266	69	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Main Equipment	**255**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24	30	31	31	37	40	38	12	9	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GIS	**1,007**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33	97	98	104	116	136	144	104	68	59	33	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Commissioning	**307**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	23	33	45	44	40	32	18	37	31	-	-	-	-	-	-	-
Mechanical, Tank Work	**242**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	57	78	78	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Piping	**452**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	33	45	52	52	52	52	52	52	40	-	-	-	-	-	-	-	-	-	-	-	-	-
Firefighting	**982**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	47	72	97	113	113	113	113	113	113	88	-	-	-	-	-	-	-	-	-	-	-	-	-
Stone column	**-**																																																
Subtotal (Subcon)	**14,422**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**235**	**252**	**252**	**472**	**514**	**767**	**904**	**833**	**897**	**860**	**940**	**924**	**637**	**701**	**620**	**576**	**657**	**703**	**657**	**623**	**334**	**259**	**221**	**211**	**173**	**44**	**40**	**32**	**18**	**37**	**31**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
SCT																																																	
Korean Staff	**693**	8	8		10	13	15	15	16	16	16	16	16	17	18	18	18	18	18	20	20	19	19	19	18	18	17	16	16	16	16	16	16	16	16	15	15	15	15	12	12	12	12	12	9	9	8	7	6
Foreign Staff	**-**	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Local Staff	**204**	-	1		1	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	3	3	2	2	2	2	2	-	-	-	-	-	-
TCN Staff	**989**	-	-		-	9	15	15	16	20	23	24	24	32	35	36	37	37	37	37	38	39	39	37	36	35	32	25	25	25	25	25	25	23	23	20	19	18	18	14	14	14	10	10	2	1	-	-	-
In-direct Labor	**449**	-	-		-	11	11	11	11	11	11	11	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	11	11	11	11	11	11	11	11	11	-	-	-	-	-	-	-
Subtotal (SCT)	**2,335**	8	9	-	11	39	47	47	49	53	56	57	59	68	72	73	74	74	74	76	77	77	77	75	73	72	68	60	60	60	60	60	60	56	56	52	48	47	46	39	39	39	24	22	11	10	8	7	6
OEM	**160**	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	16	16	16	16	16	16	-	-	-
OE	**494**	-	-		-	-	-	-	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	-	-	-
Total	**17,411**	**8**	**9**	**-**	**11**	**39**	**47**	**47**	**62**	**66**	**69**	**305**	**324**	**333**	**557**	**600**	**854**	**991**	**920**	**986**	**950**			**725**	**787**	**705**	**657**	**730**	**776**	**730**	**696**	**407**	**340**	**298**	**288**	**246**	**113**	**108**	**99**	**78**	**105**	**99**	**53**	**51**	**40**	**39**	**8**	**7**	**6**

Figure 4-121: Estimated Offshore Manpower Requirements at Das Island (Route 2)

	Total MM	2021			2022												2023												2024												2025				
		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Subcontractor																																													
Concrete	**6,478**	-	1	23	-	-	91	220	225	408	519	655	729	645	623	585	382	409	397	283	138	127	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Steel structure	**1,045**	-	-	-	-	-	-	-	-	-	-	-	53	156	155	113	223	155	21	60	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cladding	**260**	-	-	-	-	-	-	-	-	-	-	-			2	38	34	45	61	38	19	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HVAC	**934**	-	-	-	-	-	-	-	-	-	-	-			7	61	146	161	150	135	214	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cable	**845**	-	-	-	-	-	-	-	-	-	-	-			-	-	-	8	24	23	38	68	121	149	115	68	71	71	71	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Main Equipment	**1,018**	-	-	-	-	-	-	-	-	-	-	-					-	8	52	81	77	74	130	142	114	102	85	64	33	24	25	6	-	-	-	-	-	-	-	-	-	-	-	-	-
GIS	**349**	-	-	-	-	-	-	-	-	-	-	-					-	6	41	40	41	41	50	50	42	20	16	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Commissioning	**308**	-	-	-	-	-	-	-	-	-	-	-						-	-	-	-	-	-	-	-	-	-	7	23	21	23	21	30	40	33	21	18	11	29	31	-	-	-	-	-
Mechanical, Tank Work	**242**	-	-	-	-	-	-	-	-	-	-	-						-	-	-	-	-	-	57	78	78	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Piping	**452**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	33	45	52	52	52	52	52	52	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Firefighting	**1,095**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	62	87	112	128	128	128	128	121	113	88	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stone column	**270**					14	27	54	68	68	39																																		
Subtotal (Subcon)	**13,295**	**-**	**1**	**23**	**-**	**14**	**118**	**274**	**293**	**476**	**558**	**655**	**782**	**801**	**787**	**797**	**785**	**792**	**746**	**659**	**637**	**476**	**438**	**555**	**530**	**448**	**381**	**324**	**300**	**227**	**176**	**27**	**30**	**40**	**33**	**21**	**18**	**11**	**29**	**31**	**-**	**-**	**-**	**-**	**-**
SCT																																													
Korean Staff	**153**		1	2	2	5	6	6	6	6	7	4	4	5	5	5	5	5	5	7	6	6	5	4	4	4	3	3	3	3	3	3	3	3	3	3	3	1	1	1	1	1	-	-	-
Foreign Staff	**-**		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Local Staff	**85**		-	-	-	-	-	1	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	1	1	1	1	1	-	-	-	-
TCN Staff	**764**		-	-	-	10	14	14	17	19	21	17	19	22	22	22	22	22	22	22	21	22	22	22	24	28	25	25	25	25	25	25	25	25	19	19	19	17	17	17	16	16	-	-	-
Indirect labour	**462**		-	-	11	11	11	11	11	11	11	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	11	11	11	11	11	11	11	11	11	-	-	-
Subtotal (SCT)	**1,464**	-	1	2	13	26	31	32	36	38	41	37	39	43	43	43	43	43	43	45	43	44	43	42	44	48	44	44	44	44	44	44	44	42	35	35	34	30	30	30	29	28	-	-	-
OEM	**160**		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	16	16	16	16	16	16	-	-	-
OE	**238**		-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-
Total	**15,157**	**-**	**2**	**25**	**13**	**40**	**149**	**306**	**336**	**521**	**606**	**699**	**828**	**851**	**837**	**847**	**835**	**842**	**796**	**711**	**687**	**527**	**488**	**604**	**581**	**503**	**432**	**375**	**359**	**286**	**235**	**86**	**89**	**97**	**83**	**71**	**75**	**64**	**82**	**84**	**52**	**51**	**-**	**-**	**-**

Figure 4-122: Expected manpower requirements for cable installation works by JDN (Route 1 & 2)

Lightning Project	Staff	Crew
Overall site supervision	***39***	***0***
Head office	6	-
PMT - Expat	11	-
PMT - IWF	22	-
Electrical	***4***	***0***
Head office	2	-
PMT - Expat	2	-
PMT - IWF	0	-
Riser jacket fabrication & installation	***12***	***0***
Head office	4	-
PMT - Expat	7	-
PMT - IWF	1	-
Installation, burial and mattress protection	***39***	***82***
CLV 'Isaac Newton'	9	46
CLV 'Leonardo Da Vinci'	9	60
CLB 'Ulisse'	7	60
TSV 'Adhemar de Saint-Venant' – trenching & mattress installation	7	36
Head office	4	-
PMT - Expat	17	-
PMT - IWF	2	-
Rock supply & installation	***26***	***72***
SRIV 'Joseph Plateau'	11	37
SRIV 'Daniel Bernouilli' - rock installation / mattress	7	35
Head office	2	-
PMT - Expat	2	-
PMT - IWF	4	-
Dredging & backfilling	***72***	***94***
BHD 'Jerommeke'	3	8
BHD 'Gian Lorenzo Bernini'	3	8
TSHD 'Sebastiano Caboto'	3	14
Starfish x4	4	8
BHD 'DN39'	2	6
Workshop	1	14
FLAP (JDN)	2	36
Head office	4	-
PMT - Expat	21	-
PMT - IWF	29	-
Surveys	***20***	***0***
Pre-engineering surveys (Fugro + JDN client reps)	14	-
As-built surveys (2x)	6	-
Civil works onshore	***19***	***18***
Head office	4	-
PMT - Expat	13	-
PMT - IWF	2	-
Labour - Expat		2
Labour - TCN		6
Labour - local		10
Miscellaneous overarching scopes	***0***	***42***
Accommodation barge Route 1 and Route 2		6
Crew transfer vessels		6
Guard vessels		30
Onshore storage DAS in UAE		-
Overall Total =	***231***	***308***

4.3.2.3.2. Operational Phase

During the operational phase, the following manpower requirements are envisaged, as set out in Figure 4-123 below.

On weekdays and weekends the following working hours will apply:

- Day shifts will be 6am-2pm and 2pm – 10pm; and
- Nightshifts will be from 10pm – 6am.

During the weekdays, two operators will work during a day shift and one operator during the nightshift. On Fridays, only one operator will work during the day and one operator during the night shift.

A total of seven shift operators will be required per route.

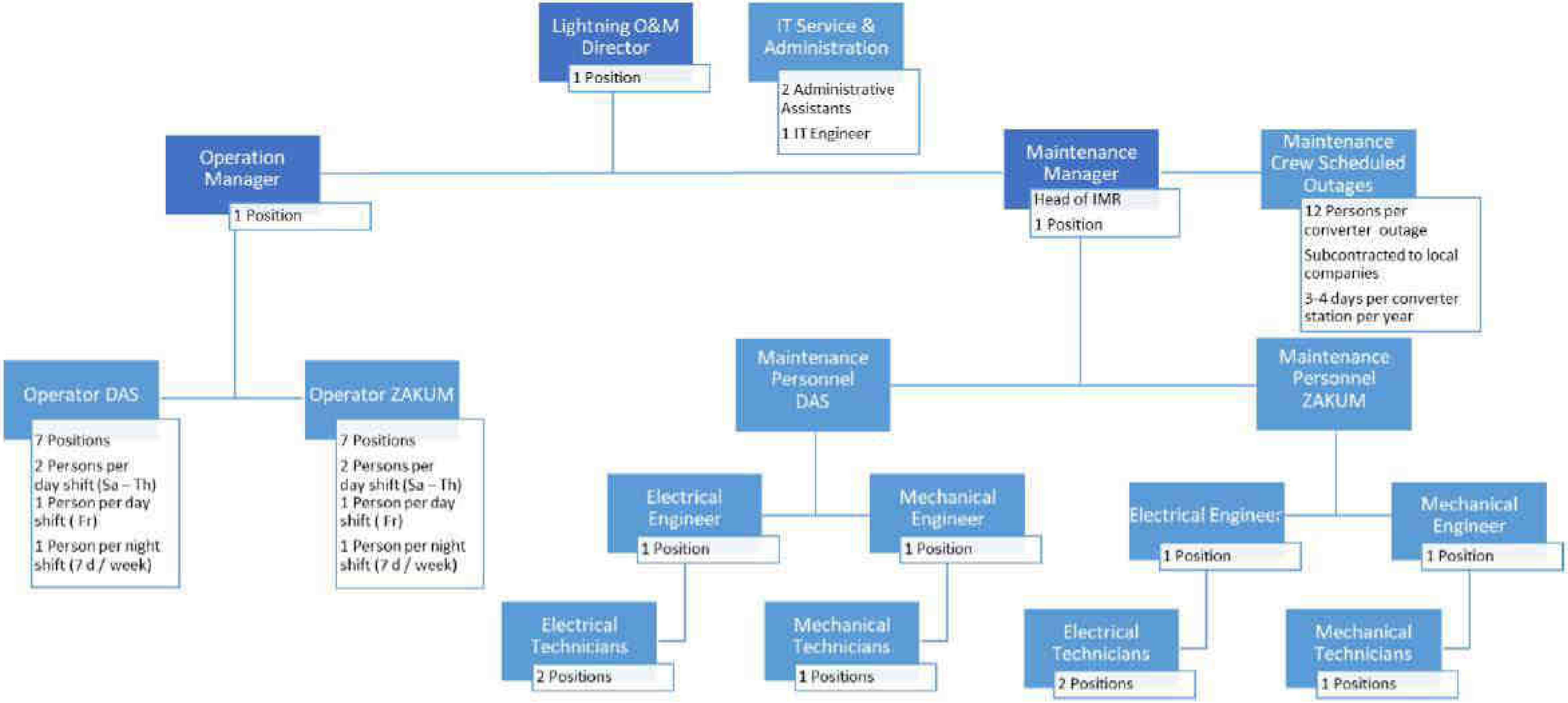


Figure 4-123: Project operational manpower requirements

4.3.2.4. Expected Types and Quantities

4.3.2.4.1. Raw Materials and Chemicals

Construction Phase

A list of the expected types of construction materials and chemicals is presented in Table 4-30 below.

Table 4-30: General list of expected raw materials and chemicals required during construction

Potential Raw Material & Chemicals used for the Project Masterplan		
– Fine aggregate	– Reinforced bar	– Bolt, nut and washer
– Coarse aggregate	– Structural steel	– Gasket
– Cement	– Sandwich panel	– Welding materials
– Admixtures	– Cable	– Stainless steel
– Water	– Subsea cable	– Carbon steel
– Alloy steel	– Electric conduit	– Paint
– Paint	– Gatch soil	– Non-shrink grout
– Oxygen	– Argon	– Diesel oil
– Gasoline oil	– Form oil	– Tar
– Waterstop	– Waterproofing membrane	– Steel grating
– Fencing	– Marine gas oil	– Lube oil
– Hydraulic oil	– Gear oil	– Grease
– Rock for cable protection		

Operational Phase

Due to the nature of the Project, it is not considered that a significant quantity of raw materials or chemicals would be required. Chemicals and paints may be utilised during routine maintenance of the converter stations, interface buildings and other tie-in elements of the Project but exact types and quantities are not currently available. It is expected that detailed raw material and chemical types and quantities will be included the OESMP to be prepared and implemented by in accordance with ADNOC operational requirements.

4.3.2.4.2. Power Usage

Construction Phase

At this stage, no power usage estimates are available for the construction phase. This will be provided in the EPC's CESMP.

Operational Phase

During operation, it is estimated that each station will utilise 2,900kW during the operational phase.

4.3.2.4.3. Expected Water Requirements

Construction Phase

Information on expected water types and quantities to be consumed during the construction phase is currently limited to the following:

- It is not expected that groundwater will be abstracted or used for construction purposes; and
- One freshwater tank of 5,000 litres capacity will be provided at each location (Mirfa, Shuweihat, Al Ghallan Island and Das Island).

Further details will be provided in the EPC's CESMP.

Operational Phase

During operation, it is estimated that each of the four stations will use 2m^3/day, for office-based activities, rather than Project processes.

4.3.2.4.4. Expected Waste Streams

Construction Phase

At this stage, estimates for expected waste streams are currently available. This will be provided in the EPC's CESMP.

Operational Phase

Solid Waste

No estimates for expected solid waste streams are currently available.

Liquid Waste

It is estimated at each station will generation 3m^3/day of sanitary wastewater to be collected in septic tanks at each location. A total of 12m^3/day is therefore expected to be generated by the Project overall.

Hazardous Waste

No estimates for expected hazardous waste streams are currently available.

4.3.2.4.5. Point Source Emissions and Pollution

Construction Phase

Construction equipment and machinery types expected to be utilised during the construction phase, including numbers required and quantities and types of fuel expected to be used have been summarised below in Table 4-31.

Table 4-31: Construction machinery and fuel consumption

Description	Fuel Consumption		Total	Max	2022	2023				2024				2025				2026	
	Consumption Rate (monthly)	Total Consumption (Ltr)	EQ-Month	EQ-Month	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q
Crane (200t)	5,200	322,400	62	18	-	-	8	16	18	6	-	-	8	6					
Crane (< 200t)	3,744	1,452,672	388	63	-	18	22	23	30	48	63	63	51	37	24	9	-		
Excavator	4,202	789,901	188	27	3	9	18	24	27	27	27	21	18	12	2				
Dump Truck	4,160	1,426,880	343	54		18	36	36	45	54	54	54	30	16					
Fork Lift	1,186	439,858	371	36		18	18	27	36	36	36	36	36	36	36	36	20		
Boom Truck	978	219,960	225	36	-	9	9	18	18	21	30	27	36	22	21	14	-	-	
Generator	4,035	3,353,251	831	108	18	45	54	66	72	84	108	108	108	90	30	18	18	12	
Trailer	3,578	1,082,224	303	36	10	18	23	30	30	34	36	36	36	24	14	6	4	3	
Manlift	2,350	1,421,992	605	72	20	35	45	60	60	68	72	72	72	48	28	11	8	6	
Truck	2,683	2,435,004	908	108	30	53	68	90	90	102	108	108	108	72	42	17	12	9	
Total =		**12,944,142**	**4,223**		**81**	**222**	**300**	**390**	**426**	**480**	**534**	**525**	**503**	**363**	**197**	**111**	**62**	**29**	

In addition, the EPC provided the following information in regard to refuelling, greasing and hydraulic oil:

- BHD and starfish excavators have automatic greasing systems meaning that the equipment will grease during its operation;
- In addition to the automatic greasing, the BHD require additional manual greasing at very regular intervals (six hours); and
- BHD and starfish excavators are hydraulically operated and have a significant amount of hydraulic oil and related equipment (hoses, filters, etc.). Preventive maintenance will occur on a daily basis.

Example of likely activities, environmental aspects and potential impacts are also provided below in Table 4-32 below although this list is not comprehensive and there could be additional activities depending on the final Project design and construction measures. Mitigation measures to address the listed potential impacts are provided in the "Mitigation Measures" chapter for each environmental aspect.

Table 4-32: Potential source of pollution and expected impacts during construction phase

Potential Impacts	Environmental Aspects	Activities
Degradation of air quality	– Dust emissions – Emission of air pollutants from fuel burning machines and vehicles etc.	– Machinery and vehicle movements – Excavation activities – Movement of fine materials (sand, soil etc.) – Operation of machines and vehicles
Pressure on waste facilities, potential contamination caused by waste mismanagement etc.	– Increase of waste generation – Mismanagement of waste etc. – Hazardous waste generated	– General construction activities – Municipal waste generated from workers etc.
Soil and Groundwater degradation and contamination	– Discharge of contaminated water – Leaks or spillages from machinery, equipment or stored chemicals (oils, fuels and chemicals etc.) – Spillages from refuelling operations; – Spillage from sanitary effluents – Incorrect practices such as unappropriated discharges in the environment etc.	– Dewatering activities – Excavation activities – Refuelling activities – Operation of machinery and equipment
Loss of terrestrial habitats, loss of flora, disturbance of fauna	– Loss of habitats – Noise emissions – Air emissions	– Site clearance and site levelling – Excavation – Construction vehicles movement – Noisy construction activities – Creation of roads – Creation of building and hard surfaces

Potential Impacts	Environmental Aspects	Activities
Noise emissions	– Increase in traffic noise – Increase in construction noise related to construction activities etc.	– Movement of materials for the Project construction – Noisy machines such as dump trucks, cement mixers, cement cutters, electric saws, tamping machines and welding machines etc.
Road and Marine Traffic impact	– Accidents – Congestion etc.	– Increase of construction vehicles movement – Increase of construction marine based vessels
Marine water quality degradation	– Discharge of contaminated water – Leaks or spillages from machinery, equipment or stored chemicals (oils, fuels and chemicals etc.) – Spillages from operation, maintenance and refuelling operations; – Spillage from sanitary effluents – Incorrect practices such as unappropriated discharges in the environment etc.	– Trenching, backfilling and dredging activities within the nearshore areas – Dewatering activities – Refuelling activities – Operation of vessels, machinery and equipment
Loss and/or disturbance of the existing marine habitat, flora and fauna	– Degradation of water quality within MMBR and surrounding areas of critical habitat – Loss of habitats, flora and/or fauna	– Dewatering activities – Chemical leakage and spills – Trenching, backfilling and dredging activities within nearshore areas – Post-lay trenching, cable laying, rock installation etc.
Construction workers accidents (health and safety impacts)	– Explosion – Fire – Falls – Mishandling of machines and dangerous chemicals – Traffic accidents etc.	– Storing chemicals – Refuelling activities – Working in heights – Driving or walking on-site etc.
Impacts upon commercial activities, businesses, and community	– General disruption to local businesses and commercial activities including EAD Pearl Farm, businesses in Mirfa, and other commercial activities as a result of the generation of dust, noise, traffic, sediment dispersion in addition to general disturbance during the construction period	– Machinery and vehicle movements – Excavation activities in the onshore areas – Trenching, backfilling and dredging in the nearshore areas – Movement of fine materials (sand, soil etc.) – Operation of machines and vehicles etc.

Potential Impacts	Environmental Aspects	Activities
Loss of buried archaeological features	– Destruction of archaeological features	– Excavation activities in the onshore areas – Trenching, backfilling and dredging in the nearshore areas – Post-lay trenching, cable laying, rock installation etc. – Vehicles movements
Climate Change impacts	– Loss of blue carbon reserves.	– Removal of habitats capable of carbon sequestration.

Operational Phase

Due to the nature of the Project, it is not expected that there will be any significant point source emissions or pollution created as a result of the operational phase. The installation of the cables will result in a reduction of existing emission levels by negating the requirement for the use of GTGs for power sources for offshore activities. It is understood that a backup diesel generator will be provided at each of the four station locations for use in emergency situations. It is expected that the use of these generators would be seldom and for limited time periods whilst operational issues relating to electricity supply are resolved. Overall, it is therefore considered that the Project will result in a net positive impact in terms of reducing greenhouse gas emissions and pollutants.

Noise emissions are expected to be minimal and to be approximately 60dB, meaning that there will be no expected exceedances of UAE or IFC allowable noise limits.

4.3.2.5. Proposed Future Expansions or Phases

No information is currently available regarding any proposed future expansions or phases for the Project.

4.3.2.6. Decommissioning Phase

It is understood that following 35 years of operation, the Project will be transferred back to ADNOC for continuing operations. During the initial 35-year operational phase, it is envisaged that three refurbishments of the Project will be undertaken.

4.4. Project Status and Schedule

4.4.1. Overall Schedule

The key dates and proposed Project schedule information is provided below in Table 4-33.

Table 4-33: Project schedule

Milestone	Final Completion Date
Submission of proposal	28 November 2020
Execution of Shareholders' Agreement and Transmission Agreement	21 December 2021
Closing Date	10 August 2022
Route 2 Scheduled Commercial Operation Date	25 September 2025
Route 1 Scheduled Commercial Operation Date	25 December 2025
Scheduled Project Commercial Operation Date	25 December 2025

4.4.2. Indicative Construction Dates

Indicative dates for the construction elements of the Project are set out below in Table 4-34. Additionally, a detailed construction schedule is presented in **Appendix 7.1.**

Table 4-34: Indicative construction dates

Activity	Start Date	Finish Date
Onshore Works		
Site investigations	17.02.2022	5.08.2022
Power cable installation (all sites)	01.01.2024	12.12.2024
Riser platform installation (all sites)	29.11.2023	17.01.2024
Civil Works		
Mirfa	26.06.2023	24.07.2024
Al Ghallan Island	18.12.2023	08.09.2024
Shuweihat	18.12.2023	20.10.2024
Das Island	03.12.2023	21.07.2024
Marine Works		
Backhoe dredger 1 – trenching	01.08.2023	24.10.2024
Backhoe dredger 1 – backfilling	08.03.2024	18.11.2024
Backhoe dredger 2 – trenching	01.08.2023	16.02.2024
TSHD – trenching	18.01.2024	24.10.2024
TSHD – backfilling	13.02.2024	22.11.2024
Starfish – trenching	22.01.2024	02.01.2025
Starfish – backfilling	14.04.2024	02.01.2025
Subsea rock installation (SRI)	10.02.2024	30.04.2025

5. ENVIRONMENT, IMPACTS, MITIGATION, MONITORING AND RISK ASSESSMENT

5.1. Air Quality

5.1.1. Description of the Environment

This section includes a summary of existing baseline information relating to the Emirate of Abu Dhabi and the Project area. As stated within the approved Project Lightning Scoping Document (27th September 2021), no air quality monitoring is considered to be necessary as construction impacts are likely to be limited to dust emissions and there will be no operational emissions. Therefore, no primary baseline data have been collected from within the Project site as part of this ESIA, although publicly available data sources and data collected by ADNOC within their offshore areas has been collected and summarised within this section.

5.1.1.1. Baseline Methodology

Existing climatic data has been collected from published sources. This provides long-term regional and seasonal baseline data from within the Project area.

Existing data has been reviewed from the established EAD network of air quality monitoring stations (AQMS) which are located throughout the Emirate of Abu Dhabi (54). Data have been reviewed for the Ruwais AQMS to provide an overview of general baseline conditions.

Lastly, air quality monitoring data from Das Island have been supplied by ADNOC to provide an indication of conditions within the ADNOC offshore areas.

5.1.1.2. Baseline Conditions

5.1.1.2.1. Climate

Abu Dhabi Overview

Temperatures within the UAE vary through the seasons with coastal zones showing less variation than inland and mountainous zones. Generally, the humidity is higher closer to the Arabian Gulf and to the Gulf of Oman, and lower in inland areas of the UAE's south, south-west and Al Ain region (55).

Abu Dhabi is characterised by a hot desert climate - Köppen climate classification BWh (56). Sunshine days can be expected throughout the year. The months of June through September are generally extremely hot and humid with maximum temperatures averaging above 41 °C. During this time, sandstorms occur intermittently, in some cases reducing visibility to a few meters (57).

The cooler season is from November to March (57), which ranges between moderately hot to mild. This period also experiences dense fog on some days and a few days of rain. On average, January is the coolest month in the year, while August is the hottest. Since the Tropic of Cancer passes through the Emirate, the southern part falls within the tropics. However, despite the coolest month having an 18.8 °C average, its climate is far too dry to be classed as tropical (57). The climatic data for Abu Dhabi is given in Table 5-1 below.

Ruwais

Data from the Ruwais weather monitoring station in Figure 5-1 (58) shows that the mean temperature reaches a high of 36.2°C in July and a low of 19.1°C in January, with the maximum temperature in July reaching 51.2°C and minimum temperature in January of 6°C.

Mirfa

Data from the Abu Al Abyad weather monitoring station in Figure 5-2 (58), located on Abu Al Abyadh Island, approximately 35km to the east of Mirfa shows that the mean temperature reaches a high of 35.1°C in August and a low of 18.5°C in January, with the maximum temperature in August reaching 48.7°C and minimum temperature in January of 7.1°C.

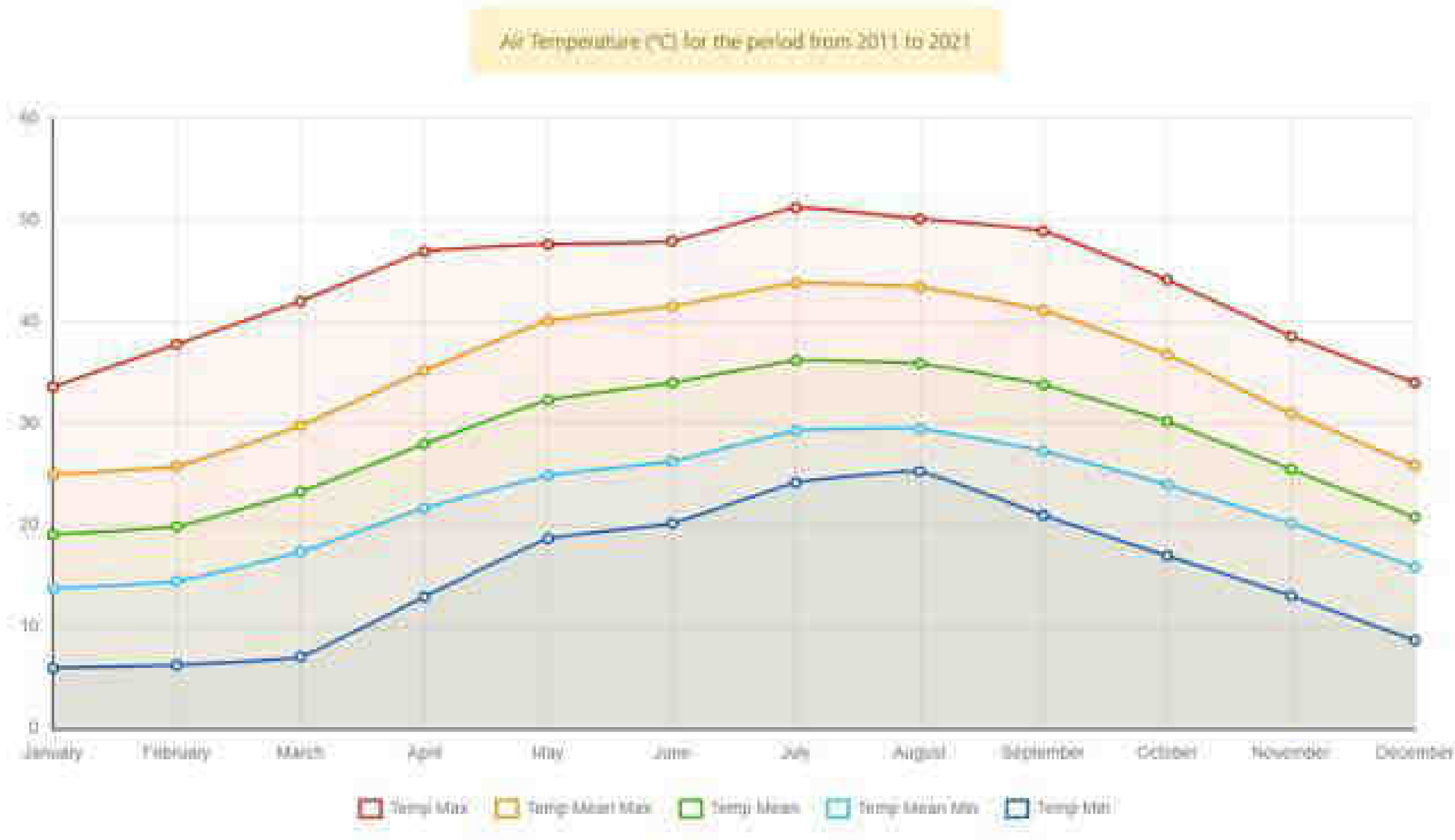


Figure 5-1: Al Ruwais temperature (58)

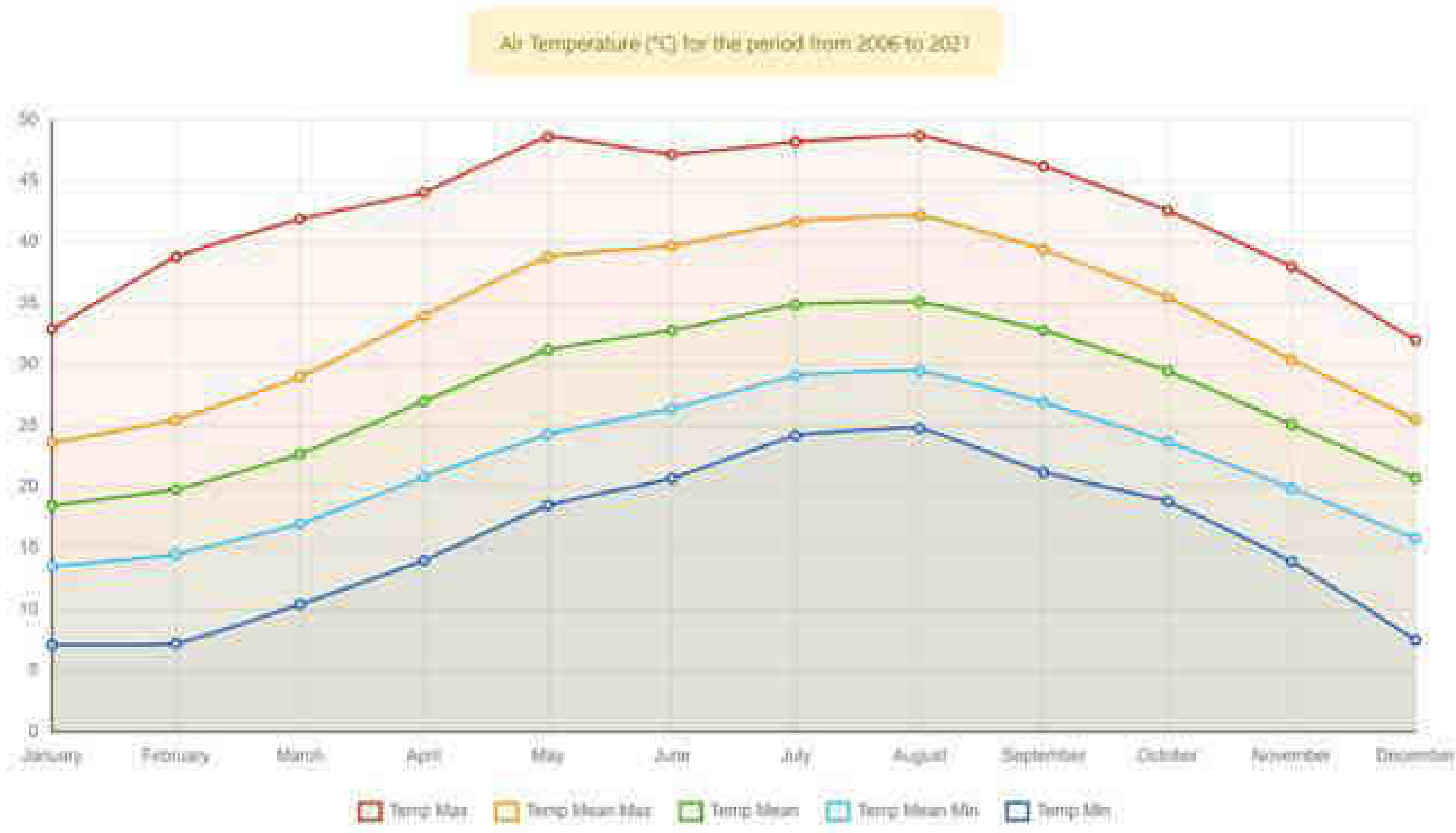


Figure 5-2: Abu Al Abyad Temperature (58)

Table 5-1: Climatic data for Abu Dhabi (57)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C	33.7	38.1	43.0	44.7	46.9	48.8	48.7	49.2	47.7	43.0	38.0	33.4	49.2
Average high °C	24.1	26.0	29.5	34.5	39.3	40.8	42.1	42.9	40.4	36.5	31.1	26.3	34.5
Daily mean °C	18.8	19.6	22.6	26.4	31.2	33.0	34.9	35.3	32.7	29.1	24.5	20.8	27.4
Average low °C	13.2	14.6	17.5	20.8	23.8	26.1	28.8	29.5	26.6	23.2	18.7	15.8	21.5
Record low °C	5.0	5.0	8.4	11.2	16.0	19.8	16.5	17.0	19.0	12.0	10.5	7.1	5.0
Average rain mm	7.0	21.2	14.5	6.1	1.3	0	0	1.5	0	0	0.3	5.2	57.1
Average rain days (≥ 0.2 mm)	1.2	2.8	2.8	1.2	0.1	0.0	0.0	0.1	0.0	0.0	0.2	1.5	9.9
Average relative humidity (%)	68	67	63	58	55	60	61	63	64	65	65	68	63
Mean monthly sunshine hours	246	233	251	280	342	337	314	308	302	305	287	258	3,462

5.1.1.2.2. Wind

UAE Overview

Within the UAE, prevailing wind direction varies depending on locations and seasons. The prevailing wind in the region is generally from a north-westerly direction. However, as discussed in the section below, there is significant variation in wind direction, largely influenced by geographical location and seasonal variations.

Wind speeds in the UAE are generally below 10 m/s for most of the year. Strong winds with mean speeds exceeding 10 m/s over land areas occur in association with a weather system, such as an active surface trough or squall line. Occasional strong winds also occur locally during the passage of a gust front associated with a thunderstorm (59). Strong north-westerly winds, called Shamal winds, often occur ahead of a surface trough, but usually do not last more than 6–12 hours (59). The Shamal winds blow from Iraq, crossing Kuwait, Saudi Arabia, Qatar and the UAE. Regionally, these winds can lead to sandstorms. However, the main source of sandstorms / events in the UAE comes from the southerly direction.

Project Area

A wind rose for Ruwais is presented in Figure 5-3, which has been derived from data collected by the EAD at their Ruwais ambient air quality monitoring station (60). This highlights that the predominant wind direction is from the north (offshore), and these northerly winds are generally associated with higher wind speeds. The next predominant wind direction is an onshore wind arising from the south and east, although these winds are generally associated with lower wind speeds.

Wind speed data from the Al Ruwais weather monitoring station as shown in Figure 5-4 (58) generally shows little variation across the year, with slightly higher mean maximums during the summer period and lower speeds during the winter. The maximum wind speeds are recorded during November.

Wind speed data from the Abu Al Abyad weather monitoring station close to Mirfa as shown in Figure 5-5 (58) generally shows little variation across the year, with slightly higher mean maximums during the summer period and lower speeds during the winter. The maximum wind speeds are recorded during March and April and again in October and November.

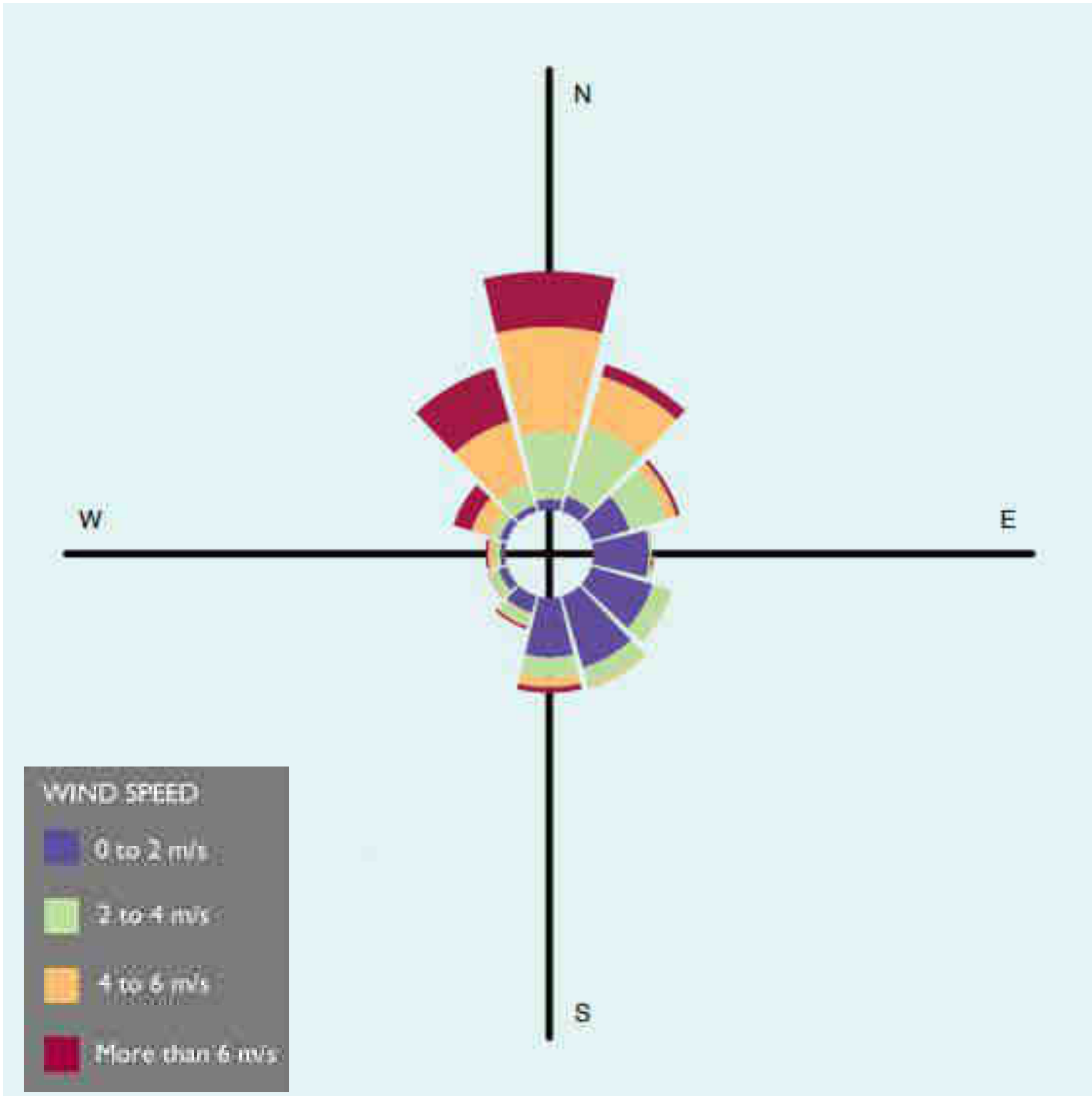


Figure 5-3: Wind rose for Ruwais EAD AQMS (60)

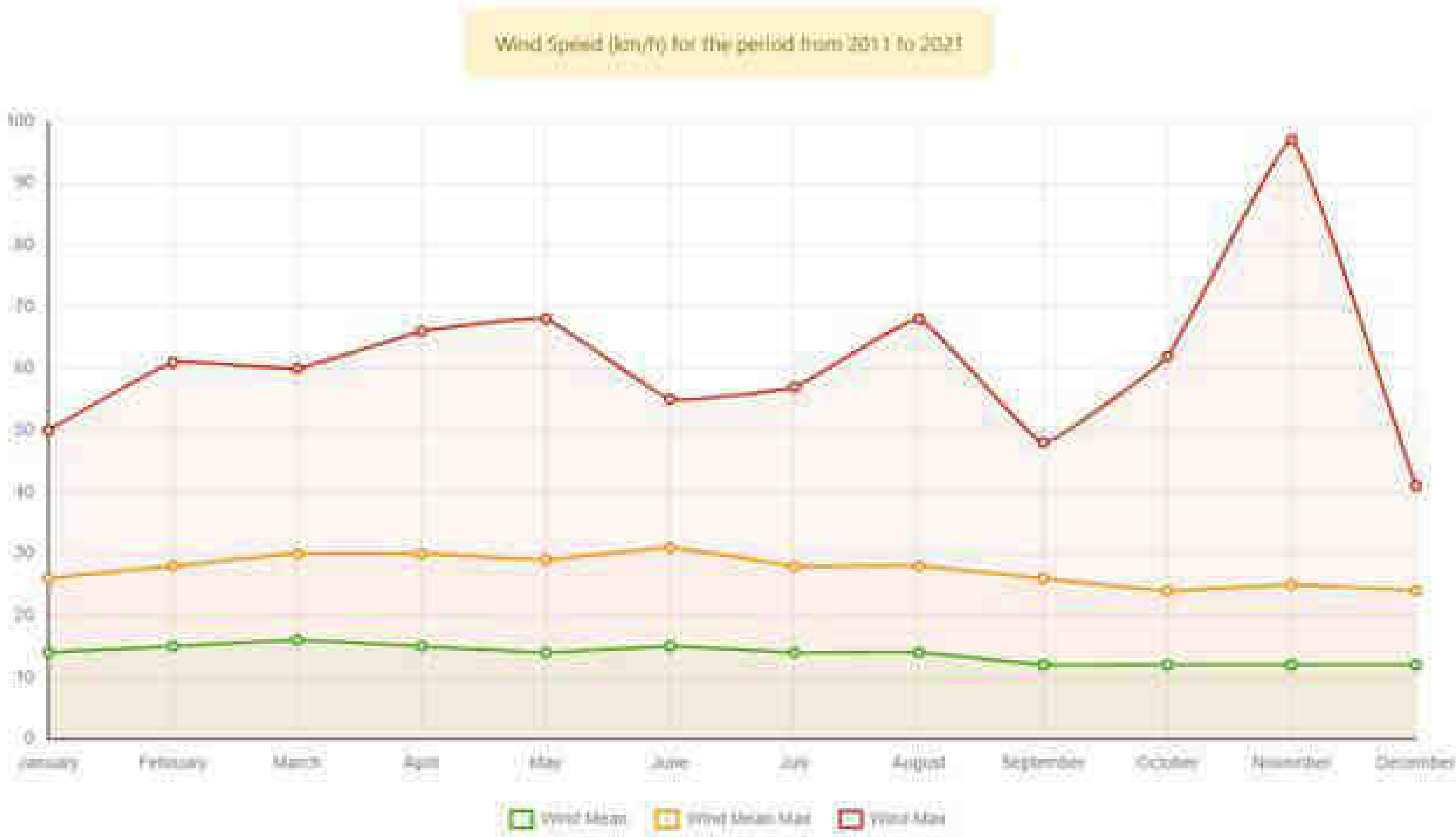


Figure 5-4: Al Ruwais wind speed (58)

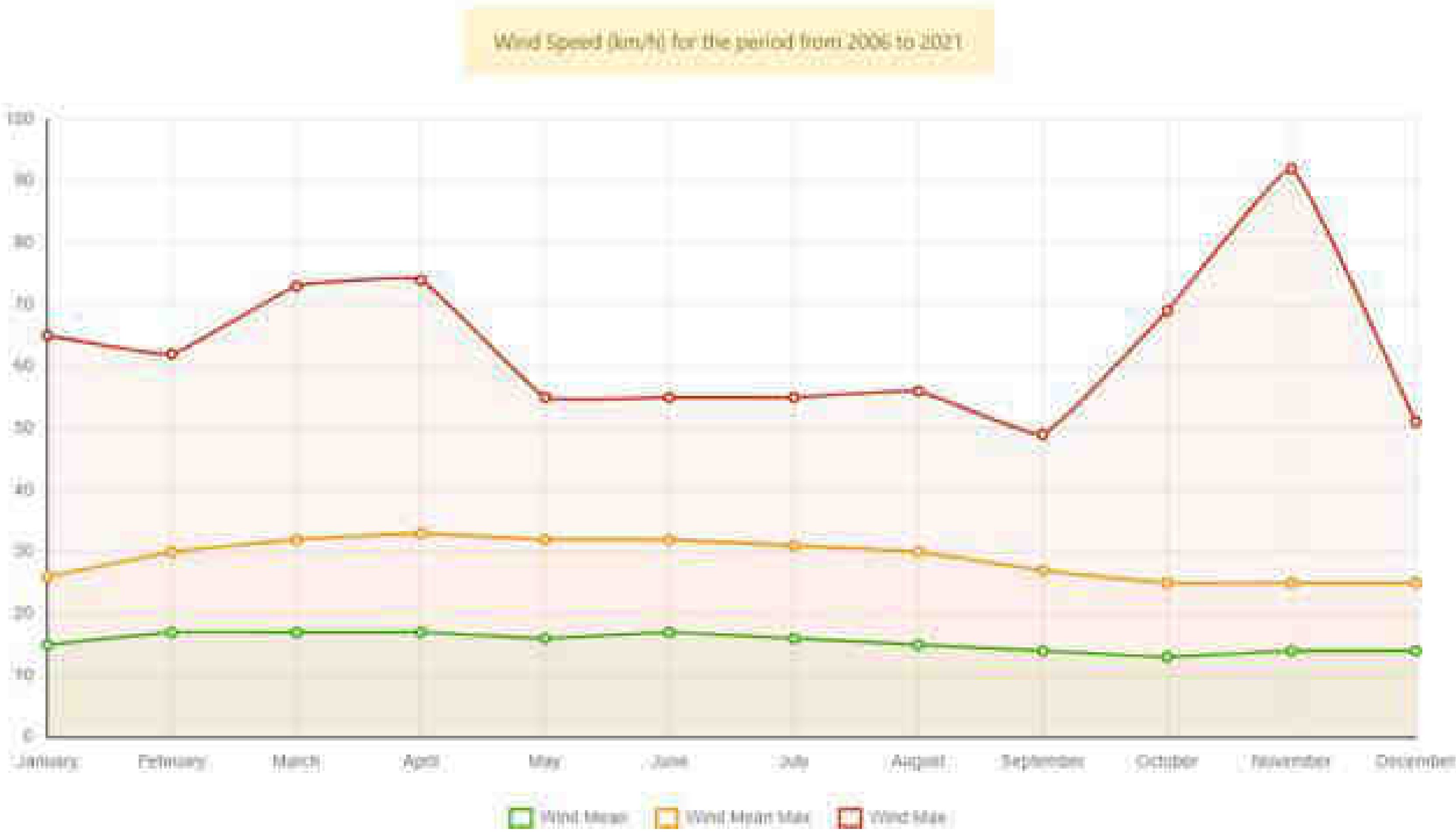


Figure 5-5: Abu Al Abyad wind speed (58)

5.1.1.2.3. Air Quality

Some parts of Abu Dhabi Emirate experience poor air quality, particularly in relation to ozone and particulates. Road traffic and industrial sources appear to be the most important contributors to high air pollution levels, but the relative importance of these sources differs in different parts of the Emirate depending on land use and emission sources (anthropogenic and/or natural).

Particulate levels do naturally show elevated levels due to the presence of large sources of dust and lack of vegetation given the aridity of the UAE. The EAD AQMS network includes an AQMS near to Ruwais City (54) which is located approximately 19km south-east from Al Shuweihat Power and Water Complex. Live data accessed in February 2022 for this station illustrated exceedances of ambient air quality standards for PM_{10} (54). However, all other pollutants were within acceptable limits and the air quality index (AQI) was 86 – Moderate.

The nearest EAD AQMS to the Al Mirfa Power and Water Complex is located adjacent to the E11 and within the Rural Traffic Category, located approximately 40km to the east of Project site. Live data accessed in early January 2022 for this station illustrated exceedances of ambient air quality standards for PM_{10} (7). The AQI for this AQMS was 90 – Moderate. However, all other pollutants were within acceptable limits. Given the location of this EAD AQMS station adjacent to a highway and with a significant separation distance from Mirfa, it is not considered that ambient air quality data from this AQMS are representative of the Project site.

It is considered that the airshed within both onshore Project locations, in addition to Das Island and Al Ghallan Island, are likely to already be degraded due to the presence of significant power and water generating facilities. Key sources of emissions within both onshore tie-in locations will be associated with both open and closed cycle gas turbines utilised within the existing power and water complexes at each location. Likely emissions will include nitrogen oxides (NO), with a smaller contribution from carbon monoxide (CO) and sulphur dioxide (SO_2).

Emissions levels from vehicles within the Project study area are likely to be significantly lower, due to limited development within the surrounding Project areas onshore. Vehicle emissions on Das and Al Ghallan Island are not considered likely to be significant.

PM_{10} levels are liable to remain elevated due to the desert environment.

5.1.2. Environmental Impact Prediction and Evaluation

5.1.2.1. Impact Assessment Methodology

5.1.2.1.1. Impact Severity

Construction Phase

As dust emissions are primarily associated with nuisance impacts at nearby receptors, a qualitative assessment of dust emissions during construction related activities has been undertaken. The significance of dust impacts is largely dependent on wind direction, rainfall and distance from point of emission, as dust formation is considered low during wet and calm periods. The assessment criteria that is presented below is based on the following key points, taking into account that the majority of the existing receptors are not located downwind of the Project site:

- At the most extreme wind speeds, dust will typically travel a maximum of 200 m from source before falling from the air column;
- At extreme wind speeds, dust is unlikely to travel more than 500 m from source; and
- Precipitation will effectively attenuate dust, with rainfall of >0.2 mm/h likely to effectively minimise dust emissions. It is noted that rainfall in the region is very low and therefore rainfall is unlikely to be a significant factor.

In order to assess the potential impact for significant dust nuisance to arise from the construction phase, the matrix detailed in Table 5-2 has been developed.

Table 5-2: Air quality impact severity (construction)

Impact Severity	Dust Assessment Criteria
No Change / Slight	Dust generating activities for <12 months Receptor > 500 m from dust source; or Dust generating activities for > 12 months; Receptor >1,000m from dust source
Low	Dust generating activities for >12 months Receptor between 200 m to 500m from dust source
Medium	Dust generating activities for >12 months Receptor within 200 m of dust source
High	Dust generating activities for >12 months Receptor within 100 m of dust source

Operation Phase

As stated within the approved Project Lightning Scoping Document (27th September 2021), no significant impacts are anticipated during operation as there will be no emissions to air with the exception of back-up generators, which would be used in emergency cases only, and no change in terms of dust generation potential. Therefore, a detailed assessment was proposed to be scoped out of the ESIA.

5.1.2.1.2. Air Quality Sensitive Receptors

The sensitivity of potential receptors that may be impacted by air quality have been identified and detailed below in Table 5-3.

Table 5-3: Air quality sensitive receptors

Sensitive Receptor	Receptor Class Value	Justification
Operational staff at adjacent facilities including Al Mirfa and Al Shuweihat Power and Water Complex, and facilities on Das Island and Al Ghallan Island.	*Medium-High*	Existing operational staff at adjacent facilities may potentially experience a degradation in air quality as a result of construction activities associated with the Project. Since the operational workers can be considered to be working in a potentially already degraded airshed, it is important to consider any additional Project related air quality impacts which may result in exceedances of ambient air quality limits and thereby represent potential health risks.
Construction workers associated with the Project	*Medium-High*	Construction workers associated with the Project will be exposed to the greatest concentration of gaseous and dust emissions, thereby rendering them as highly sensitive to degradation of air quality.
Residential properties	*Medium-High*	Residential communities are sensitive to dust and gaseous emissions from construction activities.

5.1.2.2. Construction Phase Impacts

5.1.2.2.1. Introduction

As identified within **Section 4.2.4**, the nearest sensitive receptors, in addition to the local airshed within the Project area, relate to existing operational staff within the power and water complexes at both Al Mirfa and Al Shuweihat power and water complexes and facilities at Das Island and Al Ghallan Island, and nearby residential properties at Mirfa.

The key impacts to ambient air quality associated with the Project during the construction phase are anticipated to be as follows:

- Emissions associated with construction vehicles transporting materials and personnel into and from the site i.e. offsite emissions (e.g. construction vehicles, transport of workers, and delivery vehicles) from Project construction activities;
- Gaseous emissions associated with construction activities onsite (e.g. equipment, heavy machinery and vehicle idling);
- Gaseous emissions associated with marine vessels and equipment (which will utilize diesel and MGO) undertaking offshore dredging and cable laying activities;
- Dust generated by earth working and on-site vehicle movement activities; and
- Dust generated by the transportation and movement/loading of rocks from an existing UAE based quarry (**location to be confirmed within the CESMP**) to the loading port (**to be identified within the CESMP**) for the required rock installations as cable protection.

Examples of general construction activities anticipated on site, which could give rise to air quality impacts are as follows:

- Site clearance and preparation:
  - Demolition of existing structures;
- Earthworks:
  - Vegetation removal;
  - Cable laying activities;
  - Site levelling;
  - Stockpiling of soils / spoil;
  - Wind blown from exposed soils;
  - Material handling;
  - Movement of vehicles onsite, particularly on unpaved surfaces.
- Roads, infrastructure and building construction:
  - Concreting operations;
  - Movement of vehicles onsite, particularly on unpaved surfaces;
  - Transporting rocks for subsea rock protection;
  - Road laying activities;
  - Stockpiling of materials;
  - Emissions of volatile chemicals from use of paints, solvents, adhesives.
- Dust track-out / wind blow from vehicle movements:
  - Vehicles leaving site carrying materials; and
  - Wind-blown from materials transported to/ throughout site.

- Operation of machinery and equipment:
  - Exhaust emissions from machinery, equipment and vehicles, both onshore and offshore.

5.1.2.2.2. Dust Emissions

It is anticipated that the main dust generating activities will include the following:

- Site clearance, preparation and earthworks;
- Excavation for cable laying onshore, levelling, filling and foundation works;
- Materials handling, storage, stockpiling, spillage and disposal;
- Transporting rocks for subsea rock protection;
- Movement of vehicles and construction traffic within the site (including excavators, dumper trucks, mobile cranes and bulldozers);
- Re-entrainment of particulate matter to the air from the passage of vehicles over unpaved roads/surfaces; and
- Open areas of the Project site itself can be a source of dust during windy conditions and will remain so until sealed.

At this stage, the final design and construction methodology is not available and will be the responsibility of the EPC Contractor to develop in detail. This assessment is therefore based upon reasonable assumptions in order to identify if significant air quality impacts are likely to occur, which will require the implementation of control measures.

Airborne soil dust is typically coarse and therefore remains airborne only for short periods. USEPA research shows that in excess of 90% of total airborne dust returns to the earth's surface within 100 m of the emission point and over 98% within 250 m. When working in uncontaminated soils, such dust normally represents only a nuisance to human receptors exposed, although additional potential impacts may include respiratory health conditions and discomfort.

Dust impacts are therefore considered likely within a general radius of 350m from a dust source or up to 500m on a public highway from the construction site entrance, based upon guidance issued by the IAQM (61). To be conservative, we have included all sensitive receptors up to a maximum radius of 500m to allow for adverse meteorological conditions and in cases where large quantities of dust could be generated. The nearest sensitive receptors to the Project boundary are:

- Mirfa – The cable corridor will pass within 90m of the nearest residential receptor property boundary and around 250m from the nearest residential building within these plots, and therefore cable laying activities may result in dust impacts in these areas;
- Shuweihat – no sensitive receptors (other than construction workers for the Project and operational workers for adjacent facilities, described below) are present within a 500m radius and therefore it is considered unlikely that any significant impacts will occur as a result of dust impacts;
- Construction workers for the Project would be the closest sensitive receptors in relation to dust generation;
- Existing operational staff within adjacent onshore and offshore facilities at Mirfa, Shuweihat, Das Island and Al Ghallan Island could be working within 500m of construction activities and could therefore be exposed to elevated dust levels; and
- Marine, terrestrial and intertidal habitats are located within 500m of construction activities.

A wind rose for Ruwais is presented in Figure 5-3, which highlights that the predominant wind direction is from the north (offshore) and that these northerly winds are generally associated with higher wind speeds. The next predominant wind direction is an onshore wind arising from the south and east, although these winds are generally associated with lower wind speeds. This suggests that any nearby sensitive receptors to the south would be the most impacted followed by receptors to the north-west of the Project site.

The impact significance for the separate Project areas is discussed in the below sub-sections:

Mirfa

The residential developments to the east of the Project site at Mirfa, which appear to comprise second or weekend homes, are within 500m and as close as 90m to the Project boundary at some locations (although the actual residential properties are located a minimum of 250m from the Project site). Given this proximity, impacts are likely which is considered to be an impact of *medium* severity upon receptors of *medium-high* sensitivity which is an impact of **moderate negative** significance prior to the implementation of mitigation measures.

There are a number of commercial areas (e.g. Mirfa Hotel and receptors on the outskirts of Mirfa Town) located significantly further (>1km) from the tie-in location landfall area to the south east. No impacts are predicted at these locations.

Construction workers would be exposed to dust during construction works. Given their proximity to dust generating activities, this is predicted to be an impact of *high* severity upon receptors of *medium-high* sensitivity which is an impact of **major negative** significance prior to the implementation of mitigation measures.

Operational workers within the Al Mirfa Power and Water Complex could be working within 500m of the Project site and would be exposed to elevated dust levels. This impact magnitude is predicted to be of *medium* severity upon receptors of medium-*high* sensitivity. Therefore, the impact is assessed as being **moderate negative** in significance.

It should be noted that all of the impacts identified above, will be of a temporary nature only during construction activities.

Shuweihat

There are no residential or other receptors located within 500m of the Project site. No impacts are predicted at these locations.

Construction workers would be exposed to dust during construction works. Given their proximity to dust generating activities, this is predicted to be an impact of high severity upon receptors of medium-high sensitivity which is an impact of **major negative** significance prior to the implementation of mitigation measures.

Operational workers within the Al Shuweihat Power and Water Plant could be working within 500m of the Project site and would be exposed to elevated dust levels. This impact magnitude is predicted to be of *medium* severity upon receptors of medium-*high* sensitivity. Therefore, the impact is assessed as being **moderate negative** in significance.

It should be noted that all of the impacts identified above, will be of a temporary nature only during construction activities.

Al Das Island and Al Ghallan Island

Construction workers would be exposed to dust during construction works. Given their proximity to dust generating activities, this is predicted to be an impact of high severity upon receptors of medium-high sensitivity which is an impact of **major negative** significance prior to the implementation of mitigation measures.

Operational workers on Das Island and Al Ghallan Island could be working within 500m of the Project site and would be exposed to elevated dust levels. This impact magnitude is predicted to be of *medium* severity upon receptors of medium-*high* sensitivity. Therefore, the impact is assessed as being **moderate negative** in significance.

Lastly, terrestrial and intertidal habitats, flora and fauna could be impacted by dust impacts within 500m of the construction activities. Given that high dust levels are a relatively common occurrence in the region, these are considered to be less sensitive (unless dust emissions are especially high). This is predicted to be an impact of medium severity upon receptors of medium sensitivity which is an impact of **minor negative** significance prior to the implementation of mitigation measures.

It should be noted that all of the impacts identified above, will be of a temporary nature only during construction activities.

Terrestrial and Marine Ecology

Terrestrial and intertidal habitats, flora and fauna and marine habitats and fauna could be impacted by dust impacts. These impacts are presented in **Section 5.6: Terrestrial Ecology** and **Section 5.5: Marine Ecology**.

5.1.2.2.3. Gaseous Emissions from Equipment and Vehicle Activities

The operation of onshore and offshore equipment and vehicles will result in emissions and odour which could impact upon a number of sensitive receptors. Such pollutants could include CO_2, CO, SO_2, NO_x, and TSP (including $PM_{2.5}$ and PM_{10}). Construction phase emissions are expected to arise predominantly from the following:

- Marine vessels, dredgers, barges and other marine based machinery which will utilise MGO and diesel;
- Road vehicles, particularly HGV deliveries to the Project sites; and
- Non-road vehicles (such as graders and backhoes) and stationary equipment (such as generators).

For onshore construction activities, the main emissions sources will arise predominately from the operation of non-road vehicles (such as graders and backhoes) and stationary equipment (such as generators and cranes). Experience of assessing the exhaust emissions from on-site plant and site traffic suggests that they are unlikely to make a significant impact on local air quality (62). Overall, onshore vehicle and construction equipment emissions are considered to represent an impact of **negligible** significance.

Offshore construction activities would be associated with higher emissions to air from marine vessels, dredgers, barges and other marine based machinery, which will utilise MGO and diesel. Although emissions will be greater than for onshore works, no sensitive human receptors (with the exception of construction workers) would be exposed. Therefore, the impacts are predicted to be of *medium* severity upon a receptor of *low-medium* sensitivity which is an impact of **minor negative** significance in the absence of mitigation measures.

5.1.2.3. Operational Phase Impacts

5.1.2.3.1. Emissions to Air

As stated within the approved Project Lightning Scoping Document (27th September 2021), no significant impacts are anticipated during operation as there will be no emissions to air with the exception of back-up generators, which would be used in emergency cases only, and no change in terms of dust generation potential. Therefore, a detailed assessment was proposed to be scoped out of the ESIA.

In summary, the only impacts expected during the operation phase are as follows:

- Emissions from offshore power generation facilities – the Project will allow the decommissioning of older, less efficient offshore generating facilities and replacement of electricity from more efficient conventional power generating facilities, nuclear generation and solar generation within Abu Dhabi. This is a **major positive impact** as net emissions to air from power generation at the Abu Dhabi level will be reduced; and

- Back-up generators are required at the four converter stations in case of emergency power loss. These would only be used in emergencies (or infrequently as part of testing and maintenance) and emissions from these back-up generators would be expected to be minimal. The impacts are therefore predicted to be **negligible**.

5.1.2.3.2. GHG Emissions

As mentioned in **Section 4.1**, the installation of the Project will result in a reduction of approximately 30% of existing emission levels by negating the requirement for the use of GTGs for power sources for offshore activities. The replacement of the GTGs with electricity generated from a range of more sustainable and renewable sources will result in a net **major positive** impact in terms of reducing greenhouse gas emissions and pollutants.

Table 5-4 and Figure 5-6 below provides an indication of ADNOC Offshore GHG intensity figures (kilograms of carbon dioxide per barrel of oil equivalent), assuming green power scenarios for all 32 of the current GHG abatement initiatives are being implemented by ADNOC (which includes Project Lightning). It is understood that the Project represents the key GHG abatement effort for ADNOC. As per the below figures, it can be seen that once the Project is operational (end 2025), the overall ADNOC offshore GHG Intensity will be reduced by 62% when compared from 2025 to 2030 which is understood to be the result of the Project combined with other abatement initiatives / projects.

Table 5-4: ADNOC offshore GHG intensity actual and forecasted figures

-	Actual Data				Forecasted Data								
Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
GHG Intensity *(kg CO_2e / boe*)*	5.7	5.2	6.7	7.3	6.6	6.5	6.4	6.3	4.3	2.9	2.4	2.4	2.4
GHG Intensity Reduction when compared to 2025	-	-	-	-	-	-	-	-	-32%	-54%	-62%	-62%	-62%
Note: * Kilograms of carbon dioxide/barrel of oil equivalent													

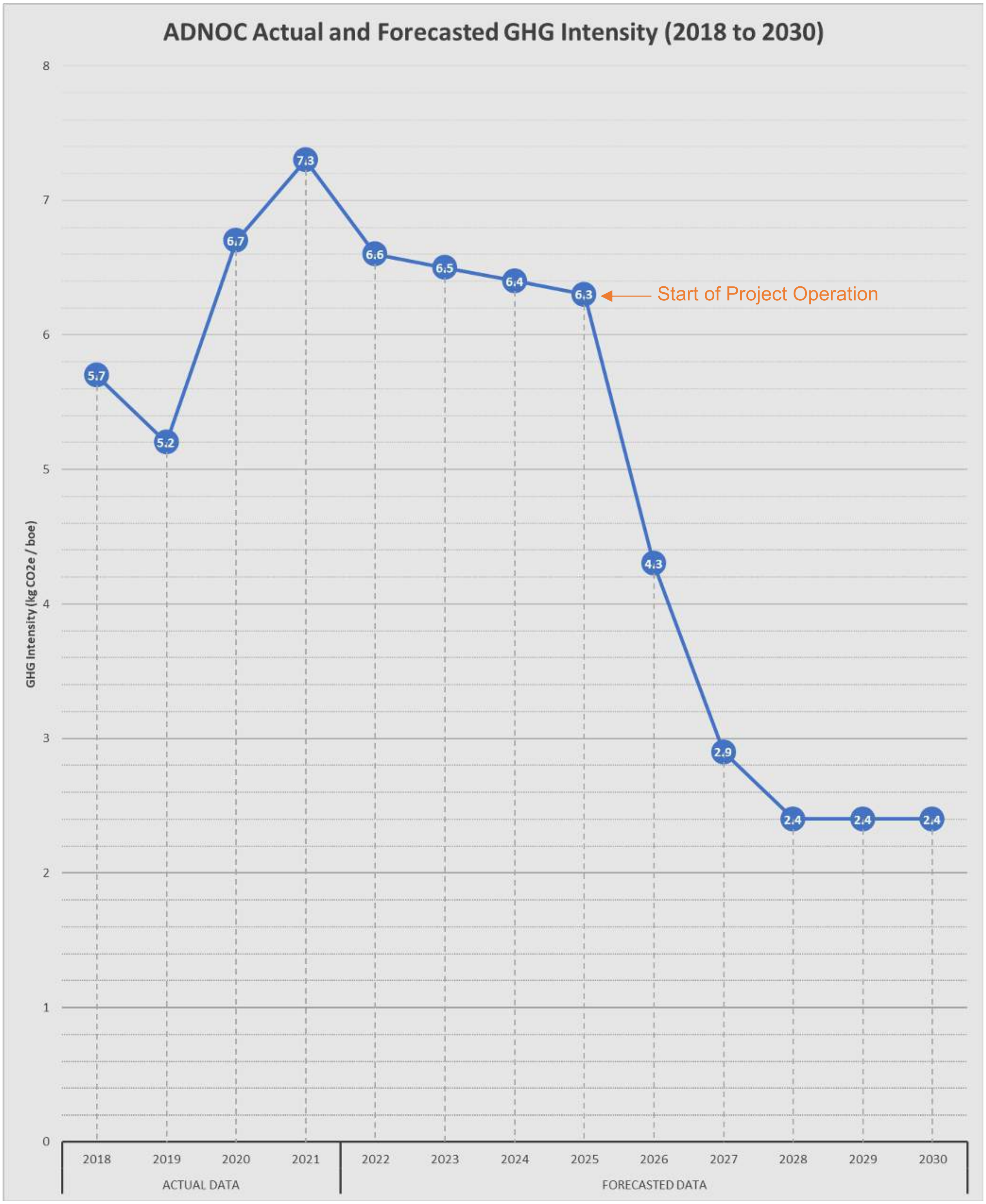


Figure 5-6: Graph of ADNOC offshore GHG intensity actual and forecasted figures (58)

5.1.2.4. Cumulative Impacts

5.1.2.4.1. Construction Phase

Type 1 cumulative impacts are expected upon sensitive receptors including the residential properties nearest to the construction corridor for the cables. Such properties are likely to experience the combined impacts of a deterioration in air quality from vehicular emissions and/or dust generation, in conjunction with potentially elevated noise levels and a reduction in visual amenity.

Type 2 impacts relating to air quality impacts are likely to occur during construction. For example, if there is a degraded airshed at residential receptors close to Al Mirfa Power and Water Complex, this could be temporarily exacerbated by dust and pollutant emissions associated with construction activities close to these sensitive receptors. In addition, the likely overlap of construction periods with the nearby Project Wave, at Mirfa and Mugharraq Port at Shuweihat which cumulatively may also increase dust and gaseous emissions within the local airshed.

5.1.2.4.2. Operation Phase

No significant cumulative impacts are anticipated once the Project becomes operational.

5.1.3. Mitigation Measures

5.1.3.1. Potential Mitigation Measures

A range of mitigation measures will be required to offset the air quality impacts associated with the Project. The potential mitigation measures which could be applied are set out within Table 5-5 below.

Table 5-5: Potential air quality impacts and mitigation measures

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
CONSTRUCTION PHASE								
1	Increased dust and PM_{10} levels affecting human health	Dust generating construction activities	At sensitive residential receptors (at Al Mirfa only)	Moderate negative	– Activities with a high propensity for dust generation will cease during excessively windy periods – Vehicle speed restrictions will be adopted and enforced, particularly on dirt roads. The allowed speed shall be of 15-20km/h maximum for off-roading and shall be monitored during construction – Physical barriers (e.g. wind breaks) will be set in areas where earth movements and trenching activities take place in close proximity to sensitive receptors	Cabinet Decree No 12 of 2006, pertaining to the protection of Air Quality	Please refer to ambient air quality standards provided within **Section 3.3.1**	Yes
2	Health impacts upon construction workers	Dust generating construction activities	Project site	Major negative	– Construction workers should be provided with appropriate PPE including masks during heavy dust generating activities or when operating in areas where significant emissions are expected – Unnecessary usage will be avoided, and equipment will be shut down and engines turned off when not in use – Any fire protection products, refrigerants, coolants and degreasing agents will be based on non-ozone depleting alternatives	Cabinet Decree No 12 of 2006, pertaining to the protection of Air Quality	Please refer to ambient air quality standards provided within **Section 3.3.1**	Yes
3	Health impacts upon operational workers	Dust generating construction activities	Adjacent workers within Al Mirfa Power and Water Complex, Al Shuweihat Power and Water Plant, Das and Al Ghallan Islands	Moderate negative	– Activities with a high propensity for dust generation will cease during excessively windy periods – Vehicle speed restrictions will be adopted and enforced, particularly on dirt roads. The allowed speed shall be of 15-20km/h maximum for off-roading and shall be monitored during construction – Physical barriers (e.g. wind breaks) will be set in areas where earth movements and trenching activities take place in close proximity to sensitive receptors	Cabinet Decree No 12 of 2006, pertaining to the protection of Air Quality	Please refer to ambient air quality standards provided within **Section 3.3.1**	Yes
4	Detrimental effect upon terrestrial and intertidal habitats, flora and fauna	Dust generating construction activities	Terrestrial and intertidal habitats within 500m of the Project site	Minor negative	– Physical barriers (e.g. wind breaks) will be set in areas where earth movements and trenching activities take place in close proximity to sensitive receptors	Cabinet Decree No 12 of 2006, pertaining to the protection of Air Quality	Please refer to ambient air quality standards provided within **Section 3.3.1**	Yes

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
5	Emissions of NOx, PM, SO_2, VOCs/HCs and CO from construction plant and equipment affecting human health	Mobile and stationary construction equipment onshore	At sensitive receptors onshore <500m from Project sites (Mirfa, Shuweihat, Das Island and Al Ghallan Island)	Negligible	– Use of low sulphur diesel only for any back-up generators etc. required – Emissions should be free from significant black smoke from each vehicle and engine – remedial maintenance measures will be taken if this is observed – Emissions from stationary equipment will be minimised through operation of equipment in accordance with manufacturer's specification as far as practicable – Emissions from stationary equipment will be visually inspected for the presence of black smoke and maintenance measures will be made to rectify burner efficiency issues as necessary – Vehicle and equipment idling should be kept to a minimum.	Cabinet Decree No 12 of 2006, pertaining to the protection of Air Quality	Please refer to emissions standards within **Section 3.3.1.**	Yes
6	Emissions of NOx, PM, SO_2, VOCs/HCs and CO from marine vessels and cable laying equipment affecting human health (construction workers)	Marine vessels, dredgers, barges and other marine support vessels using MGO and diesel offshore	Onboard the vessels or within close proximity	Minor negative	– Use of low sulphur diesel	Cabinet Decree No 12 of 2006, pertaining to the protection of Air Quality	Please refer to emissions standards within **Section 3.3.1.**	Yes
OPERATION PHASE								
7	Emissions to air from power generation	Use of onshore electricity, which includes renewables and nuclear instead of less efficient GTGs at ADNOC offshore facilities	Project site and surrounding areas	Major positive	– None required	Not applicable	Not applicable	Not applicable
8	Emissions to air from emergency generators	Emergency generators at each of the four converter stations	Project site and surrounding areas	Negligible	– Selection of best technology with minimum emissions – Use of low sulphur diesel – Appropriate maintenance and testing	Cabinet Decree No 12 of 2006, pertaining to the protection of Air Quality	Please refer to emissions standards within **Section 3.3.1.**	Yes
9	Reduction in GHG emissions	Use of onshore electricity, which includes renewables and nuclear instead of less efficient GTGs at ADNOC offshore facilities, which will lower carbon intensity of ADNOC Offshore's operations	Abu Dhabi Emirate wide	Major positive	– None required	Not applicable	Not applicable	Not applicable

5.1.3.2. Selected Mitigation Measures

5.1.3.2.1. Construction Phase

In order to reduce the potential impacts of the emissions from the construction activities, there are various mitigation and enhancement measures that shall be adopted. The recommended mitigation measures below shall be incorporated into the CESMP, which will be contractually mandated, and will include the following:

General Measures

- All site personnel will be fully trained to understand activities that generate dust and measures that should be undertaken to reduce dust emissions;
- A trained and responsible manager will be on site during working times to maintain a logbook and carry out daily site inspections;
- Inform sensitive receptors of the construction works and the programme of the works at the specific work site; and
- Develop a complaints procedure for the sensitive receptors.

Dust Mitigation Measures

In addition to the mitigation techniques listed above, for construction activity, the following options for the control of dust emissions are recommended, which should be included within the CESMP:

- Activities with a high propensity for dust generation will cease during excessively windy periods;
- Ensure that vehicles transporting rocks for subsea installation for cable protection are appropriately loaded into the vehicles and covered during transport;
- Vehicle speed restrictions will be adopted and enforced, particularly on unpaved roads. The maximum allowed speed shall be 15-20km/h for off-roading and shall be monitored during construction;
- Where a vehicle leaving a construction site is carrying materials with the potential to cause dust, the load will be covered entirely by clean impervious sheeting to ensure that the dusty materials do not leak from the vehicle;
- Hard surface site haul routes will be used;
- Vehicles moving friable and dusty material around the Project site will cover the load and drop height will be reduced;
- Stockpiles of fine material (sand, topsoil material, cement) will be located away from potential receptors, protected from wind and inspected regularly;
- Stockpiles should be covered and/or wetted down where there is a risk of dust emissions or during times when there are obvious emissions based upon visual inspections;
- Dirt roads will be visual inspected particularly during excessively dusty periods/activities and wetted down if necessary;
- Physical barriers (e.g. wind breaks) will be provided in areas where earth movements and trenching activities take place in close proximity to sensitive receptors; and

- Water supply for dust suppression will ideally come from dewatered excavations, although water may need to be specifically brought to site for this purpose.

Gaseous Emissions from Equipment and Vehicle Activities

Vehicle and equipment emissions both on and offsite will be minimized through adoption/application of the following best practice measures:

- Contractors will review vendor specification and select equipment based on emissions ratings;
- The number of vehicle trips to, from and within the Project site will be minimized through appropriate logistics planning including offshore construction works;
- All vehicles will be maintained regularly, and a record of maintenance and services retained on site, to be available for inspection;
- A list of all vehicles including engine type and emissions specification will be maintained by the EPC Contractor;
- On-road vehicles will comply with UAE set emission standards;
- Equipment emissions are to be reduced by the use of exhaust filters, regular maintenance programs and replacing old engines with new, more efficient and cleaner models;
- Only low sulphur diesel will be used for any backup generators etc. required for the Project;
- Emissions should be free from significant black smoke from each vehicle and engine – remedial maintenance measures will be taken if this is observed;
- Emissions from stationary equipment will be minimised through operation of equipment in accordance with manufacturer's specification as far as practicable. Emissions from stationary equipment will be visually inspected for the presence of black smoke and maintenance measures will be made to rectify burner efficiency issues as necessary;
- Vehicle and equipment idling should be kept to a minimum;
- Unnecessary usage will be avoided, and equipment will be shut down and engines turned off when not in use;
- Any fire protection products, refrigerants, coolants and degreasing agents will be based on non-ozone depleting alternatives;
- Alternatives to fossil fuels for vehicles and machinery will be used where possible; and
- Appropriate signage will be installed around the site;

5.1.3.2.2. Operation Phase

Emissions to Air & GHG Emissions

The Project will have a positive impact through a reduction of emissions of pollutants and increased carbon efficiency by replacing older generating units at ADNOC Offshore's facilities with more electricity generated from more efficient conventional power generating facilities, nuclear and renewables within Abu Dhabi. Additional mitigation measures for these aspects will not be required.

Emissions to air from Emergency Generators

The following mitigation measures will be implemented with respect to the emergency generators at the converter stations:

- Selection of best technology with minimum emissions;
- Selected equipment will be compliant with emissions standards set out within Cabinet Decree No 12 of 2006
- Use of low sulphur diesel; and
- Appropriate maintenance and testing, in accordance with manufacturers specifications to ensure efficient operation.

5.1.3.3. Mitigation Measures to Address Cumulative Impacts

5.1.3.3.1. Construction Phase

With regard to Type 1 cumulative impacts, it is anticipated that the mitigation measures provided in the preceding sections will serve to address cumulative impacts from multiple impact types (e.g. air quality and noise) upon a particular sensitive receptor, whereby all parties will be obligated to adhere to the EAD permitting process and implement specific measures to ensure that both construction controls (e.g. through the development of a CESMP by the EPC Contractor) and operational controls (through appropriate design and the implementation of management actions by ADNOC) are adopted.

Type 2 impacts are not expected and therefore further mitigation measures are not required.

5.1.3.3.2. Operation Phase

It is considered that the selected mitigation measures identified will be sufficient to alleviate any potential cumulative impacts associated with the Project.

5.1.3.4. Residual Impacts

Following the implementation of the selected measures, the anticipated residual impacts are shown below in Table 5-6.

Table 5-6: Air quality residual impacts

Description of the Impacts	Impact Significance Prior Mitigation Measures	Residual Impact Significance – Following Mitigation Measures
Construction Phase		
Increased dust and PM_{10} levels affecting human health and degrading habitats at sensitive residential receptors (at Al Mirfa only)	Moderate negative	Minor negative
Dust resulting in health impacts upon construction workers	Major negative	Minor negative

Description of the Impacts	Impact Significance Prior Mitigation Measures	Residual Impact Significance – Following Mitigation Measures
Dust resulting in health impacts upon operational workers within Al Mirfa Power and Water Complex, Al Shuweihat Power and Water Plant, Das and Al Ghallan Islands	Moderate negative	Minor negative
Emissions of NOx, PM, SO_2, VOCs/HCs and CO from construction plant and equipment, including marine vessels, affecting human health	Minor negative	Minor negative
Operation Phase		
Emissions to air from power generation offshore being replaced by onshore generation	Major positive	Major positive
Emissions to air from emergency generators	Negligible	Negligible
Reduction in GHG emissions	Major positive	Major positive

5.1.4. Monitoring Program

5.1.4.1. Monitoring Program for Compliance with Selected Mitigation Measures

5.1.4.1.1. Construction Phase

At a minimum, visual monitoring should be undertaken, to include:

- Daily visual inspection of dust should be conducted. The inspection will focus specifically on dust arising from construction activities or construction related transport activities. Stockpiles of loose material during trenching and earthwork activities should be covered and haul roads should be wetted down (under adverse weather conditions);
- Visual inspection for black smoke emissions and proper machine maintenance should be carried out by the EPC Contractor. Equipment emitting significant black smoke should be shut down and serviced immediately;
- Monitoring of complaints from nearby residential properties; and
- Observations of meteorological conditions, primarily high-speed winds, which may impede fugitive dust deposition.

The onsite contractor manager/foreman will be responsible for carrying out daily visual inspections as per the inspection sheet which will be provided within the CESMP and utilised to record the details of any issues relating to air pollution.

To confirm that impacts are not unacceptable, regular dust monitoring should be conducted adjacent to the holiday / weekend homes located at Al Mirfa, close to the construction site. This should include extended deployments over a number of days each month during the construction phase to ensure that worst-case wind directions (when the receptors are downwind of construction activities) are included within the monitoring.

In addition to the above, regular contact should be made with property owners, and contact details provided for the environment manager so that complaints by local residents can be swiftly resolved.

5.1.4.1.2. Operation

It is not anticipated that any monitoring during operation would be necessary.

5.1.4.2. Monitoring Program for Cumulative Impacts

It is considered that the monitoring measures specified above would be sufficient to ensure that cumulative impacts are monitored.

5.1.4.3. Monitoring Program for Residual Impacts

It is considered that the monitoring measures specified above would be sufficient to ensure that all residual impacts are adequately monitored.

5.2. Marine Water

This section of the ESIA includes an assessment of the existing marine water conditions present within the vicinity of the Project site.

The baseline conditions have been determined through surveys undertaken by Fugro in 2021 and supplemented by additional surveys undertaken by WKC in 2022. The baseline conditions have then been used to inform the assessment of potential impacts upon marine water quality, which have been predicted based upon the results of marine modelling which has been undertaken by WKC, which is presented in full within **Appendix 2.1.**

Lastly, mitigation measures have been developed to ensure that appropriate controls are in place during the development of the Project to minimise impacts to acceptable levels.

5.2.1. Description of the Environment

5.2.1.1. Baseline Methodology

5.2.1.1.1. Overview

The baseline conditions have been determined via two sources:

- Existing marine environmental baseline survey (MEBS) are available for significant sections of both route corridors, undertaken by Fugro in 2021 on behalf of ADNOC. The data is recent and therefore considered applicable for consideration within this ESIA; and
- Additional MEBS data has been collected by WKC during April 2022, due to key data gaps identified by Mott MacDonald within the Gap Analysis Report (34).

The below subsections provide a summary of the MEBS methodology conducted by Fugro and WKC.

5.2.1.1.2. Fugro Surveys – 2020

Fugro Route 1 Marine Water Quality Baseline Survey Methodology (63)

The survey was conducted to characterise the water and seabed quality through sampling at a total of 130 stations along the vicinity of Route 1. The following samples and data were collected during the duration of the survey:

- Measurements of physical parameters on site to characterise water quality at the time of the survey;
- Water column sample collection for physico-chemical analysis off site (in an accredited laboratory); and
- Marine sediment and soil sample collections for physico-chemical analysis off site (in an accredited laboratory).

Water samples were acquired from the sampling stations and a complete suite of physico-chemical sediment sub-samples was acquired at 60 stations with a partial suite of samples at 12 stations. Soil samples were acquired at nine out of the seventeen sampling stations.

Sediment sampling (including samples taken every 8km along the proposed route) was undertaken to determine the physico-chemical properties of the marine sediments. Water column sampling and water profiling was undertaken to assess water column physico-chemistry at the time of sampling.

The survey locations are presented in Figure 5-7 and Figure 5-8 below. The coordinates for each location can be found in **Appendix 2.3**.

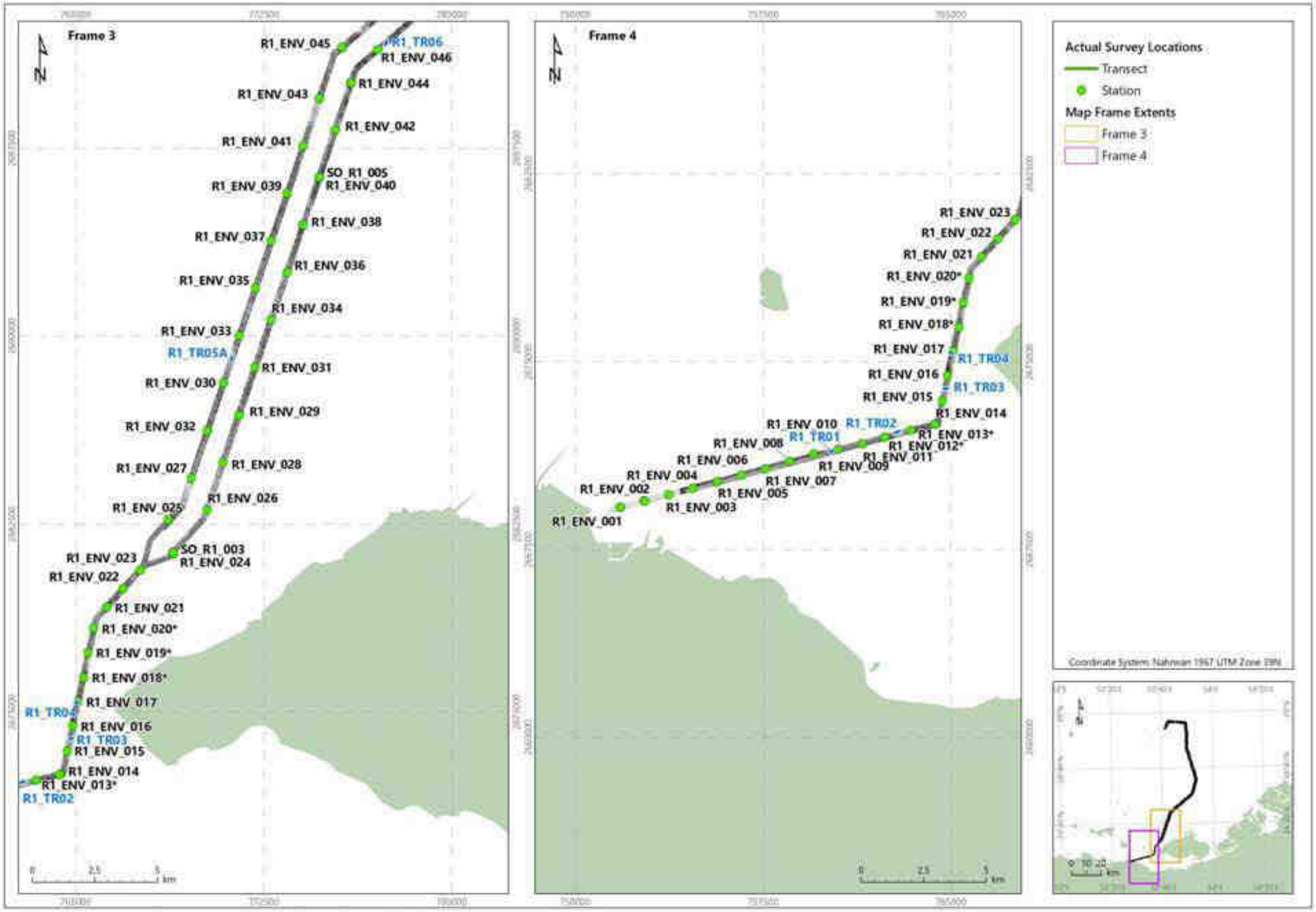


Figure 5-7: Completed environmental sampling locations overlain on survey area side scan sonar (SSS) mosaic 1 for Route 1 (from R1_ENV_001 to R1_TR06) (63)

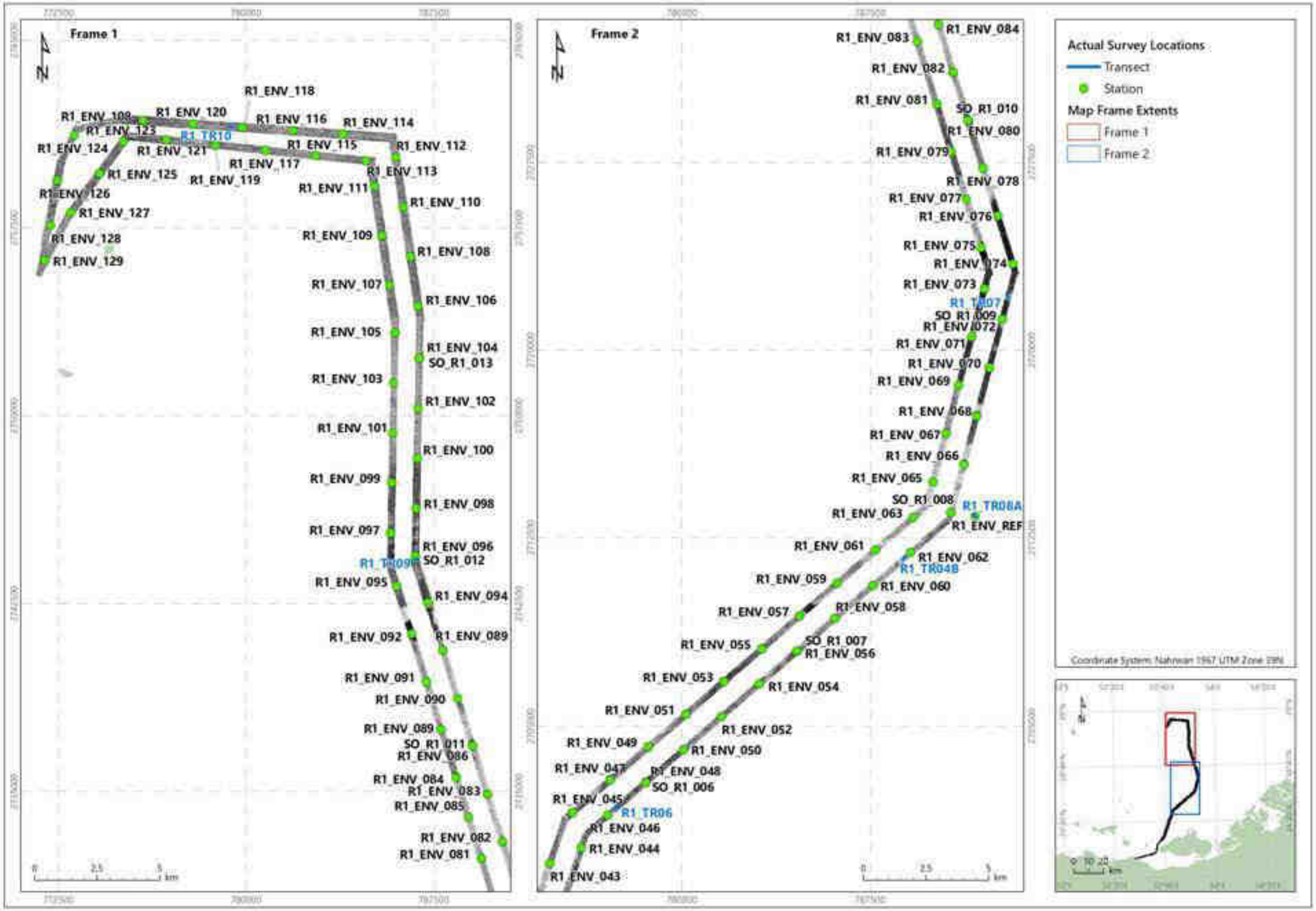


Figure 5-8: Completed environmental sampling locations overlain on survey area side scan sonar (SSS) mosaic along Route 1 (from R1_ENV_043 to R1_ENV_129) (63)

Fugro Route 2 Marine Water Quality Baseline Survey Methodology (64)

As with the Route 1, the water and sediment quality were assessed through *in situ* measurements of water quality parameters and off site analysis of water and sediment quality parameters (see subsection above).

Water column profiles and water samples for *ex situ* analysis were successfully acquired at all 135 sampling stations, in which a complete suite of physico-chemical sub-samples was acquired at 100 stations, a partial suite of samples from 11 stations and the remaining 24 stations could not be sampled due to hard substrate. A complete set of soil samples was acquired at 12 out of the 17 sampling stations, with a partial suite being acquired from one further station.

Sediment sampling (including soil samples taken every 8 km along the proposed route) was undertaken to determine the physico-chemical properties of the marine sediments.

The survey locations are presented in Figure 5-9 and Figure 5-10 below.

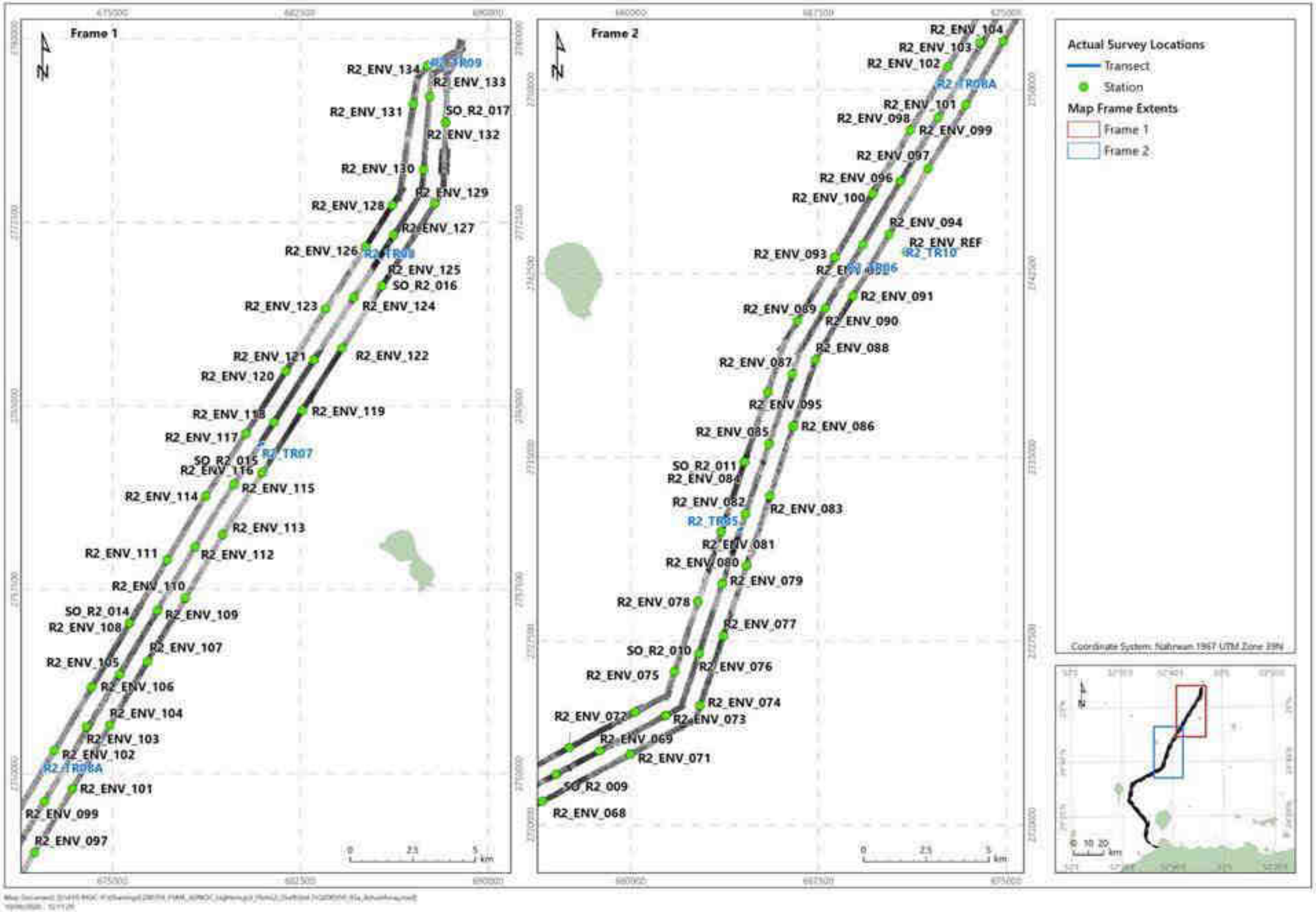


Figure 5-9: Environmental survey locations overlain on survey area side scan sonar (SSS) mosaic along Route 2-1 (64)

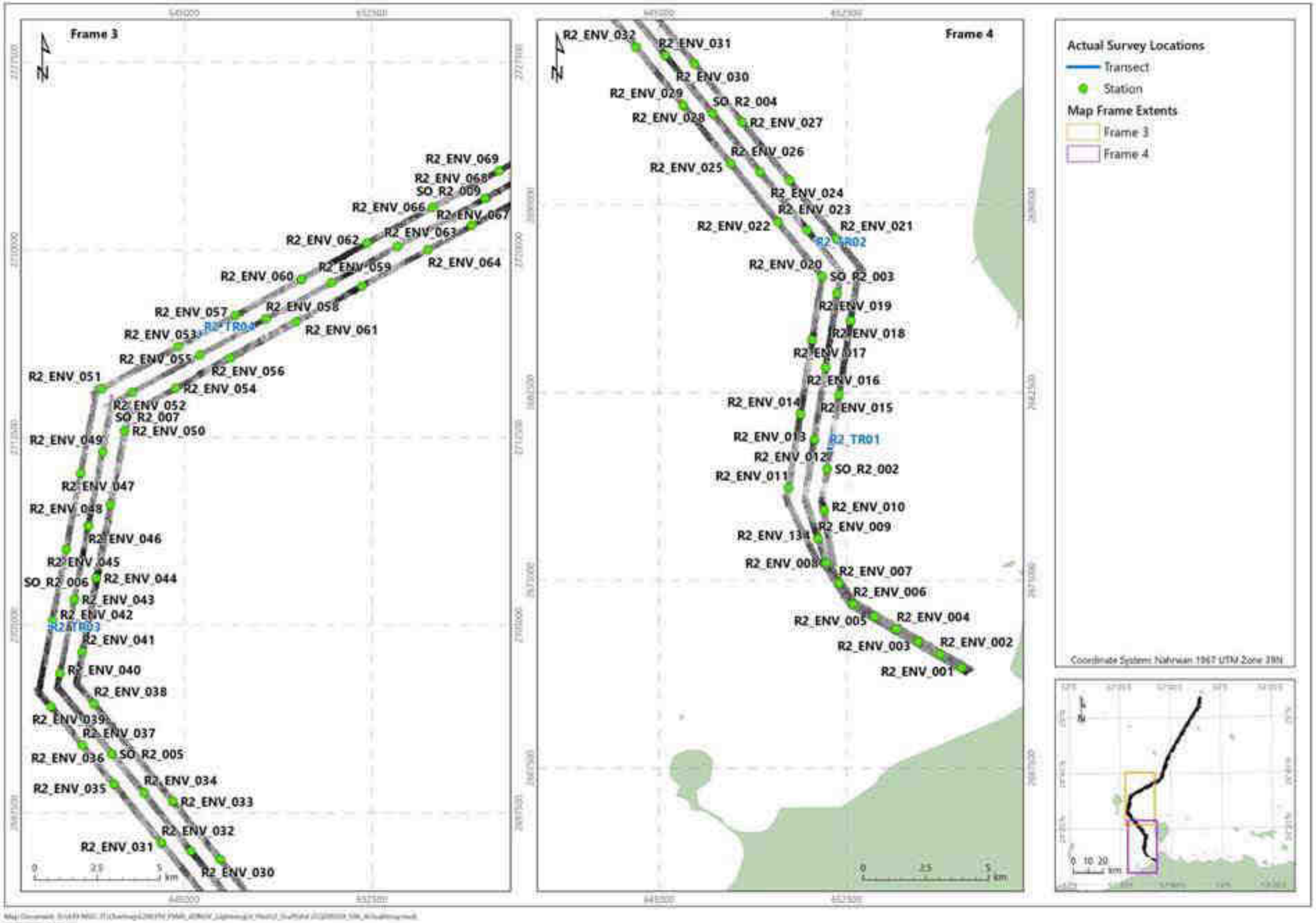


Figure 5-10: Environmental survey locations overlain on survey area side scan sonar (SSS) mosaic along Route 2 -2 (64)

5.2.1.1.3. WKC Surveys – 2022

Overview

Methodologies used to conduct the marine survey are taken and or adapted from the following survey standards:

- The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA): Standard Survey Methods for Key Habitats and Key Species in the Red Sea and Gulf of Aden;
- Australian Institute of Marine Science (AIMS): Survey Manual for Tropical Marine Resources;
- Regional Organization for the Protection of the Marine Environment (ROPME): Manual of oceanographic observations and pollutant analyses methods (MOOPAM); and
- Seagrass-watch: Manual for Mapping & Monitoring Seagrass Resources by Community (Citizen) Volunteers (McKenzie et al 2003).

The marine environment surveys were conducted over a single seasonal visit by marine biologists / marine scientists within the Project boundary only. These locations are deemed adequate to characterise the areas within the potential impact zone and suitable to provide a comprehensive assessment the impacts along the proposed channel as well as adjacent areas.

Project Survey Areas

Following the Fugro surveys undertaken in 2021 and as mentioned in **Section 2.4.1**, a Scoping Letter was issued to EAD which identified gaps within the Fugro surveys, principally the Fugro surveys did not cover the shallower nearshore areas for both Route 1 and Route 2 or the area within MMBR crossed by the Route 1. Furthermore, following completion of the Fugro surveys, Route 1 was amended and therefore additional baseline data was required to take account of this amended route, not covered by the previous surveys.

The Scoping Letter set out the planned additional surveys required to provide a complete baseline for this Project ESIA. The additional surveys undertaken by WKC were undertaken in five main areas, as follows:

- **Route 1 – Mirfa Landfall Area**: the surveys were conducted on the 7th and 8th of April 2022;
- **Route 1 – Mirfa Nearshore Area within and near MMBR**: the surveys were conducted on the 5th and 8th of April 2022;
- **Route 2 – Shuweihat Landfall Area**: the surveys were conducted on the 3rd and 4th of April 2022; and
- **Route 1 – Zakum Clusters Route 1A & 1B re-routing Area:** the surveys were conducted between 19th and 23rd May 2022.

Results of the marine water and sediment quality study are outlined in the sections below and results relating to marine ecology are summarised in **Section 5.5**. The full results of these surveys are also presented within **Appendix 2.4.**

Marine Water Quality

Water quality baseline conditions were measured both on site (*in situ*) and off-site (*ex situ*, samples collected on site were sent for testing in an accredited laboratory) to assess both physical and chemical water quality parameters.

For the *in situ* measurements, a calibrated multi-parameter water quality probe, i.e., Aquaread 5000 probe, was used to measure concentration of the following physical parameters on site:

- Dissolved oxygen (mg/l);

- pH;
- Salinity;
- Temperature (°C);
- Total Dissolved Solids (TDS); and
- Turbidity (NTU).

Measurements were taken at three depths (-1m from surface, mid-water depth and +1m from seabed) where overall depth is over 10 meters. Where the water depth is from three meters to less than 10 meters, only two depths along the water column were taken (subsurface (-1.0m) and just above the seabed (+1.0m)) at each of the designated sampling sites. For water columns less than three meters at time of sampling, only one sample was collected from mid-column.

Water samples were collected at four of the five identified Project survey areas as shown in Figure 5-11 to Figure 5-13. Actual GPS locations and depths of the sampling locations were recorded.

Samples were also collected on site for ex-situ analysis by Al Futtain Element Laboratory, an ENAS accredited testing laboratory, for chemical parameters as follows:

- Total Hydrocarbon Content (THC);
- Benzene, Toluene, Ethylbenzene and Xylene (BTEX);
- pH;
- Metals:
  - Aluminium;
  - Arsenic;
  - Barium;
  - Cadmium;
  - Chromium;
  - Copper;
  - Iron;
  - Lead;
  - Vanadium;
  - Mercury;
  - Zinc;
- Polycyclic Aromatic Hydrocarbons (PAH); and
- Phenols.

The number of samples collected was dependent on the depths of the water column as described above. Water samples were collected using a horizontal Van Doorn sampler. Collected water samples were transferred to clearly labelled sampling containers and stored in a cooler box with ice. Samples were then sent to an accredited laboratory for analysis under strict chain of custody QA/QC procedures.

Samples were described based on, but not limited to, the following: odours, colour and signs of contamination.

The laboratory reports of the marine water *ex-situ* quality assessment are provided in **Appendix 2.4**. For purposes of comparison of the results with the referenced standards, the Project site in **Route 1 – Mirfa Landfall** was considered to constitute a Marine Protected Use Area whilst **Route 2 – Shuweihat Landfall**, **Route 1 – Zakum Clusters Route 1A re-routing Area** and **Route 1 – Zakum Clusters Route 1B re-routing Area** constitutes a General Use Area.

Marine Sediment Quality

Sediment samples were collected through the use of a Van Veen grab employing best practice sediment sampling procedures (i.e., referencing the Manual of oceanographic observations and pollutant analyses methods - MOOPAM) from pre-approved sampling locations within the five identified Project survey areas as shown in Figure 5-11 to Figure 5-13. Actual GPS locations and depths of the sampling locations were recorded.

Samples were sent to an accredited laboratory for analysis for the following parameters:

- Total Organic Carbon (TOC);
- PAH;
- PCBs;
- Oil and Grease;
- Phosphorous;
- Total Nitrogen;
- Total Cyanide;
- Total Soluble Sulphate;
- THC;
- BTEX;
- Metals:
  - Antimony;
  - Aluminium;
  - Arsenic;
  - Barium;
  - Cadmium;
  - Chromium;
  - Copper;
  - Iron;
  - Lead;
  - Molybdenum;
  - Manganese
  - Mercury;
  - Nickel;
  - Silver;
  - Selenium;
  - Zinc;
- Silicon;
- Fluoride;
- Phosphate; and
- Particle Size Analysis (PSA).

The laboratory reports of the marine sediment *ex-situ* quality assessment are provided in **Appendix 2.4**. For purposes of comparison of the results with the referenced standards, the Project sites in **Route 1 – Mirfa Landfall** and **Route 1 – Mirfa Nearshore Area within and near MMBR** were considered to constitute a Marine Protected Use Area whilst **Route 2 – Shuweihat Landfall**, **Route 1 – Zakum Clusters Route 1A re-routing Area** and **Route 1 – Zakum Clusters Route 1B re-routing Area** constitutes a General Use Area.

Figure 5-11: Water and sediment quality sampling locations along Route 1 – Mirfa Landfall and Mirfa Nearshore Area within and near MMBR

Figure 5-12: Water and sediment quality sampling locations along Route 2 – Shuweihat Landfall

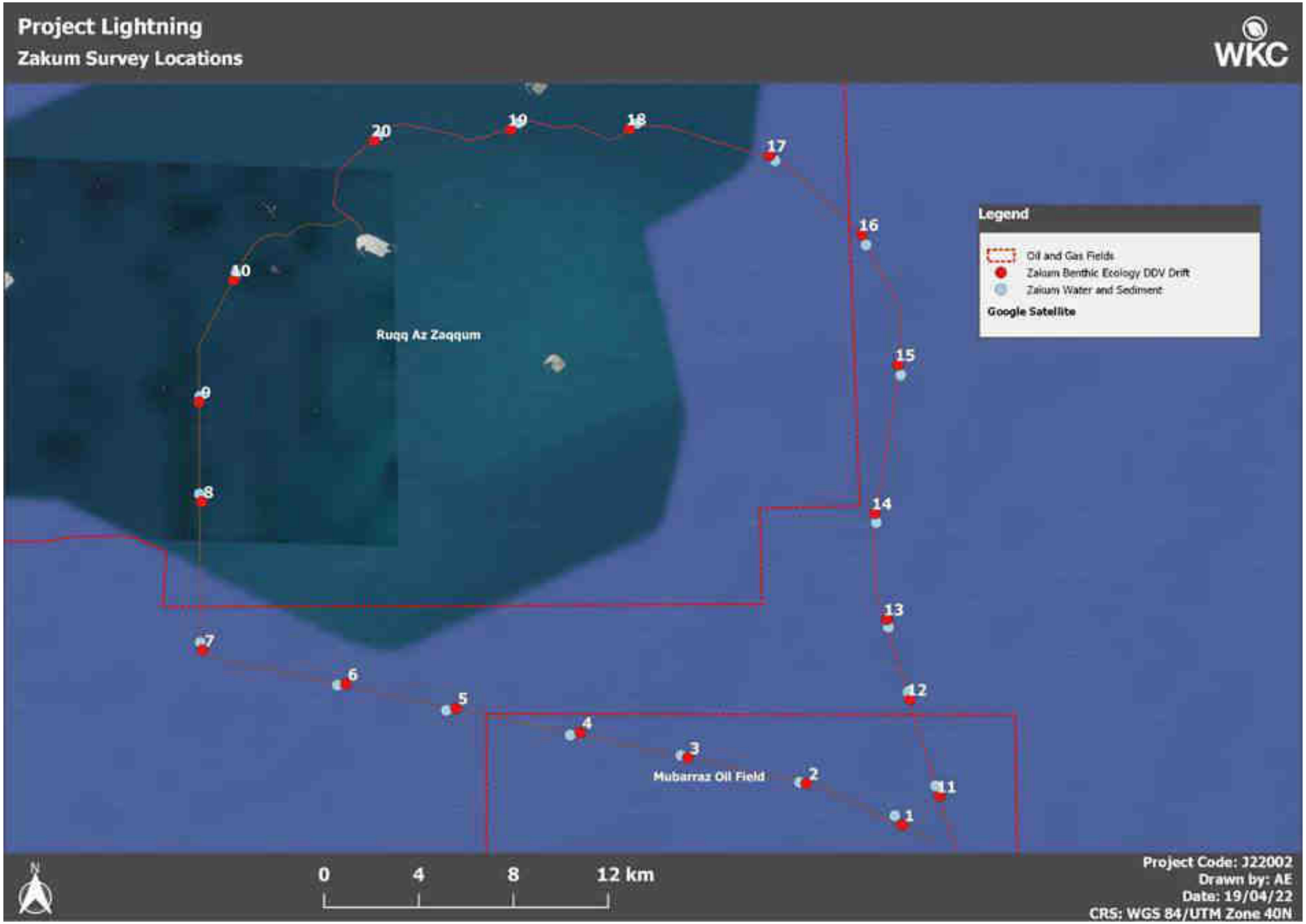


Figure 5-13: Marine water and sediment quality sampling points along Zakum Clusters Route 1A & 1B re-routing area

5.2.1.2. Baseline Conditions

5.2.1.2.1. Regional Setting

The Arabian Gulf has a high variation in surface open water temperatures, ranging from about 11°C in winter to over 36°C in summer. Maximum seawater temperatures are close to the upper limit of coral survival.

Salinity within UAE waters is typically around 43 parts per thousand (ppt); however, higher levels are anticipated within the khors surrounding adjacent islands due to evaporation and relatively limited flow. The large intertidal areas demonstrate fluctuations in salinity levels based on seasonal temperature changes in the region, with higher salinity levels during peak summer periods.

The marine sediments of the Gulf commonly originate from either terrestrial or marine biogenic sources, with a smaller proportion from evaporative sources. Eroded material may either be washed down from the coastal plains within creeks or wadis during occasional rainfall events or blown off the land by Aeolian processes (winds) into the sea. Marine-derived sediments develop from gradual decomposition of biogenic material (e.g., coral fragments, coralline algae, mollusc shells, etc.).

5.2.1.2.2. Fugro Baseline Survey Results

This section provides a summary of a MEBS undertaken by Fugro on behalf of ADNOC as presented in **Appendix 2.3**. These data have been supplied by ADNOC to Anthesis specifically for the Project and the results are summarised below.

Route 1

Water Quality

Water Column Profiles

Water temperatures within the survey area varied between stations, ranging from 26°C to 35°C. At nearshore stations (ENV_001 to ENV_023), salinity levels were generally consistent throughout the water column and ranged from approximately 44 practical salinity units (PSU) to 46 PSU. Salinity values recorded from majority of the offshore stations were between 40 PSU and 42 PSU, but overall salinity ranged from approximately 40 PSU to 44.5 PSU. Turbidity values at stations ENV_001 to ENV_023 typically ranged from approximately 0.8 nephelometric turbidity units (NTU) to 4.8 NTU, apart from station ENV_019 where the turbidity values were between 0.1 NTU and 0.5 NTU. The remaining offshore stations had turbidity values between 0.0 NTU and 1.5 NTU, but on occasions values reaching up to but not more than 14 NTU have been observed. Dissolved oxygen levels ranged from approximately 80% saturation (% sat.) to 119.3 % sat. Overall, recorded DO levels either decreased or remained relatively the same with increasing depth. Finally, pH values ranged from 7.9 to 8.2, with no clear depth-related trends in pH values at any of the stations profiled. Example profiles are provided in Figure 5-14.

Overall, the results were considered to be representative of ambient seawater conditions for the region and typical of the season across all parameters.

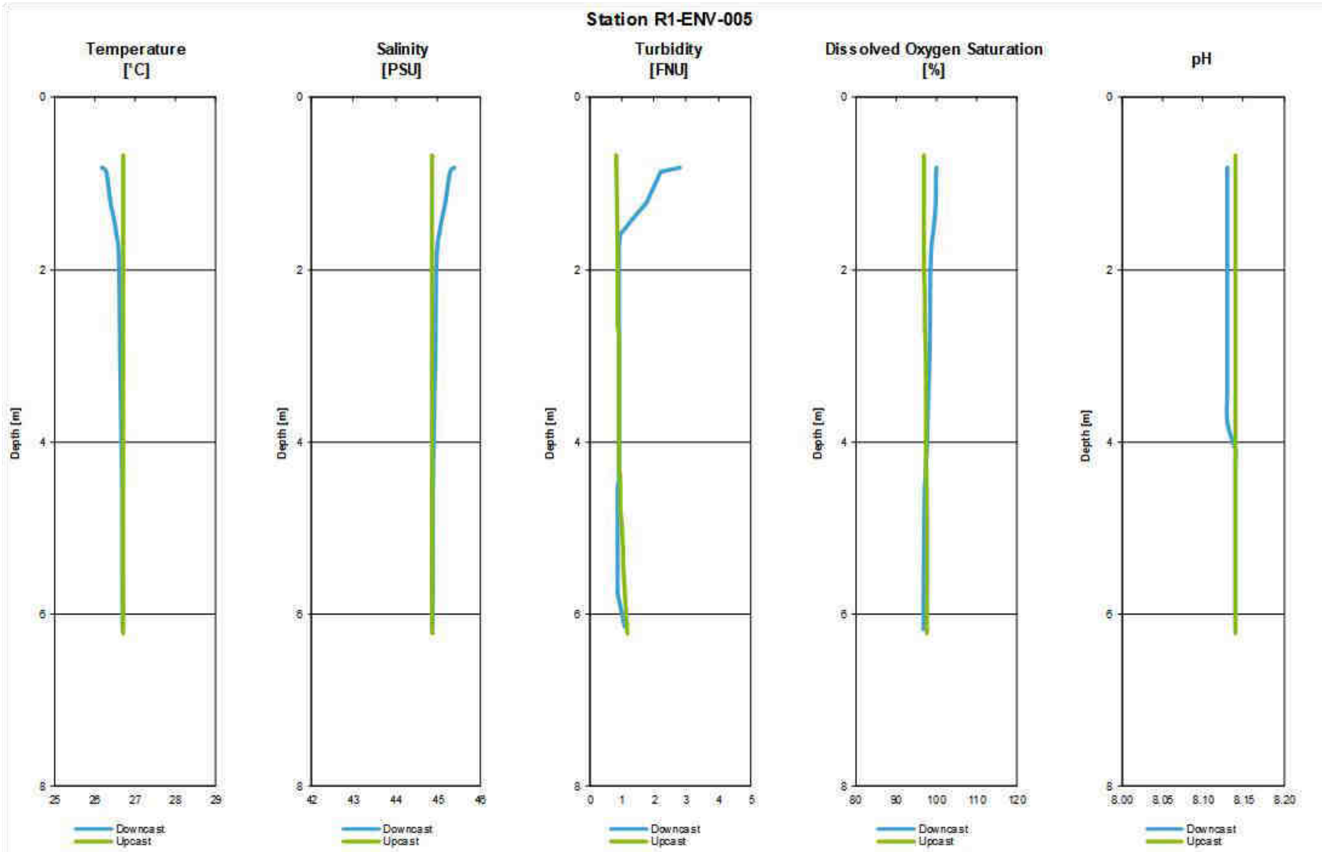


Figure 5-14: Example water profile showing temperature, salinity, turbidity, dissolved oxygen and pH at station R1_ENV_005 along Route 1 (63)

Inorganic Water Quality Parameters

The majority of inorganic water quality parameters (e.g., total suspended solids (TSS), ammonia, ammonium, silicon, sulphide, nitrite, total phosphorus, orthophosphate, chemical oxygen demand (COD), biochemical oxygen demand (BOD) and total coliform) were below their respective minimum reporting values (MRVs) at all stations across the survey area. Most parameters with values greater than the MRV (e.g., pH, total dissolved solids (TDS), sulphate, chloride and total organic carbon (TOC), total nitrogen, total cyanide, nitrate, nitrite, total phosphorus, turbidity) were considered to be of no environmental concern.

Water Column Hydrocarbons

Concentrations of volatile petroleum hydrocarbons, extractable petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), benzene, toluene, ethylbenzene and xylene (BTEX) and phenols were below their respective MRVs in all samples obtained. Naphthalene, phenanthrene and pyrene concentrations recorded at a limited number of stations were above their respective MRVs, but were within the referenced standards and limits where applicable were therefore considered unlikely to be of environmental concern. Benzene, toluene and ethylbenzene were below the Canadian Council of Ministers of the Environment (CCME) guideline values and considered to be representative of background conditions.

Water Column Metals

Chromium, copper, lead and zinc, concentrations exceeded their respective Abu Dhabi Specification (ADS) 18/2017 Ambient Marine Water Standards Maximum Allowable Concentration (MAC) for both general use areas and marine protected areas (QCC, 2017) in 100, 17, 31 and 129 samples respectively. Copper and lead concentrations exceeded the United States Environmental Protection Agency (US EPA) criterion continuous concentration (CCC) in 16 and 4 samples, respectively. Copper and zinc concentrations exceeded the US EPA criterion maximum concentration (CMC; US EPA, 2020) in 8 and 5 samples, respectively. Except for chromium, copper, lead and zinc, concentrations of all major and trace elements were below their respective ADS 18/2017 MACs, where available, as well as the US EPA CCC and CMC values and considered to be of no environmental concern.

Sediment Quality

Sediment Characterisation

Using the Wentworth (1922) sediment description, stations across the Route 1 survey area comprised coarse sand to fine silt. High interstation variability was demonstrated for all fractional composition parameters, except for sand which showed moderate variability.

Figure 5-15 presents the granulometry of the sediments at each station, whilst Figure 5-16 and Figure 5-17 present the fractional composition of the sediments spatially across the Route 1 survey area.

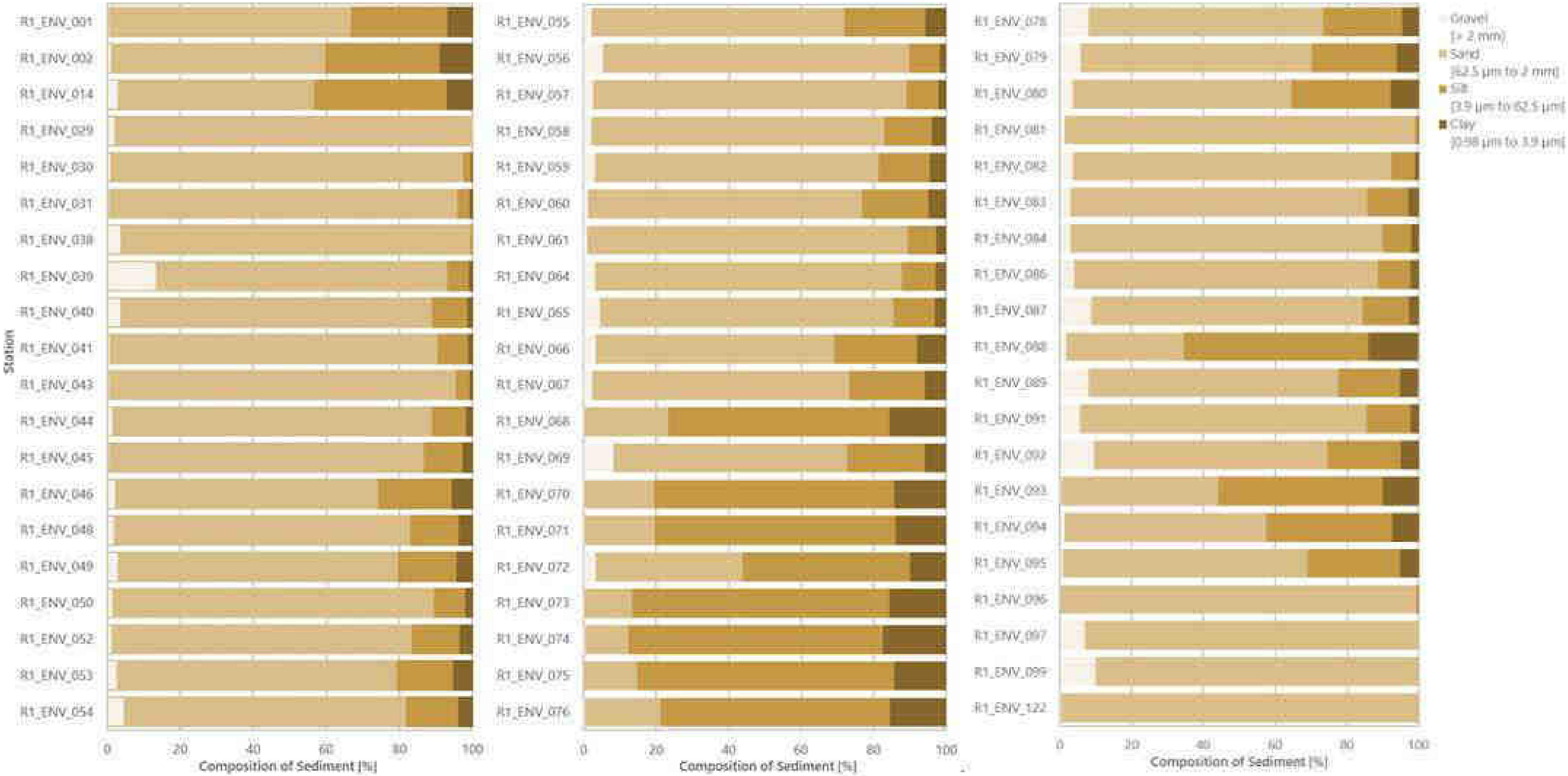


Figure 5-15: Sediment composition along Route 1

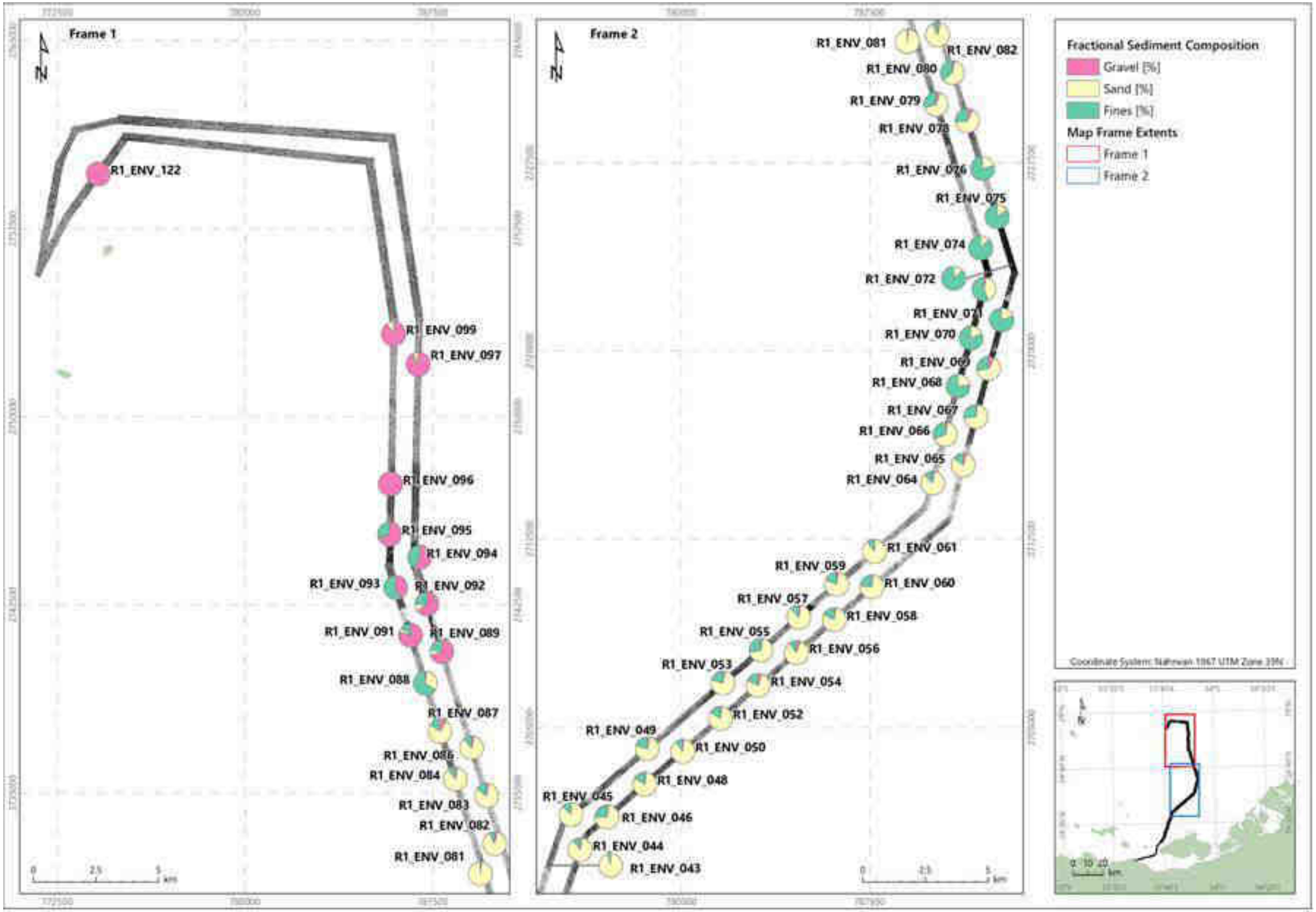


Figure 5-16: **Sediment fractional composition overlaid on bathymetry along Route 1 (R1_ENV_043 to R1_ENV_122) (63)**

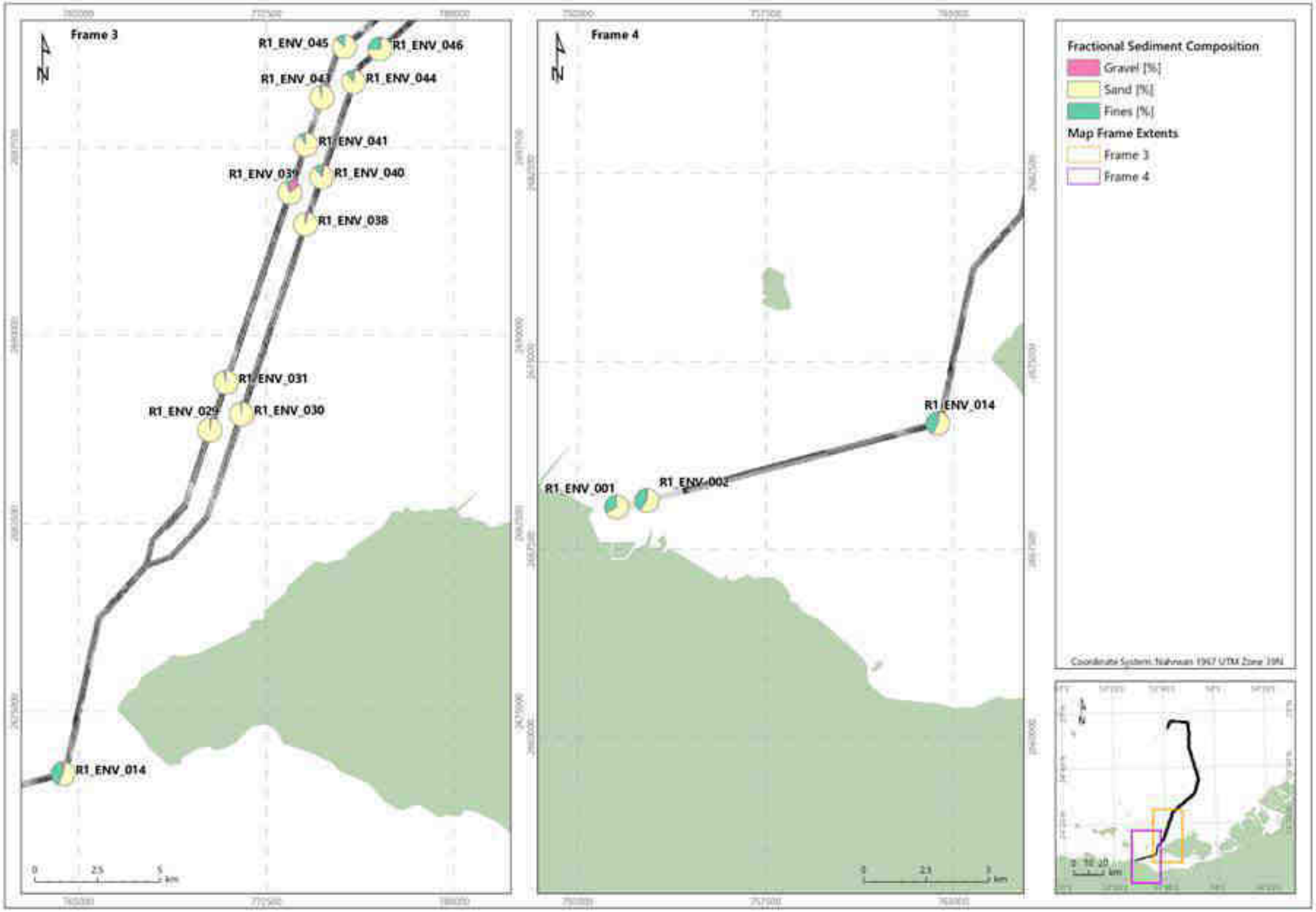


Figure 5-17: Sediment fractional composition overlaid on bathymetry along Route 1 (R1_ENV_001 to R1_ENV_046) (65)

Sediment Nutrients

All sediment nutrient concentrations across the Route 1 survey area demonstrated low to moderate variation. No spatial patterns were observed, indicating broadly homogenous sediment nutrients within the region.

Sediment Hydrocarbons

Concentrations of total hydrocarbon content were considered as typical for the region as they were comparable to concentrations previously recorded around non-industrialised coastal environments distant from hydrocarbon inputs. The concentrations of BTEX and individual PAHs were below their respective MRVs at all stations across the Route 1 survey area. Total sediment PAH concentrations were below the ADS 18/2017 MAC.

Sediment Polychlorinated Biphenyls

The concentrations of polychlorinated biphenyls (PCBs) were below the method MRV (0.020 ng/g) at most stations across the Route 1 survey area. All total PCB concentrations were below the ADS 18/2017 MAC.

Sediment Metals

All sediment metals concentrations across the survey area were below their respective US National Oceanographic and Atmospheric Administration (NOAA) effects range low (ERL) and effects range median (ERM) threshold values. With the exception of chromium, lead and nickel, concentrations of all sediment metals were below their respective ADS 18/2017 MAC for both general use areas and marine protected areas. Concentrations of chromium and nickel exceeded the ADS 18/2017 MAC (QCC, 2017) for marine protected areas at numerous stations and lead at one station. Nickel concentrations also exceeded the ADS 18/2017 MAC (QCC, 2017) for general use areas at 4 stations. There was no clear spatial distribution pattern that would indicate a point source related to possible anthropogenic activities within the survey area, and the differences recorded are therefore most likely to be associated with natural sediment variations.

Figure 5-18 below presents the overall trend in individual metals concentrations.

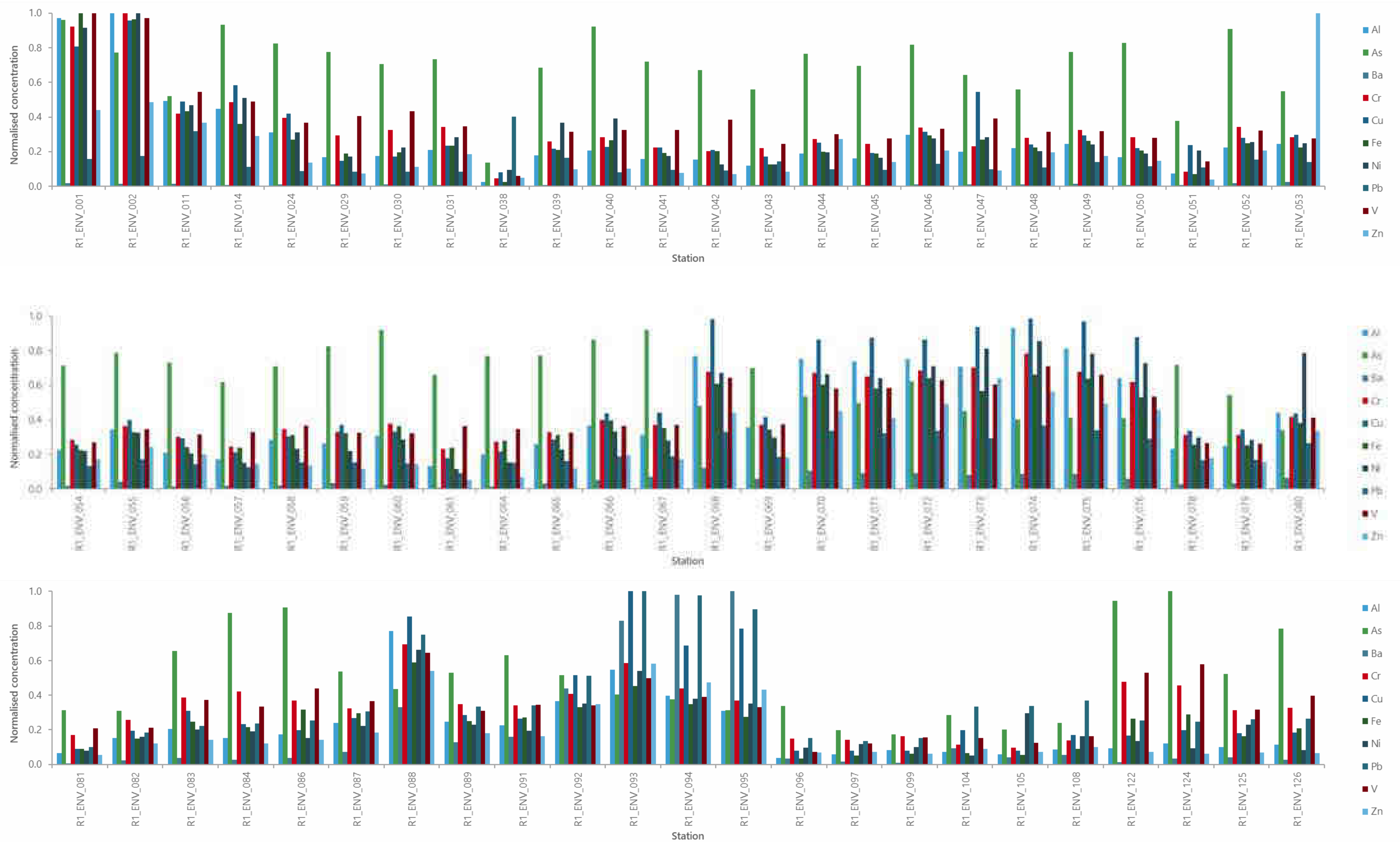


Figure 5-18: Relative (maximum normalised) elemental concentrations in sediments along Route 1 (63)

Route 2

Water Quality

<u>Water Column Profiles</u>

Water temperatures within the survey area differed between shallow and deeper waters. Water temperatures within the survey area appeared more consistent at stations with shallower waters (which ranged from approximately 23°C to 25°C), compared to those in deeper waters (which ranged from approximately 23.8°C to 33.0°C). No vertical stratification was present, with temperatures remaining broadly constant throughout the water column.

In contrast, salinity values were generally observed to be consistent throughout the water column for most stations and ranged from approximately 40 PSU to 46 PSU. A number of recorded profiles have shown turbidity levels to increase with depth, often doubling compared to shallower areas. Dissolved oxygen (DO) levels slightly decreased with increasing depth at most of the water profiles sampled. The pH values ranged from approximately 8.0 to 8.1 with no clear depth-related trends at any of the stations profiled. Overall, due to minimal differences observed across the samples obtained, the conditions encountered were considered typical for the region and season. Example profiles are provided below in Figure 5-19.

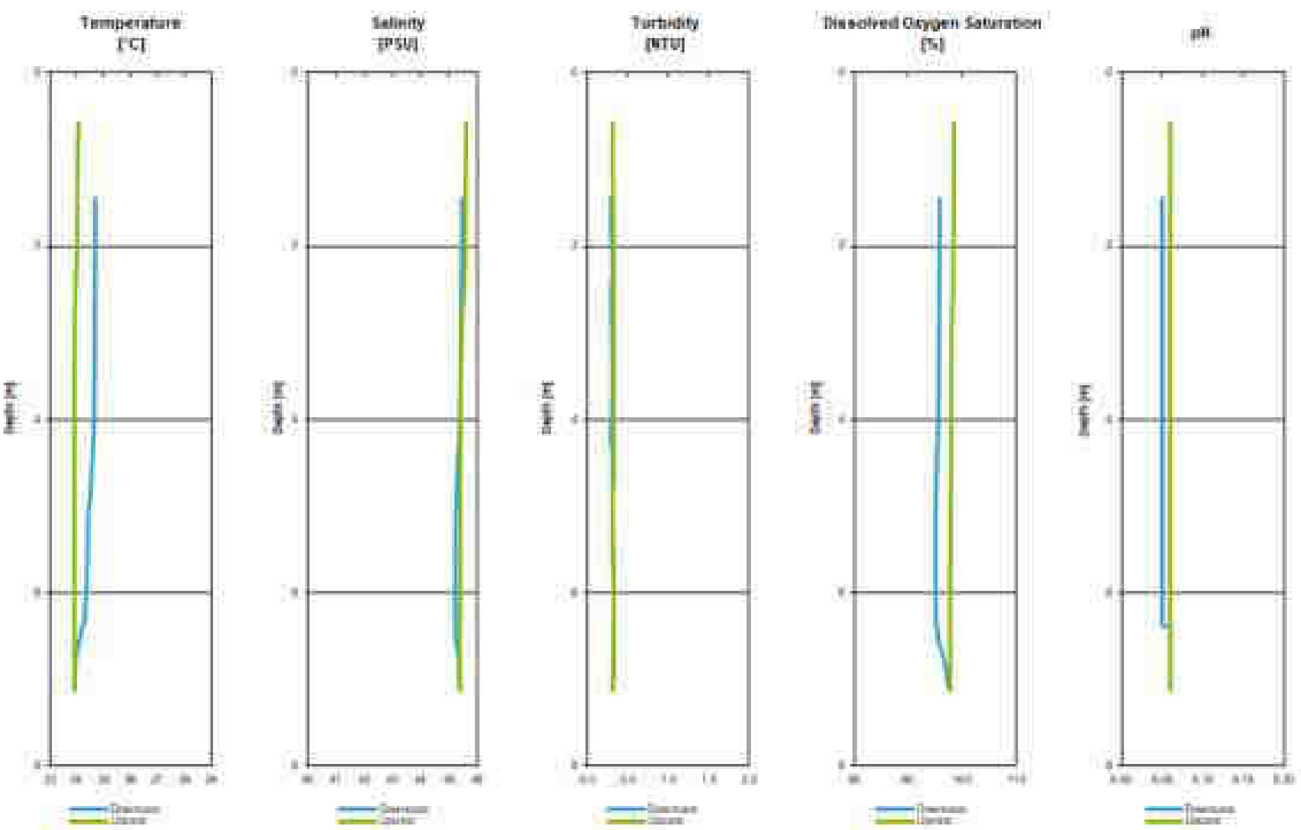


Figure 5-19: Example water profile showing temperature, salinity, turbidity, dissolved oxygen and pH at station R2_ENV_004 along Route 2 (64)

Inorganic Water Quality Parameters

The majority of inorganic water quality parameters (e.g., total suspended solids, nitrogen (ammonia), ammonium, sulphide, total nitrogen, total cyanide, orthophosphate, silicon, chemical oxygen demand (COD), biochemical oxygen demand (BOD) and total coliform) were below their respective MRVs at all stations across the survey area. Parameters with values greater than the MRV (e.g., pH, total dissolved solids (TDS), nitrate, nitrite, sulphate, chloride and total organic carbon (TOC)) showed low variability and all within referenced standards and therefore considered to be of no environmental concern.

Water Column Hydrocarbons

Concentrations of volatile petroleum hydrocarbons (VPHs), polycyclic aromatic hydrocarbons (PAHs), benzene, toluene, ethylbenzene and xylene (BTEX) and phenols were below their respective MRVs in all samples apart from extractable petroleum hydrocarbons (EPHs), fluoranthene, phenanthrene and pyrene. However, the concentrations recorded were unlikely to be of environmental concern. Benzene, toluene and ethylbenzene were below the Canadian Council of Ministers of the Environment (CCME) guideline values and considered to be representative of background conditions.

Water Column Major and Trace Metals

With the exception of cadmium, chromium, copper and zinc, concentrations of major and trace elements were below their respective Abu Dhabi Specification (ADS) 18/2017 Ambient Marine Water Standards Maximum Allowable Concentration (MAC) for both general use areas and marine protected areas (QCC, 2017), where available, as well as the United States Environmental Protection Agency (US EPA) criterion continuous concentration (CCC) and criterion maximum concentration (CMC) (US EPA, 2020) and considered to be of no environmental concern. Zinc concentrations exceeded the US EPA CCC and the US EPA CMC thresholds, in sample R2_ENV_095-Middle. Copper concentrations exceeded the US EPA CCC threshold in four samples and the US EPA CMC threshold in two samples. The ADS 18/2017 MAC thresholds for both general use areas and marine protected areas were exceeded for zinc concentrations in 29 samples, for cadmium in 1 sample, for chromium in 162 samples and for copper in 4 samples.

Sediment Quality

Sediment Characterization

Using the Wentworth (1922) sediment description, stations across the Route 2 survey area comprised mainly sand and were classified as coarse sand to medium silt. High interstation variability was demonstrated for all fractional composition parameters, except for sand which showed low variability.

Figure 5-20 presents the granulometry of the sediments at each station, whilst Figure 5-21 and Figure 5-22 presents the fractional composition of the sediments spatially across the Route 2 survey area.

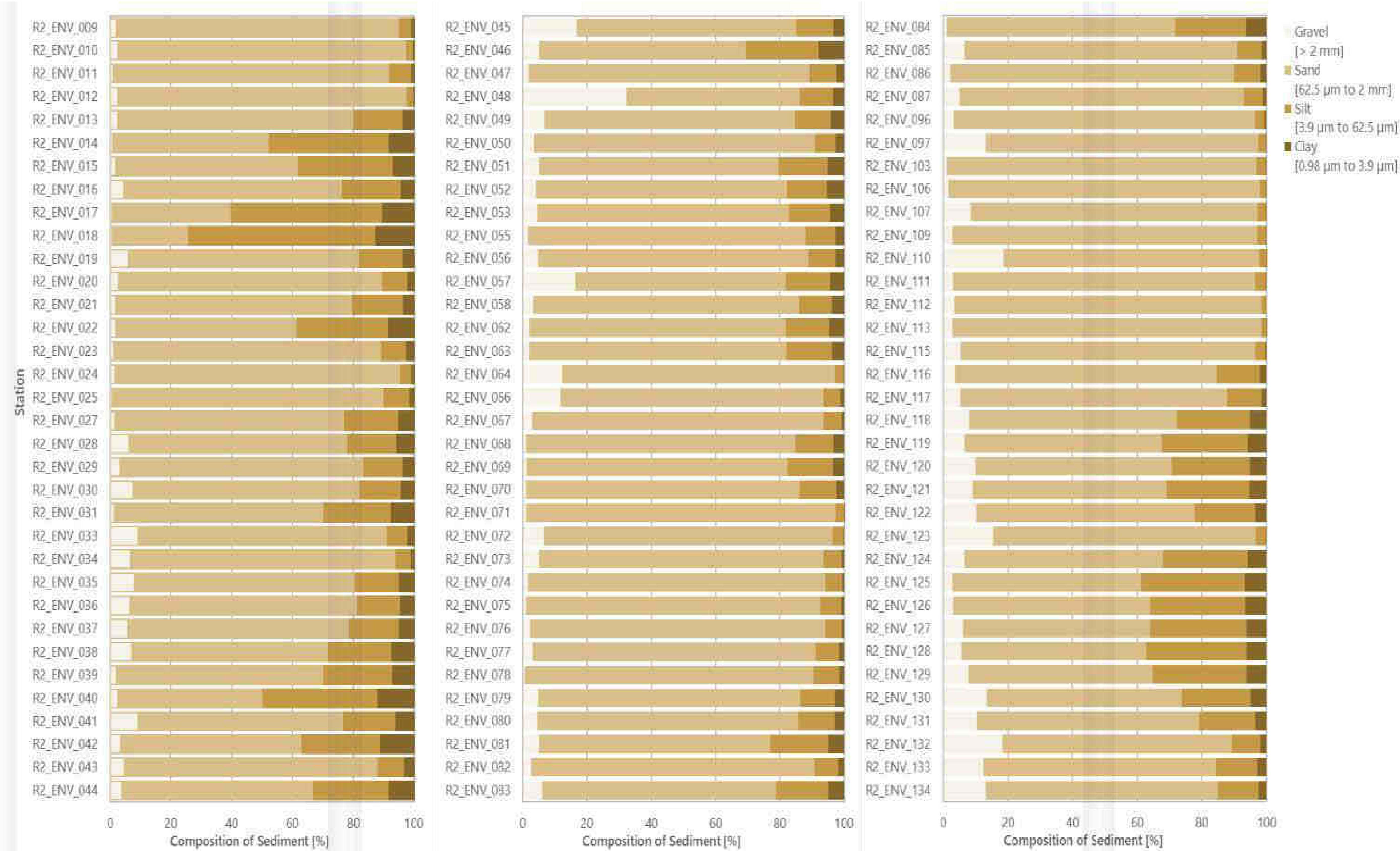


Figure 5-20: Sediment composition along Route 2 (64)

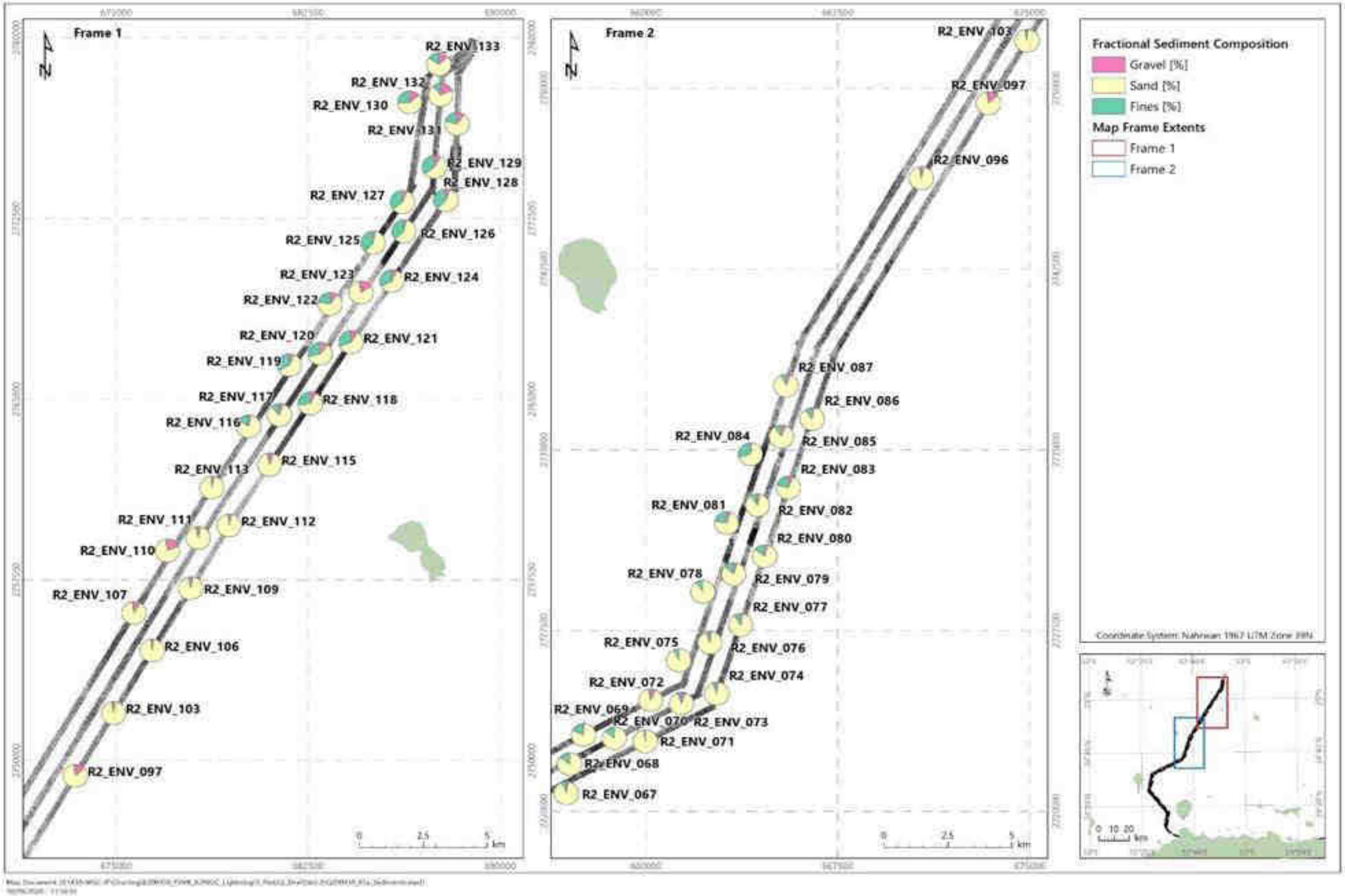


Figure 5-21: Sediment fractional composition overlain on side scan sonar (SSS) along Route 2 (R2-ENV_067 to R2_ENV_133) (64)

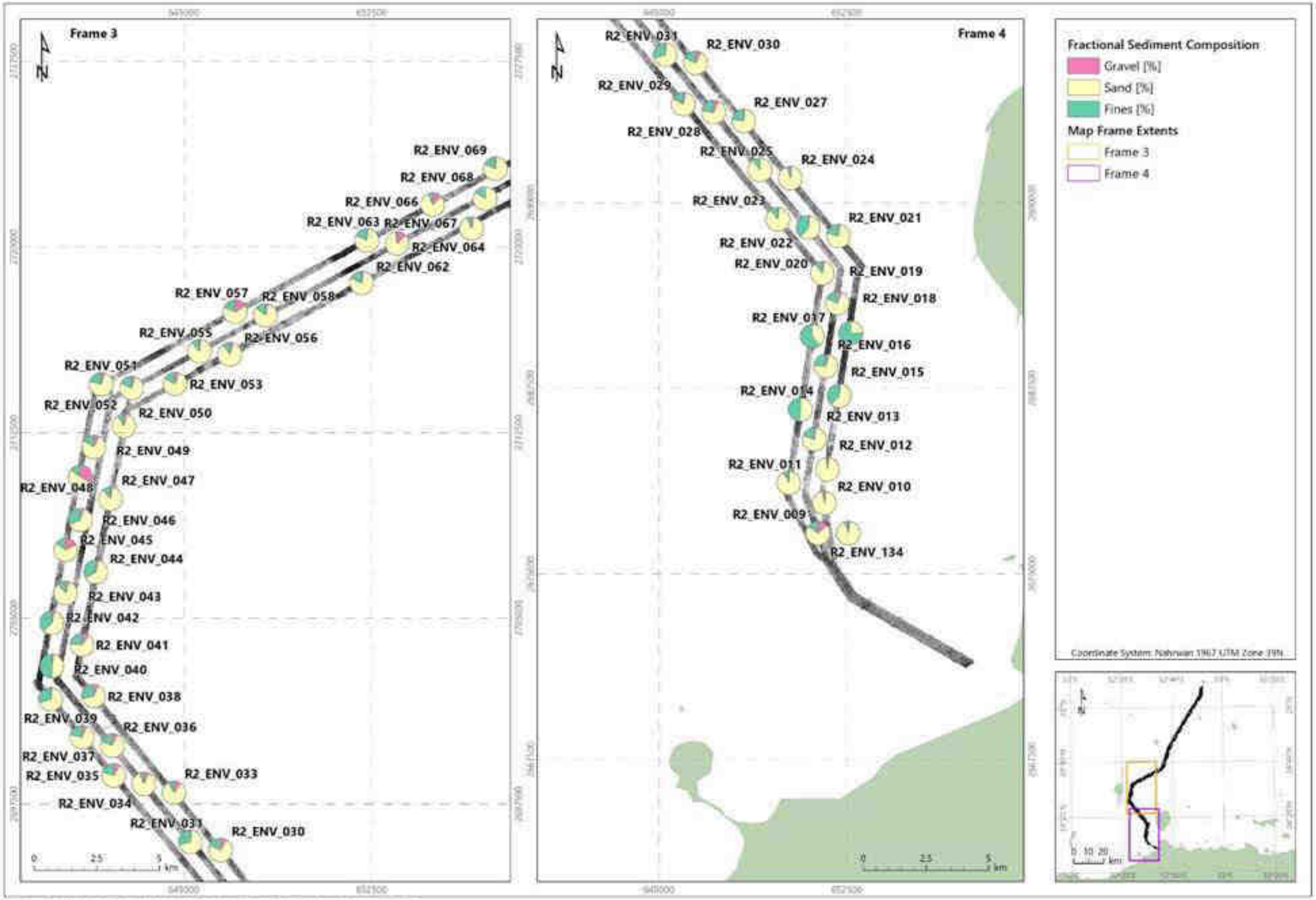


Figure 5-22: Sediment fractional composition overlain on side scan sonar (SSS) along Route 2 (R2_ENV_134 to R2_ENV_069) (64)

Sediment Nutrients

Apart from silicon, all sediment nutrient concentrations, demonstrated low to moderate variation. No spatial patterns were observed indicating broadly homogenous in terms of sediment nutrients within the region. Phosphorus concentrations reported in Route 2 were higher than those carried out previously in the Zakum oil field (Blue Sea Environmental Consultants, 2011).

Sediment Hydrocarbons

Concentrations of total hydrocarbon content recorded on site were considered as typical for the region as they were comparable to concentrations previously recorded around non-industrialised coastal environments distant from hydrocarbon inputs. The concentrations of BTEX compounds were below their respective MRVs at all stations, and the concentrations of individual PAHs were below their respective MRVs at majority of the stations across the Route 2 survey area. Total sediment PAH concentrations were below the ADS 18/2017 MAC and are therefore unlikely to harm the associated benthic macrofauna.

Sediment Polychlorinated Biphenyls

The concentrations of individual polychlorinated biphenyls (PCBs) were below the MRV (0.020 ng/g) at most stations across the Route 2 survey area. All total PCB concentrations were below the ADS 18/2017 MAC.

Sediment Metals

The majority of the sediment metals concentrations across the survey area were below their respective US National Oceanographic and Atmospheric Administration (NOAA) effects range low (ERL) and effects range median (ERM) threshold values. Arsenic concentrations at three stations exceeded their ERL threshold value, as well as the ADS 18/2017 MAC threshold (7.0 µg/g) for both general use and marine protected areas at 9 stations. Concentrations of chromium and nickel exceeded the ADS 18/2017 MAC (QCC, 2017) for marine protected areas at numerous stations, and concentrations of lead exceeded the ADS 18/2017 MAC (QCC, 2017) for marine protected areas at one station. Nickel concentrations exceeded the ADS 18/2017 MAC (QCC, 2017) for general use areas at station R2_ENV_018. There was no clear spatial distribution pattern that would indicate a point source related to possible anthropogenic activities within the survey area, and the differences recorded are therefore most likely to be associated with natural sediment variations.

Figure 5-23 below presents the overall trend in individual metals concentrations.

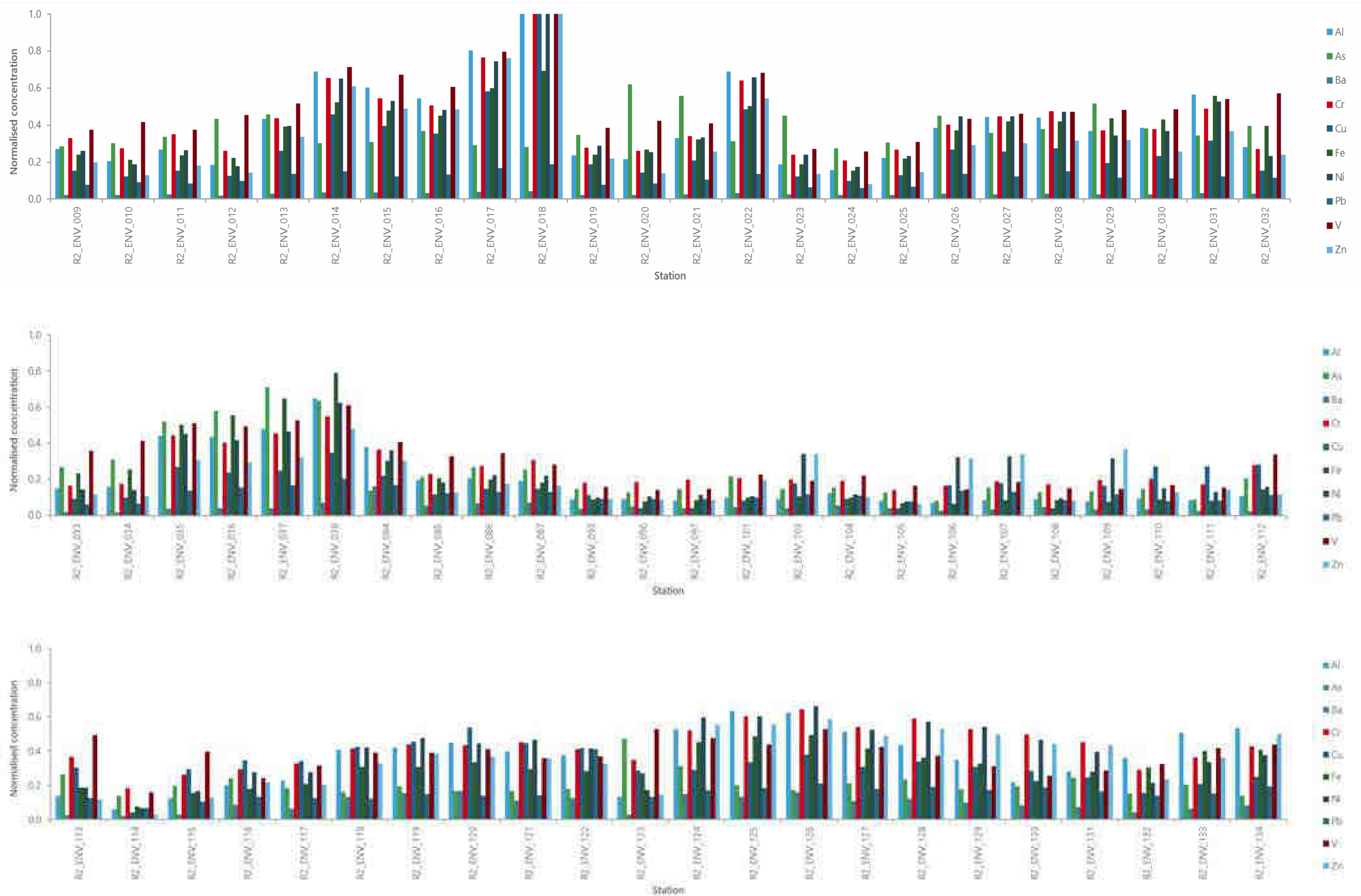


Figure 5-23: Relative (maximum normalised) elemental concentrations in sediments along Route 2 (64)

5.2.1.2.3. WKC Baseline Survey Results

Marine Water Quality

Route 1 – Mirfa Landfall

In Situ Measurements Results

The *in situ* water quality measurement results are provided in Table 5-7. Note that variation between sites was minimal across all parameters. Furthermore, all parameters were within the expected ranges and indicated the relatively good quality of the water on site. Parameters were qualified against the ADQCC where applicable. The results of the *in situ* water measurements are further discussed in the following sections.

Based on the results, there were no parameters recorded in exceedance of the reference standards and results were within the expected ranges typically recorded for the Arabian Gulf during the early summer season. The summary of the results is discussed below:

- Water temperature ranged from 25.80°C at R1-WSQ3 B to 28.70°C at R1-WSQ5 M with an average of 26.92°C. Water temperatures were within the expected range for the Arabian Gulf during the early summer season. Differences in readings between locations and depths are attributed to the time of sampling since sampling commenced in the morning and was done subsequently throughout in the afternoon;
- All sampling stations had a positive redox ranging from 1.60 mV (R1-WSQ1 M) to 125.60 mV (R1-SQ6 M). Redox potential above 100 mV implies an oxidised environment whilst reduced if below (66). However, it should be noted that redox readings are relative and can be influenced by processes that involve oxygen and microorganisms (67);
- The pH levels had similar values ranging from 8.1 to 8.3 and within EAD AWQO's permissible range;
- DO concentrations of all sampling locations were compliant with the reference standard (>5 mg/L) ranging from 6.21 mg/L (R1-WSQ5 M) to 6.78 mg/L (R1-WSQ1 M), with an average of 6.49 mg/L. Tidal flushing and good water exchange influenced the good DO concentrations in the project locations;
- Salinity ranged from 47.40 ppt (R1-WSQ2 T) to 49.20 ppt (R1-WSQ1 M). The related parameters such as conductivity and total dissolved solids (TDS) followed the same trend as salinity with little variation across sample locations. Conductivity ranged from 92.60 µS/cm (R1-WSQ4 T) to 95.77 µS/cm (R1-WSQ3 B) whilst TDS ranged from 60.19 g/L (R1-WSQ4 T) to 62.25 g/L (R1-WSQ3 B);
- Turbidity readings were very low ranging from <0.1 to 2.4 NTU, implying a high-water visibility; and
- In shallow areas (R1-WSQ1 M, and R1-WSQ5 to R1-WSQ9 M), the water clarity was surface to bottom. In other locations, the clarity ranged from 4.5 m to 6.65 m. The water clarity across sampling locations were generally good.

Ex Situ Analysis Results

Ex situ water quality results for analysed samples from this area recorded exceedances in TOC, nitrate, total cyanide, and three metals (Cadmium, Copper, and Lead), as shown in Table 5-8. The summary of the results is discussed below:

- Among inorganic parameters, only TDS and total nitrogen had an active level whilst total cyanide had an exceedance;
- TDS was recorded an order of magnitude above MDL ranging from 49,600 mg/L (R1-WSQ2 T) to 52, 000 mg/L (R1-WSQ9 M), as compared to the MDL of 5 mg/L. This is expected because of high salinity levels in the Gulf;

- Active levels above MDL were recorded for total nitrogen, except in locations R1-WSQ3 T & B, R1-WSQ4 CNTR B (Control), and R1-WSQ5 M;
- Total cyanide was recorded in exceedance only at R1-WSQ1 M (0.020 mg/L), and active levels only at R1-WSQ2 T (0.002 mg/L) and R1-WSQ7 M (0.001 mg/L). Cyanide in the ocean is significantly atmospheric in source which could rapidly disintegrate in a few months or less. There is less than 0.001 mg/L of cyanide in ocean water from atmospheric input (68);
- For anions, orthophosphate were below MDL whilst sulphate and chloride concentrations exceeded the MDL by an order of magnitude ranging from 3,100 mg/L to 3,190 mg/L whilst chloride ranged from 25,500 mg/L to 26,200 mg/L. Sulphate concentration in the Arabian Gulf seawater has been reported between 3,200 mg/L and 3,271 mg/L whilst chloride is between 21,933 mg/L to 22, 014 mg/L (69);
- Exceedance in nitrate was recorded only in R1-WSQ4 Central T with 5.75 mg/L, against the EAD AQWO standard of 0.095 mg/L. Also, active concentrations were recorded in R1-WSQ3 T, R1-WSQ7 M, R1-WSQ8 M, and R1-WSQ9 M. The rest of the samples were below MDL. The exceedance of nitrate in only one sample could be attributed to contamination of blue-green algae in the sample. In addition, nitrate concentration is generally higher in the surface layer because of nitrification. The summer season is likely to have lower nitrate concentrations due to uptake of phytoplankton;
- COD and BOD were below MDL. TOC was similar across the project locations ranging from 1.5 mg/L to 1.7 mg/L, except only for the location at R1-WSQ4 CNTR T with 18.0 mg/L, which exceeded the EAD AWQO standard of 2.5 mg/L;
- Exceedances were recorded in three (3) of the metal parameters against ADQCC: Cadmium (Cd) exceeded in R1-WSQ1 M, R1-WSQ4 CNTR B, R1-WSQ5 M, R1-WSQ6 M, and R1-WSQ7 M; Copper (Cu) exceeded in R1-WSQ1 M, R1-WSQ3 T, and R1-WSQ5 M; and Lead (Pb) exceeded in R1-WSQ1 M, R1-WSQ2 B, R1-WSQ3 M, R1-WSQ8 M, and R1-WSQ9 M. Active metal levels above MDL were recorded for Arsenic (As), Barium (Ba), Vanadium (V), Zinc (Zn), and Chromium (Cr). Generally, the sources of metals in the Arabian Gulf are atmospheric inputs due to its unique geologic environmental setting;
- Petroleum hydrocarbons, BTEX, PAHs and phenols were below MDL for all sampling locations; and
- Total coliform, a microbiological measure, was undetectable in all test locations.

Table 5-7: *In-situ* seawater quality along Route 1 – Mirfa Landfall

Location		Temp	Redox	pH	DO	Conductivity	TDS	Salinity	Turbidity	Depth	Water Clarity
Unit =		*°C*	*mV*	*pH units*	*mg/L*	*µS/cm*	*g/L*	*ppt*	*NTU*	*m*	*m*
EAD AWQO		*±3 of background concentration*	*-*	*6.5 – 8.5*	*>4*	*-*	*-*	*<5% of background concentration*	*10*		
WSQ1	M*	25.90	1.6	8.2	6.78	94.96	61.72	49.2	<0.1	-	-
WSQ2	T*	26.30	22.8	8.2	6.55	94.56	61.46	47.4	0.6	5.5	5.5
	B*	25.90	36.2	8.2	6.62	94.46	61.40	48.3	2.4		
WSQ3	T	26.40	34.3	8.2	6.50	93.79	60.96	48.3	0.3	12	4.5
	M	25.90	45.7	8.2	6.60	94.74	61.58	48.3	1.2		
	B	25.80	44.6	8.2	6.62	95.77	62.25	48.5	1.2		
WSQ4	T	27.50	45.3	8.1	6.30	92.60	60.19	48.5	<0.1	9	6.75
	M	25.90	39.6	8.3	6.63	94.43	61.37	48.4	0.3		
	B	25.90	53.4	8.2	6.65	94.96	61.72	48.4	0.1		
WSQ5	M	28.70	61.7	8.3	6.21	94.24	61.25	48.1	0.8	-	-
WSQ6	M	28.20	125.6	8.2	6.22	93.89	61.03	48.3	0.7	-	-
WSQ7	M	28.30	54.84	8.2	6.49	93.69	60.90	48.2	0.2	-	-
WSQ8	M	28.20	68.15	8.2	6.25	94.07	61.15	48.4	<0.1	-	-
WSQ9	M	28.00	37.14	8.2	6.45	93.67	60.89	48.2	0.9	-	-
Average		**26.92**	**47.92**	**8.20**	**6.49**	**94.27**	**61.27**	**48.32**	**0.79**	**N/A***	**N/A**
Minimum		**25.80**	**1.6**	**8.1**	**6.21**	**92.60**	**60.19**	**47.4**	**<01**	**N/A**	**N/A**
Maximum		**28.70**	**125.6**	**8.3**	**6.78**	**95.77**	**62.25**	**49.2**	**2.4**	**N/A**	**N/A**

* Note:
- T refers to top water layer
- B refers to bottom
- M refers to mid-water
- *: Not Applicable as not representative of the area

Table 5-8: *Ex Situ* seawater quality results along Route 1 – Mirfa Landfall

Parameters	Units	MDL*	ADQCC*	EAD AWQO	WSQ1	WSQ2		WSQ3			WSQ5	WSQ6	WSQ7	WSQ8	WSQ9	WSQ4 CNTR*		
					M*	T*	B*	T	M	B	M	M	M	M	M	T	M	B
Inorganic Parameters																		
Total Suspended Solids	mg/L	5		<33	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Total Dissolved Solids	mg/L	5			51400	49600	50800	50400	51200	51200	50700	50400	50900	51000	52000	50900	50700	50900
Dissolved & Emulsified Oil	mg/L	10			<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Free Oil	% vol./vol.	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia	mg/L	0.06			<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Nitrogen (Ammonia)	mg/L	0.05			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ammonium	mg/L	0.064			<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064
Sulphide	mg/L	0.004		0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Total Nitrogen	mg/L	0.5			0.5	0.5	0.6	<0.5	0.5	<0.5	<0.5	0.5	0.5	0.5	0.5	1.4	0.5	<0.5
Total Cyanide	mg/L	0.001		0.004	0.02	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Anions																		
Nitrate	mg/L	0.04		0.095	<0.04	<0.04	<0.04	0.04	<0.04	<0.04	<0.04	<0.04	0.09	0.09	0.84	5.75	<0.04	<0.04
Orthophosphate	mg/L	0.06			<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Sulphate	mg/L	5			3190	3100	3140	3150	3160	3160	3150	3170	3170	3160	3160	3150	3170	3170
Chloride	mg/L	2			26200	25500	26200	25900	25900	26200	25900	25900	25900	25900	26200	25900	25900	25900
Chemical Analysis																		
Chemical Oxygen Demand	mg/L	5			<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total Organic Carbon	mg/L	1		2.5	1.7	1.7	1.6	1.5	1.6	1.6	1.7	1.6	1.5	1.6	1.6	18	1.6	1.5
Biochemical Oxygen Demand	mg/L	2		5	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Metals																		
Aluminum (Al)	mg/L	0.005	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Arsenic (As)	mg/L	0.0005	-	0.005	0.0033	0.0034	0.0034	0.0039	0.0039	0.0032	0.0029	0.0032	0.0045	0.0039	0.004	0.0032	0.0037	0.0027
Barium (Ba)	mg/L	0.0005	-	-	0.0099	0.009	0.0116	0.0091	0.0123	0.0095	0.0109	0.0134	0.0099	0.0101	0.0149	0.0074	0.0079	0.0106
Cadmium (Cd)	mg/L	0.0001	0.0003	0.001	0.0003	<0.0001	0.0001	<0.0001	0.0001	<0.0001	0.0003	0.0012	0.0013	0.0002	0.0001	0.0001	<0.0001	0.0004
Copper (Cu)	mg/L	0.0003	0.003	0.01	0.0037	0.0014	0.0024	0.004	0.0022	0.0012	0.0073	0.0022	<0.0003	<0.0003	<0.0003	0.0017	0.0027	0.0004
Iron (Fe)	mg/L	0.02	-	0.3	<0.02	<0.02	0.06	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Lead (Pb)	mg/L	0.0002	0.0022	0.01	0.0022	0.0013	0.0036	0.001	0.0045	0.0013	0.0003	0.0019	0.0016	0.0027	0.0033	0.001	0.0014	0.0009
Mercury (Hg)	mg/L	0.0001	0.0001	0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Phosphorus (P)	mg/L	0.03	-	0.001	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Silver (Ag)	mg/L	0.0005	-	-	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Vanadium (V)	mg/L	0.0001	-	0.0094	0.0042	0.0037	0.0032	0.0034	0.0033	0.0034	0.0031	0.0037	0.0037	0.0036	0.41	0.0029	0.0033	0.0032
Zinc (Zn)	mg/L	0.002	0.015	0.1	0.003	0.008	0.003	<0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	0.002	<0.002	<0.002

Parameters	Units	MDL*	ADQCC*	EAD AWQO	WSQ1	WSQ2		WSQ3			WSQ5	WSQ6	WSQ7	WSQ8	WSQ9	WSQ4 CNTR*		
					M*	T*	B*	T	M	B	M	M	M	M	M	T	M	B
Silicon as SiO2	mg/L	2.8		-	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8
Chromium (Cr)	µg/L	0.3		10	0.9	<0.3	0.6	0.4	0.8	0.5	0.4	0.5	0.4	1.3	0.7	<0.3	0.5	0.8
BTEX																		
Benzene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Ethyl benzene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
m&p-Xylene	µg/L	14			<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14
o-Xylene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Toluene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Hydrocarbons																		
EPH C10-C40	µg/L	7	7	-	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
VPH C5-C10	µg/L	7	7	-	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
PAHs																		
Acenaphthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(a,h)anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	µg/L	0.02			<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenanthrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenols																		
2,4,5-Trichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,6-Trichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4-Dichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4-Dimethylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Parameters	Units	MDL*	ADQCC*	EAD AWQO	WSQ1	WSQ2		WSQ3			WSQ5	WSQ6	WSQ7	WSQ8	WSQ9	WSQ4 CNTR*		
					M*	T*	B*	T	M	B	M	M	M	M	M	T	M	B
2-Nitrophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Chloro-3-methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Nitrophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pentachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,3,4,6-Tetrachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,3,5,6-Tetrachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,6-Dichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
3-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phenol	µg/L	0.5			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Microbiology																		
Total Coliform	CFU/100mL	10		70	ND*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

* Note:

- Values highlighted in red represent exceedance of the standard
- Blue values represent above MDL
- CNTR refers to control location
- ND means not detected
- T refers to top water layer
- B refers to bottom
- M refers to mid-water.
- The ADQCC values shown are allowable concentrations for Marine Protected Use Areas.

Route 2 – Shuweihat Landfall

In Situ Measurements Results

The *in situ* water quality in this area is summarised in Table 5-9. Results from the survey were qualified against the EAD AWQO [6]. All the parameters were compliant with their applicable referenced standards and within the expected range for the Arabian Gulf during the early summer season. The summary of the results is discussed below:

- Water temperature was consistent across the sampling locations, ranging from 22.80 °C (R2- WSQ1 M & B) to 24.40 °C (R2- WSQ6 B);
- Redox potential varied between locations and depths with a positive value ranging from 22.50 mV (R2-WSQ1 T) to 151.20 mV (WSQ7 B);
- The pH levels were relatively similar, ranging from 8.0 to 8.2 and within the permissible range of EAD AWQO;
- DO concentrations were compliant with the reference standard (>5 mg/L) with a range between 6.67 mg/L (R2-WSQ7 B) to 7.40 mg/ (R2- WSQ3 B). The Project location is highly influenced by tidal flushing and good water exchange resulting in good DO concentrations;
- Salinity averaged 47.92 ppt, which is typical in the UAE. The salinity was consistent across the sampling locations, with a range from 47.50 ppt (R2-WSQ1 T) to 48.10 ppt (R2-WSQ3 T, R2-WSQ5 B, and R2-WSQ7 B). The related parameters such as conductivity and total dissolved solids (TDS) followed the same trend as salinity. The average conductivity was 89.93 µS/cm whilst TDS was 58.45 g/L;
- Turbidity values were minimal, ranging from <0.1 NTU to 2.5 NTU, compared to the referenced standard of 10 NTU; and
- Water clarity in R2-SQ4 M was surface to bottom. The rest of the locations ranged from 5 m to 8 m. The clarity was generally good considering the location depths ranging from 7.5 m to 12 m.

Ex Situ Measurements Results

The results of *ex situ* analysis of seawater quality in Route 2 indicate that most of the parameters were in compliance with their applicable limits, except for nitrate, total cyanide, two (2) trace metals, and hydrocarbon (EPH C10-C40), as shown in Table 5-10. The summary of the results is discussed below:

- TDS values across sampling locations were an order of magnitude above MDL, ranging from 49,600 mg/L to 50,000 mg/L, as compared to the MDL of 5 mg/L. This is expected because of high salinity levels in the Gulf;
- Active levels above MDL of total nitrogen were recorded only in four (4) locations at WSQ1 B, WSQ3 CNTR B, WSQ5 M, and WSQ7 T, with values of 0.5 mg/L, 0.5 mg/L, 2.5 mg/L, and 7.08 mg/L, respectively. The remaining of the sampling locations were below MDL;
- Total cyanide was only detected in WSQ2 T with 0.008 mg/L, exceeding the EAD AWQO standard of 0.004 mg/L;
- Orthophosphate was below MDL whilst sulphate and chloride concentrations exceeded the MDL by an order of magnitude ranging from 3,090 mg/L to 3,120 mg/L whilst chloride ranged from 25,200 mg/L to 25,500 mg/L. Sulphate concentration in the Arabian Gulf seawater has been reported between 3,200 mg/L and 3,271 mg/L whilst chloride is between 21,933 mg/L to 22, 014 mg/L (69);

- Exceedances in nitrate were detected at three locations: WSQ5 T (10.6 mg/L); WSQ7 T (7.08 mg/L); and WSQ2 B (0.22 mg/L). The standard of EAD AWQO for nitrate is 0.095 mg/L. Active levels above MDL were recorded for WSQ1 M & B, and WSQ3 CNTR B;
- COD and BOD were below MDL. TOC was similar across R2 locations ranging from 1.5 mg/L to 1.7 mg/L;
- Exceedances were recorded in three of the metal parameters. Copper (Cu) exceeded ADQCC in most of the locations, except in WSQ4 M, WSQ5 T, and WSQ7 T. Lead (Pb) exceeded ADQCC at WSQ1 T & B, WSQ2 M & B, WSQ3 CNTR T, WSQ5 T, M & B, and WSQ7 B. On the other hand, Zinc (Zn) exceeded EAD specifications at WSQ1 T & M;
- Active metal levels above MDL were recorded for Cadmium (Cd), Vanadium (V), and Chromium (Cr) but with no exceedances of the reference standards. Whereas, Iron (Fe), Phosphorus (P), Silver (Ag), Mercury (Hg), and Silicon (as SiO3) were below MDL;
- Petroleum hydrocarbons were detected only in WSQ7 T, with 9 µg/L of EPH C10-C40 was exceedance of the permissible limit of 7 µg/L. The remaining samples were below MDL. The exceedance of EPH C10-C40 in one sample could be attributed to contamination by fuel oils;
- BTEX, PAHs, and Phenols were below MDL for all Route 2 sampling points throughout the survey; and
- The microbial parameter, total coliform was undetected across all sampling locations.

Table 5-9: *In-situ* seawater quality along Route 2 – Shuweihat Landfall

Location		Temp	Redox	pH	DO	Conductivity	TDS	Salinity	Turbidity	Depth	Water Clarity
Unit =		*°C*	*mV*	*pH units*	*mg/L*	*µS/cm*	*g/L*	*ppt*	*NTU*	*m*	*m*
EAD AWQO		*±3 of background concentration*	-	*6.5 – 8.5*	*>4*	-	-	*<5% of background concentration*	*10*		
WSQ1	T*	22.90	22.5	8.1	7.20	91.01	59.16	47.5	0.5	12	7.5
WSQ1	M*	22.80	79.3	8.1	7.23	90.79	59.01	47.8	<0.1		
WSQ1	B*	22.80	63.8	8.1	7.28	91.27	59.32	47.9	2.5		
WSQ2	T	23.30	112.8	8.0	7.14	91.59	59.53	47.9	<0.1	11	7.5
WSQ2	M	23.00	124.1	8.1	7.21	91.36	59.38	48.0	1.0		
WSQ2	B	23.20	124.4	8.1	7.25	91.29	59.34	48.0	0.4		
WSQ3	T	24.20	150.6	8.1	6.97	91.49	59.47	48.1	0.3	9	7.25
WSQ3	B	23.50	144.3	8.2	7.40	91.61	59.55	47.9	<0.1		
WSQ4	M	23.30	113.5	8.2	7.04	67.52	43.89	47.8	<0.1	-	-
WSQ5	T	23.40	57.8	8.1	7.18	91.56	59.51	48.0	0.3	11	8
WSQ5	M	23.50	58.4	8.0	7.21	91.35	59.38	47.8	<0.1		
WSQ5	B	23.60	55.9	8.1	7.28	91.95	59.77	48.1	0.3		
WSQ6	T	23.70	106.4	8.1	7.08	91.41	59.42	47.9	<0.1	8	6
WSQ6	B	24.40	110	8.1	7.08	90.93	59.10	47.9	0.5		
WSQ7	T	24.00	146.9	8.1	6.90	91.59	59.53	48.0	<0.1	7.5	5
WSQ7	B	24.00	151.2	8.1	6.67	92.08	59.85	48.1	0.3		
Average		**23.47**	**101.36**	**8.1**	**7.13**	**89.92**	**58.45**	**47.91**	**0.678**	**9.75**	**6.87**
Minimum		**22.8**	**22.5**	**8**	**6.67**	**67.52**	**43.89**	**47.5**	**0.3**	**7.5**	**5**
Maximum		**24.4**	**151.2**	**8.2**	**7.28**	**92.08**	**59.85**	**48.1**	**2.5**	**12**	**8**

Location	Temp	Redox	pH	DO	Conductivity	TDS	Salinity	Turbidity	Depth	Water Clarity
* Note: – T refers to top water layer – B refers to bottom – M refers to mid-water										

Table 5-10: *Ex Situ* seawater quality results along Route 2 – Shuweihat Landfall

Parameters	Units	MDL*	ADQCC*	EAD AWQO	WSQ1			WSQ2			WSQ4	WSQ5			WSQ6		WSQ7		WSQ3 CNTR*	
					T*	M*	B*	T	M	B	M	T	M	B	T	B	T	B	T	B
Inorganic Parameters																				
Total Suspended Solids	mg/L	5		<33	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Total Dissolved Solids	mg/L	5			49600	49800	49600	49600	49900	49700	49900	49600	49600	49700	49600	49700	49800	50000	49700	49700
Dissolved & Emulsified Oil	mg/L	10			<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Free Oil	% vol./vol.	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia	mg/L	0.06			<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Nitrogen (Ammonia)	mg/L	0.05			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ammonium	mg/L	0.064			<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064
Sulphide	mg/L	0.004		0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Total Nitrogen	mg/L	0.5			<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2.5	<0.5	<0.5	<0.5	1.6	<0.5	<0.5	0.5
Total Cyanide	mg/L	0.001		0.004	<0.001	<0.001	<0.001	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Anions																				
Nitrate	mg/L	0.04		0.095	<0.04	0.09	0.04	<0.04	<0.04	0.22	<0.04	<0.04	10.6	<0.04	<0.04	<0.04	7.08	<0.04	<0.04	0.04
Orthophosphate	mg/L	0.06			<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Sulphate	mg/L	5			3120	3100	3110	3100	3110	3110	3100	3120	3110	3090	3100	3100	3120	3120	3100	3100
Chloride	mg/L	2			25500	25200	25500	25200	25500	25500	25500	25500	25500	25500	25500	25200	25500	25500	25200	25500
Chemical Analysis																				
Chemical Oxygen Demand	mg/L	5			<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total Organic Carbon	mg/L	1		2.5	1.7	1.6	1.7	1.7	1.7	1.6	1.6	1.6	1.6	1.6	1.5	1.7	1.6	1.6	1.6	1.6
Biochemical Oxygen Demand	mg/L	2		5	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Metals																				
Aluminum (Al)	mg/L	0.005	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Arsenic (As)	mg/L	0.0005	-	0.005	0.0022	0.0026	0.0028	0.0025	0.003	0.002	0.0033	0.0028	0.0029	0.002	0.0027	0.0021	0.0029	0.0018	0.0036	0.0027
Barium (Ba)	mg/L	0.0005	-	-	0.0094	0.0093	0.0103	0.0216	0.0124	0.0124	0.0133	0.0235	0.0116	0.0192	0.0147	0.0117	0.0118	0.0123	0.0225	0.0116
Cadmium (Cd)	mg/L	0.0001	0.0003	0.001	<0.0001	0.0001	0.0001	<0.0001	0.0001	0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	0.0002
Copper (Cu)	mg/L	0.0003	0.003	0.01	0.0037	0.0085	0.0069	0.0043	0.0032	0.0062	0.0025	0.0062	0.0058	0.0023	0.0037	0.0041	0.0019	0.0049	0.02	0.0062
Iron (Fe)	mg/L	0.02	-	0.3	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02

Parameters	Units	MDL*	ADQCC*	EAD AWQO	WSQ1			WSQ2			WSQ4	WSQ5			WSQ6		WSQ7		WSQ3 CNTR*	
					T*	M*	B*	T	M	B	M	T	M	B	T	B	T	B	T	B
Lead (Pb)	mg/L	0.0002	0.0022	0.01	0.0029	0.0017	0.0058	0.001	0.0056	0.0038	0.001	0.0044	0.0037	0.0029	0.0011	0.0015	0.0017	0.003	0.0061	0.0017
Mercury (Hg)	mg/L	0.0001	0.0001	0.001	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Phosphorus (P)	mg/L	0.03	-	0.001	<0.0005	<0.0005	<0.0005	0.0076	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Silver (Ag)	mg/L	0.0005	-	-	0.0034	0.0036	0.0038	0.0033	0.0032	0.0041	0.004	0.004	0.0041	0.0037	0.004	0.0045	0.0038	0.0037	0.0043	0.0037
Vanadium (V)	mg/L	0.0001	-	0.0094	0.011	0.012	0.008	0.008	0.003	0.004	0.007	<0.002	<0.002	0.004	0.002	<0.002	<0.002	<0.002	0.003	<0.002
Zinc (Zn)	mg/L	0.002	0.015	0.1	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silicon as SiO2	mg/L	2.8		-	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8
Chromium (Cr)	µg/L	0.3		10	0.9	0.5	1.6	0.5	0.6	0.9	0.4	1.3	1	1.4	0.8	0.5	0.6	1.1	1.7	1.1
BTEX																				
Benzene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Ethyl benzene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
m&p-Xylene	µg/L	14			<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14
o-Xylene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Toluene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Hydrocarbons																				
EPH C10-C40	µg/L	7	7	-	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	9	<7	<7	<7
VPH C5-C10	µg/L	7	7	-	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
PAHs																				
Acenaphthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	µg/L	0.01			0.01	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(a,h)anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	µg/L	0.02			<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenanthrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Parameters	Units	MDL*	ADQCC*	EAD AWQO	WSQ1			WSQ2			WSQ4	WSQ5			WSQ6		WSQ7		WSQ3 CNTR*	
					T*	M*	B*	T	M	B	M	T	M	B	T	B	T	B	T	B
Phenols																				
2,4,5-Trichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,6-Trichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4-Dichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4-Dimethylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Nitrophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Chloro-3-methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Nitrophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pentachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,3,4,6-Tetrachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,3,5,6-Tetrachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,6-Dichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
3-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phenol	µg/L	0.5			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Microbiology																				
Total Coliform	CFU/100mL	10		70	ND*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

* Note:

- Values highlighted in red represent exceedance of the standard
- Blue values represent above MDL
- CNTR refers to control location
- ND means not detected
- T refers to top water layer
- B refers to bottom
- M refers to mid-water.
- The ADQCC values shown are allowable concentrations for General Use Areas.

Route 1 – Zakum Clusters Route 1A Re-routing Area

In Situ Measurements Results

The in-situ water quality in Zakum Cluster Route 1-A is summarised in Table 5-11. Results from the survey were qualified against the EAD AWQO (70). All the parameters were compliant with their applicable referenced standards and within the expected range for the Arabian Gulf during the summer season.

- Water temperature was similar over the sampling area with little difference with depth. Temperature ranged from 27.30 °C at WSQ5 B to 28.90 °C at WSQ1 T, with an average of 27.83 °C. Water temperature was within the range expected for the Arabian Gulf during summer season. The temperature in Arabian Gulf fluctuates as much as 15 °C between winter and summer. The stability in readings suggest the absence of thermocline but rather of a well-mixed water column;
- Redox potential had positive values for all readings with an average of 67.40 mV, ranging from 25.80 mV to 110.70 mV. A positive redox potential is an indicator of good water quality with higher values indicating better water conditions;
- pH was similar for all locations with an average of 8.10 which is within the expected range;
- Dissolved oxygen (DO) was high in all recordings ranging from 6.08 mg/L at WSQ9 M to 6.42 at WSQ8 B. The project location is highly influenced by tidal currents and good water exchange resulting in good DO concentrations;
- Salinity levels were consistent across locations and depth with an average of 40.77 ppt, which is within the expected range for the Arabian Gulf. The salinity levels in the region range between 39-50 ppt and can reach up to 60 ppt in areas such as isolated lagoons during summer season. Similar with the temperature profile, the absence of salinity stratification suggests a well-mixed water column;
- The related parameters such as conductivity and total dissolved solids (TDS), showed similar results to salinity with little differences between sites and depths;
- Turbidity readings were very low ranging from <0.1 to 2.70 NTU and within the reference standard value, implying a good-water visibility; and
- The deepest sampled area was at WSQ5 and shallowest at WSQ8. All the sampled areas are more than 10 meters thus three levels within the water column were sampled. In deploying the Secchi disc, the highest water clarity was recorded at WSQ9 with 7.6 meters and the least clarity was at WSQ5 at 6.5 meters. Water clarity in the area was high, typical of Arabian Gulf offshore waters.

Ex Situ Measurements Results

The recorded concentrations of ex-situ parameters were compared to the EAD AWQO (70) and ADQCC (71) where applicable. The survey locations at Zakum Cluster Rerouting Areas are considered to constitute a Marine Protected Use Area, given the presence of ADNOC offshore facilities.

The results of ex-situ analysis of seawater quality at Zakum Cluster Route 1-A indicate that most of the parameters were in compliance with their applicable limits, except for nitrate and three trace metals (Copper, Lead and Zinc) as shown in Table 5-12 (for locations SWQ1-WSQ5) and Table 5-13 (for locations WSQ6 -WSQ10). A summary of the results is provided below:

- Among inorganic parameters, only Total Dissolved Solids (TDS) and Total Nitrogen (TN) had an active level. TDS was recorded an order of magnitude above the MDL, ranging from 45,500 mg/L to 46,400 mg/L, as compared to the MDL of 5 mg/L. This is expected because of high salinity levels in the Gulf. TN was recorded below and above the MDL ranging from <0.5 mg/L to 5.3 mg/L:
- For anions, orthophosphate was below the MDL whilst sulphate and chloride concentrations exceeded the MDL by an order of magnitude. Sulphate ranged from 3,060 mg/L to 3,120 mg/L whilst chloride ranged from 22,700 mg/L to 23,800 mg/L. Sulphate concentration in the Arabian Gulf seawater has been reported between 3,200 mg/L and 3,271 mg/L whilst chloride is between 21,933 mg/L to 22, 014 mg/L (69);
- Nitrate concentrations ranged from <0.04 mg/L to 18.6 mg/L. Exceedances were recorded against the EAD AQWO standard of 0.095 mg/L. Exceedances were recorded at eight (8) sampling locations such as: WSQ2 M; WSQ3 T& M; 5 T; WSQ WSQ4 T & B; WSQ6 B; WSQ7 T, WSQ8 T; and WSQ10 B. The summer season is likely to have lower nitrate concentrations due to uptake by phytoplankton, and mostly available in the surface layer due to nitrification. The recorded exceedances may be attributed to sample contamination with nitrogen-fixing organisms and/or other sources such as aerosols/atmospheric nitrate and diffusive mixing that transports nitrate;
- BOD was below the MDL and its reference standard whilst COD ranged from <5 mg/L to 30 mg/L, although there no existing standard for COD. On the other hand, TOC was similar across the project locations ranging from 1.4 mg/L to 2.0 mg/L;
- Exceedances were recorded in three (3) of the metal parameters against ADQCC: Copper (Cu) exceeded in all sampling locations; Lead (Pb) exceeded in WSQ1, WSQ2 M & B, WSQ3, WSQ4, WSQ5 M, WSQ6 B, WSQ7, WSQ8 T, WSQ9 M & B, and WSQ10; and Zinc (Zn) in WSQ6 M and in the top layers in WSQ7, WSQ8 and WSQ10;
- Active metal levels above MDL were recorded for Arsenic (As), Barium (Ba), Cadmium (Cd), Chromium (Cr), and Vanadium (V). Generally, the sources of metals in the Arabian Gulf are atmospheric inputs due to its unique geologic environmental setting. Whereas Aluminium (Al), Iron (Fe), Mercury (Hg), Phosphorus (P), Silicon (as SO_2), and Silver (Ag) were below MDL;
- Petroleum hydrocarbons, BTEX, PAHs and Phenols were below the MDL for all sampling locations; and
- Total coliform, a microbiological measure, was undetectable in all test locations, indicating little to no pollution from sewage sources.

Table 5-11: *In-situ* water quality profile at Zakum Clusters Route 1A

Location		Temp	Redox	pH	DO	Conductivity	TDS	Salinity	Turbidity	Depth	Water Clarity
	Unit =	*°C*	*mV*	*pH units*	*mg/L*	*µS/cm*	*g/L*	*ppt*	*NTU*	*m*	*m*
EAD AWQO		*±3 of background concentration*	*-*	*6.5 – 8.5*	*>4*	*-*	*-*	*<5% of background concentration*	*10*		
WSQ1	T*	28.90	51.60	8.20	6.15	85.36	55.48	40.80	0.5	18	7.5
	M*	27.90	66.20	8.20	6.26	85.46	55.55	40.80	0.5		
	B*	27.80	69.20	8.10	6.26	86.49	56.22	40.50	1.2		
WSQ2	T	28.60	55.80	8.20	6.18	85.52	55.59	40.40	1.4	16	7.0
	M	28.00	61.20	8.10	6.24	85.49	55.57	40.50	0.8		
	B	27.80	63.90	8.10	6.25	86.62	56.30	41.10	0.8		
WSQ3	T	28.50	25.80	7.80	6.18	85.17	55.36	40.60	2.7	16	7.2
	M	27.80	33.30	8.00	6.25	86.41	56.17	40.90	1.3		
	B	27.60	37.00	8.10	6.22	87.04	56.57	41.00	1.6		
WSQ4	T	28.10	27.90	8.10	6.22	85.62	55.65	40.60	2.4	18	7.0
	M	27.80	33.80	8.10	6.26	86.24	56.05	40.70	0.8		
	B	27.60	37.60	8.10	6.27	87.03	56.57	41.40	0.8		
WSQ5	T	28.00	101.00	8.10	6.24	85.65	55.67	40.60	0.4	21	6.5
	M	27.40	100.90	8.10	6.18	87.52	56.89	40.60	0.7		
	B	27.30	100.70	8.10	6.18	87.73	57.03	41.10	0.7		
WSQ6	T	27.80	110.70	8.10	6.25	85.44	55.53	41.20	1.2	16	7.0
	M	27.60	110.40	8.20	6.30	85.89	55.83	40.40	0.9		
	B	27.50	109.70	8.10	6.30	86.19	56.02	40.70	1.1		
WSQ7	T	27.60	86.50	8.10	6.27	86.16	56.00	40.70	1.5	14	7.1

Location		Temp	Redox	pH	DO	Conductivity	TDS	Salinity	Turbidity	Depth	Water Clarity
	M	27.50	85.80	8.10	6.28	86.55	56.26	40.60	1.6		
	B	27.50	86.10	8.10	6.26	86.67	56.33	40.70	0.5		
WSQ8	T	27.90	80.20	8.00	6.39	80.01	52.01	40.80	2.5	13	6.8
	M	27.60	85.80	8.10	6.39	85.92	55.84	40.70	0.3		
	B	27.50	86.00	8.10	6.42	86.35	56.12	40.60	0.9		
WSQ9	T	27.50	86.60	8.10	6.31	86.12	55.97	40.70	0.7	15	7.6
	M	28.50	42.90	8.10	6.08	85.27	55.42	40.70	1		
	B	28.00	45.70	8.10	6.17	86.15	55.99	41.00	1.1		
WSQ10	T	27.60	50.00	8.10	6.24	86.74	56.38	41.10	<0.1	16	7.2
	M	28.00	43.60	8.10	6.19	85.98	55.89	40.70	<0.1		
	B	27.60	46.00	8.10	6.24	86.63	56.31	40.80	<0.1		
Average		**27.83**	**67.40**	**8.10**	**6.25**	**85.98**	**55.89**	**40.77**	**1.11**	**14**	**7.4**
Minimum		**27.30**	**25.80**	**7.80**	**6.08**	**80.01**	**52.01**	**40.40**	**<0.1**		
Maximum		**28.90**	**110.70**	**8.20**	**6.42**	**87.73**	**57.03**	**41.40**	**2.70**		

* Note:
- T refers to top water layer
- B refers to bottom
- M refers to mid-water

Table 5-12: *Ex-situ* water quality profile at Zakum Clusters Route 1-A (Locations WSQ1- WSQ5)

Parameter Names	Unit	MDL*	ADQCC*	EAD AWQO	WSQ1			WSQ2			WSQ3			WSQ4			WSQ5		
					T*	M*	B*	T	M	B	T	M	B	T	M	B	T	M	B
Inorganic Parameters																			
Total Cyanide	mg/L	0.01		**0.004**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia	mg/L	0.06			<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ammonium	mg/L	0.064			<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064
Nitrogen (Ammonia)	mg/L	0.05			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Nitrogen	mg/L	0.5			<0.5	<0.5	<0.5	<0.5	5.3	<0.5	2.8	1.3	<0.5	0.6	<0.5	0.6	0.5	<0.5	<0.5
Dissolved & Emulsified Oils	mg/L	10			<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Free Oil	%vol./vol.	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Dissolved Solids	mg/L	5			45500	45700	45800	45400	45800	46000	45900	46400	46300	45800	46100	46400	45800	46300	46300
Total Suspended Solids	mg/L	5			<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Sulphide	mg/L	0.004		**0.004**	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Anions																			
Chloride	mg/L	2			23000	23400	23400	22700	23400	23400	23400	23800	23800	23400	23800	23800	23400	23800	23800
Nitrate	mg/L	0.04		**0.095**	0.04	0.04	0.04	<0.04	18.6	0.04	6.64	1.73	0.04	0.13	<0.04	0.49	0.13	0.04	0.04
Orthophosphate	mg/L	0.06			<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Sulphate	mg/L	5			3080	3090	3070	3060	3080	3090	3080	3110	3120	3090	3080	3120	3070	3110	3090
Chemical Analysis																			
Chemical Oxygen Demand	mg/L	5			8	<5	<5	<5	30	6	22	18	8	10	<5	10	8	<5	6
Total Organic Carbon	mg/L	1		2.5	1.5	1.6	1.5	1.5	1.6	1.5	1.7	1.6	1.6	1.7	1.4	1.6	1.6	1.6	1.7
Biochemical Oxygen Demand	mg/L	2		5	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Metals																			
Aluminum (Al)	mg/L	0.005	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Arsenic (As)	mg/L	0.0005	-	**0.005**	0.0028	0.0016	0.0018	0.0031	0.0024	0.0026	0.0024	0.0019	0.0028	0.0021	0.0016	0.0028	0.0024	0.0026	0.0033
Barium (Ba)	mg/L	0.0005	-	-	0.007	0.0027	0.0038	0.0077	0.0088	0.0099	0.0073	0.0065	0.0091	0.0082	0.012	0.0082	0.0059	0.0088	0.0078
Cadmium (Cd)	mg/L	0.0001	**0.0007**	0.001	0.0003	0.0001	0.0001	<0.0001	0.0002	0.0002	0.0001	0.0001	0.0001	0.0002	0.0012	0.0002	0.0001	0.0001	0.0002
Chromium (Cr)	µg/L	0.3	-	**10**	0.9	0.6	0.6	0.5	1.1	1.9	1.8	0.5	1.5	1.2	3	1.1	0.8	1.7	1
Copper (Cu)	mg/L	0.0003	**0.003**	0.01	0.0047	0.003	0.0038	0.0043	0.0091	0.0529	0.0117	0.0047	0.0048	0.0088	0.0048	0.0039	0.0048	0.0055	0.005
Iron (Fe)	mg/L	0.02		**0.3**	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Lead (Pb)	mg/L	0.0002	**0.0022**	0.01	0.0029	0.0024	0.0024	0.002	0.004	0.0079	0.0029	0.0029	0.0038	0.0023	0.0059	0.0033	0.0014	0.004	0.0014
Mercury (Hg)	mg/L	0.0001	**0.1**	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Phosphorus (P)	mg/L	0.03	-	0.001	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Silicon as SiO2	mg/L	2.8	-	-	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8
Silver (Ag)	mg/L	0.0005	-	-	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005

Parameter Names	Unit	MDL*	ADQCC*	EAD AWQO	WSQ1			WSQ2			WSQ3			WSQ4			WSQ5		
					T*	M*	B*	T	M	B	T	M	B	T	M	B	T	M	B
Vanadium (V)	mg/L	0.0001	-	**0.0094**	0.0033	0.0032	0.0036	0.0028	0.0036	0.0038	0.0037	0.0032	0.0037	0.0036	0.0039	0.0037	0.0036	0.0038	0.0037
Zinc (Zn)	mg/L	0.002	0.015	**0.01**	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.006	<0.002	<0.002	0.006	<0.002	<0.002	<0.002	<0.002	<0.002
BTEX																			
Benzene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Ethyl benzene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Toluene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
m&p-Xylene	µg/L	14			<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14
o-Xylene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Hydrocarbons																			
EPH C10-C40	µg/L	7	**7**	-	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7		9	<7	
VPH C5-C10	µg/L	7	**7**	-	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7		<7	<7	
PAHs																			
Acenaphthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(a,h)anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	µg/L	0.02			<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenanthrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenols																			
2,3,4,6-Tetrachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,3,5,6-Tetrachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,5-Trichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,6-Trichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4-Dichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Parameter Names	Unit	MDL*	ADQCC*	EAD AWQO	WSQ1			WSQ2			WSQ3			WSQ4			WSQ5		
					T*	M*	B*	T	M	B	T	M	B	T	M	B	T	M	B
2,4-Dimethylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,6-Dichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Nitrophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
3-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Chloro-3-methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Nitrophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pentachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phenol	µg/L	0.5			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Microbiology																			
Total Coliform	CFU/100mL	10		70	ND*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

* Note:
Values highlighted in red represent exceedance of the standard
Blue values represent above MDL
CNTR refers to control location
ND means not detected
T refers to top water layer
B refers to bottom
M refers to mid-water.
The ADQCC values shown are allowable concentrations for General Use Areas.

Table 5-13: *Ex-situ* water quality profile at Zakum Clusters Route 1A (Locations WSQ6- WSQ10)

Parameter Names	Unit	MDL*	ADQCC*	EAD AWQO	WSQ6			WSQ7			WSQ8			WSQ9			WSQ10		
					T*	M*	B*	T	M	B	T	M	B	T	M	B	T	M	B
Inorganic Parameters																			
Total Cyanide	mg/L	0.01		**0.004**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia	mg/L	0.06			<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ammonium	mg/L	0.064			<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064
Nitrogen (Ammonia)	mg/L	0.05			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Nitrogen	mg/L	0.5			<0.5	<0.5	<0.5	0.7	0.5	<0.5	1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3.6
Dissolved & Emulsified Oils	mg/L	10			<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Free Oil	%vol./vol.	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Dissolved Solids	mg/L	5			45800	45600	45900	45900	46000	46000	45800	45700	45700	46000	45900	45900	46100	45900	45800
Total Suspended Solids	mg/L	5			<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Sulphide	mg/L	0.004		**0.004**	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Anions																			
Chloride	mg/L	2			23400	23400	23400	23400	23400	23400	23400	23000	23000	23400	23400	23400	23800	23400	23400
Nitrate	mg/L	0.04		**0.095**	0.04	<0.04	0.13	0.13	0.04	<0.04	0.13	0.04	0.04	<0.04	0.04	<0.04	0.04	0.04	6.2
Orthophosphate	mg/L	0.06			<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Sulphate	mg/L	5			3080	3090	3090	3070	3060	3070	3070	3090	3090	3100	3110	3090	3080	3090	3090
Chemical Analysis																			
Chemical Oxygen Demand	mg/L	5			<5	<5	<5	12	8	10	<5	<5	<5	<5	<5	<5	<5	<5	22
Total Organic Carbon	mg/L	1		2.5	1.6	1.6	1.5	2	1.6	1.5	1.8	1.5	1.6	1.6	1.5	1.4	1.6	1.7	1.5
Biochemical Oxygen Demand	mg/L	2		5	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Metals																			
Aluminum (Al)	mg/L	0.005	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Arsenic (As)	mg/L	0.0005	-	0.005	0.0028	0.0027	0.0023	0.0032	0.0025	0.0023	0.0025	0.0032	0.0032	0.0021	0.0037	0.0039	0.0025	0.0032	0.0032
Barium (Ba)	mg/L	0.0005	-	-	0.0078	0.0073	0.0073	0.0108	0.0091	0.0101	0.0107	0.0082	0.0081	0.0081	0.0108	0.0141	0.0155	0.014	0.0136
Cadmium (Cd)	mg/L	0.0001	0.0007	0.001	0.0001	0.0001	0.0002	0.0005	0.0003	<0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	<0.0001
Chromium (Cr)	µg/L	0.3	-	10	1.3	0.8	1.1	1	1.1	1.1	1.2	0.6	1.1	0.8	4	2.2	2.1	1.4	1.5
Copper (Cu)	mg/L	0.0003	0.003	0.01	0.008	0.0053	0.0037	0.0101	0.0066	0.0047	0.0271	0.011	0.0139	0.0081	0.0123	0.0067	0.0096	0.0066	0.0074
Iron (Fe)	mg/L	0.02		0.3	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Lead (Pb)	mg/L	0.0002	0.0022	0.01	0.0017	0.0015	0.0022	0.0048	0.0028	0.0022	0.0032	0.0017	0.0018	0.0017	0.0029	0.005	0.0058	0.0028	0.0028
Mercury (Hg)	mg/L	0.0001	0.1	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Phosphorus (P)	mg/L	0.03	-	0.001	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Silicon as SiO2	mg/L	2.8	-	-	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8
Silver (Ag)	mg/L	0.0005	-	-	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005

Parameter Names	Unit	MDL*	ADQCC*	EAD AWQO	WSQ6			WSQ7			WSQ8			WSQ9			WSQ10		
					T*	M*	B*	T	M	B	T	M	B	T	M	B	T	M	B
Vanadium (V)	mg/L	0.0001	-	0.0094	0.0038	0.0037	0.0041	0.0041	0.0039	0.0034	0.004	0.0036	0.0033	0.0037	0.0041	0.0043	0.0046	0.0039	0.0041
Zinc (Zn)	mg/L	0.002	0.015	0.01	0.003	0.01	<0.002	0.017	0.002	<0.002	0.047	0.008	0.009	0.008	0.008	<0.002	0.013	0.008	<0.002
BTEX																			
Benzene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Ethyl benzene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Toluene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
m&p-Xylene	µg/L	14			<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14
o-Xylene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Hydrocarbons																			
EPH C10-C40	µg/L	7	**7**	-	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
VPH C5-C10	µg/L	7	**7**	-	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
PAHs																			
Acenaphthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(a,h)anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	µg/L	0.02			<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenanthrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenols																			
2,3,4,6-Tetrachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,3,5,6-Tetrachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,5-Trichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,6-Trichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4-Dichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Parameter Names	Unit	MDL*	ADQCC*	EAD AWQO	WSQ6			WSQ7			WSQ8			WSQ9			WSQ10		
					T*	M*	B*	T	M	B	T	M	B	T	M	B	T	M	B
2,4-Dimethylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,6-Dichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Nitrophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
3-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Chloro-3-methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Nitrophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pentachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phenol	µg/L	0.5			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Microbiology																			
Total Coliform	CFU/100mL	10		70	ND*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

* Note:
- Values highlighted in red represent exceedance of the standard
- Blue values represent above MDL
- CNTR refers to control location
- ND means not detected
- T refers to top water layer
- B refers to bottom
- M refers to mid-water.
- The ADQCC values shown are allowable concentrations for General Use Areas.

Route 1 – Zakum Clusters Route 1B Re-routing Area

In Situ Measurements Results

Results from the survey were qualified against the EAD AWQO (70) where applicable. In situ marine water quality measurements at Zakum Cluster Route 1-B are provided in Table 5-14. No parameters were in exceedance of the EAD AWQO and results were within the expected range for the Arabian Gulf during summer.

- Temperature profiles for the area ranged from 27.30 at WSQ 13 T & M to 28.90 °C at WSQ12 T, with an average of 27.75 °C. The readings of all the sampling locations revealed a generally stable temperature. The recorded temperature range was expected normal for the sampling season;
- Redox potential had positive values for all readings ranging from 10.60 mV (WSQ15 B) to 114.50 mV (WSQ17 M), with an average of 69.54 mV. A positive redox potential is an indicator of good water quality with higher values indicating better water conditions;
- pH levels were in the compliant range for the site with an average of 8.11;
- Dissolved Oxygen (DO) is compliant with the reference standard with an average of 6.29 mg/L;
- Salinity profiles ranged between 40.20 ppt to 41.10 ppt across the sampling locations, with an average of 40.56 ppt. Salinity was generally similar with minimal variations the salinity range in the study site and is considered normal for the time of sampling;
- The salinity related parameters such as conductivity and total dissolved solids (TDS), followed the same trend. The averages of these monitoring parameters are as follows: conductivity with 85.31 µS/cm and TDS with 55.45 g/L;
- Turbidity values were minimal, ranging from <0.1 NTU to 2.70 NTU, compared to the reference standard of 10 NTU. This implies a good water visibility and light penetration; and
- The shallowest sampled site was at WSQ20 at 15 meters and deepest at WSQ14 at 24 meters. All the sampled areas are more than 10 meters thus three levels along the water column were sampled. Water clarity was highest at 7.8 meters and the lowest clarity measurements was at WSQ17 at 6.7 meters. There were no observed algal blooms that may affect water clarity thus the high Secchi disc measurement reading.

Ex Situ Measurements Results

Ex-situ water quality results in Zakum Cluster Route 1-B recorded exceedances in TOC, nitrate, total cyanide, and three metals (Cadmium, Copper, and Lead), as shown in Table 5-15 (for location WSQ11-WSQ15) and

Table 5-16 (for locations WSQ16-WSQ20). A summary of the results is provided below:

- Of the inorganic parameters, only TDS and TN were detected above the MDL. TDS values across the sampling locations were an order of magnitude above the MDL, ranging from 45,00 mg/L to 46,100 mg/L, as compared to the MDL of 5 mg/L. This is expected because of high salinity levels in the Gulf. Active levels above the MDL of total nitrogen were recorded only in six locations at WSQ11 T, WSQ13 T, WSQ14T, WSQ15, WSQ16 T & B, and WSQ18 B. The remaining of the sampling locations were below MDL;
- Orthophosphate was below the MDL. Sulphate and chloride concentrations exceeded the MDL by an order of magnitude ranging from 3,040 mg/L to 3,110 mg/L and 22,700 mg/L to 23,400 mg/L, respectively. Sulphate concentration in the Arabian Gulf seawater has been reported between 3,200 mg/L and 3,271 mg/L whilst chloride is between 21,933 mg/L to 22, 014 mg/L (69);
- Exceedances in nitrate were detected at four (4) locations: WSQ13 T; WSQ14 T, WSQ15 T &B, and WSQ16 T. Exceedances in nitrate concentration can be ascribed to aerosol nitrate contamination, since the locations are offshore and from far domestic and riverine inputs;
- BOD was below the MDL whilst COD ranged from <5 mg/L to 8 mg/L. Exceedance was recorded in one location (WSQ17 M) with 2.9 mg/L, against the standard of 2.5 mg/L. The rest of TOC values were above the MDL but below the reference standard;
- Exceedances were recorded in four (4) of the metal parameters. Copper (Cu) exceeded ADQCC at WSQ11, WSQ12 T &M, WSQ13 M, WSQ14 T & M, and WSQ15. Lead (Pb) exceeded ADQCC at most of the locations, at WSQ11, WSQ12 T &M, WSQ13 M, WSQ14, WSQ15, WSQ16 T & B, WSQ17, WSQ18 M & B, WSQ19 T & M, and WSQ20 M. Cadmium (Cd) exceeded ADQCC only at WSQ16 T & B. Zinc (Zn) exceeded EAD specifications at WSQ11 B and WSQ16 T;
- Active metal levels above the MDL were recorded for Arsenic (As), Barium (Ba), Vanadium (V), and Chromium (Cr) but with no exceedances of the reference standards, where applicable. Aluminium (Al), Iron (Fe), Phosphorus (P), Silver (Ag), Mercury (Hg), and Silicon (as SiO3) were below the MDL;
- BTEX, hydrocarbons, PAHs and Phenols were below the MDL for all sampling points throughout the survey;
- The microbial parameter, total coliform was undetected across all sampling locations.

Table 5-14: *In-situ* water quality profile at Zakum Clusters Route 1-B

Location		Temperature	Redox	pH	DO	Conductivity	TDS	Salinity	Turbidity	Depth	Water Clarity
	Unit =	*°C*	*mV*	*pH units*	*mg/L*	*µS/cm*	*g/L*	*ppt*	*NTU*	*m*	*m*
EAD AWQO		*±3 of background concentration*	-	*6.5 – 8.5*	*>4*	-	-	*<5% of background concentration*	*10*		
WSQ11	T*	28.80	30.30	8.10	6.15	85.56	55.61	40.30	<0.1	18	7.4
	M*	28.10	37.90	8.10	6.20	86.01	55.91	40.40	<0.1		
	B*	27.90	40.70	8.10	6.22	86.83	56.44	41.10	<0.1		
WSQ12	T	28.90	91.80	8.20	6.17	84.84	55.14	40.30	0.4	22	7.8
	M	27.90	98.80	8.10	6.29	85.89	55.82	40.40	<0.1		
	B	27.70	100.30	8.10	6.31	86.74	56.38	40.90	<0.1		
WSQ13	T	27.30	70.10	8.10	6.46	85.62	55.65	40.50	0.5	21	7.1
	M	27.30	71.40	8.10	6.46	86.34	56.12	40.70	2.7		
	B	27.40	73.30	8.20	6.46	86.77	56.40	40.80	0.1		
WSQ14	T	27.70	30.90	8.10	6.29	85.41	55.52	40.50	0.8	24	6.8
	M	27.60	36.60	8.20	6.34	86.21	56.03	40.30	0.9		
	B	27.40	43.30	8.10	6.30	87.19	56.67	40.90	0.5		
WSQ15	T	28.00	16.40	8.10	6.28	84.71	55.06	40.20	0.8	19	7.1
	M	27.90	12.20	8.10	6.29	84.34	54.82	40.50	0.6		
	B	27.80	10.60	8.10	6.27	86.39	56.15	40.50	0.6		
WSQ16	T	27.90	56.20	8.10	6.68	64.58	41.97	40.50	<0.1	22	7.0
	M	27.80	57.30	8.10	6.27	85.64	55.66	40.50	1.4		
	B	27.80	57.50	8.10	6.27	85.67	55.68	40.50	1		
WSQ17	T	27.80	99.30	8.10	6.22	85.98	55.88	40.50	<0.1	16	6.7
	M	27.50	114.50	8.10	6.34	85.10	55.31	40.50	<0.1		
	B	27.50	111.90	8.10	6.30	85.58	55.62	40.40	<0.1		
WSQ18	T	27.50	109.60	8.10	6.26	86.57	56.27	40.60	<0.1	14	7.2
	M	28.10	100.40	8.10	6.18	85.46	55.54	40.60	0.9		
	B	27.80	99.70	8.10	6.21	85.96	55.87	40.60	1.5		
WSQ19	T	27.60	104.40	8.10	6.25	86.46	56.20	40.60	<0.1	18	7.2

Location		Temperature	Redox	pH	DO	Conductivity	TDS	Salinity	Turbidity	Depth	Water Clarity
	M	27.40	103.90	8.10	6.29	86.85	56.45	40.60	1		
	B	27.60	103.80	8.10	6.26	86.35	56.13	40.70	<0.1		
WSQ20	T	27.40	48.70	8.10	6.27	86.96	56.52	40.80	1	15	7.4
	M	27.40	49.10	8.10	6.27	86.97	56.53	40.70	2.5		
	B	27.80	105.20	8.10	6.20	86.20	56.03	40.50	<0.1		
Average		**27.75**	**69.54**	**8.11**	**6.29**	**85.31**	**55.45**	**40.56**	**1.01**	**16**	**6.8**
Minimum		**27.30**	**10.60**	**8.10**	**6.15**	**64.58**	**41.97**	**40.20**	**0.10**		
Maximum		**28.90**	**114.50**	**8.20**	**6.68**	**87.19**	**56.67**	**41.10**	**2.70**		

* Note:

– T refers to top water layer
– B refers to bottom
– M refers to mid-water

Table 5-15: *Ex-situ* water quality profile at Zakum Cluster Route 1B (Locations WSQ11- WSQ15)

Parameter Names	Unit	MDL*	ADQCC*	EAD AWQO	WSQ11			WSQ12			WSQ13			WSQ14			WSQ15		
					T*	M*	B*	T	M	B	T	M	B	T	M	B	T	M	B
Inorganic Parameters																			
Total Cyanide	mg/L	0.01		**0.004**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia	mg/L	0.06			<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ammonium	mg/L	0.064			<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064
Nitrogen (Ammonia)	mg/L	0.05			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Nitrogen	mg/L	0.5			0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	0.5	<0.5	<0.5	1.1	0.5	0.7
Dissolved & Emulsified Oils	mg/L	10			<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Free Oil	%vol./vol.	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Dissolved Solids	mg/L	5			45600	45800	46000	45400	45600	45800	45700	45800	45700	45600	45600	46100	45000	45500	45500
Total Suspended Solids	mg/L	5			<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Sulphide	mg/L	0.004		**0.004**	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Anions																			
Chloride	mg/L	2			22700	23000	23400	22700	23400	23400	23000	23400	23400	23000	23400	23400	22700	23000	23000
Nitrate	mg/L	0.04		**0.095**	0.04	<0.04	0.04	<0.04	0.04	<0.04	0.13	0.04	<0.04	0.13	<0.04	0.04	0.62	0.09	0.4
Orthophosphate	mg/L	0.06			<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Sulphate	mg/L	5			3090	3070	3080	3080	3110	3090	3090	3080	3090	3110	3070	3090	3040	3090	3090
Chemical Analysis																			
Chemical Oxygen Demand	mg/L	5			<5	<5	<5	12	8	10	<5	<5	<5	<5	<5	<5	<5	<5	22
Total Organic Carbon	mg/L	1		2.5	1.6	1.6	1.5	2	1.6	1.5	1.8	1.5	1.6	1.6	1.5	1.4	1.6	1.7	1.5
Biochemical Oxygen Demand	mg/L	2		5	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Metals																			
Aluminum (Al)	mg/L	0.005	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Arsenic (As)	mg/L	0.0005	-	0.005	0.0025	0.002	0.0025	0.0021	0.0021	0.0018	0.0021	0.0029	0.0022	0.0028	0.0027	0.0018	0.0021	0.0028	0.0018
Barium (Ba)	mg/L	0.0005	-	-	0.0107	0.0113	0.007	0.01	0.0074	0.006	0.0062	0.0099	0.0044	0.0073	0.0073	0.0058	0.0078	0.0054	0.0097
Cadmium (Cd)	mg/L	0.0001	0.0007	0.001	0.0003	0.0002	0.0002	0.0001	0.0006	0.0001	0.0001	0.0002	<0.0001	0.0002	0.0001	0.0004	0.0006	0.0005	0.0001
Chromium (Cr)	µg/L	0.3	-	**10**	2.2	1.6	1	1.1	0.5	<0.3	0.5	1.3	<0.3	0.5	0.9	<0.3	<0.3	<0.3	1
Copper (Cu)	mg/L	0.0003	0.003	0.01	0.0125	0.0106	0.0317	0.0078	0.0045	0.0024	0.0067	0.0044	0.0028	0.0124	0.0033	0.0026	0.003	0.0036	0.0041
Iron (Fe)	mg/L	0.02		**0.3**	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Lead (Pb)	mg/L	0.0002	0.0022	0.01	0.0059	0.0049	0.0023	0.0044	0.0141	0.0015	0.0021	0.0048	0.0007	0.0026	0.0025	0.0029	0.0039	0.0047	0.0047
Mercury (Hg)	mg/L	0.0001	0.1	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Phosphorus (P)	mg/L	0.03	-	0.001	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Silicon as SiO2	mg/L	2.8	-	-	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	37.9	<2.8	<2.8	<2.8	<2.8	<2.8
Silver (Ag)	mg/L	0.0005	-	-	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0006	<0.0005	<0.0005	<0.0005

Parameter Names	Unit	MDL*	ADQCC*	EAD AWQO	WSQ11			WSQ12			WSQ13			WSQ14			WSQ15		
					T*	M*	B*	T	M	B	T	M	B	T	M	B	T	M	B
Vanadium (V)	mg/L	0.0001	-	0.0094	0.0041	0.0024	0.0023	0.003	0.0027	0.0017	0.0019	0.0032	0.0021	0.0024	0.003	0.0024	0.0024	0.0025	0.0023
Zinc (Zn)	mg/L	0.002	0.015	0.01	0.003	0.009	0.01	<0.002	<0.002	<0.002	0.008	<0.002	<0.002	<0.002	<0.002	<0.002	0.009	<0.002	<0.002
BTEX																			
Benzene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Ethyl benzene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Toluene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
m&p-Xylene	µg/L	14			<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14
o-Xylene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Hydrocarbons																			
EPH C10-C40	µg/L	7	**7**	-	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	41	<7	<7	<7
VPH C5-C10	µg/L	7	**7**	-	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
PAHs																			
Acenaphthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(a,h)anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	µg/L	0.02			<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenanthrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenols																			
2,3,4,6-Tetrachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,3,5,6-Tetrachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,5-Trichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,6-Trichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4-Dichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Parameter Names	Unit	MDL*	ADQCC*	EAD AWQO	WSQ11			WSQ12			WSQ13			WSQ14			WSQ15		
					T*	M*	B*	T	M	B	T	M	B	T	M	B	T	M	B
2,4-Dimethylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,6-Dichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Nitrophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
3-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Chloro-3-methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Nitrophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pentachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phenol	µg/L	0.5			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Microbiology																			
Total Coliform	CFU/100mL	10		70	ND*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

* Note:

- Values highlighted in red represent exceedance of the standard
- Blue values represent above MDL
- CNTR refers to control location
- ND means not detected
- T refers to top water layer
- B refers to bottom
- M refers to mid-water.

Table 5-16: *Ex-situ* water quality profile at Zakum Cluster Route 1B (Locations WSQ16-WSQ20)

Parameters	Units	MDL*	ADQCC*	EAD AWQO	WSQ16			WSQ17			WSQ18			WSQ19			WSQ20		
					T*	M*	B*	T	M	B	T	M	B	T	M	B	T	M	B
Inorganic Parameters																			
Total Cyanide	mg/L	0.01		**0.004**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia	mg/L	0.06			<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Ammonium	mg/L	0.064			<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064	<0.064
Nitrogen (Ammonia)	mg/L	0.05			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Total Nitrogen	mg/L	0.5			0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Dissolved & Emulsified Oils	mg/L	10			<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Free Oil	%vol./vol.	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Dissolved Solids	mg/L	5			45600	45700	45700	45700	45600	45300	45800	45500	45900	45800	45900	45800	46000	45800	45800
Total Suspended Solids	mg/L	5			<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Sulphide	mg/L	0.004		**0.004**	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Anions																			
Chloride	mg/L	2			23000	23000	23000	23000	23000	23000	23000	23000	23000	23400	23400	23400	23400	23400	23000
Nitrate	mg/L	0.04		**0.095**	0.18	0.04	0.04	0.04	0.04	<0.04	<0.04	0.04	0.04	<0.04	<0.04	<0.04	0.04	<0.04	<0.04
Orthophosphate	mg/L	0.06			<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Sulphate	mg/L	5			3080	3080	3090	3100	3100	3090	3090	3070	3100	3110	3080	3090	3050	3090	3090
Chemical Analysis																			
Chemical Oxygen Demand	mg/L	5			<5	<5	6	<5	<5	<5	<5	<5	6	<5	<5	<5	<5	<5	<5
Total Organic Carbon	mg/L	1		2.5	1.7	1.6	1.6	1.4	2.9	1.4	1.5	1.7	1.6	1.5	1.4	1.5	1.4	1.6	1.6
Biochemical Oxygen Demand	mg/L	2		5	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Metals																			
Aluminum (Al)	mg/L	0.005	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Arsenic (As)	mg/L	0.0005	-	0.005	0.0017	0.0028	0.0027	0.0018	0.003	0.0034	0.0031	0.0019	0.0027	0.002	0.0033	0.0032	0.0026	0.0021	0.0031
Barium (Ba)	mg/L	0.0005	-	-	0.0057	0.0055	0.0079	0.0076	0.0056	0.0072	0.0072	0.0095	0.0191	0.0074	0.0067	0.0055	0.0073	0.0071	0.0024
Cadmium (Cd)	mg/L	0.0001	0.0007	0.001	0.0018	<0.0001	0.001	<0.0001	0.0001	0.0002	0.0002	0.0002	0.0001	0.0001	<0.0001	0.0003	<0.0001	0.0002	0.0001
Chromium (Cr)	µg/L	0.3	-	10	1.4	<0.3	0.4	0.7	<0.3	<0.3	0.8	0.3	1.7	0.5	0.7	<0.3	<0.3	<0.3	<0.3
Copper (Cu)	mg/L	0.0003	0.003	0.01	0.0038	0.0063	0.006	0.0049	0.0046	0.0041	0.0115	0.0141	0.012	0.0041	0.0096	0.0036	0.0028	0.004	0.0047
Iron (Fe)	mg/L	0.02		0.3	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Lead (Pb)	mg/L	0.0002	0.0022	0.01	0.0222	0.0019	0.0142	0.0022	0.0038	0.0033	0.0021	0.0045	0.0045	0.0027	0.0057	0.0019	0.0016	0.0112	0.0008
Mercury (Hg)	mg/L	0.0001	0.1	-	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Phosphorus (P)	mg/L	0.03	-	0.001	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Silicon as SiO2	mg/L	2.8	-	-	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8	<2.8
Silver (Ag)	mg/L	0.0005	-	-	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005

Parameters	Units	MDL*	ADQCC*	EAD AWQO	WSQ16			WSQ17			WSQ18			WSQ19			WSQ20		
					T*	M*	B*	T	M	B	T	M	B	T	M	B	T	M	B
Vanadium (V)	mg/L	0.0001	-	0.0094	0.0023	0.0022	0.0023	0.0026	0.0022	0.0022	0.0025	0.0022	0.0028	0.0026	0.0026	0.0023	0.0024	0.0022	0.0021
Zinc (Zn)	mg/L	0.002	0.015	0.01	0.021	0.006	<0.002	0.004	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	0.005	<0.002	0.007	0.005	0.008
BTEX																			
Benzene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Ethyl benzene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Toluene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
m&p-Xylene	µg/L	14			<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14	<14
o-Xylene	µg/L	7			<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
Hydrocarbons																			
EPH C10-C40	µg/L	7	**7**	-	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
VPH C5-C10	µg/L	7	**7**	-	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7	<7
PAHs																			
Acenaphthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(a,h)anthracene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	µg/L	0.02			<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Phenanthrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	µg/L	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenols																			
2,3,4,6-Tetrachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,3,5,6-Tetrachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,5-Trichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4,6-Trichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,4-Dichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Parameters	Units	MDL*	ADQCC*	EAD AWQO	WSQ16			WSQ17			WSQ18			WSQ19			WSQ20		
					T*	M*	B*	T	M	B	T	M	B	T	M	B	T	M	B
2,4-Dimethylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2,6-Dichlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Chlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
2-Nitrophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
3-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Chloro-3-methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Methylphenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
4-Nitrophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pentachlorophenol	µg/L	1			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phenol	µg/L	0.5			<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Microbiology																			
Total Coliform	CFU/100mL	10		70	ND*	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

* Note:

- Values highlighted in red represent exceedance of the standard
- Blue values represent above MDL
- CNTR refers to control location
- ND means not detected
- T refers to top water layer
- B refers to bottom
- M refers to mid-water.

Marine Sediment Quality

Route 1 – Mirfa Landfall

The results obtained from the laboratory sediment analysis are presented in Table 5-17 and have been compared to the standards provided by the Abu Dhabi Quality and Conformity Council (ADQCC) (71). Exceedances of the reference standard were recorded for three metals, namely arsenic (As), chromium (Cr) and nickel (Ni). The summary of the results is discussed below:

- pH ranged from 8.7 (R1-WSQ1 and R1 WSQ2) to 9.2 (R1-WSQ5 and R1-WSQ6);
- Oil and grease were below MDL across sampling locations;
- High levels of total nitrogen (TN) were detected in the sediments ranging from 194 mg/kg (R1-WSQ3) to 922 mg/kg (R1-WSQ2). These values were an order of magnitude above the MDL of 5 mg/kg. However, there is no referenced standard for TN;
- Active levels of silica concentration were detected in all locations with lowest value at R1-WSQ1 with 6.95 % by wt. whilst highest value at R1-WSQ5 with 28.2 % by wt;
- Orthophosphate was found to be below MDL, while fluoride and sulphate had active levels. Fluoride ranged from 1.1 mg/kg (R1-WSQ6) to 2.5 mg/kg (R1-WSQ4) whilst sulphate ranged from 0.40 %SO4 (R1-WSQ3) to 0.94 %SO4 (R1-WSQ2);
- Three (3) out of eighteen (18) trace metals analysed were recorded in exceedance of the ADQCC standards. Arsenic (As) exceeded only in R1-WSQ2 whilst the remaining locations had an active level; Chromium (Cr) and Nickel both exceeded in four locations (R1-WSQ1, R1-WSQ2, R1-WSQ3, and R1-WSQ4 CNTR);
- Cadmium (Ca), Selenium (Se), and Silver (Ag) were below their MDLs in all sampling locations. Molybdenum was detected only in R1-WSQ2 and Antimony (Sb) in R1-WSQ1, R1-WSQ2, R1-WSQ5, and R1-WSQ6. Aluminium (Al), Barium (Ba), Iron (Fe), Lead (Pb), Manganese (Mn), Phosphorus (P), Vanadium (V), and Mercury (Hg) all had active levels above MDL but below referenced standards for parameters where standards are provided. Al and Fe exceeded their MDL by an order of magnitude; and
- There were no hydrocarbons, PAHs, or PCBs found in any of the samples.

Table 5-17: Sediment quality along Route 1 – Mirfa Landfill

Parameters	Unit	MDL*	ADQCC*	R1-WSQ1	R1-WSQ2	R1-WSQ3	R1-WSQ4 CNTR*	R1-WSQ5	R1-WSQ6
Inorganic Parameters									
pH	pH units	0.1		8.7	8.7	9.0	8.9	9.2	9.2
Oil and Grease	%	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Nitrogen	mg/kg	5		880	922	194	869	419	373
Silica-SiO2	% by wt	0.01		6.95	11.1	18.1	13.1	28.2	13.6
Total Cyanide	mg/kg	0.5		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Anions									
Orthophosphate	mg/kg	0.3		<0.3	0.5	<0.3	<0.3	<0.3	<0.3
Fluoride	mg/kg	0.5		1.8	2.3	2.2	2.5	1.4	1.1
Sulphate (Acid Soluble)	%SO4	0.01		0.69	0.94	0.40	0.64	0.48	0.48
Chemical Analysis									
Total Organic Carbon	%	0.1		1.4	2.1	0.4	1.4	0.3	0.3
Metals									
Cadmium (Cd)	mg/kg	0.5	0.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Aluminum (Al)	mg/kg	130	-	3040	5170	5720	4080	1650	1200
Arsenic (As)	mg/kg	1.0	7	6.7	8.3	5.5	6.6	4.0	4.2
Barium (Ba)	mg/kg	3.0	-	16.1	24.2	11.8	17.2	11.9	11.6
Chromium (Cr)	mg/kg	1.0	11	11.7	20.1	24.1	15.8	7.6	6.2
Copper (Cu)	mg/kg	3.0	20	4.8	8.3	4.6	5.7	<3.0	<3.0
Iron (Fe)	mg/kg	70	-	2960	4980	5520	3870	1600	1170
Lead (Pb)	mg/kg	1.0	5	2.1	2.5	2.0	1.7	1.3	1.3
Manganese (Mn)	mg/kg	3.0	-	72.9	112	154	110	55.3	43.7
Molybdenum (Mo)	mg/kg	3.0	-	<3.0	3.1	<3.0	<3.0	<3.0	<3.0
Nickel (Ni)	mg/kg	1.0	7	11.2	18.4	16.9	15.2	4.9	3.6
Phosphorus (P)	mg/kg	50	-	236	267	223	268	110	112
Selenium (Se)	mg/kg	3.0	-	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Silver (Ag)	mg/kg	10	-	<10	<10	<10	<10	<10	<10
Vanadium (V)	mg/kg	1.0	-	13.8	20.3	21.6	15.7	8.1	7.4
Zinc (Zn)	mg/kg	3.0	70	8.2	13.8	12.2	10.7	3.6	<3.0
Antimony (Sb)	mg/kg	1.0	-	1.1	1.5	<1.0	<1.0	1.1	1.7
Mercury (Hg)	mg/kg	0.010	0.2	0.021	0.018	0.013	0.018	0.011	0.011
Hydrocarbons									
VPH C5-C10	mg/kg	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
EPH C10-C40	mg/kg	50		<50	<50	<50	<50	<50	<50

Parameters	Unit	MDL*	ADQCC*	R1-WSQ1	R1-WSQ2	R1-WSQ3	R1-WSQ4 CNTR*	R1-WSQ5	R1-WSQ6
PAHs									
Acenaphthene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	mg/kg	0.01	Total PAHs = 1.7	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(a,h)anthracene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCBs									
2,2`,3,3`,4,4` - Hexachlorobiphenyl (PCB 128)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,3`,4,4`,5 - Heptachlorobiphenyl (PCB 170)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,3`,4,4`,5,5`,6,6` - Decachlorobiphenyl	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,3`,4,4`,5,5`,6-Nonachlorobiphenyl (PCB 206)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,3`,4,4`,5,6 - Octachlorobiphenyl (PCB 195)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,4`,5,5',6 - Heptachlorobiphenyl (PCB 187)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,4,4`,5` - Hexachlorobiphenyl (PCB 138)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,4,4`,5,5` - Heptachlorobiphenyl (PCB 180)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,5` - Tetrachlorobiphenyl (PCB 44)	mg/kg	0.01	Total PCBs = 0.22	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,4,4`,5,5` - Hexachlorobiphenyl (PCB 153)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,4,5,5` - Pentachlorobiphenyl (PCB 101)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,5,5` - Tetrachlorobiphenyl (PCB 52)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,5 - Trichlorobiphenyl (PCB 18)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3,3`,4,4` - Tetrachlorobiphenyl (PCB 77)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3,3`,4,4`,5 - Pentachlorobiphenyl (PCB 126)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,3`,4,4` - Tetrachlorobiphenyl (PCB 66)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,3`,4,4`,5 - Pentachlorobiphenyl (PCB 118)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Parameters	Unit	MDL*	ADQCC*	R1-WSQ1	R1-WSQ2	R1-WSQ3	R1-WSQ4 CNTR*	R1-WSQ5	R1-WSQ6
2,3,3`,4,4` - Pentachlorobiphenyl (PCB 105)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,4` - Dichlorobiphenyl (PCB 8)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,4,4` - Trichlorobiphenyl (PCB 28)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Note:

- Values highlighted in red represent exceedance of the standard
- Blue values represent above MDL
- CNTR refers to control location
- ND means not detected
- T refers to top water layer
- B refers to bottom
- M refers to mid-water.
- The ADQCC values shown are allowable concentrations for Marine Protected Use Areas.

Route 2 – Shuweihat Landfall

The results of laboratory sediment analysis for this area are presented in Table 5-18 and have been compared to the standards provided by the Abu Dhabi Quality and Conformity Council (ADQCC) (71)**.** No exceedances to the referenced standard were found in any of the parameters. The summary of the results is discussed below:

- pH ranged from 8.7 at R2-WSQ5 to 9.9 at R2-WSQ3 CNTR;
- Oil and grease were below MDL for all locations;
- High levels of total nitrogen (TN) were detected in the sediments ranging from 298 mg/kg (R2-WSQ2) to 422 mg/kg (R2-WSQ5). TN is considered an effluent parameter because it is the sum NO3-N, N02-N, NH3-N, and other organically bonded nitrogen. However, there is no existing permissible limit for TN;
- High variation in silica concentration was detected among locations, ranging to lowest value of 0.63 % by wt. (R2-WSQ1) to the highest value of 20.3 % by wt. (R2-WSQ6);
- Cyanide was below MDL for all locations;
- Of the three anions tested, orthophosphate was below MDL whilst active levels were detected for fluoride and sulphate. Fluoride ranged from 1.1 mg/kg (R2-WSQ1) to 2.2 mg/kg (R2-WSQ5) whilst sulphate ranged from 0.35 %SO4 (R2-WSQ1) to 0.61 %SO4 (R2-WSQ7);
- No exceedances were detected for the 18 trace metals analysed. Cadmium (Ca), Copper (Cu), Molybdenum (Mo), Selenium (Se), Silver (Ag), and Zinc (Zn) were below their MDLs. Aluminium (Al), Arsenic, Barium (Ba), Chromium (Cr), Iron (Fe), Lead (Pb), Manganese (Mn), Nickel (Ni), Phosphorus (P), Vanadium (V), Antimony (Sb), and Mercury (Hg) all had active levels above MDL but below reference standards for parameters where standards are provided. Pb was detected only in R2-WSQ1 and R2-WSQ2, Sb in R2-WSQ1 and R2-WSQ3 CNTR, whilst Hg in R2-WSQ1, R2-WSQ2, and R2-WSQ3 CNTR; and
- Hydrocarbons, PAHs, and PCBs were below MDL for all sampling locations.

Table 5-18: Sediment quality along Route 2 – Shuweihat Landfall

Parameter Names	Unit	MDL*	ADQCC*	R2-WSQ1	R2-WSQ2	R2-WSQ3 CNTR*	R2-WSQ4	R2-WSQ5	R2-WSQ6	R2-WSQ7
Inorganic Parameters										
pH	pH units	0.1		9.7	9.2	9.9	9.8	8.7	9.2	9.5
Oil and Grease	%	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Nitrogen	mg/kg	5		400	298	319	328	422	316	420
Silica-SiO2	% by wt	0.01		0.63	1.51	1.48	0.70	9.02	20.3	0.69
Total Cyanide	mg/kg	0.5		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Anions										
Orthophosphate	mg/kg	0.3		<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Fluoride	mg/kg	0.5		1.1	1.8	1.2	1.7	2.2	1.5	1.4
Sulphate (Acid Soluble)	%SO4	0.01		0.35	0.51	0.46	0.58	0.45	0.42	0.61
Chemical Analysis										
Total Organic Carbon	%	0.1		0.2	0.3	0.2	0.3	0.4	0.3	0.2
Metals										
Cadmium (Cd)	mg/kg	0.5	0.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Aluminum (Al)	mg/kg	130	-	587	922	514	388	1520	975	432
Arsenic (As)	mg/kg	1.0	7	3.7	3.9	2.0	4.3	4.6	2.4	4.3
Barium (Ba)	mg/kg	3.0	-	9.1	9.7	9.2	9.9	11.7	8.1	9.5
Chromium (Cr)	mg/kg	1.0	11	3.3	4.5	2.9	2.4	7.0	4.7	2.1
Copper (Cu)	mg/kg	3.0	20	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Iron (Fe)	mg/kg	70	-	637	882	516	353	1520	936	444
Lead (Pb)	mg/kg	1.0	5	1.5	1.4	<1.0	1.1	<1.0	<1.0	<1.0
Manganese (Mn)	mg/kg	3.0	-	17.0	26.7	13.8	17.2	51.1	31.2	17.1
Molybdenum (Mo)	mg/kg	3.0	-	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Nickel (Ni)	mg/kg	1.0	7	1.9	2.9	1.6	1.2	4.9	2.5	1.4
Phosphorus (P)	mg/kg	50	-	205	223	136	176	201	156	185
Selenium (Se)	mg/kg	3.0	-	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Silver (Ag)	mg/kg	10	-	<10	<10	<10	<10	<10	<10	<10
Vanadium (V)	mg/kg	1.0	-	4.0	4.6	4.1	3.4	6.8	5.3	3.3
Zinc (Zn)	mg/kg	3.0	70	<3.0	<3.0	<3.0	<3.0	3.5	<3.0	<3.0
Antimony (Sb)	mg/kg	1.0	-	1.7	<1.0	1.2	<1.0	<1.0	<1.0	<1.0
Mercury (Hg)	mg/kg	0.010	0.2	0.098	0.017	0.013	<0.010	0.013	<0.010	<0.010
Hydrocarbons										
VPH C5-C10	mg/kg	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
EPH C10-C40	mg/kg	50		<50	<50	<50	<50	<50	<50	<50

Parameter Names	Unit	MDL*	ADQCC*	R2-WSQ1	R2-WSQ2	R2-WSQ3 CNTR*	R2-WSQ4	R2-WSQ5	R2-WSQ6	R2-WSQ7
PAHs										
Acenaphthene	mg/kg	0.01	Total PAHs = 1.7	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(a,h)anthracene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCBs										
2,2`,3,3`,4,4` - Hexachlorobiphenyl (PCB 128)	mg/kg	0.01	Total PCBs = 0.22	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,3`,4,4`,5 - Heptachlorobiphenyl (PCB 170)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,3`,4,4`,5,5`,6,6` - Decachlorobiphenyl	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,3`,4,4`,5,5`,6-Nonachlorobiphenyl (PCB 206)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,3`,4,4`,5,6 - Octachlorobiphenyl (PCB 195)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,4`,5,5',6 - Heptachlorobiphenyl (PCB 187)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,4,4`,5` - Hexachlorobiphenyl (PCB 138)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,4,4`,5,5` - Heptachlorobiphenyl (PCB 180)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,5` - Tetrachlorobiphenyl (PCB 44)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,4,4`,5,5` - Hexachlorobiphenyl (PCB 153)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,4,5,5` - Pentachlorobiphenyl (PCB 101)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,5,5` - Tetrachlorobiphenyl (PCB 52)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,5 - Trichlorobiphenyl (PCB 18)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3,3`,4,4` - Tetrachlorobiphenyl (PCB 77)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3,3`,4,4`,5 - Pentachlorobiphenyl (PCB 126)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,3`,4,4` - Tetrachlorobiphenyl (PCB 66)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,3`,4,4`,5 - Pentachlorobiphenyl (PCB 118)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Parameter Names	Unit	MDL*	ADQCC*	R2-WSQ1	R2-WSQ2	R2-WSQ3 CNTR*	R2-WSQ4	R2-WSQ5	R2-WSQ6	R2-WSQ7
2,3,3`,4,4` - Pentachlorobiphenyl (PCB 105)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,4` - Dichlorobiphenyl (PCB 8)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,4,4` - Trichlorobiphenyl (PCB 28)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Note:

– Values highlighted in red represent exceedance of the standard
– Blue values represent above MDL
– CNTR refers to control location
– ND means not detected
– T refers to top water layer
– B refers to bottom
– M refers to mid-water.
– The ADQCC values shown are allowable concentrations for General Use Areas.

Route 1 – Mirfa Nearshore Area within and near MMBR

The results of laboratory sediment analysis this area are presented in Table 5-17 and have been compared to the standards provided by the Abu Dhabi Quality and Conformity Council (ADQCC) (71). Two trace metals were in exceedance to the referenced standard.

Please note, due to the hard substrate encountered at S5, it was not possible to obtain a sample in this location and therefore no data is available.

- pH ranged from 8.8 at S2 to 9.2 at S3;
- Oil and grease, and total cyanide were below MDL whilst TN and silica were above MDL. High levels of TN ranged from 314 mg/kg (S8) to 925 mg/kg (S9). Whereas S7 had the lowest silica with 1.54 % by wt., and the highest level was 14.9 % by wt. at S6;
- Active levels above MDL were detected for fluoride and sulphate at all sampling locations. Fluoride was highest at S4 and S9 with 2.3 mg/kg and lowest at S8 with 1.3 mg/kg. Sulphate ranged from 0.51% (S8) to 0.84 % (S7). Whilst orthophosphate was detected above MDL only at S3;
- TOC averaged at 0.65 %, with lowest value of 0.3 % at S3 and S8, and the highest value at S6 at 0.9 %;
- Of the eighteen (18) trace metals analysed, two were recorded in exceedance of the ADQCC, and eleven (11) were recorded above MDL;
- Exceedance in Arsenic (As) was detected only in S2 with 7.1 mg/kg. Two locations, S6 and S9 had an exceedance for Nickel at 7.1 mg/kg and 8.2 mg/kg, respectively;
- In all sampling locations, Aluminium (Al), Barium (Ba), Chromium (Cr), Iron (Fe), Lead (Pb), Manganese (Mn), Phosphorus (P), Vanadium (V), and Mercury were detected above MDL and below the reference standards where applicable. Whereas Cadmium (Cd), Selenium (Se), and Silver (Ag) were below MDL;
- Copper (Cu) was detected above MDL in two locations (S6 and S9), Molybdenum (Mo) in S9, Nickel in four (4) locations (S1, S2, S6, and S9), and Antimony (Sb) in three locations (S1, S6 and S9); and
- Hydrocarbons, PAHs and PCBs were below MDL for all sampling locations.

Table 5-19: Sediment quality in sampling sites along Route 1 – Mirfa Nearshore Area within and near MMBR

Parameter Names	Unit	MDL*	ADQCC*	S1	S2	S3	S4	S6	S7	S8	S9
Inorganic Parameters											
pH	pH units	0.1		9.0	8.8	9.2	9.0	8.8	9.0	9.1	8.9
Oil and Grease	%	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Nitrogen	mg/kg	5		540	564	340	533	500	430	314	925
Silica-SiO2	% by wt	0.01		7.69	8.07	3.64	3.57	14.9	1.54	2.45	7.12
Total Cyanide	mg/kg	0.5		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Anions											
Orthophosphate	mg/kg	0.3		<0.3	<0.3	0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Fluoride	mg/kg	0.5		1.8	1.8	1.4	2.3	2.0	1.6	1.3	2.3
Sulphate (Acid Soluble)	%SO4	0.01		0.53	0.59	0.55	0.69	0.54	0.84	0.51	0.74
Chemical Analysis											
Total Organic Carbon	%	0.1		0.6	0.8	0.3	0.6	0.9	0.5	0.3	1.2
Metals											
Cadmium (Cd)	mg/kg	0.5	0.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Aluminum (Al)	mg/kg	130	-	1140	1340	750	493	1850	232	816	2020
Arsenic (As)	mg/kg	1.0	7	6.9	7.1	2.2	4.6	5.6	3.9	4.9	6.3
Barium (Ba)	mg/kg	3.0	-	16.0	16.3	11.0	10.0	14.5	9.2	12.0	13.4
Chromium (Cr)	mg/kg	1.0	11	6.2	6.5	4.3	2.4	8.0	1.4	4.4	8.3
Copper (Cu)	mg/kg	3.0	20	<3.0	<3.0	<3.0	<3.0	3.2	<3.0	<3.0	4.1
Iron (Fe)	mg/kg	70	-	1240	1440	704	491	1850	286	892	2010
Lead (Pb)	mg/kg	1.0	5	1.2	1.4	1.1	1.4	1.7	1.2	1.4	1.4
Manganese (Mn)	mg/kg	3.0	-	41.9	45.8	29.8	23.2	59.9	19.0	37.7	51.1
Molybdenum (Mo)	mg/kg	3.0	-	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3.6
Nickel (Ni)	mg/kg	1.0	7	4.5	5.4	2.6	2.1	7.1	1.3	3.0	8.2
Phosphorus (P)	mg/kg	50	-	263	261	253	258	272	279	251	224
Selenium (Se)	mg/kg	3.0	-	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0
Silver (Ag)	mg/kg	10	-	<10	<10	<10	<10	<10	<10	<10	<10
Vanadium (V)	mg/kg	1.0	-	6.9	7.5	6.1	3.6	9.3	2.1	5.8	9.0
Zinc (Zn)	mg/kg	3.0	70	4.0	4.5	<3.0	<3.0	5.3	<3.0	<3.0	6.0
Antimony (Sb)	mg/kg	1.0	-	1.1	<1.0	<1.0	<1.0	1.4	<1.0	<1.0	1.0
Mercury (Hg)	mg/kg	0.010	0.2	0.015	0.015	0.011	0.012	0.015	0.012	0.012	0.021
Hydrocarbons											
VPH C5-C10	mg/kg	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
EPH C10-C40	mg/kg	50		<50	<50	<50	<50	<50	<50	<50	<50

Parameter Names	Unit	MDL*	ADQCC*	S1	S2	S3	S4	S6	S7	S8	S9
PAHs											
Acenaphthene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(g,h,i)perylene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	mg/kg	0.01	Total PAHs = 1.7	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo(a,h)anthracene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
PCBs											
2,2`,3,3`,4,4` - Hexachlorobiphenyl (PCB 128)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,3`,4,4`,5 - Heptachlorobiphenyl (PCB 170)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,3`,4,4`,5,5`,6,6` - Decachlorobiphenyl	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,3`,4,4`,5,5`,6-Nonachlorobiphenyl (PCB 206)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,3`,4,4`,5,6 - Octachlorobiphenyl (PCB 195)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,4`,5,5',6 - Heptachlorobiphenyl (PCB 187)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,4,4`,5` - Hexachlorobiphenyl (PCB 138)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,4,4`,5,5` - Heptachlorobiphenyl (PCB 180)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,3,5` - Tetrachlorobiphenyl (PCB 44)	mg/kg	0.01	Total PCBs = 0.22	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,4,4`,5,5` - Hexachlorobiphenyl (PCB 153)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,4,5,5` - Pentachlorobiphenyl (PCB 101)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,5,5` - Tetrachlorobiphenyl (PCB 52)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,2`,5 - Trichlorobiphenyl (PCB 18)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3,3`,4,4` - Tetrachlorobiphenyl (PCB 77)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3,3`,4,4`,5 - Pentachlorobiphenyl (PCB 126)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,3`,4,4` - Tetrachlorobiphenyl (PCB 66)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,3`,4,4`,5 - Pentachlorobiphenyl (PCB 118)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

Parameter Names	Unit	MDL*	ADQCC*	S1	S2	S3	S4	S6	S7	S8	S9
2,3,3`,4,4` - Pentachlorobiphenyl (PCB 105)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,4` - Dichlorobiphenyl (PCB 8)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2,4,4` - Trichlorobiphenyl (PCB 28)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

* Note:

- Values highlighted in red represent exceedance of the standard
- Blue values represent above MDL
- CNTR refers to control location
- ND means not detected
- T refers to top water layer
- B refers to bottom
- M refers to mid-water.
- The ADQCC values shown are allowable concentrations for Marine Protected Use Areas.

Route 1 – Zakum Clusters Route

Sediment samples were collected on 20th to 22nd of May 2022. Samples were sent to an accredited laboratory for analysis. The sediment quality analysis results are presented below and laboratory reports are provided in **Appendix 2.4**. At these survey sites, the General Use Area category of ADQCC was used as standard.

<u>Route 1A Re-routing Area</u>

The results obtained from the laboratory sediment analysis are presented inTable 5-20 and have been compared to the standards provided by the Abu Dhabi Quality and Conformity Council (ADQCC) (71). Exceedances of the reference standards were found for two metals, Chromium (Cr) and Nickel (Ni). It should be noted that among the 10 sampling locations in Zakum Cluster Route 1-A, five locations were not sampled due to hardbottom characteristic of these areas (sediment grab attempts were executed at each site and only shell fragments were collected). There locations were WSQ2, WSQ7, WSQ8, WSQ9, and WSQ10. The summary of results below represents the sediment quality at WSQ1, WSQ3, WSQ4, WSQ5, and WSQ6.

- pH ranged from 8.2 (WSQ1) to 8.7 (WSQ4);
- Oil and Grease was below MDL across sampling locations;
- High levels of total nitrogen (TN) were detected in the sediments ranging from 530 mg/kg (WSQ3) to 968 mg/kg (WSQ5). These values were an order of magnitude above the MDL of 5 mg/kg. However, there is no reference standard for TN;
- Active levels of silica concentration were detected in all locations with the lowest value at WSQ3 with 2.53 % by wt. whilst the highest value was at WSQ1 with 4.81 % by wt. Orthophosphate, fluoride and sulphate had an active level above MDL. Orthophosphate ranged from 0.8 mg/kg (WSQ4) to 12.3 (WSQ1). Fluoride ranged from 1.4 mg/kg (WSQ1) to 3.3 mg/kg (WSQ5). Sulphate ranged from 0.78 %SO4 (WSQ6) to 0.95 %SO4 (WSQ5);
- Two out of eighteen metals analysed were recorded in exceedance of the ADQCC standards. Chromium (Cr) was exceeded at WSQ4 and WSQ5, whilst the remaining locations had an active level. Nickel (Ni) was exceeded at WSQ4, WSQ5 and WSQ1, with the remaining locations at an active level;
- Aluminium (Al), Arsenic (As), Barium (Ba), Iron (Fe), Lead (Pb), Manganese (Mn), Phosphorus (P), Vanadium (V) and Zinc (Zn) had active levels in all locations above the MDL but below reference standards for parameters where standards are provided. Similarly, Mercury (Hg) and Copper (Cu) were above the MDL but below the reference standard except at WSQ1 and WSQ6 for Hg and WSQ3 for Cu;
- Antimony (Sb), Cadmium (Cd), Molybdenum (Mo), Selenium (Se) and Silver (Ag) were detected below their respective MDLs; and
- There were no hydrocarbons, PAHs, or PCBs found in any of the samples.

Table 5-20: Sediment quality profile at Zakum Cluster Route 1A

Parameter Names	Unit	MDL*	ADQCC*	WSQ1	WSQ2	WSQ3	WSQ4	WSQ6	WSQ7**	WSQ8**	WSQ9**	WSQ10**
Inorganic Parameters												
pH	pH units	0.1		8.2	-	8.6	8.7	8.6	8.5	-	-	-
Oil and Grease	%	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Total Nitrogen	mg/kg	5	0.1	751	-	530	908	968	942	-	-	-
Silica-SiO2	% by wt	5		4.81	-	2.53	4.31	4.04	2.56	-	-	-
Total Cyanide	mg/kg	0.5		<0.5	-	<0.5	<0.5	<0.5	<0.5	-	-	-
Anions												
Orthophosphate	mg/kg	0.3		12.3	-	2	0.8	1.1	2.1	-	-	-
Fluoride	mg/kg	0.5		1.4	-	2.5	2.8	3.3	2.2	-	-	-
Sulphate (Acid Soluble)	%SO4	0.01		0.9	-	0.84	0.93	0.95	0.78	-	-	-
Chemical Analysis												
Total Organic Carbon	%	0.1		1.4	-	0.6	1.1	1.1	0.6	-	-	-
Metals												
Mercury (Hg)	mg/kg	0.01	0.2	<0.010	-	0.017	0.016	0.015	<0.010	-	-	-
Aluminium (Al)	mg/kg	130	-	2090	-	1200	2820	2560	1050	-	-	-
Antimony (Sb)	mg/kg	1	-	<1.0	-	<1.0	<1.0	<1.0	<1.0	-	-	-
Arsenic (As)	mg/kg	1	7	3.9	-	3.5	3	3.3	4.2	-	-	-
Barium (Ba)	mg/kg	3	-	140	-	51.8	229	426	417	-	-	-
Cadmium (Cd)	mg/kg	0.5	0.2	<0.2	-	<0.2	<0.2	<0.2	<0.2	-	-	-
Chromium (Cr)	mg/kg	1	11	9.4	-	6.6	11.9	11.3	5.6	-	-	-
Copper (Cu)	mg/kg	3	20	4.8	-	<3.0	5.7	5.7	3.2	-	-	-
Iron (Fe)	mg/kg	70	-	2180	-	1700	2700	2450	1100	-	-	-
Lead (Pb)	mg/kg	1	5	3.5	-	2.9	3.9	4.5	3.8	-	-	-
Manganese (Mn)	mg/kg	3	-	38.4	-	26.8	46.6	41.1	19.7	-	-	-
Molybdenum (Mo)	mg/kg	3	-	<3.0	-	<3.0	<3.0	<3.0	<3.0	-	-	-
Nickel (Ni)	mg/kg	1	7	8	-	4.3	11.1	10.2	4	-	-	-
Phosphorus (P)	mg/kg	50	-	601	-	593	572	534	408	-	-	-
Selenium (Se)	mg/kg	3	-	<3.0	-	<3.0	<3.0	<3.0	<3.0	-	-	-
Silver (Ag)	mg/kg	10	-	<10	-	<10	<10	<10	<10	-	-	-
Vanadium (V)	mg/kg	1	-	8	-	5.7	9.8	9.3	4.8	-	-	-
Zinc (Zn)	mg/kg	3	70	9.7	-	6	10.9	10.7	5.8	-	-	-
Hydrocarbons												
VPH C5-C10	mg/kg	0.05		<0.05	-	<0.05	<0.05	<0.05	<0.05	-	-	-
EPH C10-C40	mg/kg	50		<50	-	<50	<50	<50	<50	-	-	-

Parameter Names	Unit	MDL*	ADQCC*	WSQ1	WSQ2	WSQ3	WSQ4	WSQ6	WSQ7**	WSQ8**	WSQ9**	WSQ10**
PAHs												
Acenaphthene	mg/kg	0.01	Total PAHs = 1.7	<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Acenaphthylene	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Anthracene	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Benzo(a)anthracene	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Benzo(a)pyrene	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Benzo(b)fluoranthene	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Benzo(g,h,i)perylene	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Benzo(k)fluoranthene	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Chrysene	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Dibenzo(a,h)anthracene	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Fluoranthene	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Fluorene	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Indeno(1,2,3-c,d)pyrene	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Naphthalene	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Phenanthrene	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
Pyrene	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
PCBs												
2,2`,3,3`,4,4` - Hexachlorobiphenyl (PCB 128)	mg/kg	0.01	Total PCBs = 0.22	<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,2`,3,3`,4,4`,5 - Heptachlorobiphenyl (PCB 170)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,2`,3,3`,4,4`,5,5`,6,6` - Decachlorobiphenyl	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,2`,3,3`,4,4`,5,5`,6-Nonachlorobiphenyl (PCB 206)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,2`,3,3`,4,4`,5,6 - Octachlorobiphenyl (PCB 195)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,2`,3,4`,5,5',6 - Heptachlorobiphenyl (PCB 187)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,2`,3,4,4`,5` - Hexachlorobiphenyl (PCB 138)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,2`,3,4,4`,5,5` - Heptachlorobiphenyl (PCB 180)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,2`,3,5` - Tetrachlorobiphenyl (PCB 44)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,2`,4,4`,5,5` - Hexachlorobiphenyl (PCB 153)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,2`,4,5,5` - Pentachlorobiphenyl (PCB 101)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,2`,5,5` - Tetrachlorobiphenyl (PCB 52)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,2`,5 - Trichlorobiphenyl (PCB 18)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
3,3`,4,4` - Tetrachlorobiphenyl (PCB 77)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-

Parameter Names	Unit	MDL*	ADQCC*	WSQ1	WSQ2	WSQ3	WSQ4	WSQ6	WSQ7**	WSQ8**	WSQ9**	WSQ10**
3,3`,4,4`,5 - Pentachlorobiphenyl (PCB 126)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,3`,4,4` - Tetrachlorobiphenyl (PCB 66)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,3`,4,4`,5 - Pentachlorobiphenyl (PCB 118)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,3,3`,4,4` - Pentachlorobiphenyl (PCB 105)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,4` - Dichlorobiphenyl (PCB 8)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-
2,4,4` - Trichlorobiphenyl (PCB 28)	mg/kg	0.01		<0.01	-	<0.01	<0.01	<0.01	<0.01	-	-	-

* Note:
- Values highlighted in red represent exceedance of the standard
- Blue values represent above MDL
- ** means no sample was collected
- ND means not detected
- The ADQCC values shown are allowable concentrations for Marine Protected Use Areas.

Route 1B Re-routing Area

The results of laboratory sediment analysis at Zakum Cluster Route 1-B are presented in Table 5-21 and have been compared to the standards provided by the Abu Dhabi Quality and Conformity Council (ADQCC) (71). Exceedances to the referenced standard were found in three metal parameters (Chromium, Lead and Nickel). It should be noted that sediments in three sampling locations were not sampled due to solid hardbottom characteristic of the areas (WSQ16, WSQ18, and WSQ19). Furthermore, some tests were not carried in WSQ20 due to insufficient sample. A summary of results is presented below.

- pH ranged from 7.8 at WSQ17 to 8.6 at WSQ13 and WSQ14;
- Oil and grease was detected above the MDL at WSQ11, WSQ12, and WSQ15;
- High levels of total nitrogen (TN) were detected in the sediments ranging from 843 mg/kg WSQ12) to 1,240 mg/kg (WSQ15). TN is considered an effluent parameter because it is the sum NO3-N, N02-N, NH3-N, and other organically bonded nitrogen. However, there is no existing permissible limit for TN;
- Active level of silica was detected among locations, ranging to lowest value of 2.13 % by wt. (WSQ12) to the highest value of 4.92 % by wt. (WSQ14);
- Total Cyanide was below the MDL for all locations;
- The three anions tested, orthophosphate, fluoride and sulphate were above the MDL: Orthophosphate ranged from 0.6 mg/kg (WSQ12) to 6.4 mg/kg (WSQ17); No fluoride was detected in WSQ17 whilst other locations ranged from 1.1 mg/kg (WSQ12) to 3.6 mg/kg (WSQ15); and sulphate ranged from 0.49 %SO4 (WSQ13) to 0.95 %SO4 (WSQ15);
- Three metals were in exceedance of their respective reference standards. Chromium was in exceedance only at WSQ14 (13.1 mg/kg) against ADCCC's standard of 11 mg/kg whilst the remaining locations had an active level. Lead was in exceedance at three locations (WSQ14, WSQ15 and WSQ17) with a value of 6.8 mg/kg, 8.9 mg/kg and 5.5 mg/kg, respectively against the standard of 5 mg/kg. Nickel (Ni) was in exceedance at WSQ14 (11.4 mg/kg) and WSQ15 (8.6 mg/kg) against the 7 mg/kg standard value, whilst the remaining of the locations had an active level;
- No exceedances were detected for Antimony (Sb), Cadmium (Cd), Molybdenum (Mo), Selenium (Se), and Silver (Ag). Whereas Arsenic (As), Barium (Ba), Iron (Fe), Manganese (Mn), Phosphorus (P), Vanadium (V) and Zinc (Zn) all had active levels above the MDL but below reference standards, where applicable. Similarly, active levels of Mercury (Hg) was detected at WSQ11, WSQ13, WSQ14, and WSQ15 and Copper (Cu) at WSQ13, WSQ14, WSQ15, and WSQ20; and
- Hydrocarbons, PAHs, and PCBs were below MDL for all sampling locations.

Table 5-21: Sediment quality profile at Zakum Cluster Route 1B

Parameter Names	Unit	MDL*	ADQCC*	WSQ11	WSQ12	WSQ13	WSQ14	WSQ15	WSQ16**	WSQ17	WSQ18	WSQ19**	WSQ20
Inorganic Parameters													
pH	pH units	0.1		8.2	8.4	8.6	8.6	8.4	-	7.8	-	-	*
Oil and Grease	%	0.01		0.02	0.01	<0.01	<0.01	0.01	-	<0.01	-	-	*
Total Nitrogen	mg/kg	5	0.1	996	843	847	1100	1240	-	988	-	-	*
Silica-SiO2	% by wt	5		2.64	2.13	2.85	4.92	3.46	-	2.19	-	-	*
Total Cyanide	mg/kg	0.5		<0.5	<0.5	<0.5	<0.5	<0.5	-	<0.5	-	-	*
Anions													
Orthophosphate	mg/kg	0.3		2.5	0.6	2.5	1.2	2.3	-	6.4	-	-	*
Fluoride	mg/kg	0.5		1.8	1.1	1.4	2.8	3.6	-	<0.5	-	-	*
Sulphate (Acid Soluble)	%SO4	0.01		0.76	0.8	0.49	0.94	0.95	-	0.74	-	-	*
Chemical Analysis-													
Total Organic Carbon	%	0.1		0.7	0.8	0.6	1.4	1.1	-	0.9	-	-	*
Metals													
Mercury (Hg)	mg/kg	0.01	0.2	0.012	<0.010	0.012	0.018	0.019	-	<0.010	-	-	<0.010
Aluminium (Al)	mg/kg	130	-	1230	1110	1420	2980	2160	-	371	-	-	369
Antimony (Sb)	mg/kg	1	-	<1.0	<1.0	<1.0	<1.0	<1.0	-	<1.0	-	-	<1.0
Arsenic (As)	mg/kg	1	7	6	3.7	4.6	4.8	3.8	-	2.8	-	-	2.4
Barium (Ba)	mg/kg	3	-	69.4	84.6	205	580	768	-	162	-	--	58.6
Cadmium (Cd)	mg/kg	0.5	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	<0.2	-	-	<0.2
Chromium (Cr)	mg/kg	1	11	7	6.1	9	13.1	10.3	-	2.9	-	-	2.5
Copper (Cu)	mg/kg	3	20	<3.0	<3.0	3.4	5.7	5.3	-	<3.0	-	-	13.6
Iron (Fe)	mg/kg	70	-	1480	1190	1760	2830	2200	-	445	-	-	380
Lead (Pb)	mg/kg	1	5	2.1	2.7	3.9	6.8	8.9	-	5.5	-	-	3.5
Manganese (Mn)	mg/kg	3	-	28.2	25.5	29.6	47.7	35.9	-	15.9	-	-	12.9
Molybdenum (Mo)	mg/kg	3	-	<3.0	<3.0	<3.0	<3.0	<3.0	-	<3.0	-	-	<3.0
Nickel (Ni)	mg/kg	1	7	4.7	4.2	5.2	11.4	8.6	-	1.8	-	-	1.6
Phosphorus (P)	mg/kg	50	-	509	479	555	590	529	-	385	-	-	348
Selenium (Se)	mg/kg	3	-	<3.0	<3.0	<3.0	<3.0	<3.0	-	<3.0	-	-	<3.0
Silver (Ag)	mg/kg	10	-	<10	<10	<10	<10	<10	-	<10	-	-	<10
Vanadium (V)	mg/kg	1	-	5.6	5	7.3	10.3	8.6	-	3.5	-	-	2.9
Zinc (Zn)	mg/kg	3	70	4.6	4.7	6.7	12.6	11.9	-	7.8	-	-	5.2
Hydrocarbons													
VPH C5-C10	mg/kg	0.05		<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		
EPH C10-C40	mg/kg	50		<50	<50	<50	<50	<50	-	<50	-	-	<50

Parameter Names	Unit	MDL*	ADQCC*	WSQ11	WSQ12	WSQ13	WSQ14	WSQ15	WSQ16**	WSQ17	WSQ18	WSQ19**	WSQ20
PAHs													
Acenaphthene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
Acenaphthylene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
Anthracene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
Benzo(a)anthracene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
Benzo(a)pyrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
Benzo(b)fluoranthene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
Benzo(g,h,i)perylene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
Benzo(k)fluoranthene	mg/kg	0.01	Total PAHs = 1.7	<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
Chrysene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
Dibenzo(a,h)anthracene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
Fluoranthene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
Fluorene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
Indeno(1,2,3-c,d)pyrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
Naphthalene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
Phenanthrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
Pyrene	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.01	-	-	<0.01
PCBs													
2,2`,3,3`,4,4` - Hexachlorobiphenyl (PCB 128)	mg/kg	0.01		<0.01	<0.01	<0.0-1	<0.01	<0.01	-	<0.01			<0.01
2,2`,3,3`,4,4`,5 - Heptachlorobiphenyl (PCB 170)	mg/kg	0.01		<0.01	<0.01	<0.0-1	<0.01	<0.01	-	<0.01	-	-	<0.01
2,2`,3,3`,4,4`,5,5`,6,6` - Decachlorobiphenyl	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
2,2`,3,3`,4,4`,5,5`,6-Nonachlorobiphenyl (PCB 206)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
2,2`,3,3`,4,4`,5,6 - Octachlorobiphenyl (PCB 195)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
2,2`,3,4`,5,5',6 - Heptachlorobiphenyl (PCB 187)	mg/kg	0.01	Total PCBs = 0.22	<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
2,2`,3,4,4`,5` - Hexachlorobiphenyl (PCB 138)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
2,2`,3,4,4`,5,5` - Heptachlorobiphenyl (PCB 180)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
2,2`,3,5` - Tetrachlorobiphenyl (PCB 44)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
2,2`,4,4`,5,5` - Hexachlorobiphenyl (PCB 153)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
2,2`,4,5,5` - Pentachlorobiphenyl (PCB 101)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
2,2`,5,5` - Tetrachlorobiphenyl (PCB 52)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01

Parameter Names	Unit	MDL*	ADQCC*	WSQ11	WSQ12	WSQ13	WSQ14	WSQ15	WSQ16**	WSQ17	WSQ18	WSQ19**	WSQ20
2,2`,5 - Trichlorobiphenyl (PCB 18)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
3,3`,4,4` - Tetrachlorobiphenyl (PCB 77)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
3,3`,4,4`,5 - Pentachlorobiphenyl (PCB 126)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
2,3`,4,4` - Tetrachlorobiphenyl (PCB 66)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
2,3`,4,4`,5 - Pentachlorobiphenyl (PCB 118)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
2,3,3`,4,4` - Pentachlorobiphenyl (PCB 105)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
2,4` - Dichlorobiphenyl (PCB 8)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01
2,4,4` - Trichlorobiphenyl (PCB 28)	mg/kg	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	-	-	<0.01

* Note:

- Values highlighted in red represent exceedance of the standard
- Blue values represent above MDL
- * means some tests are not carried out due to insufficient samples
- ** means no sample was collected
- ND means not detected
- The ADQCC values shown are allowable concentrations for Marine Protected Use Areas.

5.2.1.2.4. Summary of Results and Conclusions

Route 1 – Mirfa (Fugro)

Water profiling identified an unstratified water column, in which the majority of parameters remained near-constant from sea surface to seabed. Variation recorded for all water profile parameters sampled within the water column across the survey area can be attributed to seasonality differences within sampling regimes.

The concentrations of inorganic water quality parameters > MRV (TDS, sulphate, pH, chloride, total nitrogen, total cyanide, nitrate, total phosphorus, nitrite, turbidity and TOC) displayed low to moderate variability where statistics were available and were typical of marine water. The majority of inorganic water quality parameters were below their respective MRVs at all stations across the survey area.

Concentrations of volatile petroleum hydrocarbons, extractable petroleum hydrocarbons, polycyclic aromatic hydrocarbons, BTEX and phenols in the water samples were below their respective minimum reporting values in all samples, apart from naphthalene, phenanthrene and pyrene, where some samples had values above the MRV. However, the concentrations recorded are unlikely to be of environmental concern. Benzene, toluene and ethylbenzene were below the CCME guideline values and considered to be representative of background conditions.

Except for chromium, copper, lead and zinc, concentrations of all major and trace elements were below their respective ADS 18/2017 MACs, as well as the US EPA CCC and CMC values and considered to be of no environmental concern. Concentrations of chromium, copper, lead and zinc exceeded the ADS 18/2017 MACs for both general use areas and marine protected areas in 100, 17, 31 and 129 samples respectively. Copper and lead concentrations exceeded the US EPA CCC in 16 and 4 samples, respectively. Copper and zinc concentrations exceeded the US EPA CMC in 8 and 5 samples, respectively.

Using the Wentworth (1922) sediment description, stations along the Route 1 survey area comprised mainly sand and were classified as coarse sand to fine silt. No clear spatial patterns between depth and sediment type were apparent along Route 1. Total organic carbon content was low across the survey area and lower than previous studies in the region. Conversely, the carbonate content observed within sediments was higher than previously reported values.

All sediment nutrient concentrations demonstrated low to moderate variation across the survey area with no spatial patterns, demonstrating broadly homogenous sediments.

Concentrations of THC were low and typical of concentrations recorded around non-industrialised coastal environments distant from hydrocarbon inputs. Total PAH concentrations were below the ADS 18/2017 MAC. The concentrations of BTEX in the current survey were below the MRV at all stations along the Route 1 survey area and lower than the values reported previously in the region.

The concentrations of PCBs in the current survey were below the MRV at most stations along the Route 1 survey area and lower than the values reported previously in the region. Total WHO12 PCB concentrations were below the ADS 18/2017 MAC.

All sediment metals concentrations recorded across the survey area were below their respective US National Oceanographic and Atmospheric Administration (NOAA) effects range low (ERL) and effects range median (ERM) threshold values. Except for chromium, lead and nickel, concentrations of all sediment metals were below their respective ADS 18/2017 MAC for both general use areas and marine protected areas. Concentrations of chromium and nickel exceeded the ADS 18/2017 MAC (QCC, 2017) for marine protected areas in numerous stations. Lead concentrations exceeded the ADS 18/2017 MAC (QCC, 2017) for marine protected areas in one station. Nickel concentrations also exceeded the ADS 18/2017 MAC (QCC, 2017) for general use areas in 4 stations. There was no clear spatial distribution pattern that would indicate a point source related to possible anthropogenic activities within the survey area, and the differences recorded are therefore most likely to be associated with natural sediment variations.

Route 1 – Mirfa Landfall (WKC)

Seawater quality parameters demonstrated typical seasonal conditions expected of a transition period between winter and summer.

Water temperature ranged from 25.80°C to 28.70°C with an average of 26.92°C. Water temperatures were within the expected range for the Arabian Gulf during the early summer season. The pH levels had almost similar values ranging from 8.1 to 8.3 and within EAD AWQO's permissible range. DO concentrations of all sampling locations recorded were ranging from 6.21 mg/L to 6.78 mg/ with an average of 6.49 mg/L. Tidal flushing and good water exchange influenced the good DO concentrations at the survey sites. Salinity ranged from 47.40 ppt to 49.20 ppt whilst TDS ranged from 60.19 g/L to 62.25 g/L. Turbidity readings were very low ranging from <0.1 to 2.4 NTU, implying a high-water visibility. Water clarity ranged from 4.5 m to 6.65 m. The water clarity across sampling locations were generally good.

Among inorganic parameters, only TDS and total nitrogen had an active level whilst total cyanide had an exceedance. Total cyanide was recorded in exceedance only at R1-WSQ1 M (0.020 mg/L), and active levels only at R1-WSQ2 T (0.002 mg/L) and R1-WSQ7 M (0.001 mg/L). Exceedance in nitrate was recorded only in R1-WSQ4 Central T with 5.75 mg/L. The exceedance of nitrate in only one sample could be attributed to contamination of blue-green algae in sample. COD and BOD were below MDL. TOC was similar across the project locations ranging from 1.5 mg/L to 1.7 mg/L, except only for the location at R1-WSQ4 CNTR T with 18.0 mg/L, which exceeded the EAD AWQO standard of 2.5 mg/L. Exceedances were recorded in three (3) of the metal parameters against ADQCC: Cadmium (Cd) exceeded in R1-WSQ1 M, R1-WSQ4 CNTR B, R1-WSQ5 M, R1-WSQ6 M, and R1-WSQ7 M; Copper (Cu) exceeded in R1-WSQ1 M, R1-WSQ3 T, and R1-WSQ5 M; and Lead (Pb) exceeded in R1-WSQ1 M, R1-WSQ2 B, R1-WSQ3 M, R1-WSQ8 M, and R1-WSQ9 M. Generally, the sources of metals in the Arabian Gulf are atmospheric inputs due to its unique geologic environmental setting. Total coliform, a microbiological measure, was undetectable in all test locations

Overall, the results show seawater and sediment values to be within the expected ranges and as would typically be encountered in the area. Sediment quality conditions remain stable and seawater quality appear to exhibit seasonal changes although water quality remained relatively good.

Route 2 – Shuweihat (Fugro)

Water temperatures within the survey area appeared more consistent in shallow waters, rather than deeper ones. In contrast, salinity values were generally observed to be consistent throughout the water column for most stations. A clear trend of increasing turbidity with water depth was observed at numerous water profiles, where the turbidity levels almost doubled compared to the rest of profiles obtained. A slight reduction in dissolved oxygen (DO) with increasing depth was observed at most of the water profiles sampled, with a sharp decrease of 10 % observed in 3 profiles at around 12 m depth. The pH values reported in the current survey were consistent across all profiles taken. Overall, minimal differences were observed at a few stations, hence the conditions encountered were considered typical for the region and season.

The water samples collected across the Route 2 survey area demonstrated no evidence of anthropogenic pollution with most parameters were below their respective MRVs.

Most water hydrocarbons recorded across the survey area were either comparable to, or below their respective MRV values. The concentrations of EPH in 4 samples exceeded the ADS 18/2017 MAC for both general use areas (7.0 µg/L) and marine protected areas (7.0 µg/L), however these values are considered to be potentially anomalous.

Except for cadmium, chromium, copper and zinc, concentrations of all major and trace elements for waters were below their respective ADS 18/2017 MACs, as well as the US EPA CCC and CMC values and considered to be of no environmental concern. The ADS 18/2017 MAC thresholds for both general use areas and marine protected areas were exceeded for zinc in 29 samples, for cadmium in 1 sample, for chromium in 162 samples and for copper in 4 samples. Zinc concentrations exceeded the US EPA CCC and the US EPA CMC thresholds, in sample R2_ENV_095-Middle. Copper concentrations exceeded the US EPA CCC threshold in four samples and the US EPA CMC threshold of 0.0048 mg/L in two samples.

Using the Wentworth (1922) sediment description, most stations along the Route 2 survey area comprised mainly sand and were classified as coarse sand to medium silt. No clear spatial patterns between depth and sediment type were apparent along Route 2. Total organic carbon content was low across the survey area, with a high carbonate content.

All sediment nutrient concentrations, except silicon, demonstrated low to moderate variation across the survey area with no spatial patterns, demonstrating broadly homogenous sediments. Phosphorus concentrations reported in the current survey were higher than those recorded previously in the Zakum oil field (Blue Sea Environmental Consultants, 2011).

Concentrations of THC were low and typical of concentrations recorded around non-industrialised coastal environments distant from hydrocarbon inputs. Total PAH concentrations were below the ADS 18/2017 MAC. The concentrations of BTEX in the current survey were below the MRV at all stations along the Route 2 survey area and lower than the values reported previously in the region.

The concentrations of individual PCBs were below the MRV at most stations along the Route 2 survey area. Total WHO12 PCB concentrations were below the ADS 18/2017 MAC.

The majority of the sediment metals concentrations were below their respective ERL values, except for arsenic at 3 stations. Arsenic concentrations also exceeded the ADS 18/2017 MAC threshold (7.0 µg/g) for both general use and marine protected areas at 9 stations. Concentrations of chromium and nickel exceeded the ADS 18/2017 MAC (QCC, 2017) for marine protected areas in numerous stations. Lead concentrations exceeded the ADS 18/2017 MAC for marine protected areas at one station. Nickel concentrations also exceeded the ADS 18/2017 MAC (QCC, 2017) for general use areas at station R2_ENV_018. There was no clear spatial distribution pattern that would indicate a point source related to possible anthropogenic activities within the survey area, and the differences recorded are therefore most likely to be associated with natural sediment variations.

Route 2 – Shuweihat Landfall (WKC)

Water temperature was consistent across the sampling locations, ranging from 22.80 °C to 24.40 °C. The pH levels were relatively similar ranging from 8.0 to 8.2 and within the permissible range of EAD AWQO. DO concentrations were compliant with the referenced standard (>5 mg/L) with a range between 6.67 mg/L to 7.40 mg/L. The project location is highly influenced by tidal flushing and good water exchange resulting in good DO concentrations. Salinity averaged 47.92 ppt, which is typical in the UAE. The salinity was consistent across the sampling locations, with a range from 47.50 ppt to 48.10 ppt. The related parameters such as conductivity and total dissolved solids (TDS) followed the same trend as salinity.

Turbidity values were minimal, ranging from <0.1 NTU to 2.5 NTU, compared to the reference standard of 10 NTU. Water clarity in R2-SQ4 M was surface to bottom. The rest of the locations ranged from 5 m to 8 m. The clarity was generally good considering the location depths ranging from 7.5 m to 12 m.

Total cyanide was only detected in WSQ2 T with 0.008 mg/L, exceeding the EAD AWQO standard of 0.004 mg/L. Exceedances for nitrate were detected at three locations: WSQ5 T (10.6 mg/L); WSQ7 T (7.08 mg/L); and WSQ2 B (0.22 mg/L). The standard of EAD AWQO for nitrate is 0.095 mg/L. Active levels above MDL were recorded for WSQ1 M & B, and WSQ3 CNTR B. COD and BOD were below MDL. TOC was similar across R2 locations ranging from 1.5 mg/L to 1.7 mg/L.

Exceedances were recorded for three of the metal parameters. Copper (Cu) exceeded ADQCC in most of the locations. Lead (Pb) exceeded ADQCC at WSQ1 T & B, WSQ2 M & B, WSQ3 CNTR T, WSQ5 T, M & B, and WSQ7 B. Also, Zinc (Zn) exceeded EAD specifications at WSQ1 T & M.

Petroleum hydrocarbons were detected in exceedance only at WSQ7 T, with 9 µg/L of EPH C10-C40 compared to the permissible limit of 7 µg/L. The remaining samples were below MDL. The exceedance of EPH C10-C40 in one sample could be attributed to contamination by fuel oils.

PAH – Acenaphthylene was active but not in exceedance at WSQ1 in all sampling depths. This compound is used in making soaps, pesticides, and plastics. The location of the sampling site is the farthest from the shoreline.

BTEX, PAHs (except Acenaphthylene at WQS1), and phenols (except for EPH C10-C40 at WQS7T) were below MDL throughout the survey for all R2 sampling points.

The microbial parameter, total coliform was undetected across all sampling locations.

Overall, the results show seawater and sediment values were within expected ranges and can be considered to exhibit typical conditions of the area.

Route 1 – Mirfa Nearshore Area within and near MMBR (Sediment Quality only)

For sediment samples throughout the site, the levels for fluoride and sulphate were noted to be above the MDL. TOC averaged at 0.65%, with lowest value of 0.3 % at S3 and S8, and the highest value at S6 at 0.9 %. Two (2) were recorded in exceedance of the ADQCC, and eleven (11) were recorded above MDL.

Exceedance in Arsenic (As) was detected only in S2 with 7.1 mg/kg. Two (2) locations, S6 and S9 had an exceedance with Nickel at 7.1 mg/kg and 8.2 mg/kg, respectively. In all sampling locations, Aluminium (Al), Barium (Ba), Chromium (Cr), Iron (Fe), Lead (Pb), Manganese (Mn), Phosphorus (P), Vanadium (V), and Mercury were detected above MDL and below the reference standards where applicable. Copper (Cu) was detected above MDL in two (2) locations (S6 and S9), Molybdenum (Mo) in S9, Nickel in four (4) locations (S1, S2, S6, and S9), and Antimony (Sb) in three (3) locations (S1, S6 and S8). Hydrocarbons, PAHs and PCBs were below MDL for all sampling locations.

The exceedances recorded for some metals were considered here to be possibly from geologic origin as there were no potential sources of contamination (mainly from industrial facilities or associated activities) observed at the time of the survey. This is also in consideration of the remoteness of the survey location that is generally devoid of substantial activities (industrial, economic, recreational, or otherwise).

Route 1 – Zakum Clusters Route 1A Re-routing Area

Temperature ranged from 27.30°C to 28.90°C, with an average of 27.83°C. Redox Potential had positive values for all readings with an average of 67.40 mV, ranging from 25.80 mV to 110.70 mV. pH was similar for all locations with an average of 8.10 which is within the expected range.

Dissolved oxygen was high in all recordings ranging from 6.08 mg/L to 6.42. Salinity levels were consistent across locations and depths, with an average of 40.77 ppt.

Turbidity readings were very low ranging from <0.1 to 2.70 NTU and within the reference standard value, implying a good-water visibility. In deploying the Secchi Disc the highest water clarity was recorded at 7.6 meters and the least clarity was at 6.5 meters.

Among inorganic parameters, only Total Dissolved Solids (TDS) and Total Nitrogen (TN) had an active level. TDS was recorded in order of magnitude above the MDL ranging from 45,500 mg/L to 46,400 mg/L, as compared to the MDL of 5 mg/L. TN were below and above the MDL ranging from <0.5 mg/L to 5.3 mg/L.

Sulphate ranged from 3,060 mg/L to 3,120 mg/L whilst chloride ranged from 22,700 mg/L to 23,800 mg/L. Nitrate concentrations ranged from <0.04 mg/L to 18.6 mg/L and exceedances were recorded at eight (8) sampling locations.

BOD was below the MDL and its reference standard whilst COD ranged from <5 mg/L to 30 mg/L, although there no existing standard for COD. TOC was similar across the project locations ranging from 1.4 mg/L to 2.0 mg/L.

Exceedances were recorded in three (3) of the metal parameters against the ADQCC: Copper (Cu) was exceeded in all sampling locations; Lead (Pb) exceeded in most locations and Zinc (Zn) in four of the samples Active metal levels above the MDL were recorded for Arsenic (As), Barium (Ba), Cadmium (Cd), Chromium (Cr), and Vanadium (V).

Petroleum hydrocarbons, BTEX, PAHs and Phenols were below the MDL for all sampling locations. Total coliform, a microbiological measure, was undetectable in all test locations, indicating little to no pollution from sewage sources.

For sediment quality, Oil and Grease was below the MDL across sampling locations. High levels of total nitrogen (TN) were detected in the sediments ranging from 530 mg/kg to 968 mg/kg.

Active levels of silica were detected in all locations with lowest value at 2.53% by wt. whilst the highest value was 4.81% by wt. Orthophosphate, fluoride and sulphate had an active level above the MDL. Orthophosphate ranged from 0.8 mg/kg to 12.3 and Fluoride ranged from 1.4 mg/kg to 3.3 mg/kg. Sulphate ranged from 0.78%SO_4 to 0.95 %SO_4.

Two out of eighteen metals analysed were recorded in exceedance of the ADQCC standards. Chromium (Cr) exceeded at two locations whilst the remaining locations had an active level. Nickel (Ni) exceeded at three locations, with the remaining locations at an active level. Aluminum (Al), Arsenic (As), Barium (Ba), Iron (Fe), Lead (Pb), Manganese (Mn), Phosphorus (P), Vanadium (V) and Zinc (Zn) had active levels in all locations above MD, Mercury (Hg) and Copper (Cu) were above the MDL but below the reference standard except at two locations for Mercury and one location for Copper. Antimony (Sb), Cadmium (Cd), Molybdenum (Mo), Selenium (Se) and Silver (Ag) were below their respective MDLs.

There were no hydrocarbons, PAHs, or PCBs found in any of the samples.

Overall, the results demonstrate that the values of seawater and sediment are within predicted ranges and are typical of the region. Water and sediment test results reveal a high quality of seawater and sediment in the area.

Route 1 – Zakum Clusters Route 1B Re-routing Area

Temperature for the area ranged from 27.30°C to 28.90°C, with an average of 27.75°C. Redox Potential had positive values for all readings ranging from 10.60 mV to 114.50 mV, with an average of 69.54 mV. pH levels had an average of 8.11. Dissolved Oxygen (DO) is within the reference standard with an average of 6.29 mg/L. Salinity profiles ranged between 40.20 ppt to 41.10 ppt with an average of 40.56 ppt. The level of averages for conductivity is 85.31 µS/cm and TDS with 55.45 g/L.

Turbidity values were very minimal ranging from <0.1 NTU to 2.70 NTU, compared to the reference standard of 10 NTU. Water clarity was highest at 7.8 meters and the lowest clarity measurements was at 6.7 meters.

TDS and TN were detected above the MDL. TDS values above the MDL, ranged from 45,00 mg/L to 46,100 mg/L. Active levels above the MDL of total nitrogen were recorded in six locations.

Sulphate and chloride concentrations exceeded the MDL, ranging from 3,040 mg/L to 3,110 mg/L and 22,700 mg/L to 23,400 mg/L, respectively. Exceedances in Nitrate were detected at four locations.

BOD was below the MDL whilst COD ranged from <5 mg/L to 8 mg/L. COD exceedance was recorded in one location at 2.9 mg/L, against the standard of 2.5 mg/L. TOC values were above the MDL but below the reference standard.

Exceedances were recorded in four of the metal parameters. Copper (Cu) exceeded the ADQCC at seven locations, Lead (Pb) exceeded the ADQCC at most of the locations, Cadmium (Cd) exceeded the ADQCC at two locations and Zinc (Zn) exceeded the ADQCC standard at two locations. Active metal levels above the MDL were recorded for Arsenic (As), Barium (Ba), Vanadium (V), and Chromium (Cr).

BTEX, hydrocarbons, PAHs and Phenols were below the MDL for all sampling points throughout the survey. The microbial parameter, total coliform was undetected across all sampling locations.

In sediments, oil and grease was detected above the MDL at three locations. High levels of total nitrogen (TN) were detected in the sediments ranging from 843 mg/kg to 1,240 mg/kg. Active levels of silica was detected in all locations, ranging to lowest value of 2.13 % by wt. to the highest value of 4.92 % by wt. Total Cyanide was below the MDL for all locations.

The three anions tested, orthophosphate, fluoride and sulphate were above the MDL: Orthophosphate ranged from 0.6 mg/kg to 6.4 mg/kg; fluoride was detected in one sample whilst other locations ranged from 1.1 mg/kg to 3.6 mg/kg and sulphate ranged from 0.49 %SO_4 to 0.95 %SO_4.

Three metals were in exceedances of their respective reference standards. Chromium was in exceedance only at one location whilst the remaining locations had an active level. Lead was in exceedance at three locations. Nickel (Ni) was in exceedance at two locations. No exceedances were detected for Antimony (Sb), Cadmium (Cd), Molybdenum (Mo), Selenium (Se), and Silver (Ag). Whereas Arsenic (As), Barium (Ba), Iron (Fe), Manganese (Mn), Phosphorus (P), Vanadium (V) and Zinc (Zn) all had active levels above the MDL but below reference standards. Active levels of Mercury were detected at four locations and Copper (Cu) at four locations.

Hydrocarbons, PAHs, and PCBs were below the MDL for all sampling locations.

Overall, the results demonstrate that the seawater and sediment test results were within expected ranges and considered of high quality.

5.2.2. Environmental Impact Prediction and Evaluation

5.2.2.1. Marine Water Quality Sensitive Receptors

Due to the complex nature of marine ecosystems, mainly due to its interlinked ecological entities characterised by strong spatio-temporal connectivity, the designations of receptor class values were mainly derived from the sensitivities of the receptor in terms of the ability of the receptor to support habitats (or marine ecological features) and/or biodiversity and its capacity to accommodate change to water quality status. Considering the above, the sensitivities of the marine water quality receptors are identified and detailed in Table 5-22.

Table 5-22: Marine water sensitive receptors

Sensitive Receptor	Receptor Class Value	Justification
Overall marine water and sediment in nearshore (including landfall) areas	*Medium-High*	Whilst the baseline information demonstrated the largely good quality of water and sediment and that the receiving water body is relatively large compared to the size of the Proposed project (wherein the modelling studies has demonstrated large capacity for dilution and flushing), the area supports a designated marine biosphere reserve as well as habitats (mainly those outside the reserve) considered locally as critical habitats (e.g., seagrasses and coral habitats) which in turn supports species of conservation importance (e.g., Dugongs and sea turtles that are highly threatened) is directly traversed by the alignment. Therefore, the overall marine water and sediment quality in the nearshore areas traversed by the Project including landfall locations is considered to be of **medium-high** value.

5.2.2.2. Construction Phase Impacts

5.2.2.2.1. Overview

The sensitive nature of the surrounding environment of the Project has the potential to be impacted during the lifetime of the Project. It is envisioned however that the majority of impacts upon the marine environment are likely to occur during the construction phase.

Potential impacts of the Project during construction are likely to include the following:

- Potential contamination of the marine water from spillages and leaks of chemicals and washings of the dredger and the marine vessels;
- Increased turbidity during dredging activities;
- Increased sediment loads from resuspension and transport of sediments;
- Localised sedimentation and restructuring of seabed as a result of trenching / dredging and other marine construction activities resulting in effects to localised water and sediment quality;
- Contamination due to run-off from vessels and vessel equipment washing;
- Sanitary or bilge water discharges from marine vessels; and
- Localised increase in water temperature due to discharge of cooling water from vessels.

In order to determine the extent of impacts from the Project construction, numerical modelling studies have been undertaken which is presented in the below section.

5.2.2.2.2. Numerical Modelling Studies Approach

Hydrodynamic Modelling

Overview

To facilitate the assessment of potential impacts to the marine environment associated with the Project activities, a hydrodynamic modelling and dredge turbidity plume assessment has been undertaken. The main objective of this study was to determine if the turbidity associated with dredging and trenching activities is anticipated to significantly impact water quality resources.

Simulations were conducted using the MIKE21 Hydrodynamic (HD) Flow Model (FM) and associated modules including the MIKE21 Transport Module (AD/TR) and the MIKE21 Mud Transport (MT) module. Additional detail on the method, software, inputs and results of the assessment can be found within the Hydrodynamic Modelling Report (**Appendix 2.1** to this report).

The hydrodynamics of the Project area were simulated utilising the MIKE2 FM HD module utilising global tidal predictions, meteorological data and the bathymetry of the Project area. The hydrodynamic modelling will be utilised to drive subsequent flushing and dredging assessments. The modelling assessment will be undertaken in accordance with the EAD Hydrodynamic Modelling Technical Guidance EAD-EQ-PR-TG-13 and EAD-EQ-PR-TG-12 [26] [27]. An overview of the approach to hydrodynamic model setup is presented in Table 5-23.

Table 5-23: Summary of hydrodynamic modelling approach

Task	Hydrodynamic Modelling
Model	MIKE21 HD FM & MIKE21 HD TR/AD
Model Features	2-dimensional Horizontal and depth averaged vertical plane
Tidal Data	DTU10 global ocean tide model at ≈ 0.125° resolution (72).
Meteorological Data	NCEP supported CFSR data at ≈0.2° spatial and hourly temporal resolution (73).
Period Modelled	A single scenario (baseline) was simulated for calibration and validation purposes, a further two, final scenarios were simulated concurrently with sediment dispersion to take into account real-time physical seabed changes associated with construction works. These scenarios were simulated for separate modelling domains covering Route 1 and Route 2.
Bathymetry	Simulations were conducted utilising bathymetric data provided from the client as well as from a digitized admiralty chart 3715 (obtained from MIKE C-Map) (74).
Model Verification	Verification was conducted against ADCP current and prognostic tidal gauge height data.
Resolution	Flexible mesh, variable element size from a maximum area of 750,000 m^2 (equivalent to approx. 1.7km horizonal resolution) to an area of 1400 m^2 (equivalent to approx. 37 m horizontal resolution).

Additional detail on the modelling set-up can be found within **Appendix 2.1**.

Dredging Simulations

In order to assess suspended sediment dispersion during trenching, dredging and backfilling activities, and comparison to relevant water quality criteria, the MIKE21 HD FM and MIKE21 MT modules were utilised. The hydrodynamic results from the MIKE21 HD FM module have been used to ‘drive’ the subsequent dredge induced sediment plumes using the MT module.

The hydrodynamics of the area were simulated for a baseline case and used for validation/calibration purposes, by comparison to measured ADCP data at four locations (two each along Route 1 & 2).

Hydrodynamics are simulated concurrently with the plume simulations to take into account bed changes associated with dredging, trenching, disposal and backfilling activities.

Overview

Dredge plume modelling predicts the physical behaviour of dredged sediments released into the water column, based on the results of the hydrodynamic modelling undertaken using MIKE HD FM module. The characteristics of the released sediment, the timing and location of releases by the dredging plan and the equipment used for dredging and soil disposal.

The dredge plume model requires a range of key inputs including engineering, geotechnical, meteorological, and oceanographic components. These inputs feed into the simulation process which uses data developed by the MIKE HD FM module to drive the dispersion of the particles released into the water column during dredging operations, whereas the behaviour and settling characteristics of the particles are determined by the parameters set in the MIKE MT FM module.

The basic methodology for the simulation of the dredging programme was as follows:

- In the MIKE HD FM Module:
  - Incorporate detailed bathymetry and topography data of the Project region;
  - Establish bathymetric grids covering the dredging region and surrounding coastlines;
  - Extract meteorological data from CFSR global atmospheric forecast model for the region;
- In the MIKE MT FM Module:
  - Input Particle Size Distribution Data for the seabed materials which are to be dredged;
  - Develop the dredge logs, for input to the dredging simulation model, which define the fine detail of the method of executing the dredging plan from detailed information provided by the client;
- In post-processing:
  - Analyse output from simulation(s) to provide data for initial impact assessment studies;
  - Derive exceedance statistics for TSS from MIKE MT FM output, and
  - Derive bed load depths for material originating from the dredging process.

The focus of this study is to determine the levels of turbidity and sedimentation likely to be experienced in the nearby waters deriving from dredging activities associated with the Project.

Dredging Equipment and Method

Overview

The dredging methodology for the Project consists of multiple stages and is presented in detail within **Section 4.3.2.2**. The basic stages are summarised below:

- Dredging/trenching of the cable trench;
- Laying of the cable; and
- Backfilling the cable trench.

The cables will lie within trenches for the nearshore areas whereas in the offshore areas, the cables will be post-lay trenched when encountering soft sand or laid on the bottom and covered with rock when encountering hard sand. Therefore, the marine modelling studies focused on the nearshore areas due to the significant construction activities.

Nearshore Marine Modelling

The equipment used for the dredging/trenching and backfilling will be dependent on the depth of the area which requires work. The most shallow sections will be worked using amphibious ‘starfish’ dredgers, the intermediate areas will be worked using backhoe dredgers (BHD), and the deeper areas will be worked using trailer suction hopper dredgers (TSHD).

Once the trenching has been completed, the cable will be laid within the trench and any side cast material will be backfilled, burying the cable. The method to lay the cable will be dependent on proximity to land, with nearshore areas using a float out method and areas further offshore using a cable lay vessel. The trenching activities are complicated to a degree along the Cable Route 1, where the area is too shallow to allow access to the cable lay vessel. Within these areas, a navigation channel, sufficient for the cable lay barge, will need to be cut in order to allow access, significantly increasing the scale of works within these areas. An indication of the access channel/ floatation trench dimensions is indicated in Figure 4-61 and Figure 4-62 within **Section 4.3.2.2**, along with the standard dimensions of the relatively small trench required for the cable only.

Material along the majority of the trenched route will be side cast and reserved to fill the trench once cable laying has been completed. However, the material dredged from the floatation / dredged channel cannot be replaced due to concerns regarding future access requirements for maintenance. This excess material will need to be disposed of offshore. The locations of these disposal areas are included within Figure 5-25.

Table 5-24 presents a summary of the trenching and backfilling works with Figure 5-24 and Figure 5-25 for the Route 1 and 2 respectively, providing an indication of the waypoint markers summarised within the schedule table.

Note all turbidity producing task items, including dredge volume, cutting rate, disposal rate and backfilling have been included within the simulations.

Table 5-24: Trenching and backfilling schedule

Task	Estimated Days	Equipment	Volume	Start Date	End Date
Route 1 - Trenching Navigation channel (Campaign 1)	**37 days**	**-**	**59,767 m³**	**01-Nov-23**	**07-Dec-23**
Trench 1 // 18.010 - 18.500	3.3	BHD	1,650 m³	01-Nov-23	04-Nov-23
Trench 1 // 18.500 - 18.700	24.0	BHD	18,190 m³	01-Nov-23	25-Nov-23
Trench 1 // 18.800 - 20.000	10.6	BHD	33,884 m³	25-Nov-23	05-Dec-23
Trench 1 // 20.000 - 20.200	1.9	BHD	6,043 m³	05-Dec-23	07-Dec-23
Route 1 - Hammering scope (Campaign 1)	**41 days**	**-**	**18,175 m³**	**04-Nov-23**	**15-Dec-23**
Trench 1a // 18.010 - 18.800	13.1	BHD	5,751 m³	04-Nov-23	17-Nov-23
Trench 1a // 20.280 - 21.100	7.6	BHD	3,337 m³	30-Nov-23	08-Dec-23
Trench 1b // 18.010 - 18.800	13.1	BHD	5,751 m³	17-Nov-23	30-Nov-23
Trench 1b // 20.280 - 21.100	7.6	BHD	3,337 m³	08-Dec-23	15-Dec-23
Route 1 - Trenching scope Route 1 (Campaign 2)	**116 days**	**-**	**503,346 m³**	**17-Dec-23**	**12-Apr-24**
Trench 1a // 0.000 - 1.020	9.9	Starfish	7,498 m³	17-Jan-24	27-Jan-24
Trench 1a // 1.020 - 1.510	2.3	BHD	3,567 m³	17-Dec-23	20-Dec-23
Trench 1a // 1.510 - 10.000	5.7	TSHD	105,955 m³	06-Jan-24	12-Jan-24
Trench 1a_bis // 10.000 bis - 15.630 bis	38.0	BHD	40,986 m³	20-Dec-23	27-Jan-24
Trench 1a // 15.000 - 17.500	1.7	TSHD	31,200 m³	18-Jan-24	19-Jan-24
Trench 1a // 17.500 - 17.610	0.3	BHD	801 m³	21-Jan-24	22-Jan-24
Trench 1a // 17.610 - 18.010	0.3	TSHD	4,992 m³	21-Jan-24	22-Jan-24
Trench 1a // 18.800 - 20.280	4.7	BHD	10,774 m³	22-Jan-24	27-Jan-24
Trench 1a // 21.100 - 25.310	2.8	TSHD	52,541 m³	24-Jan-24	27-Jan-24
Trench 1b // 0.000 - 1.220	11.8	Starfish	8,954 m³	31-Mar-24	12-Apr-24
Trench 1b // 1.220 - 1.400	0.9	BHD	1,310 m³	10-Apr-24	11-Apr-24
Trench 1b // 1.400 - 10.000	5.7	TSHD	107,328 m³	12-Jan-24	18-Jan-24
Trench 1b_bis // 10.000bis - 15.641bis	38.1	BHD	41,066 m³	03-Mar-24	10-Apr-24
Trench 1b // 15.000 - 18.010	2.0	TSHD	37,565 m³	19-Jan-24	21-Jan-24
Trench 1b // 18.800 - 20.280	4.7	BHD	10,744 m³	15-Mar-24	19-Mar-24
Trench 1b // 21.100 - 24.150	2.0	TSHD	38,064 m³	22-Jan-24	24-Jan-24
Route 1 - Cable installation schedule	**-**	**-**	**-**	**-**	**-**
Cable installation 1a	7.0	Cable	-	01-Feb-24	08-Feb-24

Task	Estimated Days	Equipment	Volume	Start Date	End Date
Cable installation 1b	7.0	Cable	-	17-Apr-24	24-Apr-24
Route 1 - Backfiling Route 1 (Campaign 2)	**129 days**	**-**	**788,229 m³**	**11-Feb-24**	**18-Jun-24**
Backfill 1a // 0.000 - 1.020	9.9	Starfish	7,498 m³	11-Feb-24	20-Feb-24
Backfill 1a // 1.020 - 1.500	2.0	BHD	3,675 m³	11-Feb-24	12-Feb-24
Backfill 1a // 1.500 - 10.000	26.1	TSHD	176,592 m³	11-Feb-24	08-Mar-24
Backfill 1a // 10.000bis - 15.63bis - bis route	27.9	BHD	45,040 m³	12-Feb-24	11-Mar-24
Backfill 1a // 15.000 - 17.500	7.7	TSHD	52,000 m³	08-Mar-24	15-Mar-24
Backfill 1a // 17.500 - 17.610 Single float	1.0	BHD	825 m³	11-Feb-24	12-Feb-24
Backfill 1a // 17.610 - 18.010	1.2	TSHD	8,320 m³	15-Mar-24	17-Mar-24
Backfill 1a // 18.010 - 20.280 Combined float 1a + 1b	20.7	BHD	17,025 m³	12-Feb-24	03-Mar-24
Backfill 1a // 20.280 - 21.100	3.3	BHD	6,150 m³	11-Mar-24	15-Mar-24
Backfill 1a // 21.100 - 25.310	12.9	TSHD	87,568 m³	17-Mar-24	29-Mar-24
Backfill 1b // 0.000 - 1.220	11.8	Starfish	8,954 m³	27-Apr-24	08-May-24
Backfill 1b // 1.220 - 1.400	0.7	BHD	1,350 m³	27-Apr-24	27-Apr-24
Backfill 1b // 1.400 - 10.000	26.4	TSHD	178,880 m³	27-Apr-24	23-May-24
Backfill 1b // 10.000bis - 15.461bis - bis route	27.9	BHD	45,128 m³	27-Apr-24	25-May-24
Backfill 1b // 15.000 - 18.010	9.3	TSHD	62,608 m³	23-May-24	01-Jun-24
Backfill 1b // 18.010 - 20.280	20.7	BHD	17,025 m³	25-May-24	15-Jun-24
Backfill 1b // 20.280 - 21.100	3.3	BHD	6,150 m³	15-Jun-24	18-Jun-24
Backfill 1b // 21.100 - 25.310	9.4	TSHD	63,440 m³	01-Jun-24	11-Jun-24
Route 2 - Trenching scope (Campaign 2)	**143 days**	**-**	**159,081 m³**	**29-Jun-24**	**19-Oct-24**
Trench 2 // -0.850 - 1.440	30.5	Starfish	17,791 m³	29-Jun-24	30-Jul-24
Trench 2 // 1.440 - 2.750	15.3	BHD	6,708 m³	14-Jul-24	30-Jul-24
Trench 2 // 2.750 - 5.030	1.5	TSHD	28,454 m³	28-Jul-24	30-Jul-24
Trench 2a // -0.850 - 1.440	28.2	Starfish	16,448 m³	11-Aug-24	09-Sep-24
Trench 2a // 1.440 - 2.750	18.3	BHD	8,051 m³	19-Aug-24	06-Sep-24
Trench 2a // 2.750 - 5.030	1.5	TSHD	28,454 m³	21-Aug-24	22-Aug-24
Trench 2b // -0.850 - 1.440	30.9	Starfish	18,013 m³	18-Sep-24	19-Oct-24
Trench 2b // 1.440 - 2.750	15.3	BHD	6,708 m³	29-Sep-24	15-Oct-24
Trench 2b // 2.750 - 5.030	1.5	TSHD	28,454 m³	01-Oct-24	02-Oct-24

Task	Estimated Days	Equipment	Volume	Start Date	End Date
Route 2 - Backfilling scope (Campaign 2)	**106 days**	**-**	**223,923 m³**	**14-Aug-24**	**26-Nov-24**
Backfill 2 // -0.850 - 1.440	23.4	Starfish	17,791 m³	14-Aug-24	06-Sep-24
Backfill 2 // 1.440 - 2.750	5.3	BHD	9,825 m³	14-Aug-24	19-Aug-24
Backfill 2 // 2.750 - 5.030	7.0	TSHD	47,424 m³	14-Aug-24	21-Aug-24
Backfill 2a // -0.850 - 1.340	21.6	Starfish	16,448 m³	24-Sep-24	15-Oct-24
Backfill 2a // 1.340 - 2.750	5.7	BHD	10,575 m³	24-Sep-24	29-Sep-24
Backfill 2a // 2.750 - 5.030	7.0	TSHD	47,424 m³	24-Sep-24	01-Oct-24
Backfill 2b // -0.850 - 1.550	23.7	Starfish	18,013 m³	03-Nov-24	26-Nov-24
Backfill 2b // 1.550 - 2.750	4.9	BHD	9,000 m³	03-Nov-24	07-Nov-24
Backfill 2b // 2.750 - 5.030	7.0	TSHD	47,424 m³	03-Nov-24	10-Nov-24
Route 2 - Cable installation schedule	**-**	**-**	**-**	**-**	**-**
Cable installation 2	10.0	Cable	-	04-Aug-24	14-Aug-24
Cable installation 2a	10.0	Cable	-	14-Sep-24	24-Sep-24
Cable installation 2b	10.0	Cable	-	24-Oct-24	03-Nov-24

Figure 5-24: Waypoint markers for Route 2

Figure 5-25: Waypoint markers (including disposal areas) for Route 1

Particle Size Distribution and Settling Velocities

The formation of sediment plumes is largely associated with the finer fraction of material. It is therefore necessary to understand the relative distribution of material, particularly that smaller than 100 microns (1 micron = 10-6 m).

The particle settling velocity values were based on analyses of sand and silt by CSIRO Australia data from previous dredging programs using a sedigraph, shown below in Table 5-25 (75). Sodium hexametaphosphate was used by CSIRO as the medium through which the measured particles fall. The data was later corrected to consider the difference in the settling velocities in sea water and with consideration of drag resulting in a terminal velocity in seawater.

Table 5-25: Particle size distribution and settling velocities

-	Size	Settling Rate (mm/s)	Group	Descriptor
Particle Size Distribution	2000	3156.000	8	Coarse Sand
	1000	789.000		
	600	284.200		
	400	126.300		
	250	49.300	7	Fine Sand
	150	17.760		
	100	7.890	6	Very Fine Sand
	80	5.050		
	60	2.842	5	Coarse Silt
	40	1.262		
	20	0.316	4	Medium Silt
	10	0.079	3	Very Fine Silt
	5	0.020		
	2	0.003	2	Medium Clay
	1	0.001	1	Very Fine Clay

For the purposes of this modelling study, the material was divided into eight groups based on the PSD information from a geotechnical survey (76) and the Wentworth Grain Size Chart, developed by the United States Geological Survey (77).

The geotechnical surveys indicated that a variety of sediment types along the route of the trenching area, ranging from very silty sand (>20% silt content) to sandy gravel (<5% silt content). Sand and silt fractions of the potentially resuspended sediment were simulated. Considering that the Gravel category would consist of particles with a diameter of more than 2mm, these particles will not contribute to the overall sediment suspension due to dredging and was not included in the model.

Due to the vast majority of sediment in the area consisting of Sand, this category was divided into 3 different classifications, namely Coarse Sand, Fine Sand and Very Fine Sand with particle size ranges as indicated in Table 5-26. Silt fractions were also broken down into three fractions, and clay broken into two fractions, considering these fractions are likely to settle more slowly and contribute disproportionally to water turbidity.

Table 5-26: Particle size distribution and settling velocities of simulated sediment fractions

-	Size	Settling Rate (mm/s)	Group	Descriptor
Particle Size Distribution	>400	789.000	8	Coarse Sand
	150-400	25.0	7	Fine Sand
	80-150	6.470	6	Very Fine Sand
	40-80	2.052	5	Coarse Silt
	20-40	0.316	4	Medium Silt
	5-20	0.049	3	Very Fine Silt
	2-5	0.003	2	Medium Clay
	<2	0.001	1	Very Fine Clay

The characteristics of the sediment within the dredged areas was defined utilising data from a number of boreholes from the geotechnical surveys (76), with the appropriate borehole characteristics being selected based on proximity. Table 5-27 presents the location, and characteristics of these boreholes along the proposed Route 1 & 2.

Table 5-27: Relevant borehole summary

Borehole Ref	Coordinates East (m)	Coordinates North (m)	Water Depth (m)	Borehole Depth (m)	% Silt	% Sand	% Gravel
Route 1							
BH-01	751802	2609184	8.8	3.3	12	84	4
BH-04	752763	2669443	10.3	3.2	33	64	3
BH-14	764371	2675509	5.2	3.3	20	75	5
BH-15	764665	2673464	6.3	3.4	5	67	28
BH-17	765082	2673418	7.7	3.0	17	79	4
BH-21	766221	2679183	6.0	3.0	5	30	65
Route 2							
BH-01	657092	2671534	3.9	2.9	21	73	6
BH-02	656228	2672038	8.4	3.5	6	69	25
BH-03	655363	2672542	7.9	3.5	20	74	6

Dredging Simulations

The dredge programme was simulated by MIKE MT FM to predict the behaviour of particles released into the water column, driven by 3D currents from MIKE HD FM, the dredge log and particle size distributions at each time step.

The dredge modelling predicted the X-Y-Z coordinates of all particles throughout the full simulation and the results were stored on a 10-minute timestep. These results were then analysed to determine the distribution of TSS developed over the total simulation, as well as the maximum depth-averaged concentrations which were attained over the entire dredge programme.

Hydrodynamic Modelling

The bathymetric data collected was a combination of bathymetry points obtained through digitisation of historic navigation charts, bathymetric (both physical survey data and Satellite Derived (SDB) data) obtained from the client, as well as relevant archived WKC bathymetric data surrounding the project area. Bathymetry obtained from the navigational charts were used for most of the surrounding areas within the modelling domain whilst the accurate survey data was used specifically around the area of interest. The ocean floor is a dynamic and constantly changing environment, therefore it is possible that for certain bathymetric data used, some variation between modelled bathymetry and actual bathymetry may exist. It is however not expected that this variation is significant enough to change the outcomes of this assessment.

Dredging Simulations

Dredging simulations were carried out based on the methodology supplied by the EPC Contractor with estimated dredge rates, volumes and spill rates supplied by the dredging contractor. There are likely to be minor variations in theses agreed values during the actual dredging operations.

The dredge modelling relies on the best available meteorological and bathymetric information and information concerning the proposed dredging methodology and material to be dredged. All these inputs can be subject to error and so where there was potential uncertainty in model parameters, conservative values were chosen such that the model would tend to overestimate the impact.

Numerical Modelling Results

Hydrodynamic Modelling

Overview

Currents speeds within the two areas of interest are variable both within the domain and between Route 1 & 2 domains. Currents within both the areas of interest are complicated by nearby islands and shoals creating both restricted channels with high current speeds and sheltered areas with limited tide or wind driven currents.

The tides are generally of a mixed diurnal and semi-diurnal nature. The current velocities within the Project area are largely driven by the flood and ebb tidal events with some influence from wind effects (due to the predominant north-westerly wind direction).

The area of landfall with the Abu Dhabi mainland for the Route 2 area is sheltered by both the Jebel Dhana headland and Sir Bani Yas Island. Current speeds are high through the narrow channel that separates Sir Bani Yas Island from the Abu Dhabi mainland, however currents on either side of the Jebel Dhana headland are sheltered during both the flood and ebb tide and are generally below 0.1m/s.

Current speeds within the nearshore area of the Route 1 are generally higher during both the flood and ebb tide and are largely tidal driven due to some sheltering from wind affects from islands and shoals offshore. The currents are generally in the east to west orientation following the lay of the mainland coast with the channel that separates the mainland from both Marawah and Abu al Abyad Islands. The cable route turns towards the north and exploits an existing channel between tidal shoals, where an existing navigation channel has been dredged. Currents supplying and emptying the nearshore areas during the flood and ebb tide respectively are particularly strong through this channel, frequently exceeding 1.0 m/s.

Figure 5-26 and Figure 5-27 present a typical ebb tide at both the Route 1 & 2 respectively whereas Figure 5-28 and Figure 5-29 present the flood tide.

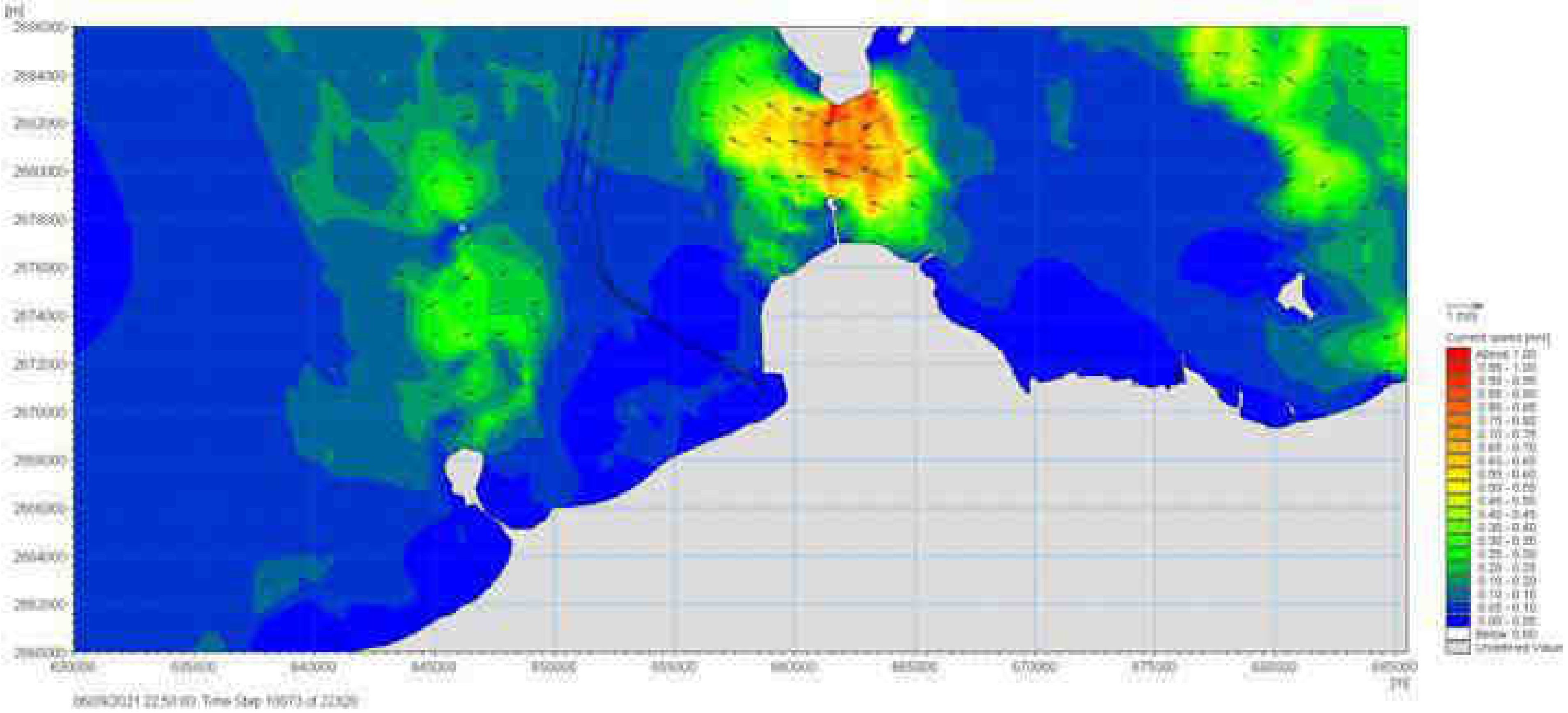


Figure 5-26: Typical ebb tide currents for Route 2

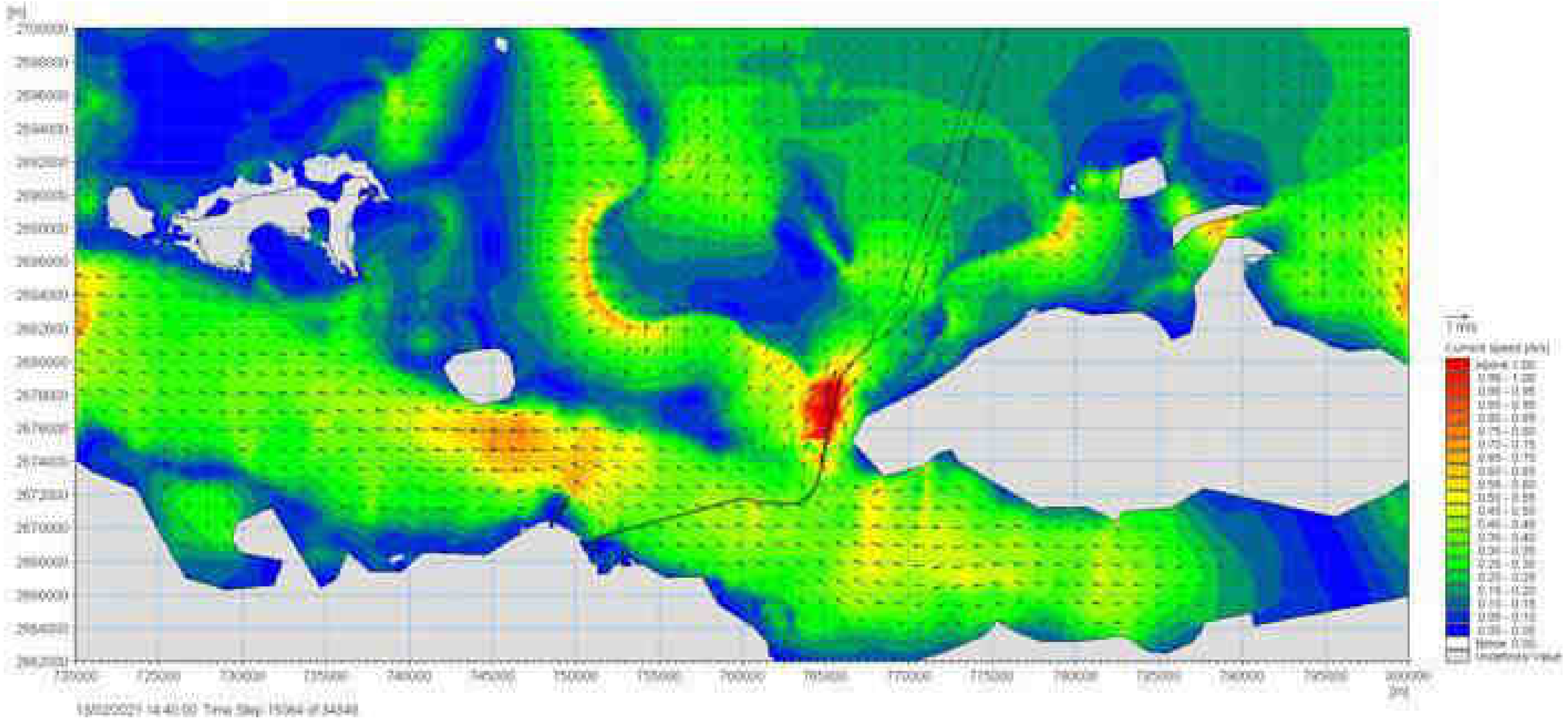


Figure 5-27: Typical ebb tide currents for Route 1

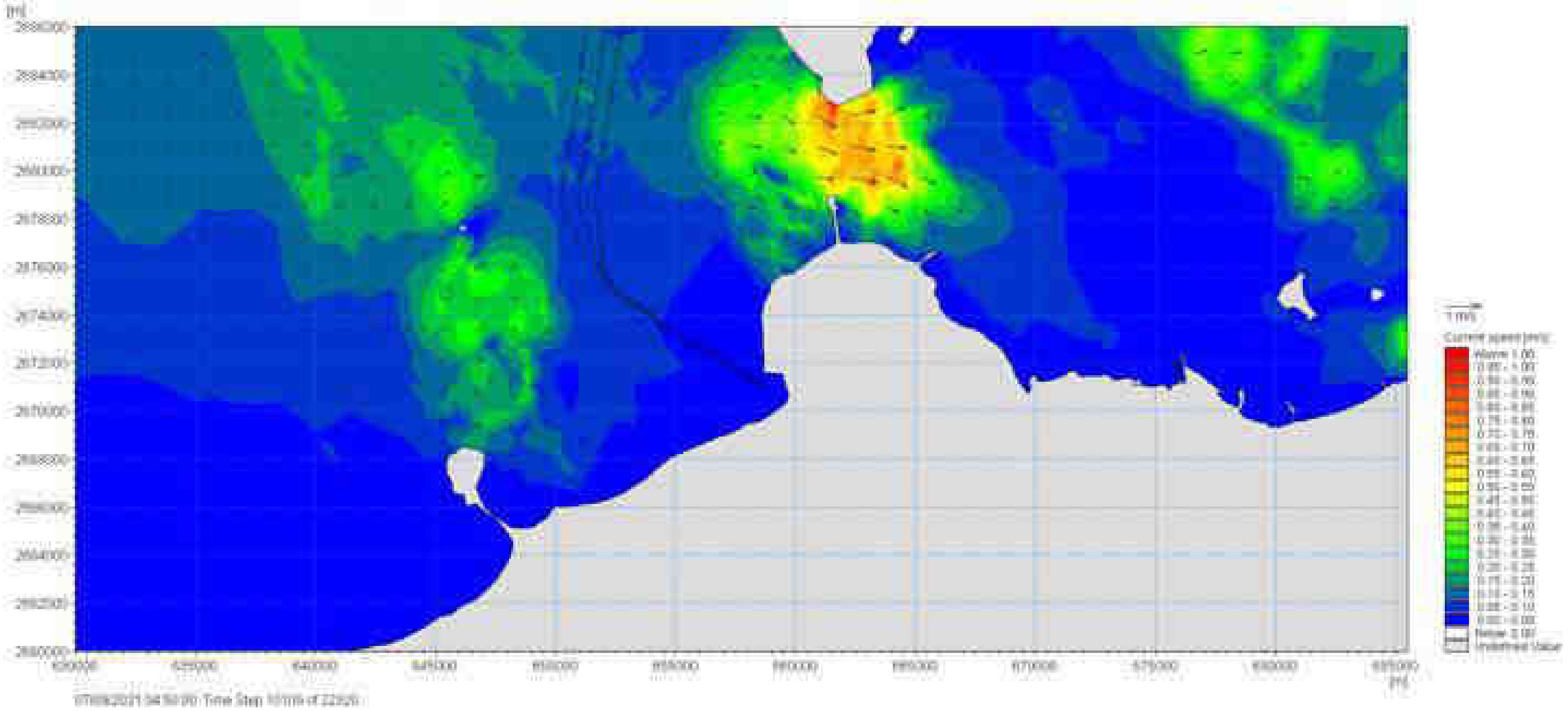


Figure 5-28: Typical flood tide currents for Route 2

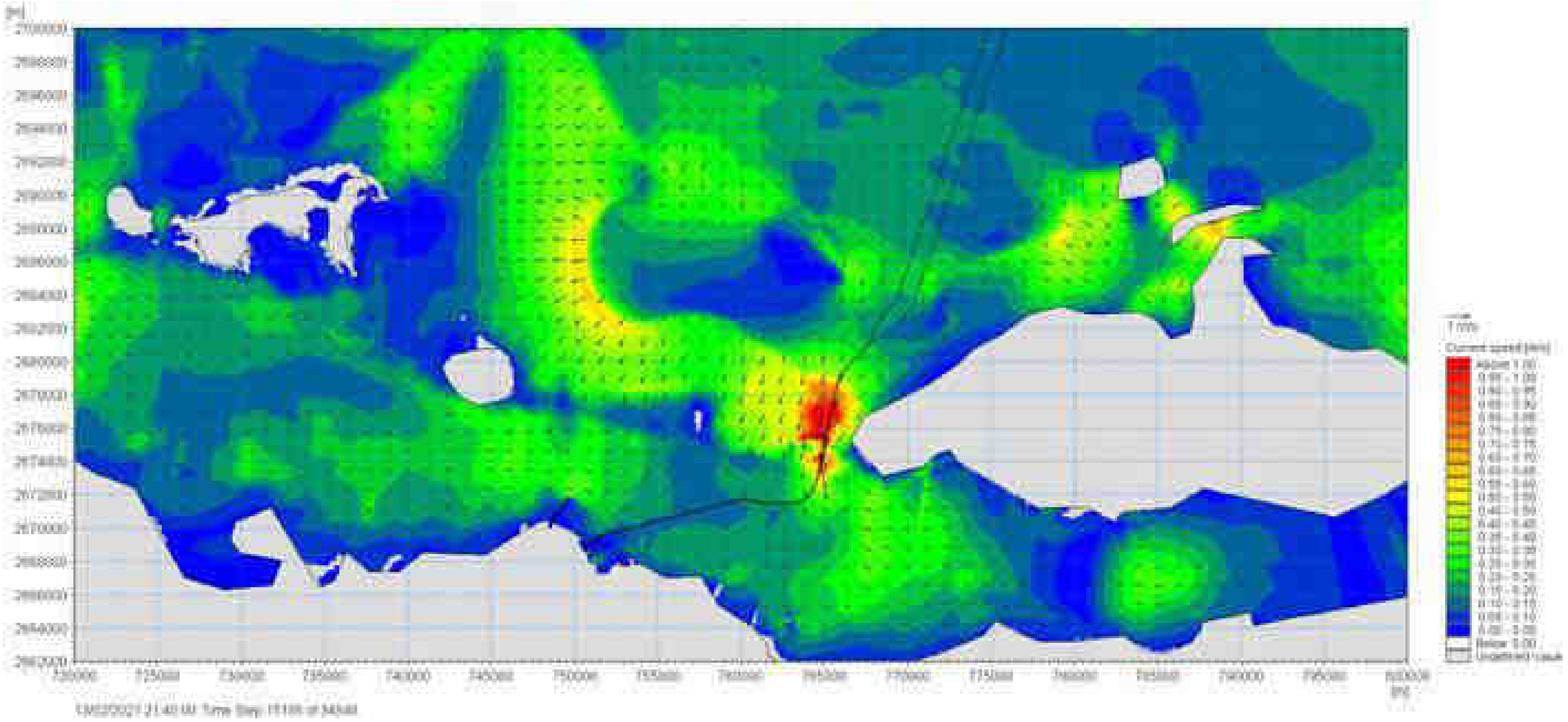


Figure 5-29: Typical flood tide currents for Route 1

Area of Interest Variation - Route 2

Currents within the area of interest, where dredging and backfilling will occur, are largely tidal in nature. However, currents within the area are complicated by the presence of Sir Bani Yas Island, and the Jebel Dhana headland. Whereas normally the currents would be orientated east to west along the coastline of Abu Dhabi, these two features create a shadow effect within the area of interest, instead the tides pass through the narrow channel between the mainland and Sir Bani Yas Island.

Average currents speeds within the area where trenching and backfilling will occur are below 0.05 m/s, with maximum current speeds rarely exceeding 0.3 m/s. It is anticipated that this area of relatively low currents speeds will limit dispersion of any sediment suspended into the water column; although this may reduce the area of impact, this will also result in less efficient dilution of TSS concentrations within this area.

Area of Interest Variation – Route 1

The area of interest containing the proposed trenched areas along the proposed Zakum Cable route is partially separated from the open Gulf by various islands and shoals, which complicates and restricts tidal flows within this area. In general, the tidal currents move along the coastline in an east to west direction but are deflected by various shoals and islands.

Average current speeds along the majority of the trenched route are approximately 0.2 m/s reaching a maximum of 0.4 – 0.5 m/s. A small gap in the shielding influence of the islands and shoals lies immediately west of Abu al Abyad Island, although shallow, a small access channel has been historically dredged here. This gap allows the flood and ebb to move in a north and south direction, however the restriction here results in average current speeds of up to 0.7 m/s and maximum currents speeds of over 1.5 m/s.

Figure 5-30 and Figure 5-32 present the mean and maximum current speeds respectively for the area of interest surrounding the proposed Das Island Cable Route trenching area, whereas Figure 5-31 and Figure 5-33 present the same for the area of interest along the proposed Zakum Cable Route.

Results of the simulation in video format for both the pre-development and post-development scenarios are provided as a submission package to EAD.

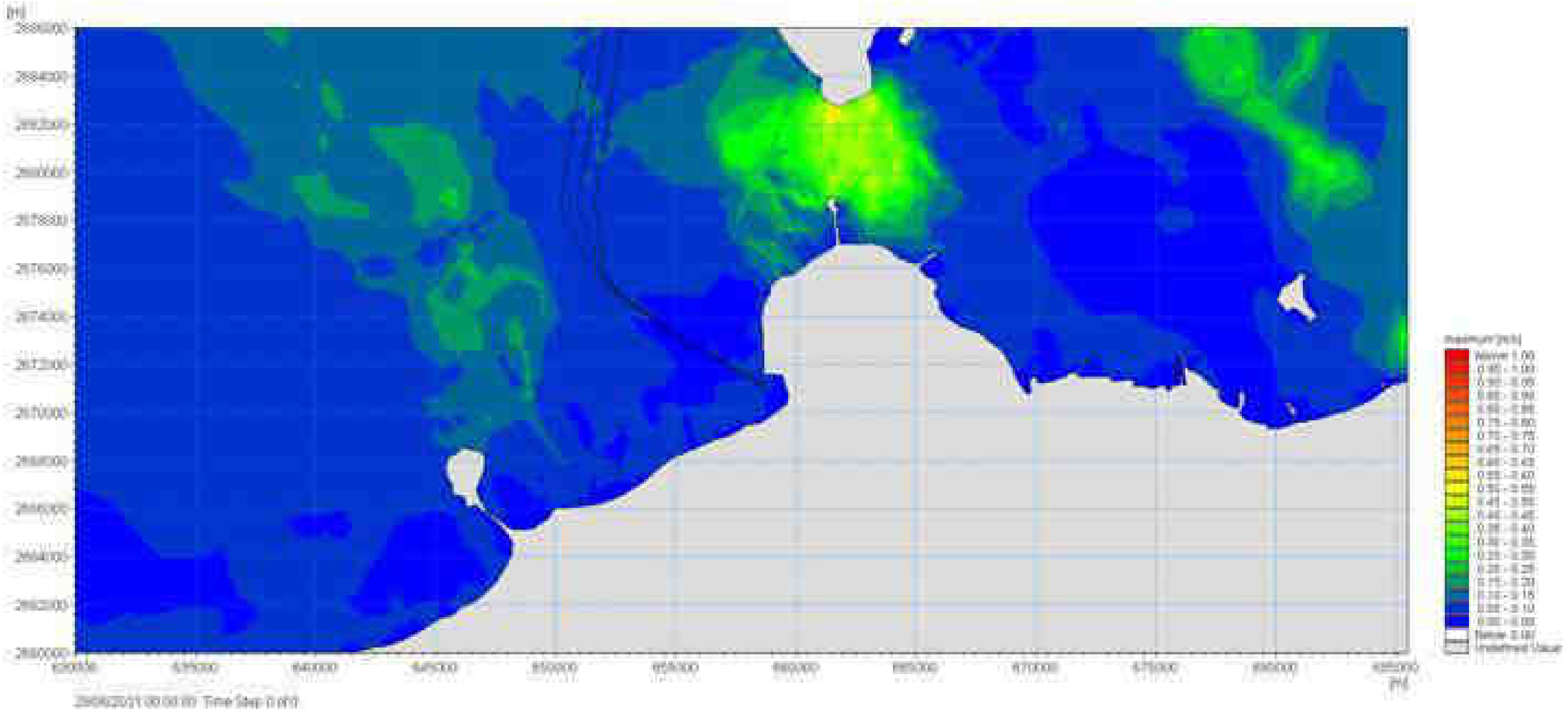


Figure 5-30: Mean current speeds along Route 2

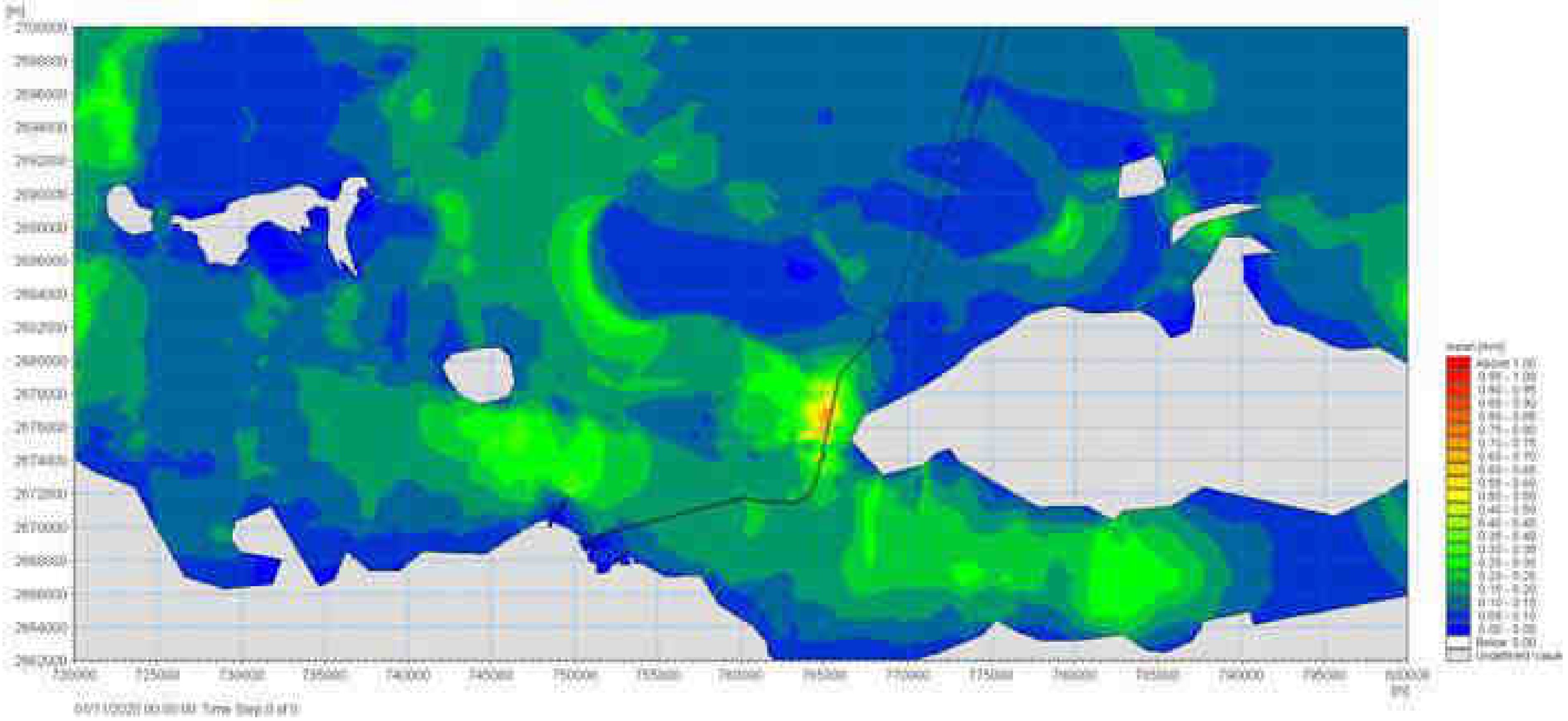


Figure 5-31: Mean current speeds along Route 1

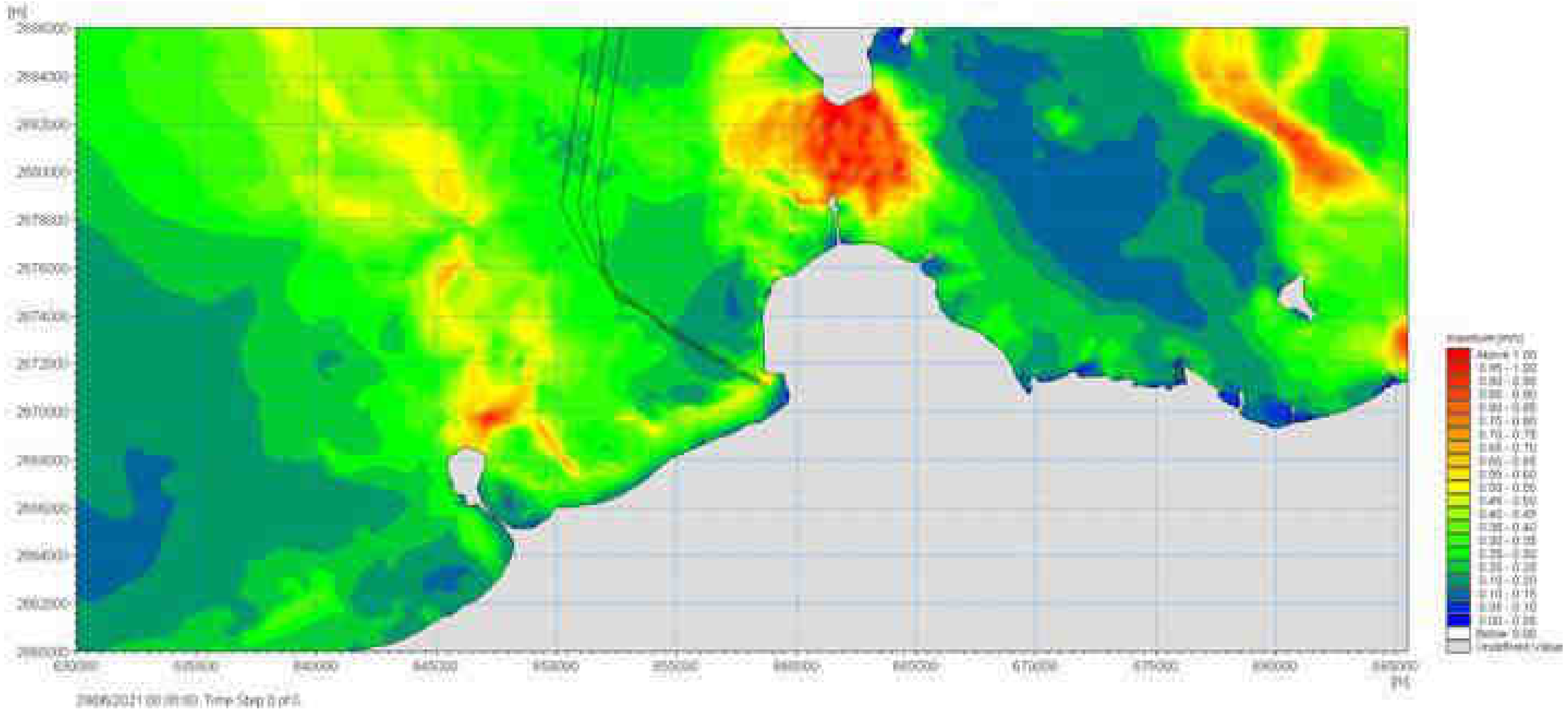


Figure 5-32: Max current speeds along Route 2

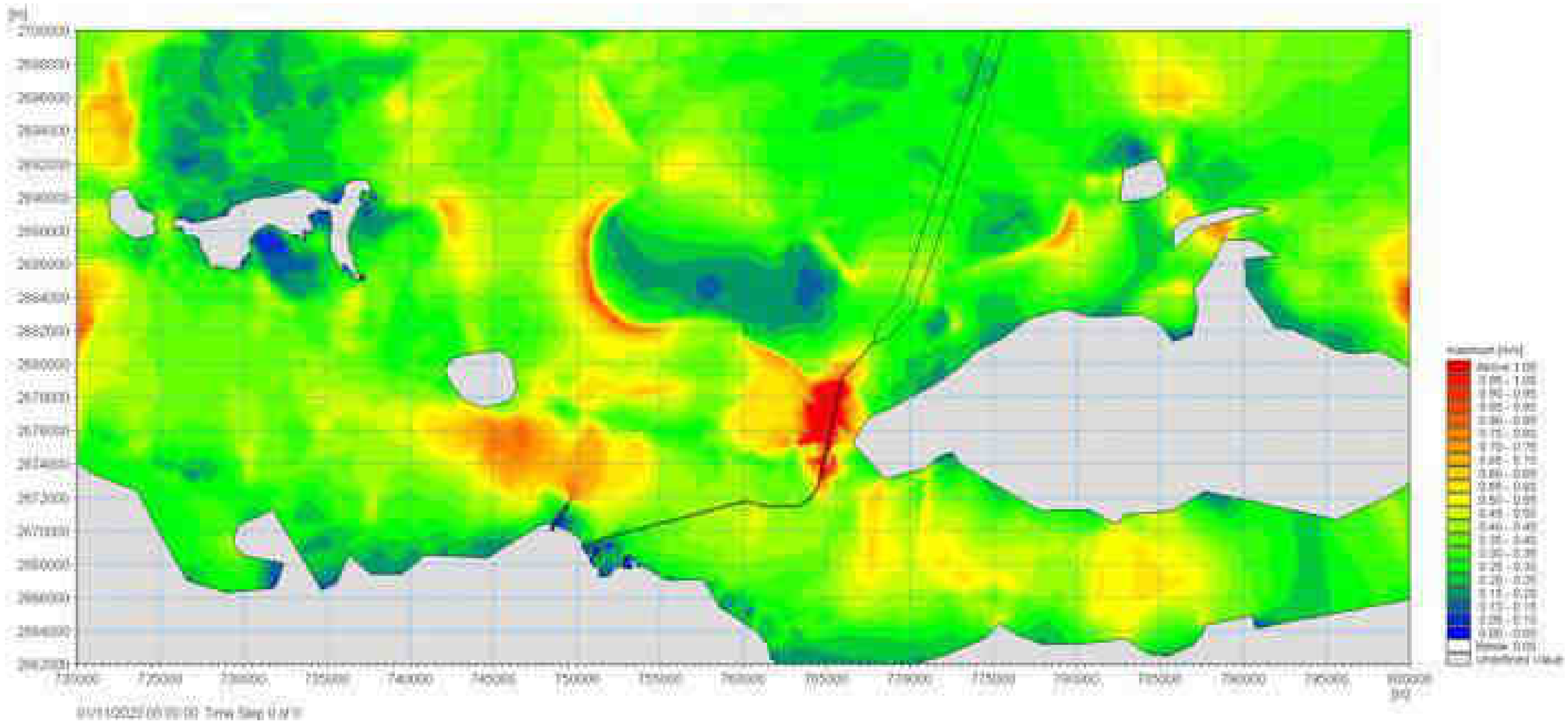


Figure 5-33: Max current speeds along Route 1

Dredging Modelling Assessment

Two dredging scenarios were simulated within separate domains to take into account proposed trenching, backfilling and dumping methods for the proposed cable routes leading to Das Island (Route 2) and Al Ghallan Island (Route 1). These simulations were conducted to predict turbidity concentrations and deposition patterns during the dredging activities that are proposed for the Project areas as discussed in **Section 5.2.2.2.2**.

The results were analysed to determine the mean concentration and predicted maximum Total Suspended Solids (TSS) concentration in kg/m^3 exceeded 5% of the time (otherwise known as the 95th percentile) across the region as well as the total deposition/sedimentation depth/thickness resulting from the dredging activities. The statistics were conducted over the entire dredging period (approximately five months for Route 2 and eight months for Route 1).

The mean and 95th percentile concentrations are presented for Route 2 in Figure 5-34 and Figure 5-35 and for Route 1 within Figure 5-36 and Figure 5-37.

Suspended sediment concentrations within the trenching area of the Route 2 are, on average, anticipated to meet ambient water quality objectives (33 mg/l), however within a minority of conditions (i.e., <5% of the time) the area exceeding the ambient water quality objective is predicted to spread over 5 km to the south-west. The suspended sediment generation rate within this area is relatively limited due to the small volume being trenched and backfilled, and the relatively small size of the equipment conducting the work. The sediment being dredged within the area is however also relatively high in silt content, increasing the potential for suspended sediment to remain suspended within the water column for longer periods of time before settling on the seabed. Low current speeds within the area of interest greatly reduce suspended sediment dispersion and dilution. The shadow created by the Jebel Dhana headland creates a relatively slack area where sediment dispersion is not optimal.

The potential for suspended sediment generation within the Route 1 trenching area is greater than that for the Route 2, due to the longer length of cable route that requires trenching, and the requirement to dredge a navigation/floating channel to allow access of the cable lay vessel, and the use of two disposal areas. Although sediment generation is larger, current speeds are generally significantly higher in this area, particularly within the shallow areas which require substantial dredging for the navigation/floating channels. The higher currents aid dispersion in two ways, first they will generally increase the dilution rate of any dispersed sediment, but also by ensuring that the sediment being dredged is of a larger particle size due to natural erosion processes. Mean TSS concentrations, when averaged throughout the entire 8-month programme, are anticipated to be below AWQOs, however for a minority of the time (<5%) an area of approximately 5-10 km^2 may exceed AWQOs within the proximity of the dredging of the navigation/floatation channel.

The trenching and backfilling involved within the construction programme for both Route 1 & 2 are sparsely spread both temporally (occurring over five months and eight months respectively) and spatially (consisting of a very narrow dredge cross section over a long overall length). Due to this sparsity in activities, the statistical analysis of concentrations (e.g. mean and 95th percentile) may be considered too optimistic when looking at the potential for significant exceedance in AWQOs. Therefore Figure 5-38 and Figure 5-39 present the area within which a certain number of days are expected to exceed AWQOs. Exceedances within the AOI for the Route 2 are expected to occur for over two weeks, whereas within the Route 1 AOI, exceedance is generally limited to less than one week, likely due to the faster mixing processes associated with higher current speeds.

In the immediate areas surrounding the dredging activities, high dropout rates of course material (coarse and medium sand particles) are predicted and is likely to cause deposition in the vicinity near the dredger. However, although a large volume of the dredged material is relatively course, certain areas do contain fine fractions which may spread further afield and deposit on sensitive habitats.

The deposition depth associated with the dredging activities along the Route 2 are presented within Figure 5-40. Although sediment within the area does contain a fair fraction of silt, the limited currents speeds within the area generally restrict dispersion of suspended sediment, therefore deposition depth is generally limited to < 1mm, with the area of deposition greater than 1 mm extending over approximately 2 km^2.

Deposition associated with the trenching and navigation/floating channel within the Route 1 area of interest is generally larger. This is likely due to the larger volume of work, the fact that disposal areas will be used, and the higher current speeds increasing dispersion. The area where deposition is predicted to be greater than 1 mm is anticipated to cover approximate 40 km^2, whereas the area where deposition is anticipated greater than 5 mm is anticipated to cover approximately 15 km^2.

Video outputs of the dredging activities have been created and will be submitted to EAD as part of this ESIA Package.

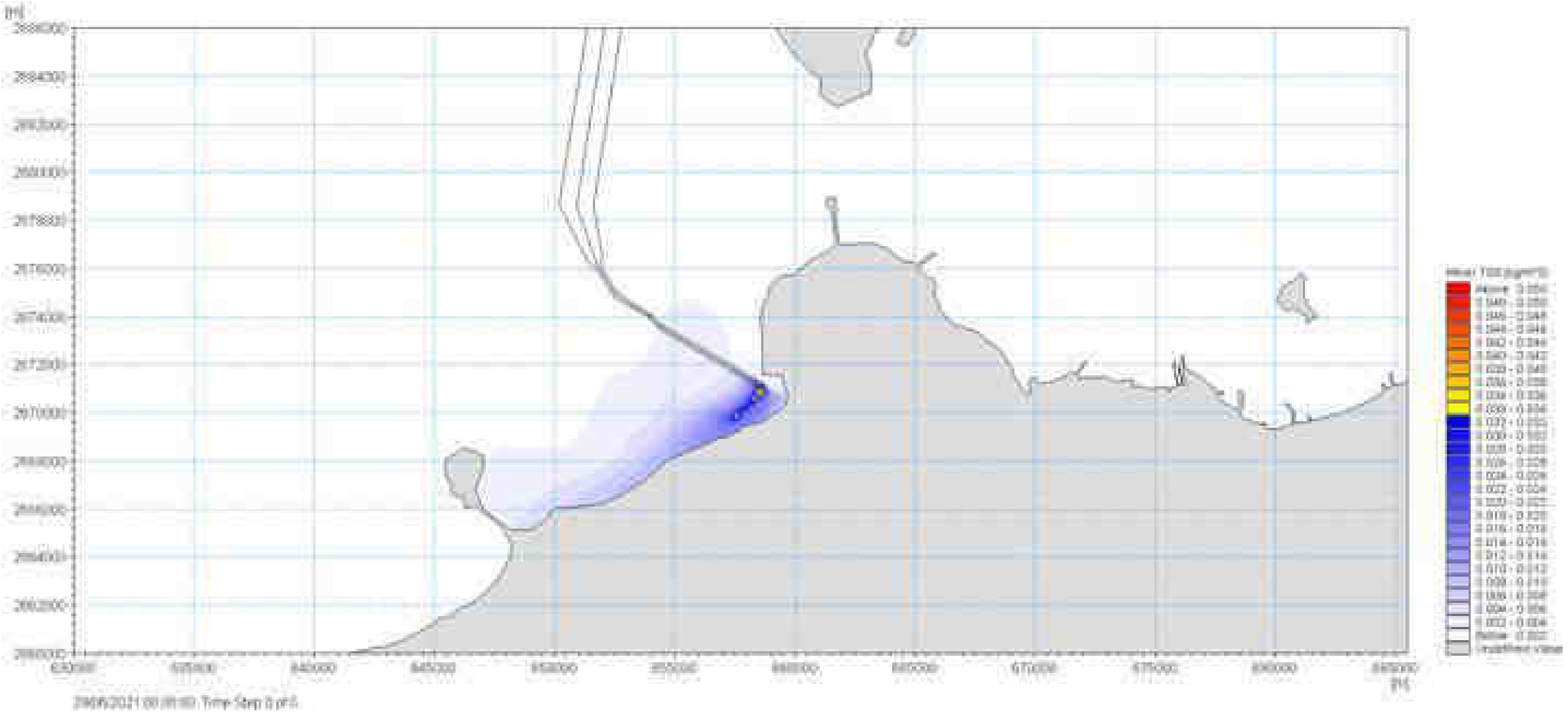


Figure 5-34: Mean TSS concentration for Route 2

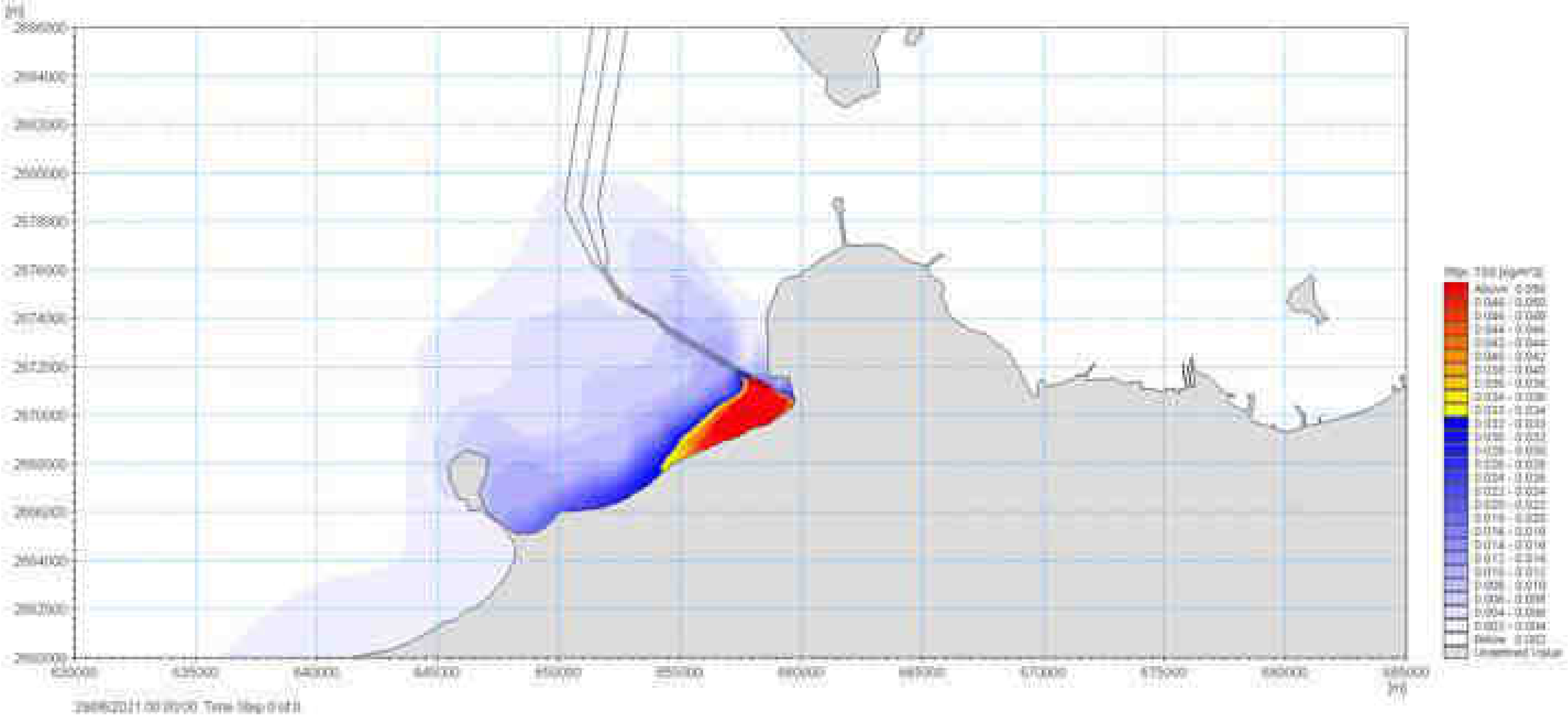


Figure 5-35: 95th percentile TSS concentration for Route 2

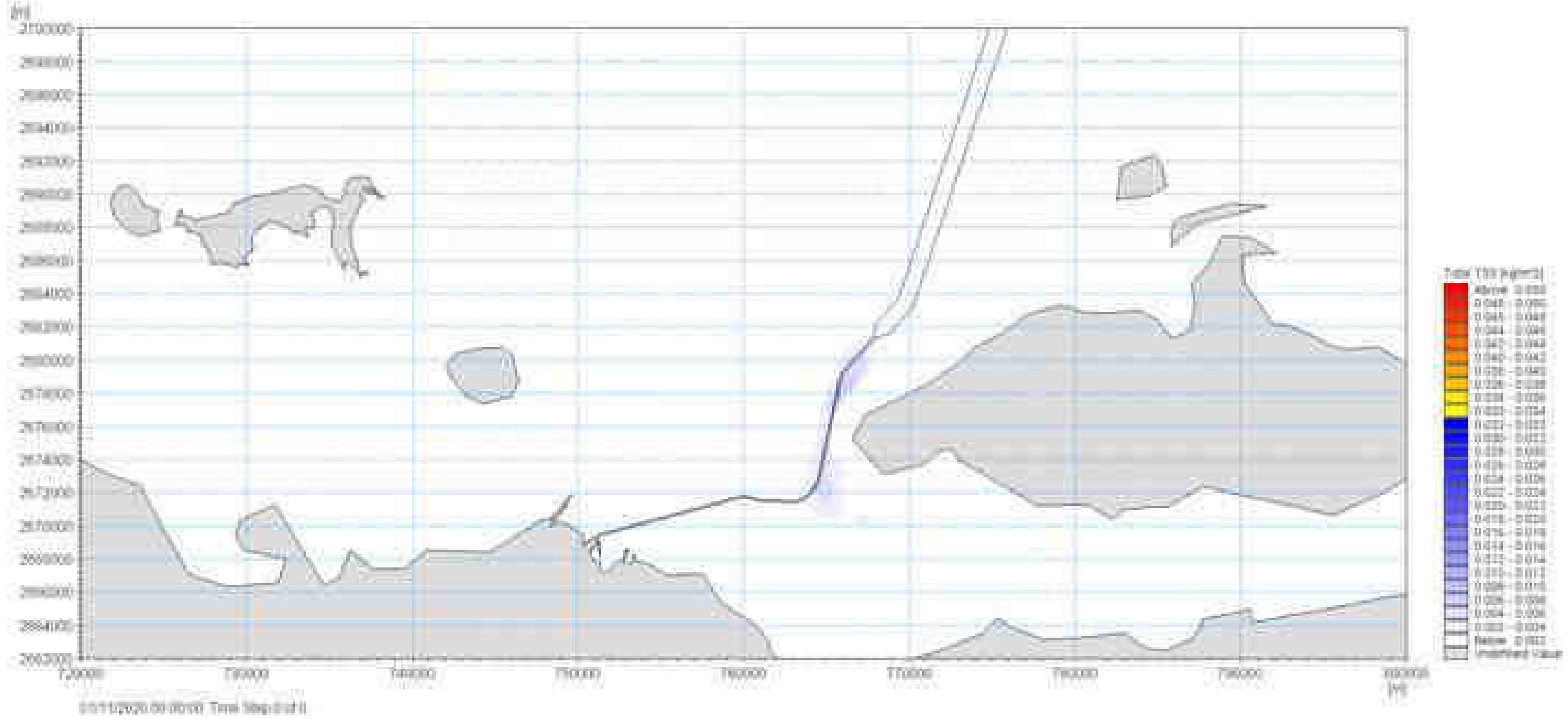


Figure 5-36: Mean TSS concentration for Route 1

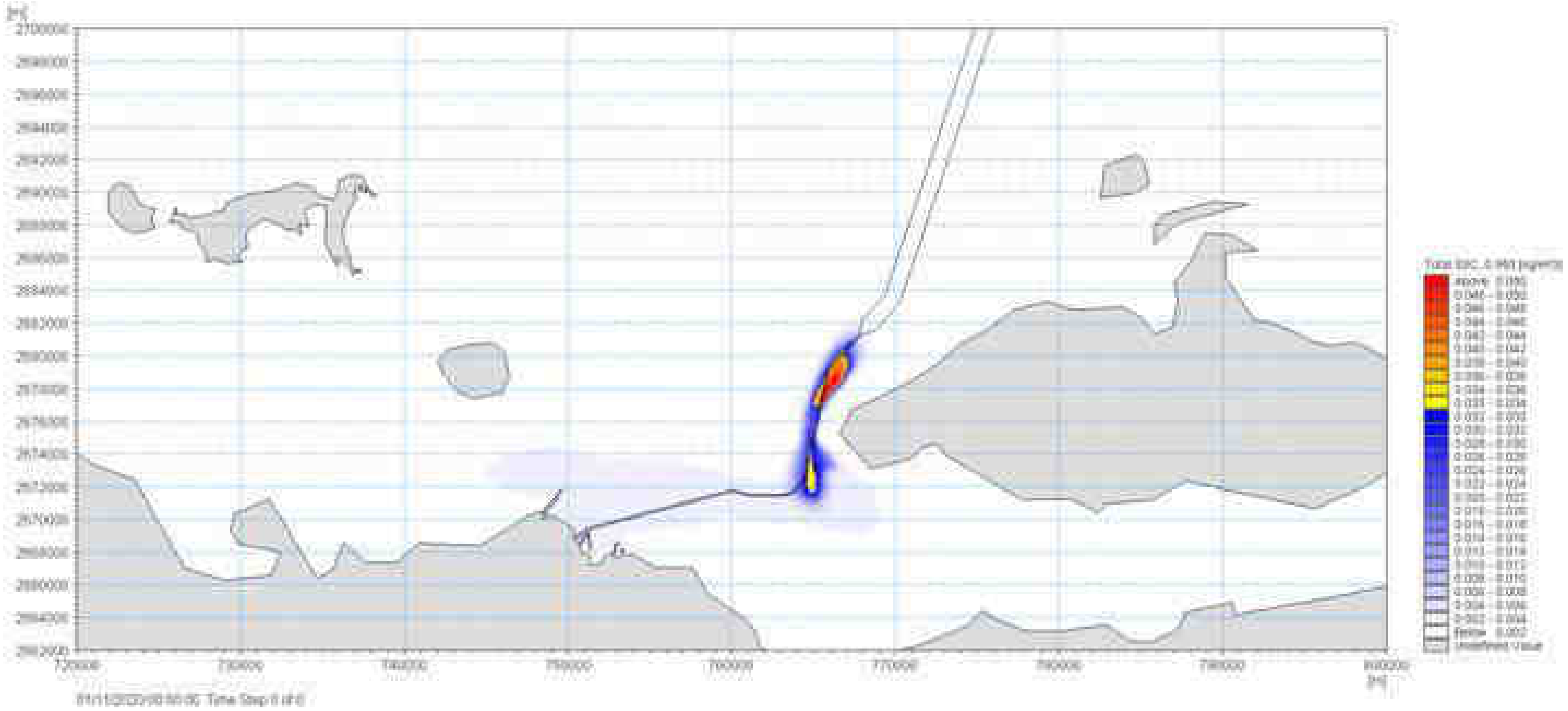


Figure 5-37: 95th percentile TSS concentration for Route 1

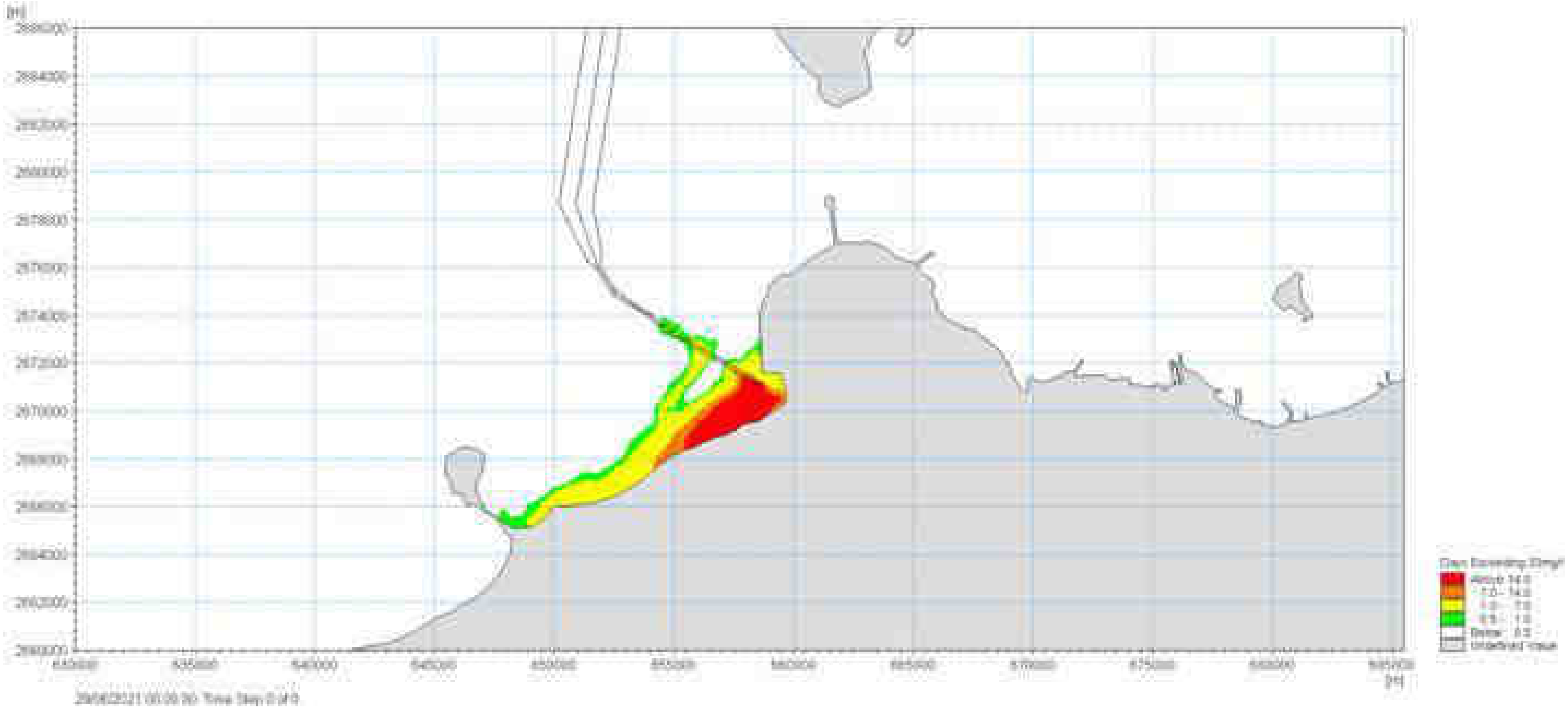


Figure 5-38: Days exceeding TSS AWQO (33 mg/l) for Route 2

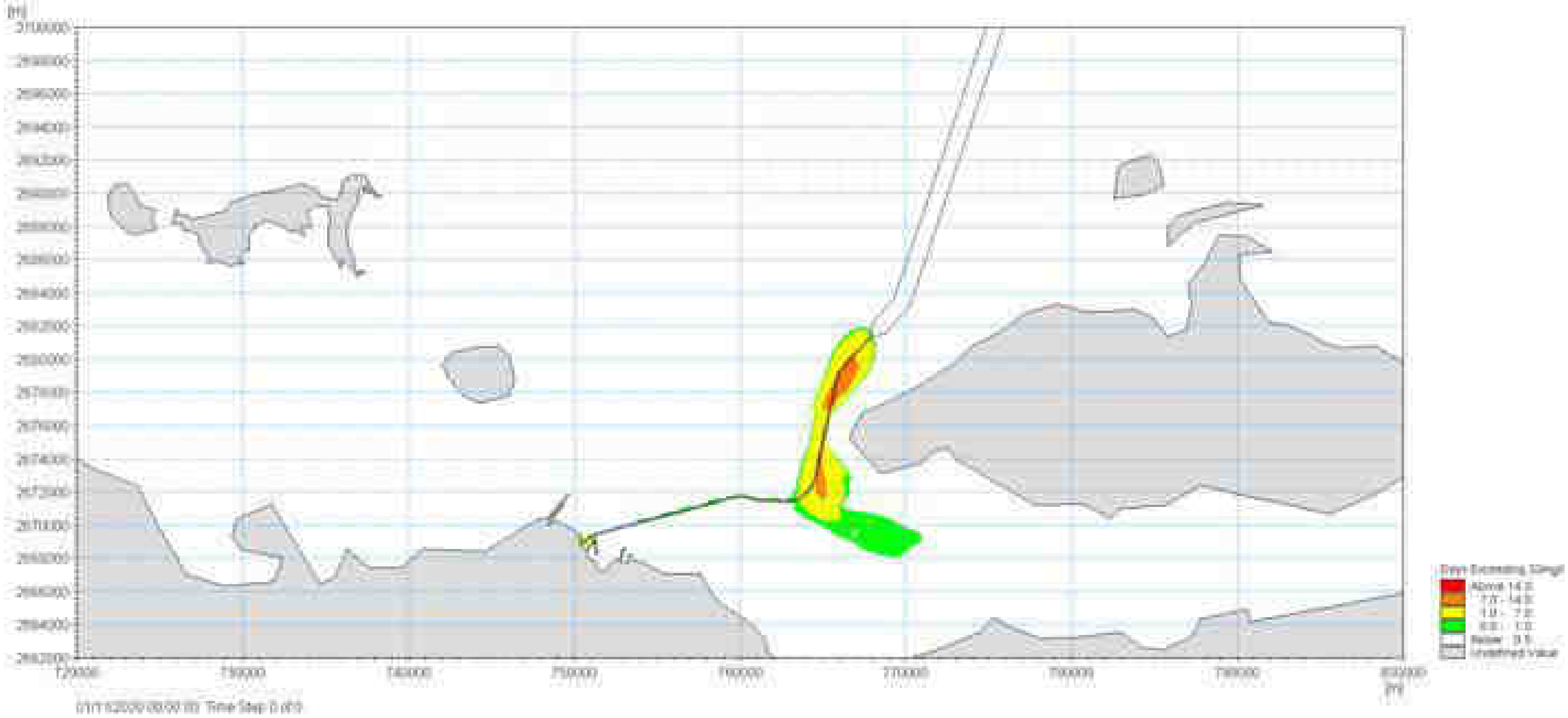


Figure 5-39: Days exceeding TSS AWQO (33mg/l) for Route 1

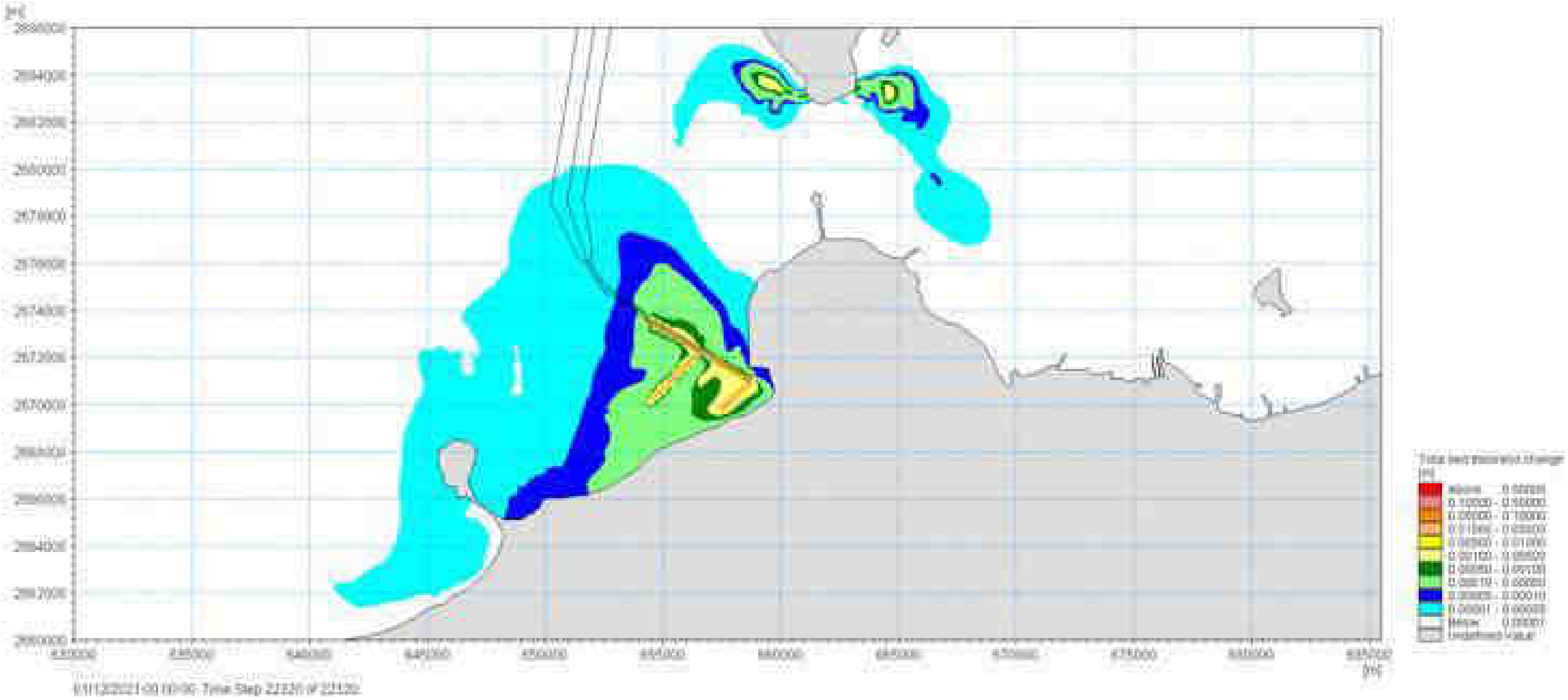


Figure 5-40: **Cumulative deposition depth for Route 2**

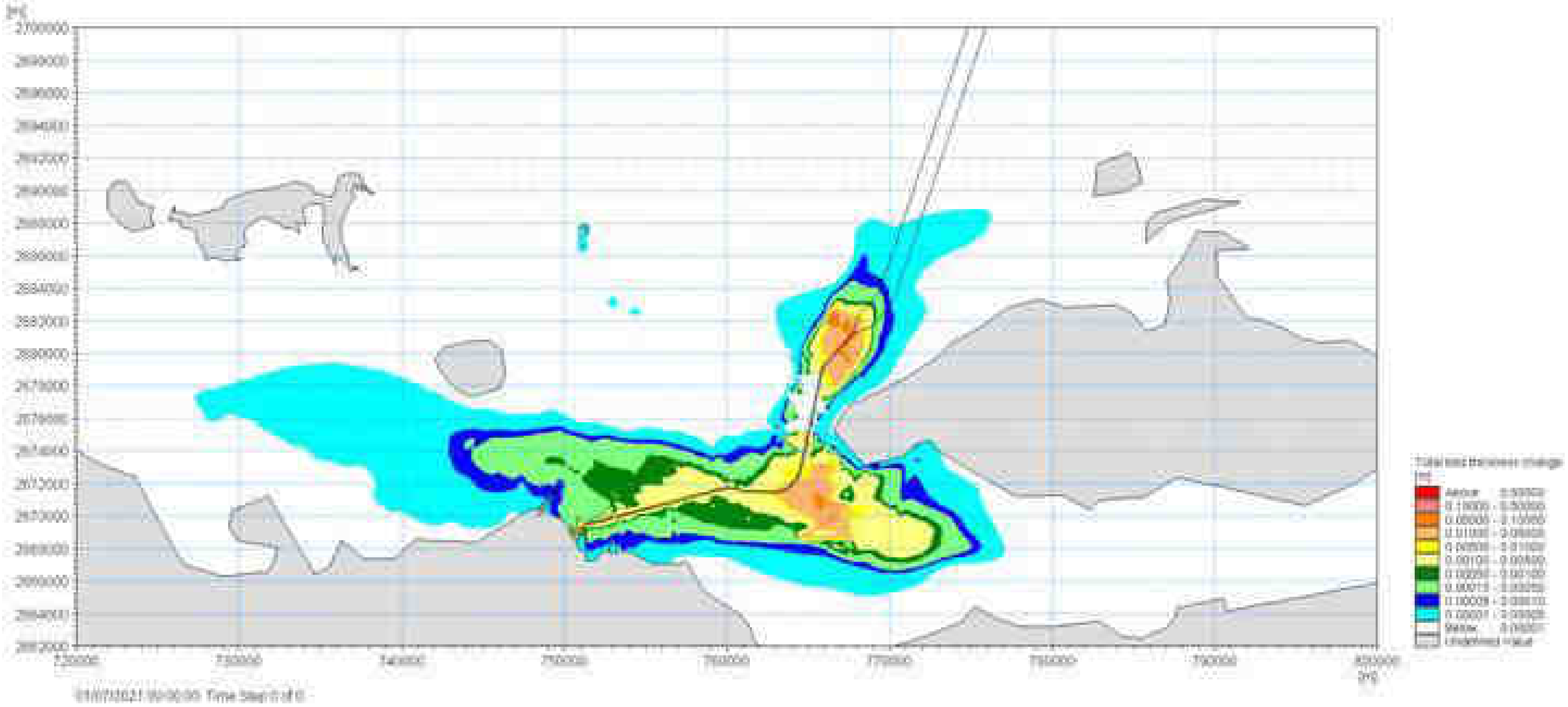


Figure 41: **Cumulative deposition depth for Route 1**

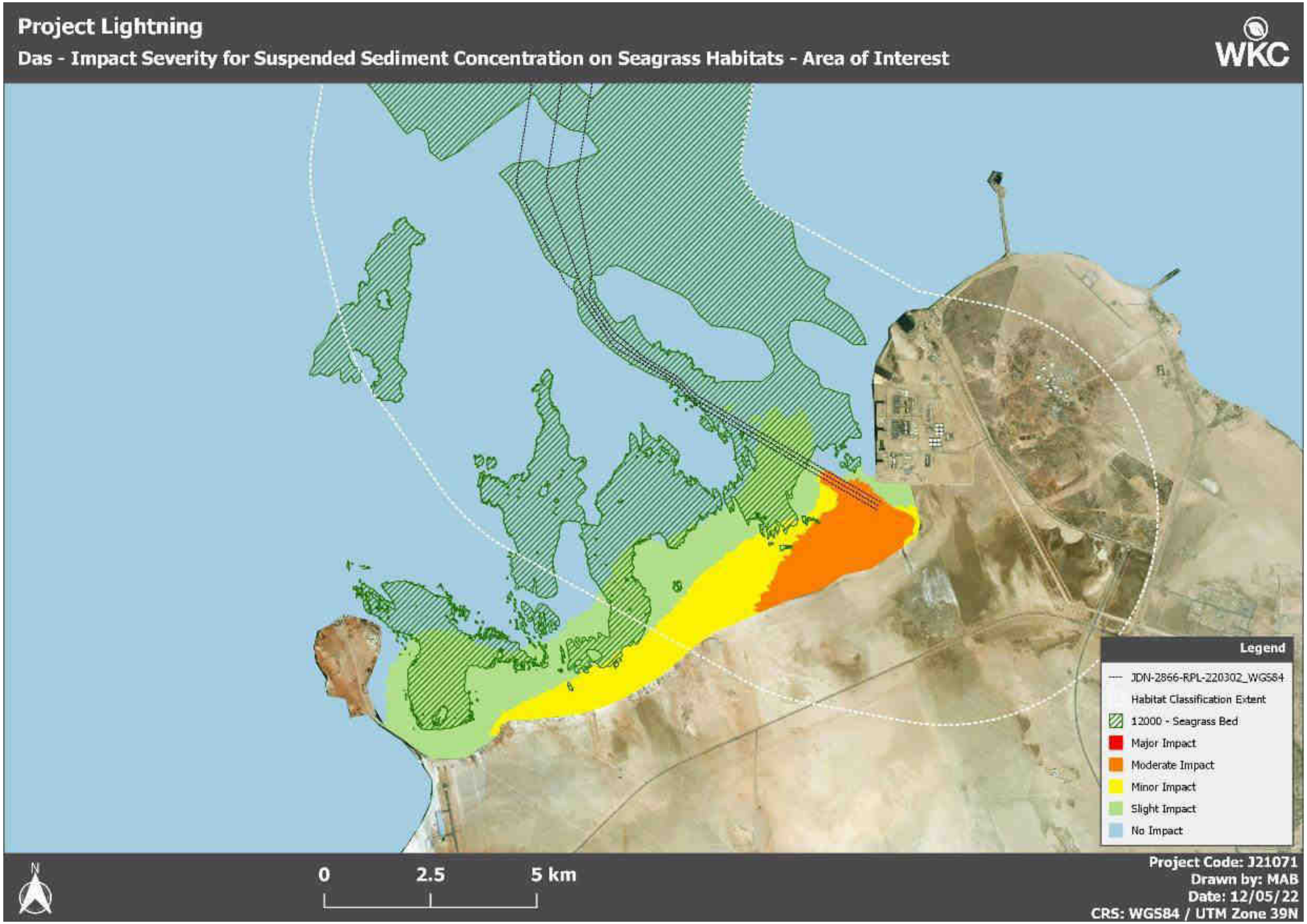


Figure 5-42: Impact of suspended sediment on seagrass habitats along Route 2

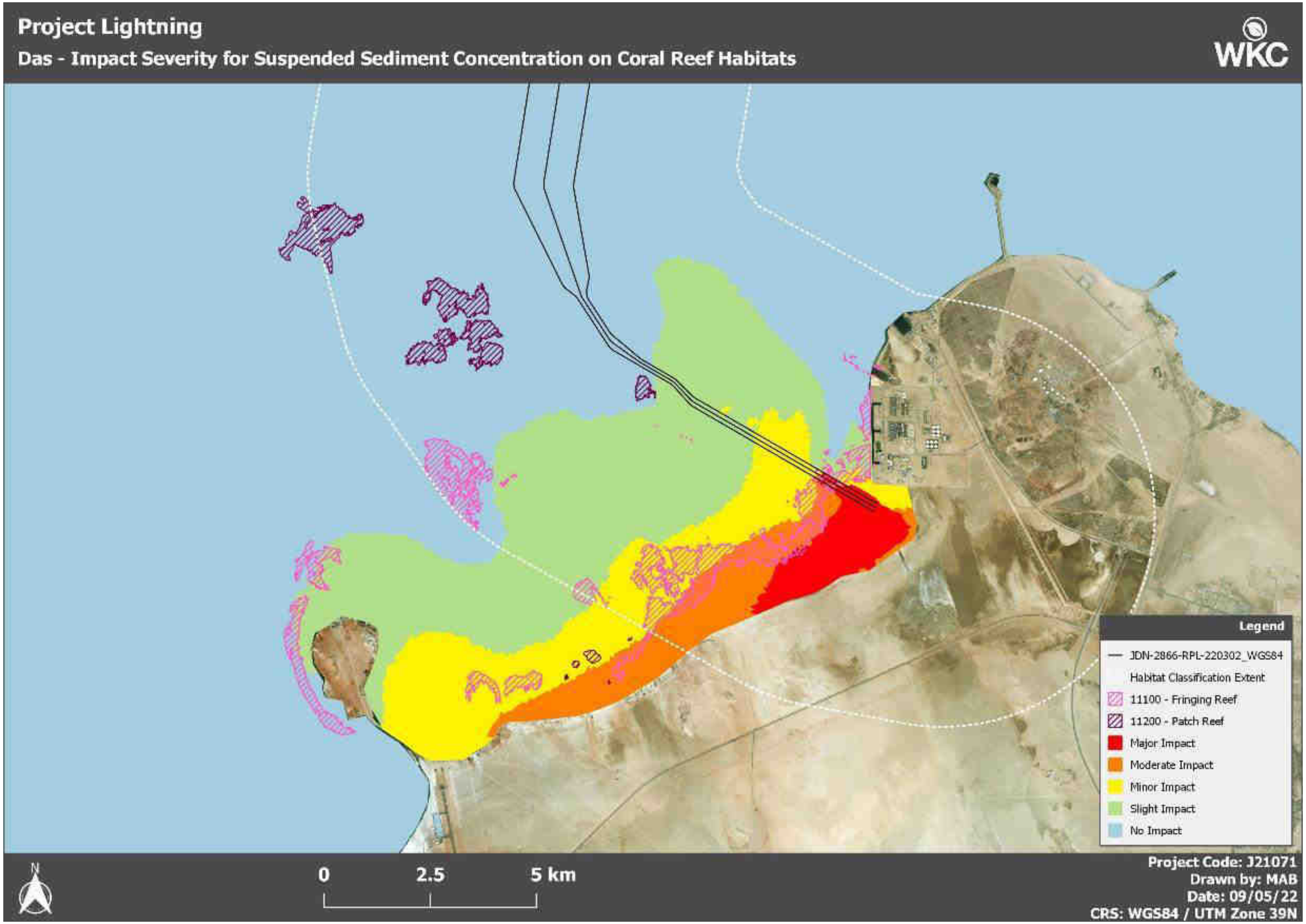


Figure 5-43: Impact of suspended sediment on coral reef habitats along Route 2

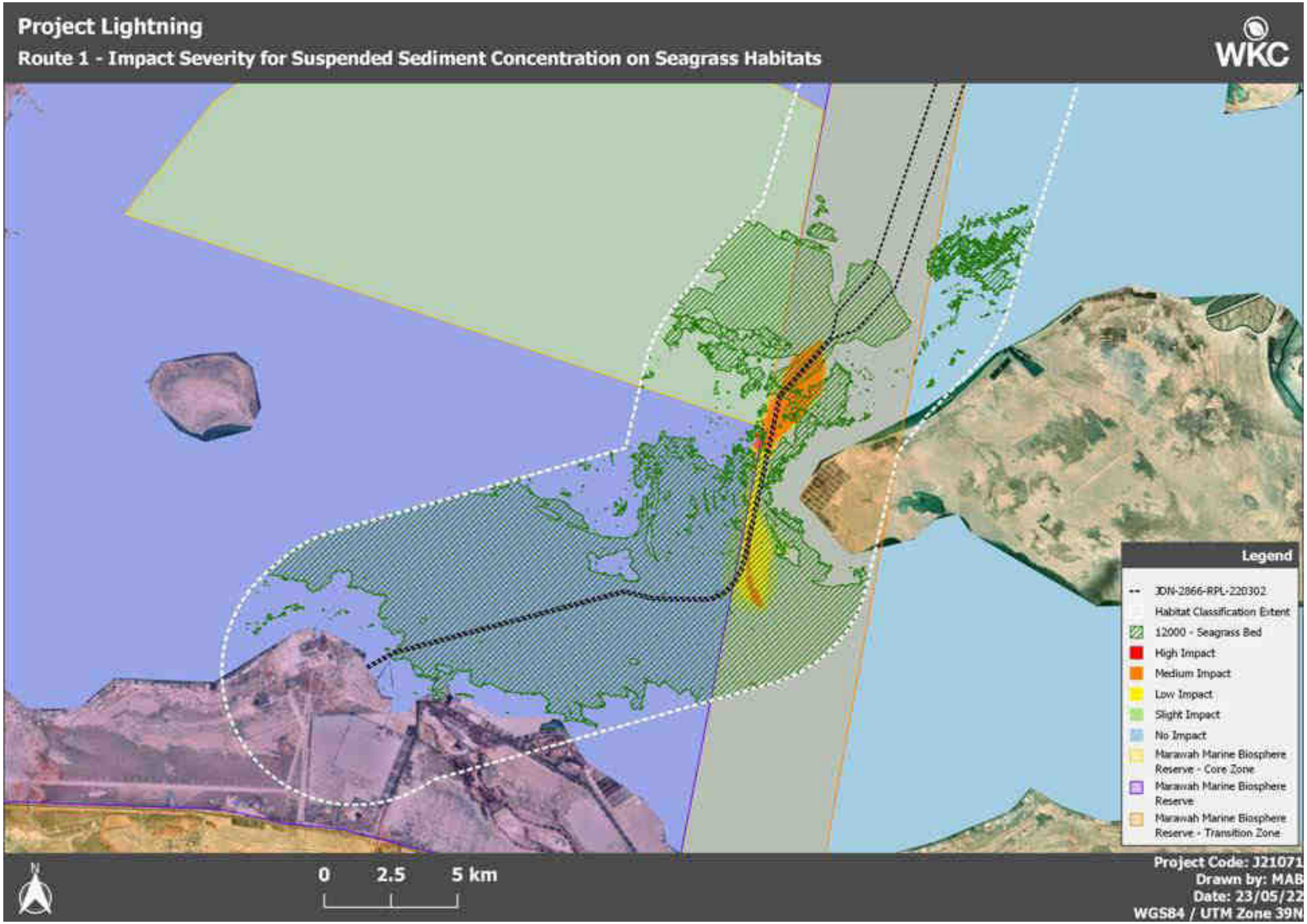


Figure 5-44: Impact of suspended sediment on seagrass habitats along Route 1

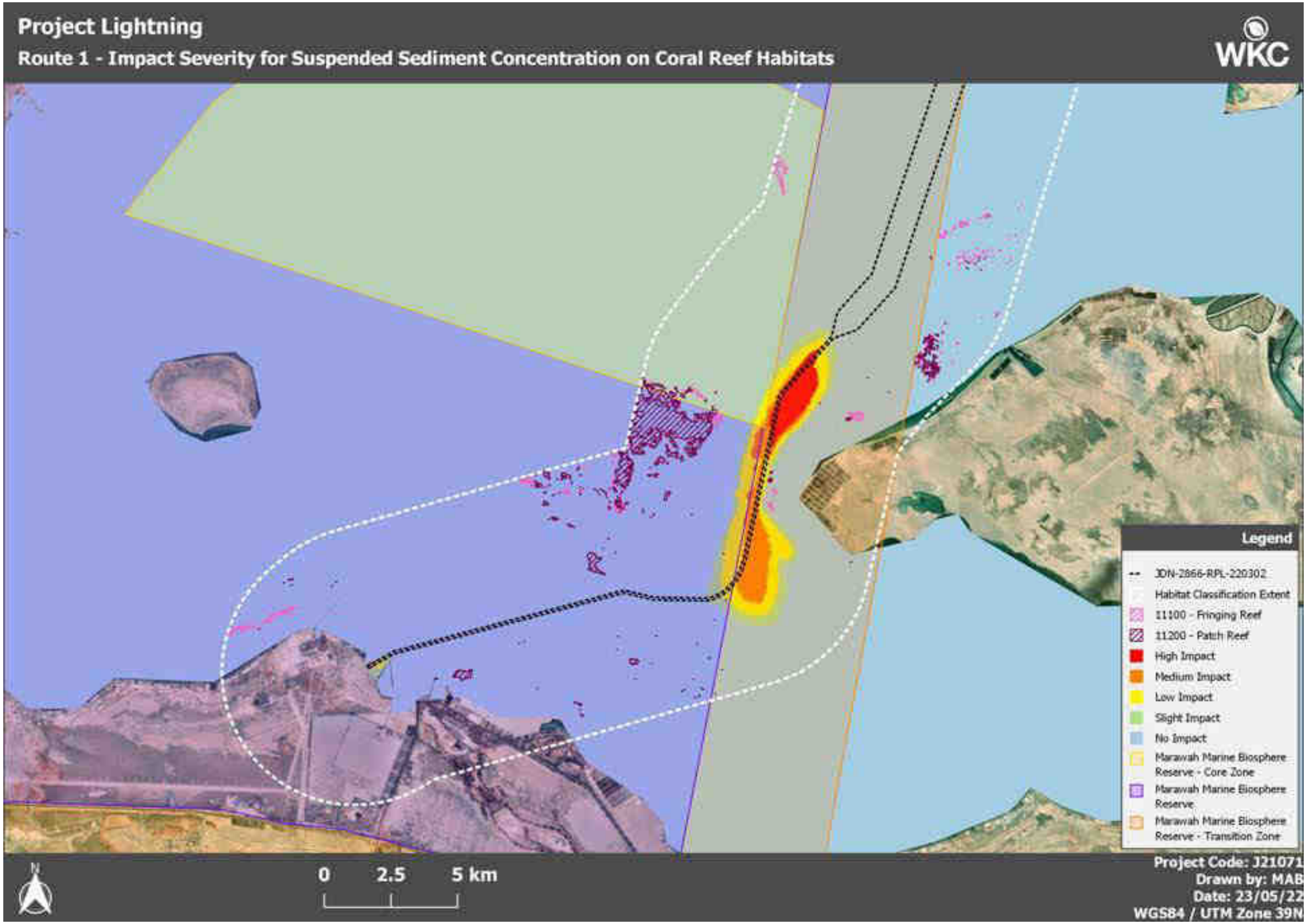


Figure 5-45: Impact of suspended sediment on coral reef habitats along Route 1

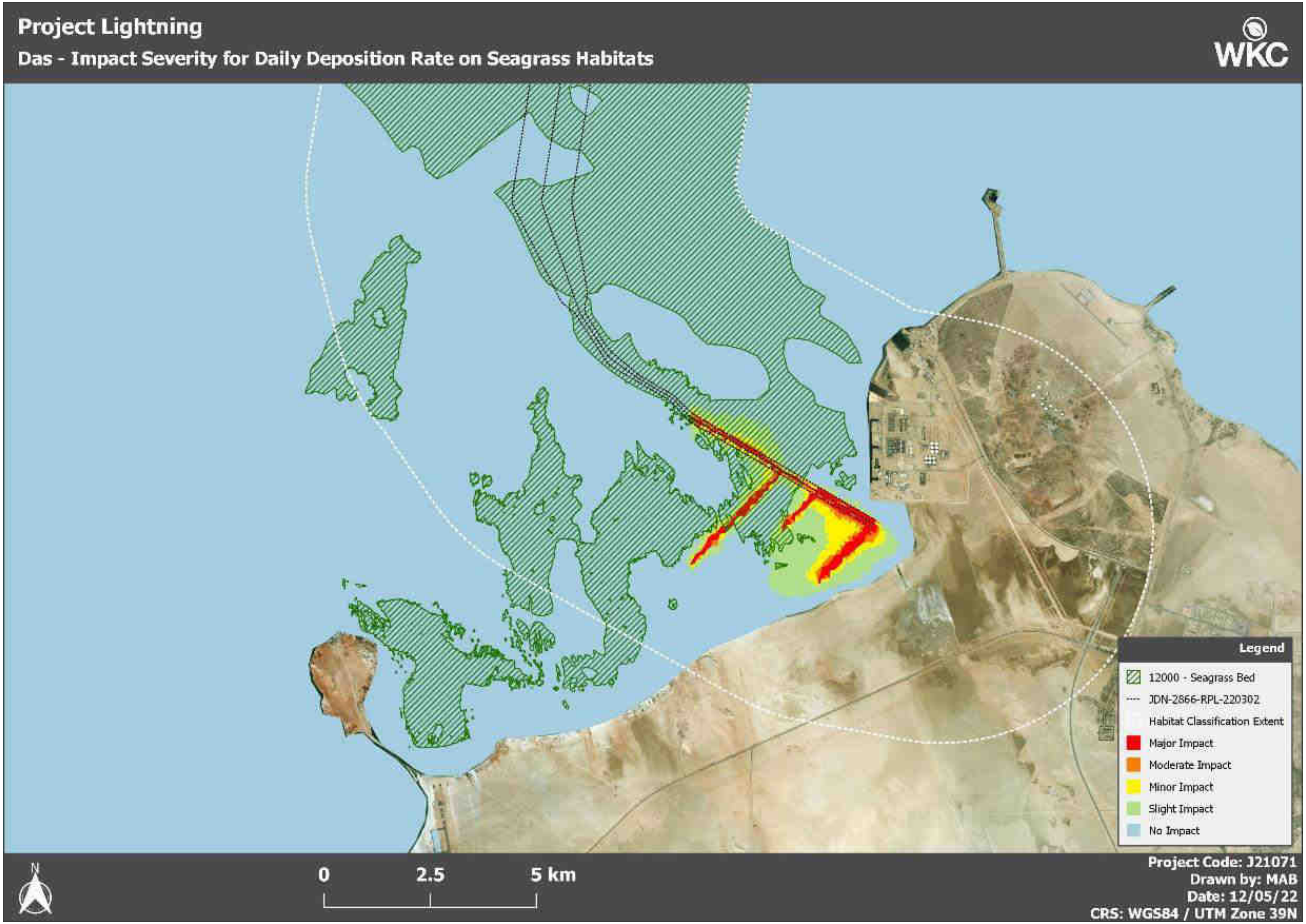


Figure 5-46: Impact of average daily sediment deposition on seagrass habitats along Route 2

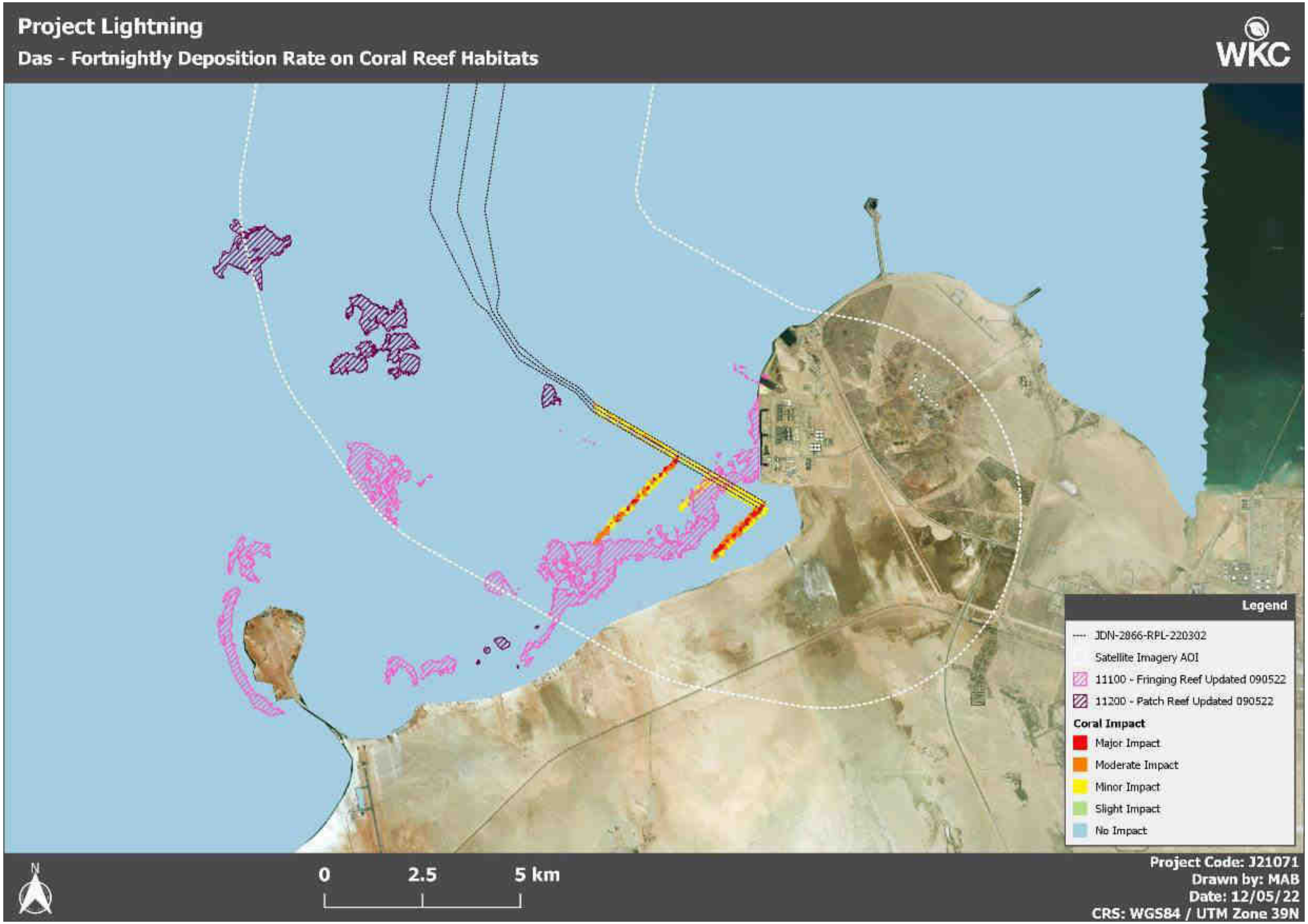


Figure 5-47: Impact of average fortnightly sediment deposition on coral reef habitats along Route 2

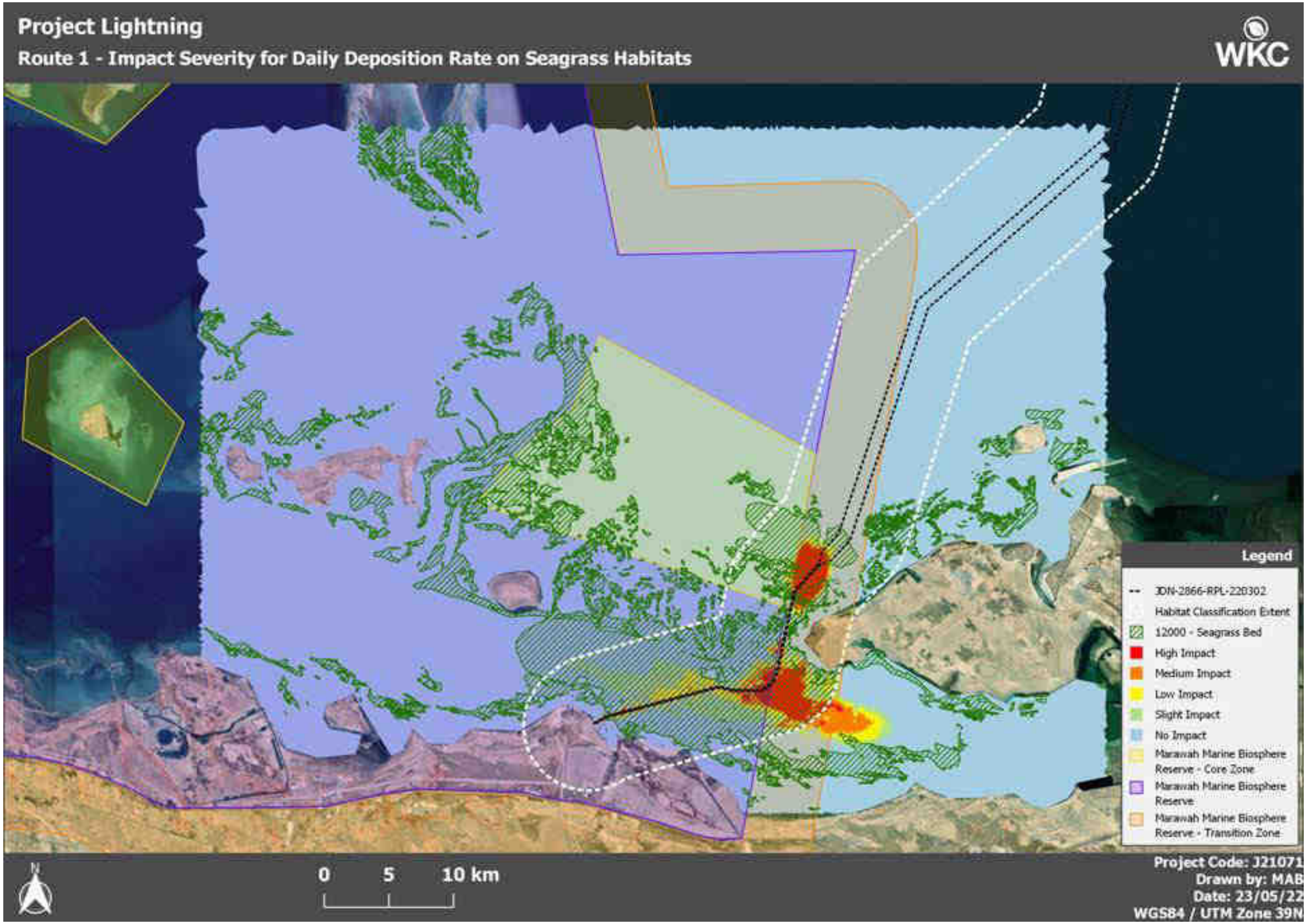


Figure 5-48: Impact of average daily sediment deposition on seagrass habitats along Route 1

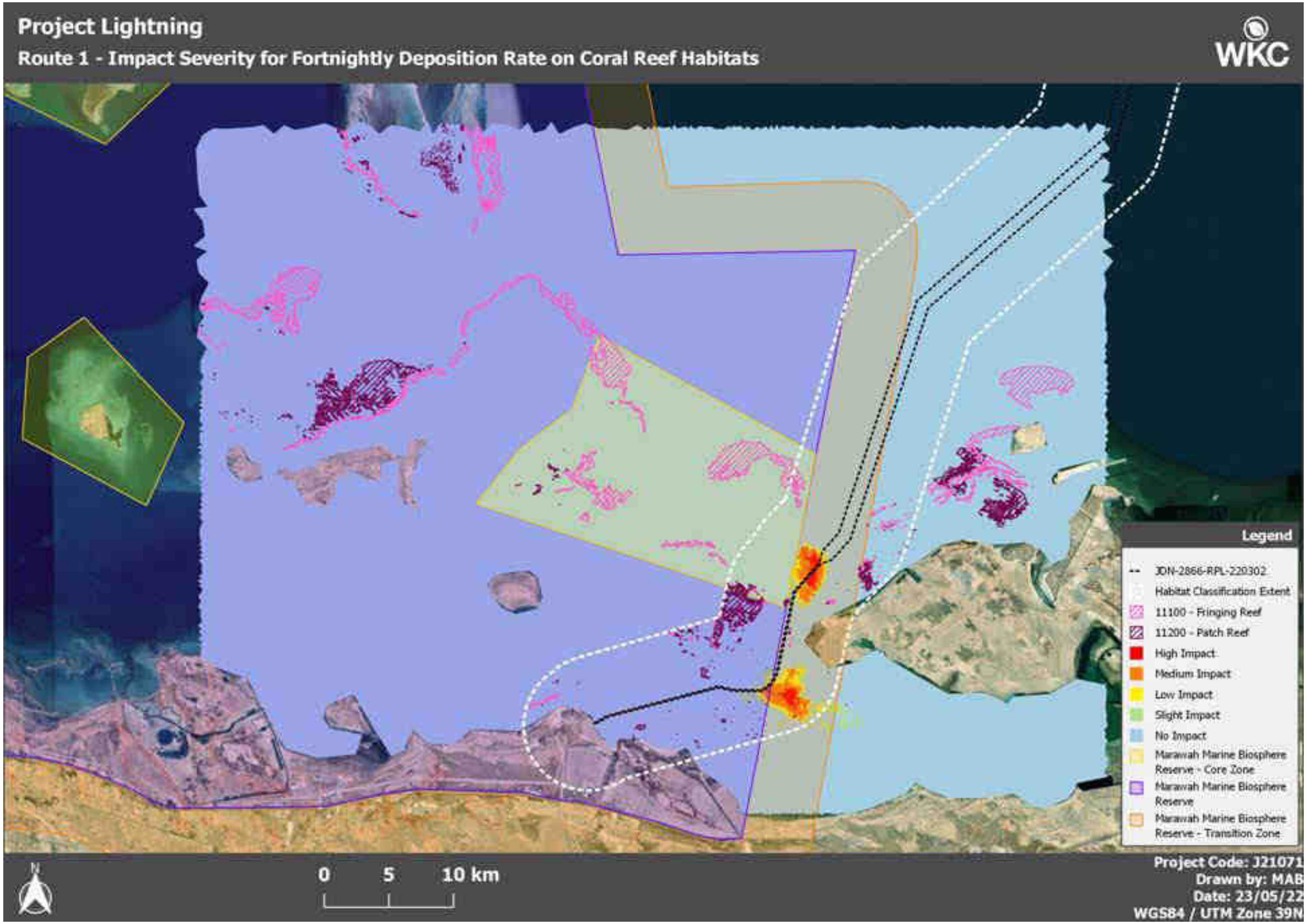


Figure 5-49: Impact of average fortnightly sediment deposition on coral reef habitats along Route 1

Numerical Studies Summary and Conclusions

Hydrodynamics

The hydrodynamics of the project area were simulated utilising the MIKE21 HD FM model, driven by meteorological data from CFSR and tidal constituent amplitude and phase predictions sourced from the DTU10 global ocean tide model from the Technical University of Denmark.

Current speeds within the two areas of interest are variable both within the domain and between Route 1 & 2 domains, being generally higher at the Route 1 location. Currents within both the areas of interest are complicated by nearby islands and shoals creating both restricted channels with high current speeds and sheltered areas with limited tide or wind driven currents.

The tides are generally of a mixed diurnal and semi-diurnal nature. The current velocities within the Project area are largely driven by the flood and ebb tidal events with some influence from wind effects (due to the predominant north-westerly wind direction).

Validation was conducted again data obtained at four locations using ADCPs. Validation of the hydrodynamics was considered to be very good to excellent.

Dredging Assessment

Two dredging scenarios were simulated within separate domains to take into account proposed trenching, backfilling and dumping methods for the proposed cable routes leading to Route 2 and Route 1. These simulations were conducted to predict turbidity concentrations and deposition patterns during the dredging activities that are proposed for the cable routes.

Suspended sediment concentrations within the trenching area of Route 2 are, on average (over five months), anticipated to meet ambient water quality objectives (33 mg/l), however within a minority of conditions (i.e. <5% of the time) the area exceeding the ambient water quality objective is predicted to spread over 5 km to the south-west. Mean TSS concentrations within the Route 1 area of interest, when averaged throughout the entire 8-month programme, are anticipated to be below AWQOs, however for a minority of the time (<5%) an area of approximately 5-10 km^2 may exceed AWQOs within the proximity of the dredging of the navigation/floatation channel.

The deposition depth associated with the dredging activities along the Route 2 is generally limited to < 1mm, with the area of deposition greater than 1 mm extending over approximately 2 km^2. Depositions associated with the trenching and navigation/floating channel within the Route 1 area of interest is predicted to be greater than 1 mm cover approximately 40 km^2, whereas the area where deposition is anticipated greater than 5 mm is anticipated to cover approximately 15 km^2.

Summary of Impacts as a Result of Sediment Transportation due to Trenching

There are limited habitat implications from the change to sedimentation:

- Sediment moving in the ebb (seaward) direction is likely to occur as trenching will take place at Route 2 Shuweihat landfall that will cut through a fringing reef. These cuts in the reef will facilitate localised increases in current flow that could carry and transport sediment seaward. This sediment transport though the channels will increase the occurrence of sand spreads across the adjacent areas, which typically cause short-term smothering of habitat present;
- Sediment interception will locally modify the adjacent area of unconsolidated sandy bed. Typical long-term seabed adjustment adjacent to trench channels on the fringing reef includes winnowing of surface sediments (reduction of fines) 'downdrift' for 5-10 times the channel width. Although the overall change is permanent, perception of winnowing is episodic, with fresh sediment supply, usually occurring seasonally, providing a new veneer of sediments that include fines; and

- Higher rates of sedimentation, expected to occur where the ebb tidal channel nears the proposed fringing reef channel at Route 2 Shuweihat landfall, will limit the capacity of benthic vegetation to establish in channel, due to smothering.

5.2.2.2.3. Construction Impacts Assessment

Spill of Hazardous Material to the Marine Environment

Although the development footprint covers a relatively large area, the quantity of the material dredged is low, and therefore the overall scale of construction is relatively small. The construction activities will be limited to trenching works only, and no significant temporary facilities will be constructed, with all maintenance of equipment and vessels being conducted in existing yards away (i.e., offsite) from environmental sensitivities within the Project area. Therefore, no significant quantities of hazardous materials are anticipated to require storage on-board the vessels, as these materials will be collected at a suitably designed and designated material (and waste) handling areas on the dredging vessel. In case of wastes, these are periodically collected for disposal to mainland as per best practices and in line with regulatory requirements.

However, limited volumes of grease, oils, fuel, batteries etc. are likely to be required for operation and maintenance of dredging equipment, vessels and generic on-board vessel equipment. Adequate procedures and controls should be in place for storage, transport and handling of volumes of hazardous materials. Should there be a failure of these procedures, the potential for these materials, in particular liquid wastes, chemicals and fuels, to leak or spill into the marine environment can cause a negative impact to marine water quality in the immediate vicinity of the Project site. Additionally, and as mentioned in **Section 4.3.2.4.5**, the BHD and Starfish excavators have automatic greasing as well as regular manual greasing (every six hours). As this equipment is not manoeuvrable, the maintenance will need to occur in the location where the equipment is at that moment operational. Appropriate mitigation measures such as the use of biodegradable oils are presented in the mitigation section (**Section 5.3.2.3.1**).

The area surrounding the Project site contains a relatively pristine marine water which is hosting productive marine habitats, and particularly the nearshore and landfall areas, supports species of international conservation importance, the environmental sensitivity of the associated marine habitats and biodiversity is assessed to be of high value. However, considering that the likelihood of impacts from pollutants being spilt at concentrations of concern (either acutely or chronically toxic) is reduced by the relatively good water exchange in the area and the low likelihood of this occurring as marine vessels involved in the Project construction will very unlikely be handling and/or storing substantial quantities of hazardous materials. As such the overall value of the identified marine water receptor in the area (nearshore and landfall area) is considered to be medium-high. Given this, the impacts of the Project are considered to be likely of *low severity* upon the nearshore marine water receptors which is of *medium-high* value thereby resulting in an impact of **minor negative** significance prior to implementation of mitigation measures.

Generation of Sediments and Increased Turbidity from Activities Related to Trenching Resulting in Impacts to Localised Water Quality

Marine construction programmes involving trenching activities will cause an increase in suspended sediment from multiple sources, including spill from the backhoe bucket, and overflow of dredged material from barges and hoppers. This increase in suspended sediment in turn increases turbidity and reduces water clarity. This localised change in water quality has the potential to impact ecological receptors (seagrass and corals) within the area of impact.

The release of suspended sediments due to trenching and unloading at disposal areas may also result in elevated levels of TSS which directly impact water clarity by increasing turbidity. TSS and turbidity (i.e., as NTU) are not directly correlated and depends on the physical parameters of the sediment suspended in the water column. Turbidity is a measure of how well light passes through a liquid, whereas TSS is an expression of suspended mass. How this mass contributes to turbidity depends on size and, colour and structure, whereas turbidity accounts for TSS and other parameters such as algae, organic material, and other microscopic particles.

Considering this, the discussion on impacts to water quality associated with dredging and reclamation works, focuses on a comparison to regulations and guidance on TSS. Regulations for the discharge of treated effluent into the sea, recommend a maximum TSS concentration of 50 mg/l and EAD ambient water quality guidance recommends an ambient concentration of 33 mg/l. Conservative modelling simulations estimate that during the Project construction activities, the criteria of 33 mg/l will be exceeded infrequently (less than 5% of the time) over an area which is localised at the landfall area within Route 1 (Mirfa), Route 2 (Shuweihat) and at Route 1 – Mirfa Nearshore Area within and near MMBR locations. A percentage of the exceedance plume will potentially reach sensitive habitat locations. However, the impact is likely to be Medium due to the limited exposure brought about by the short trenching duration and nature of scale of such trenching activity for subsea cable installations.

Furthermore, average ambient TSS concentrations are expected to remain within recommended water quality criteria for the duration of the trenching programme. In addition, the duration of impact is anticipated to be momentary at any one point, minimising localised impacts. It is believed that the short construction period will be effective in reducing the extent of the sediment plume. Additionally, the application of mitigation measures (e.g., silt curtains) will certainly confine the dispersion of the sediment plume to be limited around the trenching works. As further detailed in the mitigation and monitoring sections of **Section 5.5**, it is recommended that silt curtains should be deployed as per the arrangement in Figure 5-186 and Figure 5-189 (refer to **Section 5.5**) in order to protect sensitive habitats nearby. These silt curtains will be effective for up to fine sediment fractions below 1 micron. It is considered necessary for Type IV silt curtains to be used, where practicable. Additionally, other mitigation measures have been presented in addition to monitoring measures such as the deployment of turbidity buoys will allow direct data of TSS concentrations.

It is important to note the transient nature of the reduction in water quality associated with turbidity and the limited area of impact that will experience reduction in water quality for an extended period of time. In addition, it is generally considered that such activity will result in short duration impacts. In the event of exceedances beyond the regulatory limits expanding over a relatively large area it may have potential impacts upon marine sensitivities. However, note that this was based on the results of the modelling applying inherently conservative modelling assumptions. As such, whilst trenching and backfilling activities impacts will certainly occur, the anticipated impacts upon a nearshore receptor of medium-high value with *medium severity* is considered to be of **moderate negative** significance prior to implementation of mitigation measures.

Reduction in Water Quality due to Re-mobilisation of Contaminated Marine Sediment

The dredging of the proposed channel has the potential to impact upon seawater quality through the re-suspension of contaminated sediment. Contamination by these means would require that the sediment was previously contaminated (perhaps due to an historic spill or leak), and that the trenching activities disturbed the location of previous contamination. An impact of this type is a hypothetical impact, as it cannot be definitively known whether contamination exists within the trenching route.

For an impact of this type to occur it would require that the sediment be previously contaminated, however, the area is undeveloped and therefore likely represents very low potential for occurrence of historical contamination. In addition, baseline characterisation of the marine sediment in the area showed absence of significant signs of contamination (the exception being a number of samples from Route 1 – Mirfa Nearshore Area within and near MMBR location which are slightly above the referenced limits for nickel and arsenic, and some elevated concentrations of the metals chromium, nickel and arsenic recorded from samples from Mirfa landfall areas). However, these exceedances are considered to be largely of natural (geologic) origin.

In consideration of the above, it is likely that re-suspended sediments during the works will be largely uncontaminated due to the general lack of substantial contamination recorded on the sediments from the Project areas. In addition, any re-suspension of pollutants contained within the marine sediment would likely be sourced from minor, undetected spills or leaks (e.g., from passing vessels). As such, it is therefore considered that the impact is considered likely to be of *medium severity*. Such impact on a receptor of *medium-high* value is considered to result in **moderate negative** significance prior to implementation of mitigation measures.

Contamination due to Run-off from Vessel and Vessel Equipment Washing

Uncontrolled management of run-off from equipment washing has the potential to result in liquid effluent (containing pollutants from vessel and vessel equipment and the wash-down vessel deck areas) reaching the marine environment. This run-off water may contain oils, combustion emissions (e.g., soot), cleaning fluids and fuels and chemicals, causing a localised reduction in marine water quality.

The volumes and pollutant load of these effluents are anticipated to be relatively small. However, pollutant concentrations under such a scenario would be diluted but remain in the area for extended time due to the physical nature of the marine environment. This impact is considered to be of *low severity*, upon which such impacts upon receptor of *medium-high* sensitivity are anticipated to result in **minor negative** significance prior to the implementation of mitigation measures.

Sanitary or Bilge / Ballast Water Discharges from Marine Vessels

Bilge water is the mixture of water, oily fluids, lubricants, cleaning fluids, and other similar wastes that accumulate in the lowest part of a vessel from a variety of different sources including the main and auxiliary engines; boilers, evaporators, and related auxiliary systems; equipment and related components; and other mechanical and operational sources found throughout the machinery spaces of a vessel. It is not uncommon on ships for oil or water to leak into the bilge from these sources, various seals, gaskets, fittings, piping, connections, and from related maintenance and activities associated with these systems. These leaks, along with on-board spills, wash waters generated during the daily operation of a vessel, and wastewater from operational sources (e.g., condensate from air coolers, etc.) collect in the bilge.

In addition to oil and grease, bilge water may contain solid wastes such as rags, metal shavings, paint, glass, and a variety of chemical substances (78). Bilge water may contain various oxygen-demanding substances, VOCs, semi-volatile organics, inorganic salts, and metals. Bilge water also may contain other contaminants such as soaps, detergents, dispersants, and degreasers used to clean the engine room. These cleaning agents create an emulsion and prevent separation of oil and water. Moreover, they are often incompatible with oily water separators and oil content monitors. Due to the various sources that contribute to the production of bilge water, the composition of bilge water varies from vessel to vessel, and from day to day.

Bilge and ballast water can also contain diseases and invasive species, which if released can cause impacts to human and ecological receptors.

The discharge of bilge and ballast waters within the Arabian Gulf is not permitted under MARPOL requirements due to the Gulf's classification as a 'special area'. Discharge is permitted only if certain conditions are met with regards to the vessel operation and practices. According to the standard practice, bilge water will be stored on-board and periodically transferred to an onshore facility for treatment and disposal. With regards to ballast water, any vessel coming outside of UAE territorial waters will first exchange the original ballast water with clean ballast water before entering UAE waters. Therefore, only clean ballast will be released (in an accident or emergency) within the Project area.

Sanitary discharges from marine vessels have the potential to cause elevated levels of nutrients within the receiving environment, leading to excess algae / phytoplankton growth and eutrophication if these elevated levels are not normalised by flushing. The sanitary effluent has a risk of causing algal blooms (potentially toxic) due to these elevated levels of nutrients, however, this requires that nutrient levels are the existing limiting factor to algal growth within the Project area. The effluent may also contain elevated levels of ammonia, heavy metals and treatment chemicals which can be directly toxic to marine organisms.

Considering the scale and nature of the Project, the dredging works associated with the Project construction are anticipated to require the use of a relatively small number of boats with limited crew numbers and for a limited period. It is also anticipated that the vessels to be used for this Project will include adequate holding tanks for sanitary waste. Where such sewage stored on these holding tanks is accidentally discharged, such materials would be untreated. Due to the short period of marine works (dredging), discharges from marine vessels during the construction period are anticipated to be of relatively limited volumes and will occur infrequently which will likely allow time for any elevated nutrient levels or pollutants to be flushed and dispersed within a short timeframe. As such, the impact is considered to be of *low severity*, upon which such impacts upon receptor of *medium-high* sensitivity are anticipated to result in **minor negative** significance prior to the implementation of mitigation measures.

Temperature Impact and Potential Contamination of Seawater from Cooling Water Discharges of Dredging Equipment

During dredging operations, cooling water will be pumped through the moving parts of the dredger to act as a medium to transport heat away from the mechanical equipment. It is anticipated that the cooling water quantities will be limited, as the size of the dredger required will be relatively small. However, the discharge of cooling water into the marine environment has the potential to increase temperatures in the immediate vicinity of the discharge to levels that are not tolerable to marine organisms inhabiting the area.

Corals in particular, being immobile benthic species, and already existing at the extreme of their thermal range within the Arabian Gulf, are particularly sensitive to changes in seawater temperature. Increases in ambient seawater temperatures within the Arabian Gulf have caused multiple past bleaching events. These stresses cause the coral to become pale white in colour (the expulsion of coloured endosymbiotic zooxanthellae) which can very rapidly kill coral communities. However, it is highly anticipated the requirements of cooling water will be minimal and therefore the extent of significant temperature increases is largely anticipated to be limited. As such, the impact is considered to be of *low severity*, upon which such impacts upon receptor of *medium-high* sensitivity are anticipated to result in **minor negative** significance prior to the implementation of mitigation measures.

5.2.2.3. Operational Phase Impacts

It is considered that most of the impacts would have occurred during the construction. In addition, as the Project involves mainly cable installations, and that once the Project is completed and operational, no effluents or releases are anticipated such that no further interaction with the water and sediment quality is anticipated to occur. In case of subsea cable repair, whilst there is the potential for digging up the cable, it is unlikely to represent significant impacts.

5.2.2.4. Cumulative Impacts

5.2.2.4.1. Construction Phase

Due to the scale and nature of the Project and with the relatively short duration of activities anticipated to interact with the marine water and sediment, no Type 1 or Type 2 cumulative impacts are considered likely due to the construction activities associated with the Project.

5.2.2.4.2. Operation Phase

No substantial impacts were identified to result from the operation of the Project and therefore no cumulative impacts are anticipated for this stage of the Project.

5.2.3. Mitigation Measures

5.2.3.1. Potential Mitigation Measures

During construction, the key mitigation measures will involve the adoption of working practices that reduce the potential for contamination, dispersion of sediment and direct impact on the environment. These working practices will be detailed based on current conditions at the site and best practice.

During the operations phase, spillage of any refuse from the marine vessels may be mitigated by making provisions for suitably designed waste bins within all vessels. Measures to mitigate impacts to the environment will also include minimisation of risk of accidental discharge to the environment and minimise volumes of potentially contaminating effluents reaching the marine environment. Mitigation will also include implementation of good practice maintenance procedures to minimise unnecessary environmental risk.

The control measures identified within this ESIA would be implemented through the formation and adoption of a Project specific Environmental Management Plan (EMP) applicable to the construction works.

During dredging activity, one of the key mitigation measures will involve the adoption of working practices that reduce the potential for significant contamination of, and releases to, the marine environment. This would involve controls such as selecting working methods which are the least environmentally damaging and the use of appropriate, well-maintained, and operated equipment. Real time turbidity monitoring can also be considered during dredging activities to safeguard and monitor agreed sensitive locations and once exceedances are recorder, dredging operations can be stopped. The real time monitoring stations may be used as an early warning mechanism with realistic trigger values in case of exceedances for prolonged periods.

The potential mitigation measures for the marine water and sediments impacts due to the construction of the Project are summarised in Table 5-28.

No impacts are anticipated for operation and therefore mitigation measures are not required.

Table 5-28: Potential marine water impacts and mitigation measures

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
CONSTRUCTION PHASE								
1	Spill of hazardous material to the marine environment leading to localised contamination of marine water and sediments	Dredging	Dredging area and immediate adjacent habitat	Minor negative	– Use non-polluting materials wherever possible (e.g. biodegradable oils etc.) – Store hazardous materials at designated containers and appropriate areas on the vessel – Refuelling, oil change and greasing to be done under strict supervision of project engineers and specialists to avoid spills and contamination of marine water – Provide appropriate (110% volume) secondary containment system at chemical and fuel storage areas – Containerising and labelling waste – Spill Response Plan to be developed for inclusion within EMP for construction – Appropriate spill kits and spill clean-up material available on marine vessels, at chemical, fuel, and waste storage areas, and at re-fuelling and maintenance areas	Not applicable	Not applicable	Yes
2	Generation of sediments and increased turbidity from activities related to the dredging of the channel resulting in effects to localised water quality	Dredging	Dredging area and immediate adjacent habitat	Moderate negative	– A dredging Management Plan (DMP) to be developed as part of the CESMP – Minimisation of duration and extent by design – Selection of construction methods / equipment to minimise impacts to marine habitats – Installation of Type IV silt curtain between source of plume and critical habitat receptors. Silt curtains should be deployed to protect sensitive receptor in the area – Monitoring of turbidity by continuous monitoring buoys and multiparameter probe outside of silt curtains and at sensitive locations with dredging to cease if threshold values are exceeded – Undertake monitoring post construction	EAD Recommended Ambient Marine Quality Standard	Please refer to **Section 3.3.5**	Yes
3	Reduction in water quality due to re-mobilisation of contaminated marine sediment	Dredging	Dredging area and immediate adjacent habitat	Moderate negative	– Minimisation of duration and extent by design – A dredging Management Plan (DMP) to be developed as part of the CESMP	EAD Recommended Ambient Marine and Sediment Quality Standards	Please refer to **Section 3.3.5**	Yes
4	Contamination due to run-off from dredging equipment and vessel washing	Maintenance of vessels and equipment	Dredging area and immediate adjacent habitat	Minor negative	– Wastewater collected in sump to be treated as liquid waste and disposed of appropriately – Marine vessels to be washed off-site within appropriate port facilities	EAD Recommended Ambient Marine Quality Standard	Please refer to **Section 3.3.5**	Yes

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
5	Pollution contamination of marine water and sediment from bilge water	Sanitary or Bilge / Ballast Water Discharges from Marine Vessels	Marine water of local ports where maintenance area is permitted	Minor negative	– Strictly no bilge water discharge policy for all vessels assigned to the Project – In cases of accidental bilge and discharge containment measures should be adopted as required and stipulated in the Contractor EMP applicable for construction – It is understood that all sanitary wastes generated onboard Project related vessels will be collected within adequate holding tanks and discharged in accordance with MARPOL regulations – Environmental Management induction shall be conducted to all personnel engaged in the Project with particular emphasis on pollution prevention – Vessel and all its equipment shall undergo inspection to be conducted prior to mobilisation for work at Project site	EAD Recommended Ambient Marine Quality Standard	Please refer to **Section 3.3.5**	Yes
6	Temperature impact and potential contamination of seawater from cooling water discharges of dredging equipment	Pumping cooling water through the moving parts of the dredger	All areas	Minor negative	– Minimisation of duration and extent by design – Selection of construction methods / equipment to minimise impacts to marine habitats	EAD Recommended Ambient Marine Quality Standard	Please refer to **Section 3.3.5**	Yes

5.2.3.2. Selected Mitigation Measures

5.2.3.2.1. Construction Phase

The majority of the abovementioned mitigation measures are considered to be feasible for adoption for the Project, and these are consequently recommended to be implemented and incorporated in the Project EMP to be developed by the designated contractor in order to minimise the potential for damage to marine water and sediment quality in the vicinity of the Project site.

Recommended mitigation measures during the construction phase include design-related measures, as well as the selection of dredging practices which minimise the risk or effect of liquid emissions to the marine environment. A Dredging Management Plan (DMP) will be required to be developed as part of the CESMP. Detailed mitigation measures are presented below (note that additional measures are also provided within **Section 5.5: Marine Ecology**, which should be read in conjunction with this section):

- Use non-polluting materials wherever possible (e.g. biodegradable oils etc.);
- Store hazardous materials at designated containers and appropriate areas on the vessel;
- Refuelling, oil change and greasing to be done under strict supervision from project engineers and specialists to avoid spills and contamination;
- Provide appropriate (110% volume) secondary containment system at chemical and fuel storage areas;
- Containerising and labelling waste;
- Spill Response Plan to be developed;
- Appropriate spill kits and spill clean-up material on on-site at all time including on marine vessels and always in the vicinity of chemical, fuel, waste storage areas, maintenance areas, fuelling areas etc.;
- Correct material refilling and usage techniques;
- Repairs to vessels only on designated mooring and port areas;
- Minimisation of duration and extent by design;
- Installation of Type IV silt curtains between source of plume and critical habitat receptors. Silt curtains should be deployed as per the arrangement in Figure 5-186 and Figure 5-189 (refer to **Section 5.5**) in order to protect the sensitive receptors in the area;
- Wastewater collected in sump to be treated as liquid waste and disposed of appropriately;
- Marine vessels to be washed off-site within appropriate port facilities;
- Strictly no bilge water discharge policy for all vessels assigned to the Project;
- Environmental management induction shall be conducted to all personnel engaged in the Project with particular emphasis on pollution prevention;
- Vessel and all its equipment shall undergo inspection to be conducted prior to mobilisation for work at Project site;
- Regulating vessel size and speed for vessel within the channel;
- Over-dredge to minimise maintenance dredging frequency;
- A Dredging Management Plan (DMP) shall be developed as part of the CESMP;
- Minimisation of duration and extent by design; and

- Selection of construction methods / equipment to minimise impacts to marine habitats.

The implementation of the adopted mitigation measures will minimise the potential to cumulatively add to existing or future impacts to the marine environment.

5.2.3.2.2. Operation Phase

No mitigation measures identified as there are no impacts anticipated during operation.

5.2.3.3. Mitigation Measures to Address Cumulative Impacts

Through implementation of the mitigation measures listed above, and the correct adherence to the protocols which will be included in an EMP developed by the contractor, the probability of unnecessary discharges and spill into the water column and sediments will be minimised and the risk of accidental spills reduced. The construction Contractor will be obliged to fulfil all directives outlined within the contractor EMP and it is thus expected that any cumulative impact to water quality will be negligible.

No operational impacts are anticipated.

5.2.3.4. Residual Impacts

As presented in Table 5-29 below, no significant residual impacts are anticipated for the Project in relation to marine water should the mitigation measures be successfully implemented for both construction and operation phases of the Project.

Table 5-29: Marine water residual impacts

Description of the impacts	Impact significance prior to mitigation measures	Residual impact significance
Construction Phase		
Spill of hazardous material to the marine environment leading to localised contamination of marine water and sediments.	Minor negative	Minor negative
Generation of sediments and increased turbidity from activities related to the dredging of the channel resulting in effects to localised water quality (Nearshore areas)	Moderate negative	Minor negative
Reduction in water quality due to re-mobilisation of contaminated marine sediment. (Nearshore areas)	Moderate negative	Minor negative
Contamination due to run-off from dredging equipment and vessel washing.	Minor negative	Minor negative
Pollution contamination of marine water and sediment from bilge water.	Minor negative	Minor negative
Temperature impact and potential contamination of seawater from cooling water discharges of dredging equipment.	Minor negative	Minor negative

5.2.4. Monitoring Programme

5.2.4.1. Monitoring Program for Compliance with Selected Mitigation Measures

5.2.4.1.1. Construction Phase

Water quality monitoring will involve in-situ measurements, sampling and ex-situ laboratory analysis of collected samples.

***In situ* Measurements**

During the marine construction period, in-situ water quality monitoring shall be conducted by the EPC Contractor to determine any impacts related to construction activities. Seawater characteristics will be measured at seven locations daily using a multi-parameter probe, or other suitable equipment, to investigate the following parameters:

- Salinity (ppt) & temperature (°C);
- DO (mg/l and %);
- pH;
- Specific conductivity (mS/cm^3);
- TDS (g/l);
- Turbidity (NTU);
- Chlorophyll a (µg/l); and,
- TSS (mg/l).

Concentrations of TSS can be calculated if required (either by the probe or otherwise) with measurements calibrated against ex-situ samples analysed at a laboratory.

Measurements will be taken at midwater and at locations 50, 150 and 300 m away from the source of plume in both upstream and downstream corridor and testing will also be conducted 500 m away from the plume source taken as reference data. This activity is to provide an overview of water column characteristics

***Ex situ* Analysis**

Due to the potential for Project-related activities to accidentally release contaminants into the marine environment during construction period, and for purposes of verifying / calibrating the in-situ analysis (TSS), it is recommended that ex-situ analysis be conducted and analysed at an accredited laboratory (Table 5-30). Samples are to be taken monthly at four locations with source of plume at the centre and sampling points 50m away from the four sides of the vessel or marine works machine such as the starfish and BHD. Samples during marine dredging activities will be tested for parameters detailed in Table 5-30.

Table 5-30: *Ex situ* water quality parameters

Parameter	Unit	MDL	Limits
Nitrate	mg/l	0.04	0.095
Orthophosphate	mg/l	0.06	0.034
BOD	mg/l	2	5
COD	mg/l	5	-

Parameter	Unit	MDL	Limits
TOC	mg/l	1	2.5
Residual Chlorine	mg/l	0.02	0.01
Ammonia	mg/l	0.06	0.004
Ammonium	mg/l	0.064	-
Ammonia Free (NH3-N)	mg/l	0.004	0.004
Nitrogen (ammonia)	mg/l	0.05	-
Dissolved & Emulsified Oil	mg/l	10	-
Free Oil	% vol./vol.	0.01	-
TSS	mg/l	5	-
Sulphide	mg/l	0.005	0.004
Turbidity	NTU	0.1	10
Total Petroleum Hydrocarbons	µg/l	7	7
Chromium (VI)	mg/l	0.05	0.0002
Aluminium (Al)	mg/l	0.005	0.005
Arsenic (As)	mg/l	0.0005	0.0003
Cadmium (Cd)	mg/l	0.0001	0.0002
Chromium (Cr)	mg/l	0.0001	0.003
Copper (Cu)	mg/l	0.0003	-
Iron (Fe)	mg/l	0.02	0.0022
Lead (Pb)	mg/l	0.0002	-
Manganese (Mn)	mg/l	0.001	0.0001
Mercury (Hg)	mg/l	0.0001	0.003
Nickel (Ni)	mg/l	0.0001	0.015
Zinc (Zn)	mg/l	0.002	35
Enterococci	CFU / 100 ml	10	0.001

Parameter	Unit	MDL	Limits
Phenol	µg/l	0.5	70
Total Chloroform	MPN / 100 ml	1.8	0.0002

Monitoring shall commence one week prior to the commencement of marine construction works.

Sediment quality tests shall be carried out using Van Veen grab and the point of sampling will be at the trench line before and after backfilling with a sampling interval of 500 meters at the floatation channel and every five kilometers along the cable route outside of the floatation channel. It is recommended that sediment monitoring will be confined to pre-construction and immediately after post-construction period of all marine based construction activity (trenching). The sediment tests should be tested by an ENAS accredited laboratory and include the parameters presented in Table 5-31.

Table 5-31: Sediment quality parameters

Parameter Name	Unit	MDL	Limits
Inorganic Parameters			
Oil and Grease	%	0.01	-
Total Nitrogen	mg/kg	5	-
Anions			
Orthophosphate	mg/kg	0.3	-
Chemical Analysis			
TOC	%	0.1	-
Hydrocarbons			
Total Polychlorinated Biphenyls	ug/kg	10	22
Total Polycyclic Aromatic Hydrocarbons	mg/kg	1.0	1.7
Metals			
Mercury (Hg)	mg/kg	0.01	0.2
Aluminium (Al)	mg/kg	130	-
Arsenic (As)	mg/kg	1	7.0
Cadmium (Cd)	mg/kg	0.1	0.2
Chromium (Cr)	mg/kg	1	11
Copper (Cu)	mg/kg	3	20

Parameter Name	Unit	MDL	Limits
Iron (Fe)	mg/kg	70	-
Lead (Pb)	mg/kg	1	5
Nickel (Ni)	mg/kg	1	7
Zinc (Zn)	mg/kg	3	70
BTEX	mg/kg	0.01	-
PSA	%		-

Summary

A summary of the monitoring program to be implemented during construction is provided in Table 5-32 below.

Table 5-32: Monitoring program for marine water and sediment during construction

Impact	Phase	Monitoring Activity	Frequency and Location	Responsible Party
Water	Construction	In-situ Water Sampling	Daily at seven locations: – three locations 100m, 300m and 500m upstream from dredging activities – three locations 100m, 300m and 500m downstream from dredging activities – One reference point location at a location 1 km away from dredging activities	EPC Contractor
		Continuous In-situ Water Sampling	– Continuous monitoring buoys to be deployed at three locations (two on either side of the route and one at reference point) in sensitive habitats within 500m of dredging activities (both Route 1 and Route 2). Buoys will continuously monitor TSS, temperature and salinity. The buoys will include full telemetry set-up with exposure thresholds set to trigger alarms. Minor threshold exceedances will require a slowing of works or for the environmental team to check the status of the implemented mitigation measures (e.g. silt curtains). In the event that moderate or high threshold criteria are exceeded, all works should be ceased immediately.	EPC Contractor
		Ex-situ Water Analysis	– During construction, four water samples will be taken at midwater level, 50 meters at four points around the vessel or marine works machine on a monthly basis for the duration of the construction work; – Pre and post trenching with interval of 500 meters at floatation dredged channels and every five	EPC Contractor

Impact	Phase	Monitoring Activity	Frequency and Location	Responsible Party
			kilometres along the cable route outside of the floatation channels	
Sediment	Construction	Sediment Sample Analysis	– Pre and post trenching with interval of 500 meters at floatation dredged channels and every five kilometres along the cable route outside of the floatation channels	EPC Contractor

5.2.4.1.2. Operation Phase

The potential for impact to the marine environment within the post construction period is relatively low. However, in order to monitor impacts to water quality it is proposed that *ex situ* sampling be conducted twice a year for 1 year (corresponding to summer and winter seasons) to assess the quality of water and sediments within the Project area. Water and Sediment quality sampling shall be conducted at the same location previously sampled during monitoring surveys which is assumed to be along the trench line. Results will be assessed to represent water and sediment quality condition after construction. Parameters to be tested should follow the construction phase monitoring programme.

A summary of the proposed monitoring for marine water and sediment during operation is provided in Table 5-33.

Table 5-33: Summary of monitoring for marine water and sediment during operation

Impact	Phase	Monitoring Activity	Frequency and Location	Responsible Party
Water	Operation	Ex-situ Water Analysis	Twice a year (seasonally) at monitoring locations previously identified during construction (along the trench line)	Operator
Sediment	Operation	Sediment Sample Analysis	Twice a year (seasonally) at monitoring locations previously identified during construction (along the trench line)	Operator

5.2.4.2. Monitoring Program for Cumulative Impacts

It is anticipated that the monitoring programme listed above will be sufficient to monitor cumulative impacts in conjunction with existing baseline data.

5.2.4.3. Monitoring Program for Residual Impacts

No significant residual impacts were identified for the implementation of the Project. Therefore, no additional monitoring is required or proposed.

5.3. Waste Management

5.3.1. Description of the Environment

5.3.1.1. Baseline Methodology

This waste assessment has included a desk-based data collection exercise to identify the current waste management framework within the UAE and Emirate of Abu Dhabi to enable the identification of current waste management opportunities and constraints, based on publicly available information. This desk-based research has been supplemented by site visits undertaken on 18th and 19th January 2022 to gain an overall understanding of any existing waste management issues at the Project site.

5.3.1.2. Baseline Conditions

5.3.1.2.1. Abu Dhabi Emirate Overview

Recognising the growing need to manage ever increasing waste volumes generated by the concurrently expanding population and economy with the Emirate of Abu Dhabi, the Government of Abu Dhabi established the Centre of Waste Management – Tadweer, in 2008. Tadweer provides policy, strategy and contractual systems for all waste management related aspects in Abu Dhabi Emirate.

Despite the creation of Tadweer, the Abu Dhabi State of Environment Report 2017 (79) identifies that with high levels of population growth in Abu Dhabi, the development of the Emirates associated waste management infrastructure has not managed to keep pace. This shortfall in infrastructure, together with few incentive and deterrence mechanisms has led to a continued significant increase in waste volumes and an issue with illegal waste dumping. In addition, the current treatment and disposal methods are heavily focused upon disposal. There is typically no segregation of wastes at source and very limited availability of recycling facilities, which poses a significant challenge to achieving diversion from landfill targets. Lastly, there is limited capacity at existing hazardous waste treatment facilities and there is no hazardous waste disposal facility within Abu Dhabi Emirate, which therefore poses challenges to industrial generators and to Tadweer as the Authority responsible for the collection and treatment of wastes within Abu Dhabi Emirate, including municipal solid, commercial, medical, agricultural, industrial, construction and demolition wastes.

The most recent waste data available for Abu Dhabi is detailed within the Statistical Yearbook of Abu Dhabi 2020 (80).

In 2019, total waste generation estimates for the Emirate of Abu Dhabi as being 11,227,633 tons, of which 10,979,476 tons being non-hazardous, with a daily average waste generation rate of 30,081 tons (80). Of these totals, commercial and industrial wastes were estimated to account for the majority of these waste streams, with commercial wastes contributing to 37% and construction and demolition waste was estimated to contribute 34% of total wastes generated within Abu Dhabi Emirate in 2019.

The quantities of different types of non-hazardous and hazardous wastes generated within Abu Dhabi Emirate during 2019 has been calculated by the Statistics Centre Abu Dhabi (SCAD) (81) and are presented in Table 5-34 below. The total quantity of waste generation shows that a significant amount is due to the large-scale construction activities taking place throughout Abu Dhabi Emirate, resulting in the generation of approximately 3,703,033 tons of construction waste in 2019. However, construction and demolition waste generation rates have experienced a significant reduction in recent years, most likely attributable to both a slowing in the construction intensity previously experienced within the Emirate, but also due to greater focus being placed on streamlining construction activities and efforts being made to minimize quantities of construction and demolition wastes generated. The waste statistics published by SCAD identifying a 62% reduction in non-hazardous wastes generated in 2019 when compared to 2012. In 2016, 4,532,379 tons of construction waste were created, which at that time represented just over 47% of the total volume of wastes generated. In 2019, construction and demolition wastes contributed to just 34% of total waste volumes generated.

Table 5-34: Non-hazardous and hazardous waste generation in Abu Dhabi Emirate by region and source 2019 (81)

Source	Total (tons)	Abu Dhabi (tons)	Al Ain (tons)	Al Dhafra (tons)
Daily Average	30,081	18,138	9,131	2,811
Construction and demolition waste	3,703,033	1,808,292	1,313,379	581,363
Industrial and commercial waste	4,094,397	3,210,296	800,944	83,158
Agriculture waste	1,198,789	397,737	602,619	198,433
Municipal waste	1,927,065	1,148,033	615,856	163,175
Other *	56,192	56,192	-	-
Total	**10,979,476**	**6,620,550**	**3,332,798**	**1,026,128**
Note: * Waste from oil and gas sector				

Disposal methods and associated quantities for solid wastes are presented below in Table 5-35, which identifies that recycling rate estimates within Abu Dhabi Emirate account for 35.5% of waste disposal in 2019 (81). It can be seen that each year significant quantities are still being sent to dumpsites.

Table 5-35: Abu Dhabi Emirate solid waste generation by method of disposal (81)

Source	2012	2013	2014	2015	2016	2017	2018	2019
Recycling	3,805,411	3,198,113	1,812,052	2,198,109	2,854,149	2,687,932	3,329,498	3,894,334
Incineration	37,830	40,917	4,774	21,510	9,824	7,514	7,003	9,061
Composting	367,273	458,491	463,355	452,627	228,126	209,188	110,351	21,629
Landfill	452,704	470,725	149,298	172,794	181,555	561,940	906,164	866,471
Dumpsite and Other*	8,042,684	7,594,356	7,489,111	5,584,958	6,325,315	6,010,463	5,450,416	6,187,981
Total	**12,705,902**	**11,762,602**	**9,918,590**	**8,420,998**	**9,598,969**	**9,477,037**	**9,803,432**	**10,979,476**
Note: *Disposed through other specialised companies								

EAD has led the development of a five-year Waste Management Strategy for the Emirate of Abu Dhabi in partnership with Tadweer and the Department of Municipal Affairs (DMA). This strategy establishes targets and the initiatives required to achieve them. Central to the strategy is to achieve the diversion of 85% of municipal solid waste and 90% of construction and demolition waste from landfill.

The UAE has additionally set two strategic targets to be achieved by all Emirates by 2021 as part of the UAE Vision 2021 (82), as follows:

- 1.5kg MSW capita/day; and
- 75% of MSW generated to be treated.

Furthermore, Abu Dhabi Emirate set a target that 60% of total waste generated should be treated using environmentally and economically sustainable methods; the target timeframe for achieving this was stated as 2020. Recent data is not currently available to determine if these targets have been met.

Hazardous waste generation rates within the Emirate of Abu Dhabi between 2014 – 2019 are summarised in Table 5-36 below, which shows variations in the levels of hazardous wastes generated each year, identifying an overall upward trend in quantities of hazardous wastes generated.

The hazardous wastes generated in 2019 amounted to 248,157 tons, as shown in Table 5-37 below. These quantities are considered to be unsustainable given the lack of facilities for the treatment of hazardous wastes and absence of hazardous waste disposal facilities within Abu Dhabi (83). This is emphasized by the data in Table 5-38.

below, which shows a breakdown of quantities, sources and disposal outlets for hazardous solid waste. This identifies that 47% of all hazardous materials are disposed of to landfill, presumably within facilities which are not designed for the disposal of hazardous wastes.

Table 5-36: Hazardous solid waste generation by source activity (81)

Source	2014	2015	2016	2017	2018	2019
Industrial waste	66,768	32,147	17,857	19,828	26,450	24,085
Medical waste	1,732	4,573	6,316	6,374	9,275	6,019
Other*	14,720	20,805	51,920	154,208	146,212	218,053
Total	**83,220**	**57,525**	**76,093**	**180,410**	**181,937**	**248,157**
Note: *Including sewage sludge (heavy metal) and exported wastes.						

Table 5-37: Hazardous solid waste generation by disposal method and source activity in Abu Dhabi Emirates in 2019 (81)

Source	Recycling	Hazardous waste landfilled	Incineration	Other	Total (tons)
Industrial waste	4,366	1,861	-	17,859	**24,086**
Medical waste	-	3,702	2,317	-	**6,019**
Other waste	-	111,157	-	106,895	**218,052**
Total	**4,366**	**116,720**	**2,317**	**124,754**	**248,157**

As of 2019, the following waste management facilities were available within the Emirate of Abu Dhabi, as listed in Table 5-38 below, which identifies that waste generated within The Western Region are handled by three waste facilities which are within close proximity of the Project site areas. These are understood to be controlled dumpsites and include:

- Al Mirfa dumpsite;
- ADNOC dumpsite; and
- Ruwais dumpsite.

Table 5-38: Waste management facilities in Abu Dhabi Emirate (81)

Name and Location of Waste facility	Waste Capacity
3 Transfer stations (Al Hiyar, Sweihan, Remah) Al Ain	Not available
Medical waste incinerator, Al Ain	Two lines with operational capacity of about 200 kg/hour each
Fallen stock incinerator, Al Ain	Two lines with design capacity of about 650 kg/hour each
Sanitary Landfill, Al Ain	Not applicable
C & D Waste crushing plant, Al Ain	2,000 tonnes/day
Tyre Recycling plant, Al Ain (Gulf Rubber Factory LLC)	About 6.3 tonnes/hour
Plastic recycling plant, Al Ain	High-density line with a throughput of 1 tonne/ hour and low-density throughput of 0.4 tonne/ hour
Sorting station, Al Ain	1,000 to 1,200 tonnes/day
Compost plant, Al Ain	400 tonnes/day
Controlled dumpsite, Al Ain	Not applicable
Used oil recycling plant, Abu Dhabi	1,500 litres/hour
Transfer station, Al Mafraq	Not available
Al Dafrah dumpsite, Abu Dhabi	Not applicable
Compost plant, Al Mafraq Compost plant, Al Khatim Compost plant, Liwa	Combined designed capacity of about 100,000 tonnes/annum
Controlled dumpsites: – ADNOC Dumpsite; – Ruwais Dumpsite; – Sila Dumpsite; – Al Mirfa Dumpsite; – Medina Zayed Dumpsite; – Liwa/ Al Jifn; – Liwa/ Al Jabbana; and – Liwa/ Um Al Ghurban (Arada)	Not Applicable
C & D Waste Crusher Plant, Al Dhafrah – Abu Dhabi	8,000 tonnes/day

5.3.1.2.2. ADNOC Waste Management Facilities and Requirements

The majority of waste streams generated by ADNOC operations in the western region are received and treated at its purpose-built integrated waste management facility, BeeAAT, the Central Environment Protection Facility in Ruwais.

It is understood that all waste streams generated by the Project offshore will be received, handled, treated and disposed of at the BeAAT facility. Any waste streams which are unable to be received by these ADNOC facilities will be transferred to Tadweer facilities.

Waste streams generated by the onshore components of the Project at Mirfa and Shuweihat will be disposed of by Tadweer, under municipality waste collections.

5.3.1.2.3. Route 1 Zakum Cluster

Mirfa

No photographs were permitted during the site visit. No significant areas of waste generation or waste storage was observed since the Project footprint is undeveloped and immediately adjacent to the Al Mirfa Power and Water Complex.

Al Ghallan Island

No access is available to the island and no site visit was subsequently undertaken. It is assumed that a number of waste streams are likely to be generated on the island including industrial wastes, both hazardous and non-hazardous, in addition to waste streams from staff accommodation and offices. These are assumed to be stored on the island and regularly removed by ADNOC to the mainland for treatment and disposal.

5.3.1.2.4. Route 2 Das Island Cluster

Shuweihat

No photographs were permitted during the site visit. No significant areas of waste generation or waste storage was observed since the Project footprint is undeveloped and immediately adjacent to the Al Shuweihat Power and Water Complex. Flotsam and jetsam is however common on the shore line to the south of the power station, which is unsightly, although no obvious hazardous waste materials were identified.

Das Island

No access is available to the island and no site was subsequently undertaken. It is assumed that a number of waste streams are likely to be generated on the island including industrial wastes, both hazardous and non-hazardous, in addition to waste streams from staff accommodation and offices. These are assumed to be stored on the island and regularly removed by ADNOC to the mainland for treatment and disposal.

It is understood that a Hazardous Waste Transfer Facility (HWTF) is present on Das Island and that hazardous waste generated is handled at this facility by ADNOC.

5.3.2. Environmental Impact Prediction and Evaluation

5.3.2.1. Sensitive Receptors

The potential sensitive receptors that may be impacted by waste generation / storage have been identified and detailed in Table 5-39 below.

Table 5-39: Sensitive receptors in relation to waste

Sensitive Receptor	Receptor Class Value	Justification
Waste infrastructure within Abu Dhabi	*High*	Waste generation is exceeding capacity for treatment, recycling and disposal within Abu Dhabi Emirate
Marine Ecology	*High*	Extensive areas of critical habitat including seagrass and mangroves and intertidal flats are located adjacent to the onshore Project sites are Mirfa and Shuweihat. The Project site at Mirfa is located adjacent to MMBR
Marine Water Quality	*High*	The Project site at Mirfa is located adjacent to MMBR
Terrestrial and Intertidal Ecology	*High*	Fauna and flora are vulnerable to degradation of the environment which may result from waste materials being inadequately handled and/or stored.
Construction workers associated with the Project	*High*	Exposure to hazardous waste materials as a result of inadequate management may result in significant health impacts.
Operational personnel associated with the Project and adjacent facilities	*High*	Exposure to hazardous waste materials as a result of inadequate management may result in significant health impacts.
Soil	*Low*	Majority of the soil within the Project site is disturbed and/or contains little vegetation.
Groundwater	*Low*	No groundwater was detected during sampling.

5.3.2.2. Construction Phase Impacts

5.3.2.2.1. Overview

Significant amounts of solid waste can be generated as a result of construction activities. The type and amount of waste generated is, however, dependent upon the type and scale of development, the construction techniques employed and the specific design of the development.

As certain elements of the Project are still within the design stage, specific construction activities and methodologies have not been approved and construction waste materials and quantities cannot yet be confirmed. However, the offshore cable laying methodologies have been defined and as such, estimates of dredged material quantities are available.

Potential impacts associated with the generation of a variety of waste streams are discussed below, based on the expected project activities and likely consequences relating to both primary impacts (terrestrial, marine and air impacts for example, both within the Project site and surrounding areas) and secondary impacts (relating to waste infrastructure and local and regional transport networks which may be impacted).

5.3.2.2.2. Pressure on Waste Facilities due to Waste Generation

Generation of Construction Wastes

It is anticipated that the following general construction wastes other than excavation, hazardous and liquid waste, will arise as a result of construction of the Projects main items of operational equipment, installation of cable lines and any associated temporary infrastructure such as access roads, offices, workshops, equipment storage areas, and services distribution:

- Site clearance wastes e.g. at the proposed converter station and interface building locations, including existing litter, unlicensed dumping and cleared vegetation;
- Construction materials including packaging materials, timber, concrete, metals and plastics associated with construction of both onshore and offshore components; and
- Domestic and office wastes from on-site office and welfare facilities.

Offshore wastes generated will be handled by ADNOC. For onshore Project sites, waste streams will be handled by Tadweer and therefore waste materials will be disposed of within Abu Dhabi's waste infrastructure. It is anticipated that the quantity of construction waste materials generated by the Project will represent an impact magnitude of *medium* severity, due to the size of the Project (particularly considering the length of cables to be installed and therefore associated materials and packaging which are likely to be associated with these), upon a receptor of *medium-high* sensitivity (local waste management infrastructure in Abu Dhabi, in which generation is exceeding capacity for treatment, recycling and disposal), thereby resulting in an impact of **moderate negative** significance upon existing waste management infrastructure in the absence of mitigation measures.

Generation of Excavation Waste

A significant amount of excavation will be required within the onshore Project areas in relation to the onshore cable corridors. The majority of the excavation material resulting from the cable laying onshore will be reused as back fill, however it is currently understood that an excess of 1,300m^3 of excavated material will be surplus. The proposed destination for this surplus material has not yet been specified. Additional excavation waste may also be generated during site preparation works, construction of access roads and excavating and installing foundations for the onshore elements such as converter stations and interface buildings and service tranches. It is assumed that the majority of excavated material will comprise of natural ground, which is likely to be classified as non-hazardous and will remain *in situ*. However, there is the possibility of areas of contamination being discovered which will require appropriate disposal. Considering the above, it is considered that the impact magnitude is *low* in severity upon receptors of *low* sensitivity (it is not considered that the excavated material will be removed from the Project site), therefore resulting in an impact of **negligible** significance.

Generation of Dredged Materials

Additionally, the Project will involve significant dredging works within the shallow offshore areas of the cable routes. Using a variety of mechanical excavation techniques (depending upon the depth of the area to be dredged) within the shallow near shore areas, excavated material from the sea-bed will be side cast whilst the cable is installed, and the trench will then be backfilled. However, it has been identified that approximately 830,000m^3 of surplus materials from floatation/dredged channels (including trenches in floatation/dredged channels) will require disposal, for which two potential dedicated disposal areas have been identified which can fully accommodate the expected quantities of dredged materials. Further information relating to the location and methodology proposed for disposal of excavation wastes at the disposal sites is provided in **Section 4.3.2.2.2**.

Since the identified disposal areas have been selected on the basis of their adequate capacity to accommodate the expected volume of excavation waste material generated during marine works, the magnitude of the impact will be of *low* severity, upon a receptor of *low* sensitivity. Therefore, the impact will be of **negligible** significance in terms of potential impacts upon the environment and/or existing waste management infrastructure.

Generation of Hazardous Wastes

Offshore wastes generated will be handled by ADNOC. For onshore Project sites, waste streams will be handled by Tadweer and therefore waste materials will be disposed of within Abu Dhabi's waste infrastructure.

At this stage a detailed construction methodology is not yet available, and the volumes of hazardous wastes cannot therefore be determined. It is anticipated that hazardous waste streams associated with the construction of the Project are likely to include the following:

- Paints;
- Thinners;
- Chemical waste (e.g. adhesives) and chemical waste containers;
- Used oils; and
- Construction chemicals.

Hazardous waste generation and disposal is anticipated to represent an impact magnitude of *medium* severity (due to the relatively low amounts expected) upon a receptor of *medium-high* sensitivity (local hazardous waste infrastructure) therefore resulting in an impact of **moderate negative** significance in the absence of mitigation measures.

Generation of Wastewater

During construction, the following types of wastewater are likely to be generated at the onshore tie-in locations at Mirfa and Shuweihat Project sites, and offshore at Das Island and Al Ghallan Island:

- Wastewater from offices and welfare facilities, including sanitary effluents. It is understood that the Project sites will contain chemical toilets for this purpose;
- Stormwater run-off;
- Dewatering effluent; and
- Wash water from construction related washing - such as equipment & machinery cleaning, wheel washing for trucks etc.

Marine based operations are also likely to result in the following wastewater streams:

- Generation of sanitary effluents by crew and workers on marine vessels associated with trenching/backfilling and cable laying;
- Bilge/Ballast water exchange; and
- Run-off from vessel and vessel equipment washing.

Detailed construction methodologies are not currently known. The nature of liquid waste generated has the potential to include both hydrocarbons and sanitary waste which can impact on the surrounding environment and worker welfare, in addition to adding pressure to the wastewater treatment facilities and infrastructure available within the Emirate of Abu Dhabi.

Liquid waste generation is considered to represent an impact of *medium* severity (due to the multiple construction sites at Mirfa, Shuweihat, Das Island and Al Ghallan Island), upon a receptor of *medium* sensitivity (local waste infrastructure), therefore resulting in an impact of **minor negative** significance upon the existing waste management infrastructure in the absence of mitigation measures.

It is understood that all sanitary wastes generated onboard Project related vessels will be collected within adequate holding tanks and discharged in accordance with MARPOL regulations, most likely in association with a licensed sewage collection company and/or onboard processing plant. However, some releases to the marine environment are possible if allowed according to MARPOL and local regulations. The requirements for enabling discharge to the marine environment, if permitted, will need to be detailed within the CESMP. The impact magnitude is considered to be of *low* severity, upon a receptor of *high* sensitivity and therefore the impact is considered to be of **minor negative** significance. Please refer to **Section 5.2.2.2.3** for further information.

Additionally, ballast water represents the potential to impact the marine environment through the introduction of invasive non-native species. This is further discussed and assessed within **Section 5.2**.

5.3.2.2.3. Impacts on Sensitive Receptors due to Improper Storage and Handling of Wastes

One of the key issues at the Project site level associated with the generation of waste is storage, which if inadequate or incorrect could result in several impacts which are detailed in the sub-sections below.

Surrounding Environment

Soil and Groundwater

Inadequate or inappropriate storage of solid and liquid waste generated from construction activities can result in the direct contamination of the soil and groundwater through accidental leaks and spillages or during storm events where surface run-off is present.

There is however also the potential for hazardous wastes to impact the immediate Project site, associated with emergency conditions such as a fuel spillage and subsequent clean-up. If not stored correctly prior to transportation off site, hazardous waste has the potential to contaminate soil, surface water and groundwater. This is considered and assessed further in **Section 5.4.2.2**.

Due to the nature of the construction works, as well as the quantities of hazardous wastes, the potential for a major contamination event is generally limited and any contamination events would be expected to affect a highly localised area only. However, considering the proximity to sensitive intertidal and marine environments adjacent to the Project sites, particularly at Mirfa, in combination with the fact that the incident is likely to be relatively small in scale, the impact magnitude is assessed as being of *low* severity and the receptor sensitivity is classified as *medium-high*. The impact significance is therefore considered to be of **minor negative** significance prior to the implementation of mitigation measures. This is further discussed in **Section 5.4.2.2**.

Terrestrial and Intertidal Ecology

Improper storage and handling of waste generated from construction can impact the flora and fauna of the Project area through ingestion of contaminated materials, vermin infestations and contamination of habitats through contaminated run off or spillages. The following considerations have been made when assessing the potential for impacts upon terrestrial ecology:

- The size of the area affected by any liquid chemical pollution is likely to be limited;
- There is a low diversity and abundance of species within the footprint areas and many of these are likely to be displaced due to increased noise and anthropogenic activity during construction. However, there are environmentally sensitive and critical habitats within the tie-in locations at the interface between the marine and terrestrial environments e.g. mangroves; and

- Storage of chemicals is likely to be in areas already cleared of any vegetation and not supporting any natural species.

On the basis of the assumptions above, impact magnitude is considered to be of *low* severity upon receptors ranging from *low* to *high* sensitivity, therefore resulting in impacts ranging from **negligible** to **moderate negative** significance.

Marine Water Quality and Ecology

Improper storage and handling of waste generated from construction can impact the marine water quality and flora and fauna of the Project area through ingestion of contaminated materials and contamination of habitats through contaminated run off or spillages. Due to the highly sensitive nature of the marine environment, particularly at Mirfa where the Project site lies within the MMBR, the impact magnitude is considered to be of *low* severity (since the incident is likely to be relatively small in scale) upon a receptor of *high* sensitivity, resulting in an impact of **moderate negative** significance prior to the implementation of mitigation measures.

Health and Safety

With regards to this Project there are two primary health and safety concerns associated with the improper management, storage and treatment or disposal of waste materials, as set out below.

<u>Exposure to Harmful Substances</u>

There is the potential for members of the construction workforce to be exposed to harmful substances, which could include skin contact with chemicals and/or inhalation of harmful fumes. Given the health and safety implications of exposures to harmful substances, the impact magnitude is considered to be *high*, and receptor sensitivity is classified as *high*. The impact significance is therefore considered to be of **major negative** significance prior to the implementation of mitigation measures.

<u>Potential Fire Hazards</u>

The potential for a fire scenario to occur within the Project site, whilst unlikely, must be considered in terms of potential health and safety impacts, in addition to the possible loss of assets e.g. construction materials and machinery. This is due to the likely presence onsite of flammable material (waste timber, paper, plastic, fuel storage etc.). It is expected that a fire scenario would therefore represent an impact magnitude of *high severity* upon a receptor of *high sensitivity* therefore resulting in an impact of **major negative** significance in the absence of mitigation measures.

Aesthetic

Improper storage of large quantities of construction materials will have a negative impact on landscape aesthetics.

At Shuweihat, due to the lack of sensitive receptors, it is expected that the impact would be localised in an area of already limited visual quality and impact magnitude will therefore be of *low* severity upon a receptor of *low* sensitivity, resulting in an impact of **negligible** significance in the absence of mitigation measures.

At Mirfa, due to the presence of sensitive receptors including residents on the eastern shoreline, the visual impacts resulting from the presence of stockpiled waste construction materials or uncontained debris etc. may represent a more significant impact. It is expected that this impact would be highly localised and within an area already visually degraded by the presence of an existing power station and associated industrial buildings and assets, but which also benefits from coastal views, and therefore impact magnitude is defined as being of *low* severity upon a receptor of *medium* sensitivity, resulting in an impact of **minor negative** significance, in the absence of mitigation measures.

Odour

The improper storage and handling of waste, particularly wastewater streams including sewage, can result in the uncontrolled release of odour into the Project site and potentially the surrounding area. It is expected that the impact magnitude of potential odour issues will be of *low* severity upon receptors of *medium* sensitivity (construction workers at the Project site and residential receptors and operational personnel at Mirfa and Shuweihat) therefore resulting in an impact of **minor negative** significance in the absence of mitigation measures.

5.3.2.2.4. Transportation of Construction Waste

The potential impact of the off-site movement and disposal of wastes, either to a designated landfill site or to a recycling centre, will result in increased traffic movements both within the Project site and on the local road networks. The increased truck movements associated with this waste transport can result in traffic congestion, in addition to noise and air quality impacts, which are discussed further in the following sections:

- **Section 5.1.2: Air Quality**; and
- **Section 5.7.2: Noise**.

In the absence of construction waste generation estimates for the Project, it is not possible to accurately assess potential impacts associated with transportation. However, it is considered that the transportation of construction waste is likely to represent an impact of *low* severity upon receptors of *low* to *medium* sensitivity (e.g. ranging from sensitive receptors in the wider area, beyond 2km from the Project site, to sensitive residential receptors within 90m of the Project boundary at Mirfa). The resultant impacts are therefore likely to range from **negligible** to **minor negative** significance in the absence of mitigation measures.

5.3.2.3. Operational Phase Impacts

5.3.2.3.1. Overview

Operational waste impacts are associated with the operation of the onshore and offshore components including the converter stations, interface buildings and associated facilities. It is expected that waster, solid waste and hazardous wastes will be generated.

5.3.2.3.2. Pressure on Waste Facilities due to Waste Generation

Generation of Wastewater

The expected sources of wastewater anticipated to be generated during the operational phase of the Project are as follows:

- Sanitary effluents from service buildings at Mirfa, Shuweihat, Al Ghallan Island and Das Island; and
- Wastewater from maintenance activities.

Oily wastewater generated during the operational phase will be collected in remote common underground oil retention tanks in each converter station and will be removed by an authorised tanker and disposed of offsite. Sanitary effluents will be stored in septic tanks, with an estimated 3m^3/day expected to be generated, per Project site and removed to a treatment facility by an authorised tanker.

As the Project is still in the design stage, it is not possible to further quantify the amounts of wastewater that are expected to be generated as a result of the operational activities. Wastewater generation can however, be considered to represent an impact magnitude of *low* severity upon a receptor of *medium* sensitivity, therefore resulting in an impact of **minor negative** significance upon the existing waste management infrastructure in the absence of mitigation measures.

Generation of General Waste

During the operational phase, it is expected that waste streams generated will be minimal, and limited to incidental scheduled maintenance activities or emergency incidents, in addition to wastes generated by the operational workers and could include:

- Non-hazardous waste;
- Municipal waste;
- Organic material from the kitchen facilities;
- Recyclables: paper, cardboard, plastic, metal and glass;
- Waste Electrical and Electronic Equipment (WEEE); and
- Bulky waste.

General waste streams associated with the Project will be associated with the onshore and offshore converter station locations and would therefore be handled as part of any waste streams generated with the associated existing onshore and offshore substation facilities. Waste generated by offshore facilities will be handled and treated by ADNOC. Onshore activities will be received by the local Abu Dhabi waste infrastructure managed by Tadweer. It is considered that impacts arising from such waste streams will be of *low* severity upon a receptor of *high* sensitivity, there will therefore be of **minor negative** significance upon the existing waste management infrastructure in the absence of mitigation measures.

Generation of Hazardous Wastes

Hazardous waste streams which may arise during the operational phase including the following:

- Fluorescent light bulbs;
- Batteries;
- Cartridges;
- Paints;
- Used oils;
- Cleaning materials;
- Solvents; and
- Flammable materials.

It is not currently possible to determine the quantities of hazardous wastes likely to be generated as a result of the Project. Nevertheless, impact severity is assessed as being *low* (due to the limited amounts expected and relatively small-scale nature of the Project) and receptor sensitivity will be *high* (the surrounding environment in case of contamination being a protected area and/or the local waste infrastructure, which is limited in terms of hazardous waste capacity, with the exception of hazardous wastes generated offshore, which will be handled and treated by ADNOC). This can therefore be considered to result in an impact of **moderate negative** significance in the absence of mitigation measures.

Impacts on Surrounding Receptors due to Improper Storage and Handling

One of the key issues at the Project site level associated with the generation of waste is storage, which if inadequate or incorrect could result in several impacts which are detailed in the below sub-sections.

Surrounding Environment

The storage of waste generated from operational activities, may, if inadequate or incorrect, result in the direct contamination of soil and groundwater through storm events where surface run-off is present

Therefore, the potential exists for hazardous wastes to impact the immediate Project site, associated with emergency conditions such as a fuel or chemical spillage (from storage or cable car maintenance) and subsequent clean-up. If not stored correctly prior to transportation off site, hazardous waste has the potential to contaminate the surrounding soil, surface water, ground water and the adjacent marine environment. The potential for major contamination events is generally limited and any contamination events would be expected to affect a highly localised area only. This is considered and assessed further in **Section: 5.4.2** and the impact was assessed as **moderate negative** significance prior to the implementation of mitigation measures.

Health and Safety

Due to flammability of some waste materials, particularly highly inflammable materials waste which may arise from maintenance activities, the possibility for fire events to occur as a result of improper storage and handling of waste streams must be considered. It is expected that a potential fire event will be of *high* severity upon a receptor of *high* sensitivity therefore resulting in an impact of **major negative** significance in the absence of mitigation measures.

Odour

The improper storage and handling of waste generated from sanitary facilities associated with the Project facilities can result in the uncontrolled release of odour into adjacent areas, which would impact upon operational staff and potentially the surrounding area. It is expected that the magnitude of the odour will be of *low* severity upon a receptor of *medium* sensitivity therefore resulting in an impact of **minor negative** significance in the absence of mitigation measures.

5.3.2.3.3. Transportation of Operational Waste

The potential impact from the off-site movement and disposal of wastes, either to a designated landfill site or to a recycling centre, relates to the increased traffic movements both within and from the Project site.

In the absence of operational waste generation estimates for the Project, it is not possible to accurately assess potential impacts associated with transportation. However, the transportation of waste materials is not likely to result in significant congestion or air and noise impacts upon the local road network due to the largely undeveloped nature of the areas surrounding the Project sites at Mirfa and Shuweihat and relative lack of sensitive receptors e.g. residential areas. This is based on the assumption that the waste haulage would not require to route through either Mirfa or Ruwais and all operational waste vehicles would bypass the settlements. At this stage, it is therefore considered that the transportation of operational waste is likely to represent an impact of *low* severity, upon receptors of *low* sensitivity, therefore rendering the overall impact to be of **negligible** significance in the absence of mitigation measures.

5.3.2.4. Cumulative Impacts

5.3.2.4.1. Construction Phase

With regard to Type 1 cumulative impacts, waste management issues may impact upon construction workers, operational workers in adjacent facilities and residents nearby in Mirfa in regard to health and safety, odour and attraction of pests. These receptors may also be impacted by health and safety problems, noise, vibration, traffic and other socio-economic impacts. Therefore, if no proper mitigation measures are in place during construction and operation, Type 1 cumulative impacts could be impacting these sensitive receptors. No Type 1 cumulative impacts are considered likely in terms of pressure upon the local waste infrastructure.

Construction activities are likely to be underway in relation to Project Wave at Mirfa and Mugharraq Port at Shuweihat concurrently with this Project and therefore Type 2 cumulative impacts are possible, but not possible to quantify at this stage. Furthermore, it is not possible to quantify the additional waste generation resulting from other projects in the Dhafra region which would add additional pressure onto existing waste infrastructure. Nevertheless, it is understood that waste facilities are under significant pressure from the high number of construction activities on-going in the Emirate of Abu Dhabi.

5.3.2.4.2. Operation Phase

Type 2 cumulative impacts are possible in relation to waste streams generated during operation, since the Project will be operating concurrently with other projects within the vicinity, including Project Wave and Mugharraq Port, in addition to the existing power and water complexes and other facilities nearby at both Mirfa and Shuweihat. The addition of the waste streams generated by the Project can be considered to be contributing to the overall operational waste streams generated within the area which will therefore, cumulatively, increase pressure upon local waste infrastructure.

5.3.3. Mitigation Measures

5.3.3.1. Potential Mitigation Measures

A range of mitigation measures will be required to offset the waste impacts associated with the Project, particularly where major impacts have been identified. The potential mitigation measures for waste related impacts are provided below in Table 5-40.

Table 5-40: Potential waste impacts and mitigation measures

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
CONSTRUCTION PHASE								
➢ **Pressure on waste facilities due to waste generation**								
1	Generation of non-hazardous construction waste	Offsite disposal of packaging, timber, concrete, metals and plastic from construction activities	Local waste infrastructure and landfill capacity	Minor negative	– Training and toolbox talks provided to all construction workers to inform on best practice waste management practices and recycling initiatives – Emphasis should be placed on the waste minimisation hierarchy: reduce, reuse, and recycle	– Federal Law No. 12 of 2018 on the Integration of Waste Management	Not applicable	Yes
2	Generation of excavation waste	Trenching onshore in relation to cable laying activities	Project sites	Negligible	– Reuse of excavated material where possible within the Project sites onshore	– Federal Law No. 12 of 2018 on the Integration of Waste Management	Not applicable	Yes
3	Generation of dredged materials	Offshore dredging activities	Disposal sites offshore	Negligible	– Selection of appropriate disposal areas within the marine environment to dispose of excess dredged material	– Not applicable	Not applicable	Yes
4	Generation of hazardous waste	Offsite disposal of Chemicals, paints, oils etc.	Local hazardous waste infrastructure and landfill capacity	Moderate negative	– Minimisation of the use of chemicals, paints and any other hazardous materials where possible	– Executive Order of Federal Law No. (24) Regulation for Handling Hazardous Materials, Hazardous Wastes and Medical Wastes	Not applicable	Yes
5	Generation of wastewater	Stormwater runoff, sanitary effluents, dewatering effluents etc.	Local wastewater infrastructure	Minor negative	– Provision of wastewater storage tanks appropriate to the size of the workforce – Functional and well-maintained sanitary facilities provided – Appropriate disposal of sludge generated by the sanitary effluents by licensed waste contractor – Storage of hazardous wastes within a bunded area with a minimum volume if 110% of the largest container stored within	– Federal Law No. 12 of 2018 on the Integration of Waste Management – The International Convention for the Prevention of Pollution from Ships (MARPOL)	Not applicable	Yes
➢ **Impacts on sensitive receptors due to improper storage and handling of wastes**								
6	Degradation of soil and groundwater	Accidental leaks and spillages or during storm events	Project site and surrounding areas	Minor negative	– Ensure all hazardous wastes are stored within appropriate containers of adequate strength – Segregate hazardous materials which are incompatible – Ensure all hazardous chemicals etc are clearly marked and signed in relation to their nature and quantity and that all materials include a MSDS	– Executive Order of Federal Law No. (24) Regulation for Handling Hazardous Materials, Hazardous Wastes and Medical Wastes	Not applicable	Yes
7	Degradation of terrestrial and intertidal ecology	Accidental leaks and spillages or during storm events	Terrestrial and intertidal habitats	Negligible to moderate negative	– Stormwater drainage will be carefully managed to minimise the potential for contamination events – Ensure all hazardous chemicals etc are clearly marked and signed in relation to their nature and quantity and that all materials include a MSDS	– Executive Order of Federal Law No. (24) Regulation for Handling Hazardous Materials, Hazardous Wastes and Medical Wastes	Not applicable	Yes

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
8	Degradation of marine water quality and ecology	Accidental leaks and spillages or during storm events Release of bilge/ballast water and/or sanitary water from vessels.	Marine environment	Moderate negative	– Ensure all hazardous chemicals etc are clearly marked and signed in relation to their nature and quantity and that all materials include a MSDS – Provision of appropriate holding tanks for wastewater onboard vessels – The stormwater drainage system will be carefully managed to minimise the potential for contamination events	– Executive Order of Federal Law No. (24) Regulation for Handling Hazardous Materials, Hazardous Wastes and Medical Wastes	Not applicable	Yes
9	Health and safety impacts from exposure to harmful substances	Ingestion, contact or inhalation of construction related waste streams	Project site	Major negative	– Training and toolbox talks should be provided – Provide a comprehensive induction to all workers to identify appropriate H&S protocol and handling of potentially hazardous materials; – Provision of adequate PPE	– Executive Order of Federal Law No. (24) Regulation for Handling Hazardous Materials, Hazardous Wastes and Medical Wastes	Not applicable	Yes
10	Potential fire hazards	Flammable materials and liquids within the Project site	Project site	Major negative	– Careful storage of flammable materials	– Executive Order of Federal Law No. (24) Regulation for Handling Hazardous Materials, Hazardous Wastes and Medical Wastes	Not applicable	Yes
11	Reduction in aesthetic quality of the surrounding area at Mirfa and Shuweihat	Presence of construction machinery, stockpiles of materials	Project site area, particularly at residential receptors at Mirfa	Minor negative	– Installation of hoarding particularly at Mirfa to minimise visual impacts upon sensitive receptors	– Not applicable	Not applicable	Yes
12	Generation of odours	Emissions from vehicles and sanitary installations for construction workers	Project site and surrounding areas	Minor negative	– Ensure vehicles are maintained regularly – Removal and disposal of sanitary effluents from site; and – Good practice regarding handling, storage and removal of food wastes from construction workers etc.	– Federal Law No. 12 of 2018 on the Integration of Waste Management	Not applicable	Yes
13	Congestion and disturbance to road users and sensitive receptors adjacent to road network	Movement of vehicles carrying construction wastes	Local road network	Negligible to Minor negative	– Appropriate management of onsite wastes and organisation of waste removal to ensure efficient loading of waste contractor vehicles; – Recycle conventional wastes where possible; – Ensure fully licenced waste contractors are used and waste containers are checked before leaving the Project sites to ensure that waste containers are clean and not leaking.	– Federal Law No. 12 of 2018 on the Integration of Waste Management	Not applicable	Yes
OPERATION PHASE								
➢ **Pressure on waste facilities due to waste generation**								
14	Generation of wastewater	Emergencies or malfunction of wastewater treatment facilities	Local wastewater infrastructure	Minor negative	– Appropriate and regular maintenance and emptying of septic tanks on site.	– Executive Order of Federal Law No. (24) Regulation for Handling Hazardous Materials, Hazardous Wastes and Medical Wastes	Not applicable	Yes
15	Generation of general non-hazardous waste streams	Operational maintenance activities etc	Local waste infrastructure	Minor negative	– Implement measures for reducing waste streams and recycle where possible – Where waste generation is unavoidable, implement a waste management strategy for storage, collection and appropriate disposal of all waste streams – Specify disposal routes to ensure that potential impacts relating to local and regional transport infrastructure are minimised where possible	– Federal Law No. 12 of 2018 on the Integration of Waste Management	Not applicable	Yes

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
16	Generation of hazardous waste	Offsite hazardous waste disposal	Local hazardous waste infrastructure and landfill capacity	Moderate negative	– Minimise the use of hazardous products where possible – Effectively manage the handling and storage onsite of hazardous wastes to ensure efficient collection and transportation of wastes, avoiding unnecessary journeys	– Executive Order of Federal Law No. (24) Regulation for Handling Hazardous Materials, Hazardous Wastes and Medical Wastes	Not applicable	Yes
➢ Impacts on surrounding receptors due to improper storage and handling								
17	Degradation of the soil and groundwater, terrestrial, intertidal and marine environments	Accidental leaks and spillages or during storm events	Project site and surrounding terrestrial and marine environments	Moderate negative	– All hazardous materials should be stored within appropriate containers of adequate strength – Provide appropriate on-site storage, including appropriately covered waste storage areas and dedicated hazardous waste storage facilities – Each area containing hazardous materials and/or substances should contain an emergency spillage kit	– Executive Order of Federal Law No. (24) Regulation for Handling Hazardous Materials, Hazardous Wastes and Medical Wastes	Not applicable	Yes
18	Fire hazards	Flammable materials and liquids within the Project site	Project site	Major negative	– Careful storage of flammable materials – Provision of appropriate fire fighting equipment including multi-type fire extinguishers appropriate to the potential fire risk within each area	– Executive Order of Federal Law No. (24) Regulation for Handling Hazardous Materials, Hazardous Wastes and Medical Wastes	Not applicable	Yes
19	Odour	Emissions from operational vehicles and sanitary effluents	Project site and surrounding areas	Minor negative	– Practice good housekeeping for all areas including waste storage and appropriate storage and disposal of kitchen/sanitary wastes.	– Federal Law No. 12 of 2018 on the Integration of Waste Management	Not applicable	Yes
➢ Transportation of operational wastes								
20	Congestion and disturbance to road users and sensitive receptors adjacent to road network	Movement of vehicles carrying operational waste	Local road network	Negligible	– Ensure that waste storage is efficient in terms of space and collections are timed accordingly to ensure that waste contractors are removing fully loaded containers	– Federal Law No. 12 of 2018 on the Integration of Waste Management	Not applicable	Yes

5.3.3.2. Selected Mitigation Measures

5.3.3.2.1. Construction Phase

Pressure on Waste Facilities due to Waste Generation

Generation of Construction Waste

During the construction phase of the Project, the EPC Contractor will be required to develop a CESMP which will determine projected volumes of C&D waste, as well as Key Performance Indicators (KPIs) for recycling and the identification of recycling facilities to be utilised by the Project. Finally, the CESMP will include the implementation of best practice and Project specific measures in accordance with this ESIA. As part of this, a site-specific Site Waste Management Plan (SWMP) will be prepared. This document shall be compiled in accordance with the requirements provided within applicable UAE legislation, EAD guidance documents and ADNOC Codes of Practice for waste management.

The EPC Contractor must include the following requirements within the SWMP:

- The SWMP shall identify, at a minimum, measures for reducing waste streams generated during the construction phase and identify those streams suitable for recycling;
- For waste streams which are unavoidable and unrecyclable the SWMP will provide a waste management strategy for storage, collection and appropriate disposal of aforementioned construction waste streams. Additionally, the waste disposal routes will need to be clearly identified to ensure that potential impacts associated with the local and regional transport infrastructure are minimised as far as possible;
- The SWMP will particularly provide consideration of and control measures for wastes which may require to be transported via specific routes due to the quantity or nature of the waste stream e.g. contaminated soils identified during the site preparation phase. This will enable the closest possible disposal location to be identified for each particular waste stream;
- The SWMP should also include the following provisions:
  - Identify who will be responsible for the management of construction waste;
  - What types of waste will be generated and in what volumes;
  - Targets for the diversion of waste from landfill;
  - How waste will be treated – with the adoption of a waste hierarchy with an order of priority as follows:
    1. Avoidance;
    2. Reduction;
    3. Reuse;
    4. Recycling; and
    5. Disposal as the final option only. •
- Measures for testing of soils and fill material to identify contaminated materials, where relevant;
- Targets for the reuse of excavated spoil materials and prevent as far as practicable transport and disposal of these wastes;
- Training and toolbox talks should be provided to educate all construction workers regarding best practice waste management practices and recycling initiatives, and to encourage more sustainable working practices. Emphasis should be placed on the waste minimisation hierarchy: reduce, reuse, and recycle;
- Requirements for permits from authorities for storage, transport and treatment/disposal of wastes;

- Allocation and development of waste storage areas, with necessary provisions for segregation of waste types and appropriate means of avoiding contamination;
- The methods of transportation;
- The final destination of wastes for treatment or disposal;
- Identification of which licensed waste management contractors will be used; and
- How the types and quantities of waste generated by the Project and the achievement of targets to avoid landfill will be measured and reported.

In addition, and in accordance with the IFC EHS Guidelines (Waste Management), waste minimisation should be encouraged among suppliers. This is likely to involve suppliers committing to reducing surplus packaging associated with any construction materials; particularly common packaging materials such as plastics (shrink wrap and bubble wrap), cardboard and wooden pallets. This may also involve improved procurement and consultation with selected suppliers regarding commitments to waste minimisation, recycling and the emphasis on continual improvements in environmental performance.

Generation of Excavated Waste Materials

No mitigation is considered necessary in relation to onshore excavated materials since the materials are expected to be reused in backfilling cable trenches. Any surplus material is likely to be limited in volume and can spread across the Project corridor.

The identification of appropriate offshore disposal areas is considered to be sufficient as mitigation against any potential impacts associated with the quantities of surplus dredged material generated by the laying of cables along the seabed.

Generation of Hazardous Waste

All hazardous waste materials must be collected by licensed hazardous waste management contractors and disposed of at authorized treatment and disposal facilities under the appropriate licenses.

Generation of Wastewater

The EPC Contractor must include the following requirements within the SWMP:

- Onshore:
  - Wastewater storage tanks will be introduced to the site to provide adequate containment facilities for the construction workforce;
  - Functional and well-maintained sanitary facilities must be available on site at all times;
  - Sludge arising from temporary toilets should be disposed of by an appropriately licensed contractor in accordance with the appropriate environmental guidelines and other pertinent legislation and with an emphasis on preventing risk to public health and safety;
  - Adequate removal of sanitary liquid waste from temporary toilets, in conjunction with inspections will avoid any overflow and create a zero-leakage site; and
  - Removal of liquid sanitary waste from temporary toilets should be undertaken by a licensed waste management sub-contractor and transported to the nearest sewage treatment plant.
- Offshore:
  - Strictly no bilge water discharge policy for all vessels assigned to the Project unless in compliance with MARPOL Regulations;
  - In cases of accidental bilge and discharge containment measures should be adopted as required and stipulated in the Contractor EMP applicable for construction;
  - Provision of appropriately sized holding tanks for all wastewater streams generated by Project vessels, and regular discharge to a licensed onshore waste management sub-contractor;

- Environmental Management induction shall be conducted to all personnel engaged in the Project with particular emphasis on pollution prevention; and,
- Vessel and all its equipment shall undergo inspection to be conducted prior to mobilization for work at Project site.

5.3.3.2.2. Impacts on Surrounding receptors due to Improper Storage and Handling of Wastes

The EPC Contractor must include the following requirements within the SWMP:

- All hazardous materials will be stored in a container of sufficient strength and structural integrity to ensure that it is unlikely to burst or leak in its ordinary use;
- All hazardous liquid waste must be stored within a bunded area with a minimum volume if 110% of the largest container stored within;
- Incompatible hazardous materials must be segregated and stored separately, e.g.: flammable liquids will be segregated from caustic / acidic materials, if relevant;
- Storage, handling and disposal of fuels, oils, lubricants and other potentially harmful chemicals (and their containers) will be undertaken under proper supervision in accordance with manufacturer's instructions;
- Storage areas will be clearly marked and signed with regard to the quantity and hazardous characteristics of the materials stored Material Safety Data Sheets (MSDS);
- Containers will be stored in designated areas that are isolated from surface water drains, open water and are bunded to contain any spillages;
- Emergency spillage kit will be located at strategic locations and in proximity of the main storage areas;
- Leaking or empty oil drums will be removed to the hazardous waste storage area to be treated or disposed of via an approved waste disposal contractor; and
- Emergency response procedures will be formulated and available to be implemented in the event of an incident and to minimise the impact of contamination incidents should they occur.

Exposure to Harmful and/or Hazardous Substances

The EPC Contractor must include the following requirements within the SWMP:

- Training and toolbox talks should be provided to educate all construction workers regarding appropriate hazardous material handling;
- All workers will be provided with a comprehensive induction to demonstrate which wastes are segregated in adequately labelled containers;
- An emergency response plan will be prepared and conveyed to all staff; and
- Specific PPE and training will be provided, and PPE must be worn by employees at all times specific to the nature of their task.

Waste Handling and Transport

The EPC Contractor must include the following requirements within the SWMP:

- Waste is suitably disposed of by a licensed approved operator;
- All relevant consignments of waste (waste manifests) for disposal or recycling should be recorded indicating their type, destination and name of the carrier. This will indicate whether the waste is to be treated, recycled or disposed of to a landfill site and discharge liability from the waste producer by ensuring that disposal activities are in accordance with local regulations;
- Final disposal of wastes will be to an EAD approved waste treatment plants or landfill site, as agreed by the relevant competent administrative authority;
- Waste manifests must be countersigned by the receiving facility;
- Where possible, conventional wastes (i.e. paper/cardboard, plastic) will be recycled by an approved company or removed from the Project Site by approved Contractors; and
- Waste containers shall be checked prior to leaving the site to ensure:
  - The waste containers are clean on the outside, sealed, and not leaking;
  - The required forms for wastes and other documents required for shipment are completed and correct;
  - Waste separation will be done by staff wearing suitable PPE such as gloves and dust masks.

5.3.3.2.3. Operational Phase

Generation of operational waste streams

The Operator will be required to develop an OEMP, which will include sustainable waste management practices commensurate with the activities which will be undertaken as part of this major industrial development. This will include the following general measures as a minimum:

- Ensuring compliance with national and international best practice guidance, including IFC and Equator Principles;
- Encouraging opportunities to minimise waste, based upon the principle of the hierarchy of waste prevention and reduction through to reuse, recovery (energy and materials) and disposal via landfill as a final option;
- Providing suitable waste facilities, including the segregation of waste streams for recycling and general waste for disposal to landfill;
- Targets for the diversion of waste from landfill;
- Ensuring good on-site storage practices, including appropriately covered waste storage areas and dedicated hazardous waste storage facilities;
- Emergency spillage kit will be located at strategic locations and in proximity of the main storage areas;
- Appointing dedicated personnel responsible for waste management issues;
- A clear process for the monitoring and recording waste, including a schedule of monitoring and periodic audits to inform the OESMP process;
- The financial resources necessary to implement and operate a suitable waste management system shall be specified, as well as those people responsible for making those resources available; and

- Capacity building and training needs shall be identified to ensure that waste can be properly managed and controlled;
- For waste streams which are unavoidable and unrecyclable, development of a waste management strategy for storage, collection and appropriate disposal operational waste streams.
- The waste disposal routes will need to be clearly identified to ensure that potential impacts associated with the local and regional transport infrastructure are minimised as far as possible;
- The methods of transportation;
- Requirements for permits from the relevant authorities for storage, transport and treatment/disposal of wastes;
- Allocation and development of waste storage areas, with necessary provisions for segregation of waste types and appropriate means of avoiding contamination;
- The final destination of wastes for treatment or disposal;
- Identification of which licensed waste management contractors will be used; and
- How the types and quantities of waste generated by the Project and the achievement of targets to avoid landfill will be measures and reported.

Generation of Wastewater

The following wastewater system will be included to collect, treat, equalize and discharge wastewater streams generated by the Project will ensure that potential impacts are minimized as far as possible. All elements of the wastewater treatment facilities will require regular maintenance. It is understood that the wastewater treatment system will treat the following:

- Sanitary wastewater will be collected within septic tanks at each Project location (for both service building and guard house) for disposal by tanker to an offsite facility. It is currently estimated that approximately $3m^3$/day of sanitary wastewater will be generated per location;
- Industrial and process wastewater collection, treatment and transfer systems with neutralization, flocculation and detoxification for all chemicals containing wastewater streams (e.g. areas of chemical storage, boiler blow-down water, chemical cleaning effluents etc.) in addition to sludge dewatering equipment;
- Oily wastewater will be collected at remote common oil retention tanks (7.7mx16mx5.5m/station) at each Project site location for collection by tanker and disposal at an offsite facility; and
- Stormwater collection (capacity for $1.363m^3$/hr) and transfer facilities.

5.3.3.3. Mitigation Measures to Address Cumulative Impacts

It is anticipated that the development of an SWMP by the EPC Contractor in accordance with the above requirements, in addition to adherence to the EAD permitting process and associated implementation of specific control measures (e.g. through the development of a CESMP) will ensure that any cumulative effects from multiple impact types (e.g. air quality and noise, waste generation, odour etc.) upon a particular sensitive receptor during the construction phase will be adequately controlled for Type 1 cumulative impacts.

For Type 1 and Type 2 cumulative impacts, it is anticipated that the mitigation measures presented in **Section 5.3.3.2** will serve to reduce significantly all waste impacts upon all relevant sensitive receptors through implementation of appropriate waste measures set as part of an OESMP. The risk of waste impacts will be minimised and therefore the contribution of the Project to potential cumulative impacts (Type 1 and Type 2) during construction and operation will be minimised as far as practicable.

5.3.3.4. Residual Impacts

Following the implementation of the recommended mitigation measures and control measures described previously, the anticipated residual impacts are presented below in Table 5-41.

Table 5-41: Residual waste impacts

Environmental Impacts		Impact Significance Prior to Mitigation Measures	Residual Impact Significance – Following Mitigation Measures
Construction Phase			
Pressure on Waste Facilities	Generation of non-hazardous construction waste	Minor negative	Negligible
	Generation of excavation waste	Negligible	Negligible
	Generation of dredged materials	Negligible	Negligible
	Generation of hazardous wastes	Moderate negative	Minor negative
	Wastewater generation	Minor negative	Negligible
Impacts on Sensitive Receptors due to Improper Storage & Handling of Wastes	Degradation of soil and groundwater	Minor negative	Negligible
	Degradation of terrestrial and intertidal habitats and species	Negligible to Moderate negative	Minor negative
	Degradation of marine habitats and species	Moderate Negative	Minor negative
	Health and safety impacts relating to exposure to harmful substances or waste streams	Major negative	Minor negative
	Fire hazards	Major negative	Minor negative
	Aesthetic degradation	Minor negative	Negligible
	Odour	Negligible to Minor negative	Negligible
	Transportation of construction wastes impacting upon local road network and sensitive receptors nearby	Negligible to minor negative	Negligible

Environmental Impacts		Impact Significance Prior to Mitigation Measures	Residual Impact Significance – Following Mitigation Measures
Operational Phase			
Pressure on waste facilities due to waste generation	Generation of wastewater	Minor negative	Negligible
	Generation of general non-hazardous waste streams	Minor negative	Negligible
	Generation of hazardous waste	Moderate negative	Minor negative
Impacts on surrounding receptors due to improper storage and handling	Degradation of the soil and groundwater, terrestrial, intertidal and marine environments	Moderate negative	Minor negative
	Fire hazards	Major negative	Minor negative
	Odour	Minor negative	Negligible
Transportation of operational waste	Transportation of operational wastes impacting upon local road network and sensitive receptors nearby	Negligible	Negligible

5.3.4. Monitoring Program

5.3.4.1. Monitoring Program for Compliance with Selected Mitigation Measures

5.3.4.1.1. Construction Phase

In order to enforce and understand the effectiveness of the selected mitigation measures, the SWMP to be developed by the EPC Contractor(s) will include the following monitoring and auditing procedures:

- Records of raw material wastage;
- Quantitative records for the generation of each waste stream;
- Methods by which the waste streams are being handled and stored;
- Quantifying the wastes diverted from landfill, with records for each treatment method;
- Monthly collation of waste consignment data from all sub-contractors and receipt at waste treatment/disposal facilities;
- Review of all waste permits;
- Records of any waste complaints or incidents; and
- Review of effectiveness of SWMP procedures and update as necessary.

5.3.4.1.2. Operational Phase

No operational monitoring program is considered necessary.

5.3.4.2. Monitoring Program for Cumulative Impacts

It is considered that the monitoring measures specified above would be sufficient to ensure that cumulative effects are monitored.

5.3.4.3. Monitoring Program for Residual Impacts

It is considered that the monitoring measures specified above would be sufficient to ensure that all residual effects are monitored.

5.4. Geology, Seismicity, Soil and Groundwater

5.4.1. Description of the Environment

5.4.1.1. Baseline Methodology

Baseline soil and groundwater conditions within the Project site and surrounding areas were assessed using the following methodologies described below, including both desk-based and the results of field sampling surveys undertaken by Nautica in 2021 (**Appendix 2.2**) (84) (41) (85), to facilitate an assessment of potential impacts and mitigation measures to ensure appropriate controls are in implemented across the Project site, to minimise impacts.

5.4.1.1.1. Desk-based Study

A desk-based review of the prevailing geological, hydrological and land use features within and surrounding the Project site was undertaken, including a review of the EADs Enviroportal Viewer; The Soil Atlas of Abu Dhabi Emirate and the Environmental Atlas of the Abu Dhabi Emirate. The Environmental Screening Report prepared by Mott MacDonald in 2020 in support of the Project has also been referred to (48).

5.4.1.1.2. Soil and Groundwater Baseline Sampling

Project site specific baseline soil and groundwater surveys were undertaken by Nautica on behalf of Mott MacDonald in May 2021 (41) (84) (85); the results of these surveys have been referred to for the purposes of informing the baseline for this ESIA at Mirfa, Shuweihat and Das Island. No sampling was undertaken on Al Ghallan Island, as this is recently reclaimed. Specifically, these surveys included the following:

- A Phase 1 non-intrusive investigation was undertaken by means of a walkover survey to identify any potential sources of existing contamination. No potential sources or visible signs of potential contamination were identified at Mirfa, Shuweihat or Das Island;
- 8 soil samples were collected within the Project corridor by hand auger to a maximum depth of 2 metres where possible (up to 0.5m at Das Island) or where bedrock or groundwater was encountered. Sampling locations are provided below within Figure 5-50 to Figure 5-52 and sampling coordinates are provided within Table 5-42 to Table 5-44 below;
- Soil samples were analysed at an ENAS accredited laboratory for a wide range of parameters which are provided in full in **Appendix 2.2**;
- The sampling results were compared against Abu Dhabi Quality and Conformity Council (ADQCC) Environmental Specification for Soil Contamination Soil Limits for Industrial and Commercial Use (ADS 19/2017); and
- One groundwater sample was collected at Shuweihat, although the sample was taken outside of the Project study area and therefore is not considered applicable in terms of enumerating baseline conditions within the Project site. No groundwater sampling was undertaken at Mirfa or Das Island.

Table 5-42: Soil sampling coordinates at Mirfa

Soil sampling location	Latitude (N)	Longitude (E)	Depth of sample taken (m)
S01	24.1131	53.463	1.2
S02	24.1151	53.4601	1.0
S03	24.1168	53.4568	1.1
S04	24.1159	53.454	1.0
S05	24.11204	53.455	1.0
S06	24.1113	53.4641	1.4
S07	24.1117	53.4564	1.0
S08	24.108	53.4519	1.0

Table 5-43: Soil sampling coordinates at Shuweihat

Soil sampling location	Latitude (N)	Longitude (E)	Depth of sample taken (m)
S01	24.143799	52.563299	1.9
S02	24.145000	52.571300	1.5
S03	24.147300	52.565100	1.5
S04	24.141600	52.571899	1.6
S05	24.141200	52.576200	1.7
S06	24.144700	52.582999	1.2
S07	24.145000	52.567500	1.8
S08	24.147200	52.565100	1.6

Table 5-44: Soil sampling coordinates at Das Island

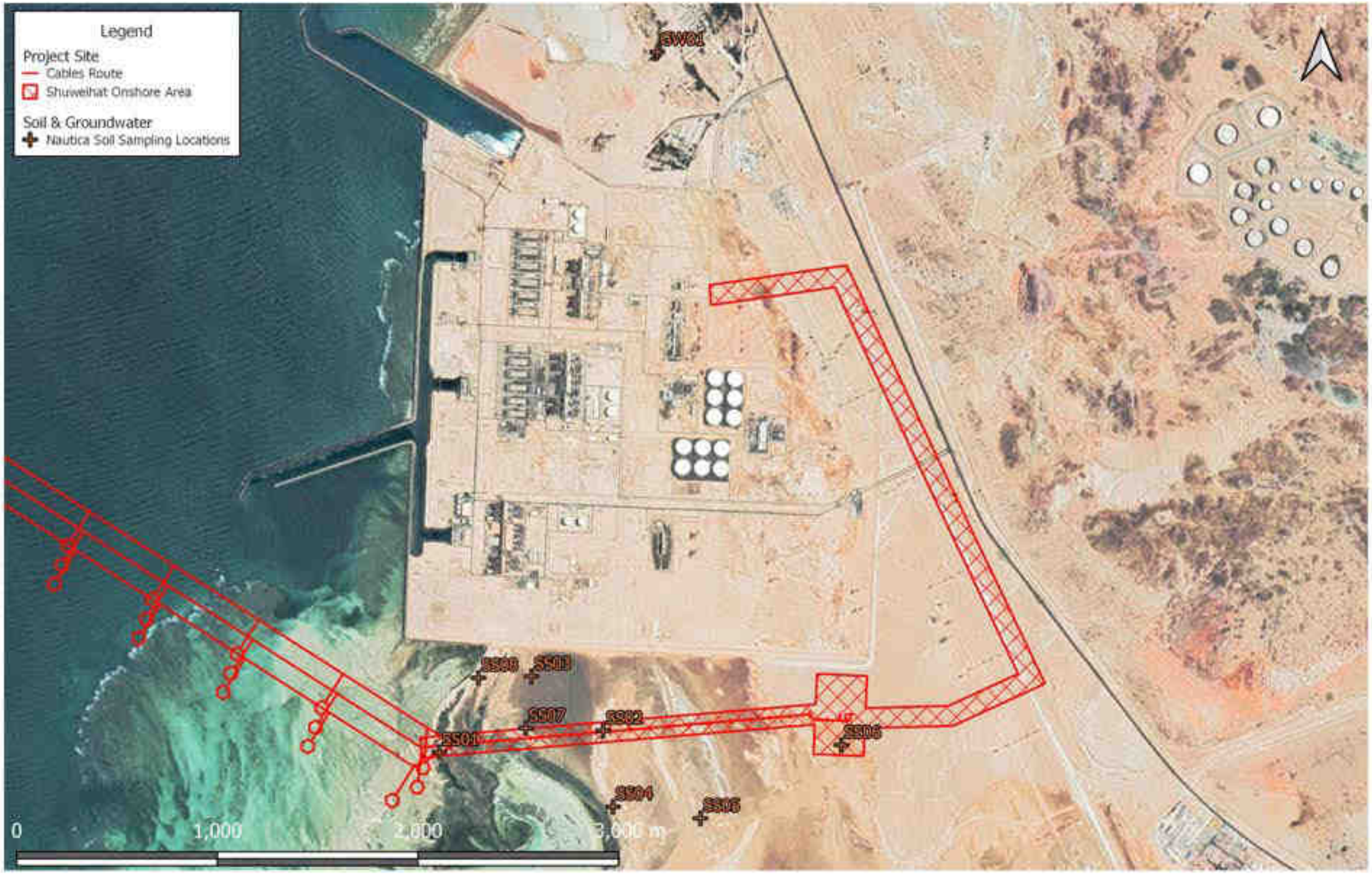
Soil sampling location	Latitude (N)	Longitude (E)	Depth of sample taken (m)
S01	25.12391	52.87748	0.5
S02	25.11850	52.87764	0.5
S03	25.12601	52.87889	0.5
S04	25.12392	52.87891	0.4
S05	25.12411	52.87791	0.5
S06	25.12251	52.87746	0.4
S07	25.12483	52.87791	0.5
S08	25.12255	52.87643	0.5

Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:11702
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 22/04/22

Anthesis

Figure 5-50: Nautica soil and groundwater sampling locations at Mirfa



Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:23404
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 22/04/22

Figure 5-51: Nautica soil and groundwater sampling locations at Shuweihat

Figure 5-52: Nautica soil sampling locations at Das Island

5.4.1.2. Baseline Conditions

5.4.1.2.1. UAE Context

Soils and Geology

The UAE is situated on the southernmost section of the Arabian Gulf, with Abu Dhabi Emirate located on the northeastern section of the Arabian Plate. The predominant geological feature of the UAE is that of desert sand formations underlain by sedimentary rock deposits over 950 million years ago (48).

The Arabian Gulf comprises a shallow tectonic depression which was created during the Tertiary period with the Zagros Mountains rising beyond. The depression is asymmetrical and therefore steep coastal slopes and deeper water towards Iran has resulted in a low-lying coastline positioned adjacent to the shallow sea floor on the southern side of the Arabian Gulf. Subsequently, the UAE comprises an extensive low lying plain to the west climbing gradually to the Hajar Mountains in the east (48).

The soils of Abu Dhabi (86) can be broadly categorized as sandy and sandy calcareous, gypsiferous, saline, saline-gypsiferous, and hard pan soils etc. These soils have been classified into three soil orders (Aridisols, Entisols and Inceptisols) of the Soil Taxonomy (87). Entisols are the most commonly occurring soils, followed by Aridisols to a relatively lesser extent, and Inceptisols are the least common in the Emirate. Soil classification is described in which detailed descriptions of soil masses and their discontinuities are made in test soil pits and soil profiles and is also supported by laboratory soil data (88). These soils are described in the context of their formation, temperature and moisture regimes, properties and occurrence in the Emirate. Surface deposits of sandy soils are described from erosion and transport mechanism point of view (87).

Topography

The regional topography within the UAE is defined by the Gulf coastline in the northwest and the Oman-UAE mountains in the southeast. The land rises steadily inland from a narrow flat coastal plain reaching a level of 265 m above sea level at Al Ain International Airport and then rises rapidly into the Oman-UAE mountains e.g. 1166 m at Jebal Hafeet.

Seismicity

Seismicity within the UAE is monitored by the Seismic Department of the National Centre of Meteorology (NCM), including seismic activity within the country, neighbouring countries and globally. The Seismic Department exchanges data and information both locally, regionally and internationally, with the overall aim of *'assessing seismic hazard in the United Arab Emirates through identifying all seismic activity zones and its characteristics and their effects on all types of buildings and infrastructures, to reduce losses and contribute to the preservation of the achievements of the state growth and prosperity*' (89). The NCM provides warning maps and maps identifying monitoring stations throughout the UAE, in addition to real time maps identifying active and recent earthquake events.

The EAD Environmental Atlas (90) also provides detailed information and mapping data relating to seismicity within the region and describes how the movements of the Arabian Plate relative to surrounding tectonic plates generates pressure and heat. This then results in an enormous force being placed upon the sub-surface rocks within the region. The persistent and massive stresses result in sub-surface rocks breaking or 'faulting.' Faults develop and then represent zones of weakness which in turn can become earthquake zones. Earthquake epicentres can largely be found within the northernmost areas of the Arabian Gulf and Iran (90).

The continuing compression of the Zagros Range results in frequent but moderately weak earthquakes within the region. Infrequent large movements at vertical linear faults, including the north–south trending Nayband Fault situated in south-east Iran, typically result in large and significant earthquakes which are frequently felt throughout the Gulf. Additionally, the south-west branch of the Nayband Fault lies underneath Dibba, within the north-eastern Emirates. The Nayband Fault is not thought to reach the Emirate of Abu Dhabi (90).

Figure 5-53 below illustrates the tectonic plate boundaries within the region and recent earthquakes which are measured in magnitudes on the Richter scale. A magnitude 5.3 earthquake would rank as a moderate earthquake, and a magnitude 6.3 would rank as a strong earthquake. The Richter scale is logarithmic, and an increase in whole numbers signifies a ten-fold increase in earthquake amplitude or intensity (90).

Figure 5-54: and Figure 5-55 presents data relating to seismic activity within the region between 1964 to 2006 and from the 19th November 2017 to 19th February 2018. These maps identify a significant amount of seismic activity within the surrounding regions, but it appears that seismic risk within the Emirate of Abu Dhabi is low to moderate and it is not considered likely that any seismic events would result in significant damage to assets or infrastructure, either within the Project site or the wider area of Abu Dhabi Emirate.

Groundwater

Groundwater movement in the UAE is generally from east to west, towards the Arabian Gulf. Flow times from recharge zones in the east to the sabkha discharge zones along the Gulf coastline can take up to 15,000 years. The slow groundwater movement allows for considerable dissolution of salts in the groundwater.

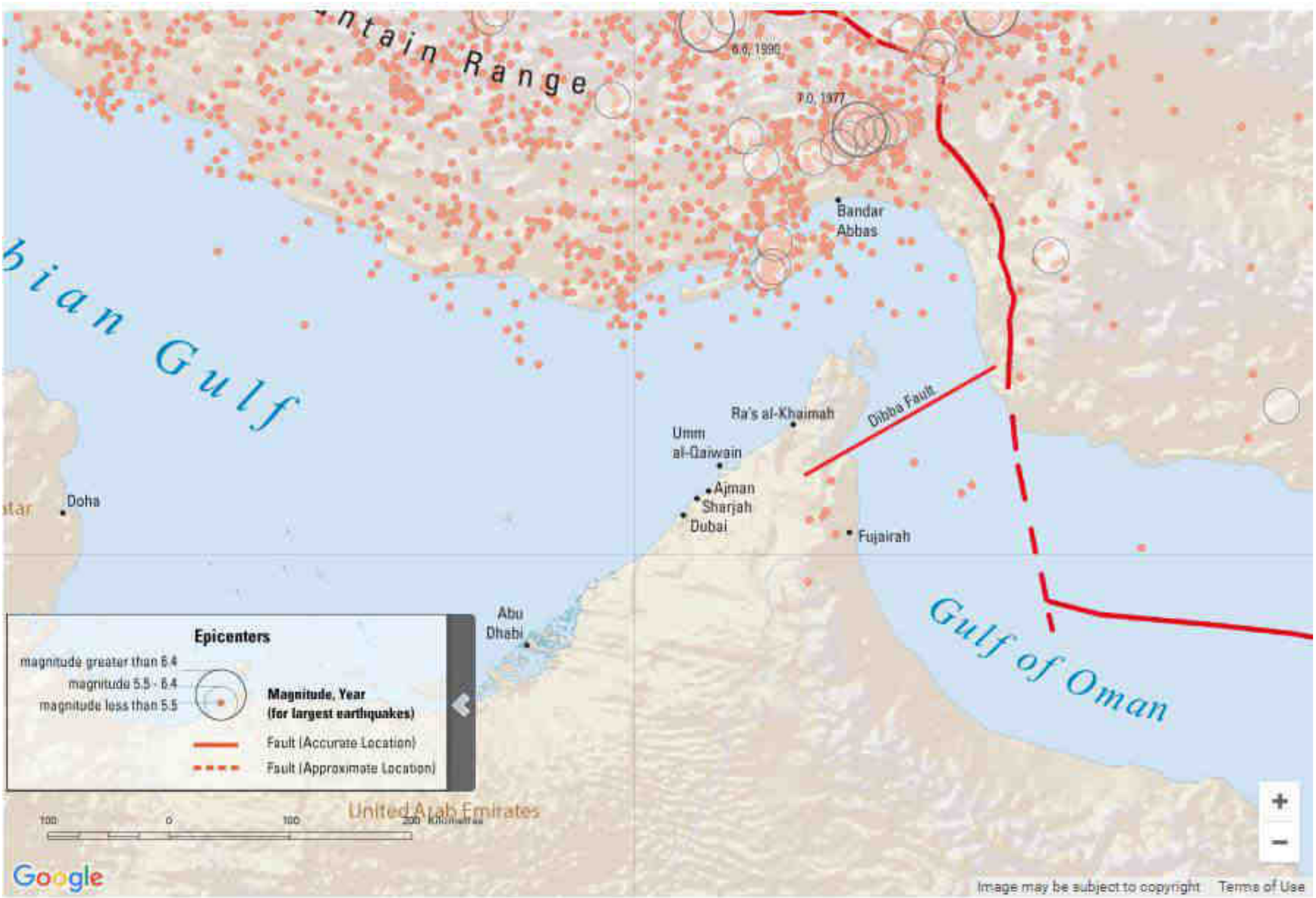
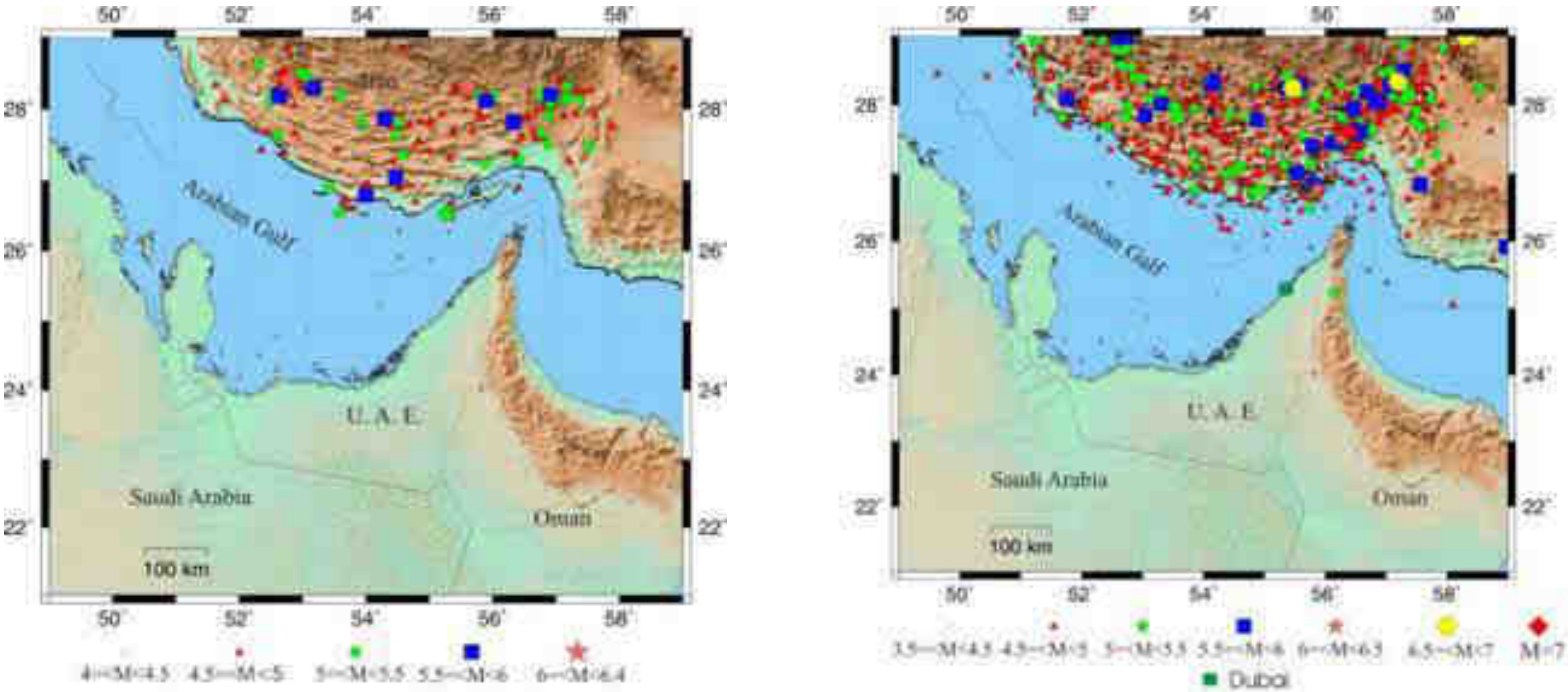


Figure 5-53: Seismic events & tectonic plate boundaries (90)



Seismicity in & around UAE during the period from 1964-1973.

(ISC Bulletin)

Seismicity in & around UAE during the period from Jan.1973-Feb. 2006

Figure 5-54: Historical seismicity in the Middle East region between 1964 – 2006 (91)

Figure 5-55: Seismicity event from 19th November 2017 to 19th February 2018 (91)

5.4.1.2.2. Project Site

Topography

The topography of the Project site areas at Mirfa and Shuweihat can be described as largely flat within low-lying coastal areas. Given their location adjacent to existing industrial facilities, much of the adjacent land has been previously graded as part of site preparation works relating to the existing power and water complexes present.

The topography on Das Island is largely flat, with the majority of the island having been levelled and graded at the time of its development as an offshore ADNOC facility area. Al Ghallan Island is a purpose-built reclaimed island and therefore it is assumed that topography is uniformly graded throughout.

Soil and Groundwater

Mirfa

According to the Environmental Screening Report prepared by Mott MacDonald in 2020 (48), the soil types within the Mirfa Project site area consist predominantly of low relief (<3m) Torripsamments (48). Salinity of the soils is high, ranging from 16-40dS/m). Groundwater presence is classified as being none-rare (0-9.9%) across the Project site and groundwater salinity is reported as being 125,000 – 160ppm (brine) (48).

Shuweihat

According to the Environmental Screening Report prepared by Mott MacDonald in 2020 (48), the soil types within the Shuweihat Project site area consist predominantly of Torripsamments ranging from low to medium height (3-<9m), in addition to tidal flats, and petrogypsic haplosalids. Soil salinity levels vary greatly, from non-saline (0-<2dS/m) to highly saline (>40dS/m) within small, isolated areas (48). The presence of groundwater ranges from none to rare (0-9.9%) throughout the majority of the Project area to 50-100% within a restricted area. Groundwater salinity was ound to be 125,000 – 160,000 ppm (brine) (48).

Das Island

No data is currently available in relation to Das Island, other than the results of the soil and groundwater sampling baseline surveys.

Al Ghallan Island

No data is currently available in relation to Das Island

Results of the Nautica Soil and Groundwater Sampling

No exceedances were detected within any samples collected at Mirfa, Shuweihat or Das Island. No samples were collected for Al Ghallan Island.

5.4.2. Environmental Impact Prediction and Evaluation

5.4.2.1. Sensitive Receptors

The key sensitive receptors associated with soil and groundwater related impacts resulting from the Project include the following, as set out within Table 5-45.

Table 5-45: Soil and groundwater sensitive receptors

Sensitive Receptor	Value	Justification
Soil	*High*	Although large portions of the Project sites are graded and/or disturbed, significant areas of protected habitats are present at Mirfa (which is situated within MMBR) and Shuweihat within the intertidal areas. This, in conjunction with the proximity of the Project sites to the marine environment warrants a *high* sensitivity rating.
Groundwater	*High*	No groundwater was detected during sampling, however the proximity of the Project sites, particularly at Mirfa adjacent to sensitive marine habitat renders the sensitivity as *high*.
Terrestrial and intertidal habitats	*High*	A number of critical and environmentally sensitive areas are present within close proximity to both onshore Project areas at Mirfa and Shuweihat, including mangroves and saltmarsh areas.
Marine water quality and ecology – MMBR	*High*	MMBR contains a variety of sensitive and critical habitats and species.

5.4.2.2. Construction Phase Impacts

5.4.2.2.1. Soil Erosion

Soil quality can be negatively impacted during construction due to activities such as removal of vegetation, grading and filling, excavation etc. Left unprotected, construction sites can be further degraded by erosion and may begin to affect the surrounding environment. It is likely that the majority of soil erosion would result from wind-blown dust and as sediments within surface run-off during storm events. Minimal vegetation is present within the Project sites at Mirfa and Shuweihat, and it is assumed that vegetation is limited at Das or Al Ghallan Island. Therefore, the limited vegetation, minimal topsoil cover and infrequent rainfall, render the impact magnitude associated with soil erosion as *slight* severity and the receptor sensitivity is considered to be *high.* The impact significance is therefore considered to be of **minor negative** significance.

5.4.2.2.2. Soil and Groundwater Contamination

Construction activities resulting in accidental leakages and spills

During the construction phase, the potential exists for contamination of soil and groundwater to occur through several possible pathways. General construction activities, stockpiling of construction materials and the use and storage of commonly used hazardous materials such as solvents, fuels, paints and chemicals may, if inappropriately handled or stored, result in the release of contaminants e.g. the spillage of fuels, spillages within vehicle maintenance areas, overflow at vehicle wash-down areas, overflow of sanitary effluent and any improper storage of hazardous materials.

Due to the nature of the construction works, which for the land-based elements are confined to the construction of the converter station buildings and tie-in buildings adjacent to existing industrial facilities (at Mirfa, Shuweihat, Das Island and Al Ghallan Island) in addition to the installation of the cable corridor from the landing point to the tie-in locations at Mirfa and Shuweihat, the potential for major contamination events to occur is generally limited although any contamination event, regardless of the extent, may result in indirect detrimental impacts to the surrounding environment. For example, contamination events resulting in the degradation of soil within the area may impact upon local flora and fauna e.g. through habitat degradation, or by inducing health impacts within the construction workforce. Considering the above, the impact magnitude is *medium* in severity and the receptor sensitivity being classified as *high*. The impact significance is therefore considered to be **major negative** prior to the implementation of mitigation measures.

Potential contamination impacts upon both marine and terrestrial habitats and associated species are discussed further in **Section 5.5: Marine Ecology** and **Section 5.6: Terrestrial Ecology**, respectively.

Mobilisation of Existing Contamination

During the Phase 1 site walkover, no obvious signs of contamination or potential pathways for contamination to occur within the soil and groundwater present were identified. Similarly, no exceedances of parameters were noted during soil and groundwater sampling undertaken by Nautica (84) (41) (85). However, the potential remains for unidentified sources of contamination to be present within the soil and groundwater particularly given the industrial nature of the surrounding landuses. Dewatering activities and any discharges to the environment, in addition to excavation activities which may disturb pockets of existing contamination could result in the mobilisation of existing contamination. The impact magnitude of disposing of contaminated groundwater or unintentionally mobilising contamination present within the soil is considered as *low* in severity (since the likelihood of any unidentified contamination being identified is considered to be low) and the sensitivity of soil and groundwater is considered to be *high* (given that the Project site is located adjacent to, and within the MMBR). Consequently, the impact significance is considered to be of **moderate negative** significance prior to the implementation of mitigation measures.

Potential contamination impacts upon both marine and terrestrial habitats and associated species are discussed further in **0 5.5: Marine Ecology** and **Section 5.6: Terrestrial Ecology**, respectively.

Contamination from Dewatering and Disposal of Effluent

Aqueous effluents from dewatering activities used for temporary construction facilities, washing down and dust damping activities may lead to the contamination of soil and potentially groundwater if untreated water is used or if appropriate methods are not adhered to.

Vehicle and plant washdown water can carry traces of lubricants and other contaminates. Concrete washout is alkaline in nature due to the materials involved. The incorrect or improper disposal of these liquids on site can negatively impact local soil and groundwater.

This impact is likely to be temporary in nature and will only be applicable during the construction phase. Any contamination events would be expected to affect a highly localized area only, albeit within a protected area in the case of the Mirfa Project site

Therefore, the impact magnitude of inappropriate disposal of water is assessed as *medium*. The soil and groundwater sensitivity is considered as *high*. Consequently, the impact significance is considered to be of **major negative** significance prior to the implementation of remedial measures.

5.4.2.2.3. Generation of Sanitary Effluents

Temporary sanitary facilities (chemical toilets) will be provided at the construction sites at Mirfa, Shuweihat, Al Ghallan Island and Das Island. Sewage waste generated from the workers contains high levels of bacteria such as coliforms and high levels of nutrients which can contaminate soil. Soil and groundwater contamination is possible in the event of leakages or poor maintenance of the chemical toilets provided.

This impact is likely to be temporary in nature and will only be applicable during the construction phase and any contamination events would be expected to affect a highly localised area only. Therefore, the impact severity is *low*, although the receptor sensitivity is classified as *high*. The impact significance is therefore considered to be of **moderate negative** significance prior to the implementation of mitigation measures.

5.4.2.2.4. Rock Quarrying for Subsea Rock Installations

It is understood that 2.6 million tons of rock will be required for the subsea cable protection. The rock will be sourced from a quarry in the UAE and will be produced in accordance with EN 13383-1,2. **At this stage, details and location of the selected quarry is not available and will be provided as part ot the CESMP.** Note however that an existing quarry with appropriate permitting will be utilised and therefore no impacts are predicted in terms of soil and groundwater.

5.4.2.3. Operational Phase Impacts

During the operational phase, it is not considered that any significant risks to soil or groundwater will occur. The land-based elements of the Project will consist of buildings housing converter equipment and areas of hardstanding which will contain oil retention systems and appropriate containment areas and tanks, with few potential pathways for contamination events to occur. Nevertheless, the potential exists for accidental leaks and spillages to occur, particularly during times of maintenance and repair. The cable corridors are not considered to represent a pathway for any contamination events to occur and have therefore not been considered further in this instance.

The following potential scenarios are described to ensure that any potential impacts relating to contamination within the converter stations and associated buildings and components of the Project are considered and appropriate mitigation is provided and embedded within the Project design.

5.4.2.3.1. Soil and Groundwater Contamination

Contamination from Inappropriate Storage and/or Use of Hazardous Materials and Waste

Regular maintenance activities may include the use of some hazardous materials e.g., cleaning chemicals etc. but it is not considered that the use of these would be extensive, and it is assumed that they would be appropriately stored, handled and disposed of in accordance with ADNOC standards and requirements.

It is expected that the following potentially hazardous materials and liquids will be stored on-site:

- Waste chemicals and chemical containers;
- Paints;
- Fuels;
- Waste oil and grease from maintenance activities;
- Fluorescent lighting tubes;
- Sanitary effluents; and
- Washdown wastewater.

However, any mismanagement of both hazardous and non-hazardous materials associated with the operational phase, although expected to be minimal, could potentially cause soil and groundwater contamination if not appropriately mitigated. The potential for major contamination events is generally limited and any contamination events would be expected to affect a highly localized area only. Therefore, the impact magnitude would be *low* although the receptor sensitivity would be *high*, therefore representing an impact of **moderate negative** significance, in the absence of mitigation measures.

Contamination from Stormwater Run-Off

To serve the Project site, a stormwater drainage system will be developed for the land-based Project areas, to ensure no flooding of the operational areas and protection of critical equipment. A 20% allowance will be applied to the rainfall intensity values to allow for climate change.

The risk of contamination during the operational phase is mainly related to stormwater run-off from paved surfaces where contaminants (such as oil and grease) may have accumulated from vehicle use and waste storage.

Prior to mitigation measures, if the stormwater drainage network is not properly designed and if no filtration (natural or not) is implemented prior to discharge into the channel, the impact severity is considered to be *low* and the sensitive receptor sensitivity is considered to be *high*. Therefore, the significance of the impact prior to further mitigation is considered to be **moderate negative**.

Contamination from Wastewater Collection Facilities

As identified within **Section 4.3.1**, the Project will include septic tanks for sanitary waste and dedicated tanks for oily wastewater. In case of emergencies or malfunction, release of untreated wastewater streams including raw sewage could occur from unmaintained storage tanks, inappropriate storage or infrequent collections. This could lead to widespread contamination of the soil and groundwater if not properly accounted for in the design of the plant. The impact magnitude is considered to be of *medium* severity and the sensitivity of the soil and groundwater is assessed as *high* due to the proximity to, and in parts location within, the MMBR. Potential impacts are therefore assessed to be of **major negative** significance prior to the development of mitigation measures.

5.4.2.3.2. Structural damage

The seismicity risk in Abu Dhabi is considered to be low to moderate. Liquefaction can occur due to the build-up of pore water pressures from sudden cyclic loads such as an earthquake and can result in a loss of ground strength leading to ground bearing failure and/or excessive total or differential settlement. The potential for liquefaction can be related to the magnitude of an earthquake, the strength of the soils and the engineering characteristics of the soils at the site.

It is known that the potential for liquefaction increases in generally loose, saturated or partially saturated sands which have the greatest potential for inter-particle movement and are therefore most prone to liquefaction. The potential impact from liquefaction is therefore of potential **major negative** significance, if not properly mitigated.

5.4.2.4. Cumulative Impacts

5.4.2.4.1. Construction Phase

No Type 1 cumulative impacts are considered to be applicable in terms of impacting upon the soil and groundwater.

Type 2 impacts are possible, considering the likely overlap of construction with Project Wave at Mirfa and Mugharraq Port at Shuweihat. The possibility exists for multiple contamination events to occur in the event of poorly managed wastes, or inadequately stored or handled hazardous chemicals and liquids within the project sites. Given the proximity of the project sites to the sensitive marine and intertidal areas, particularly at Shuweihat, it is considered that this cumulative impact has the potential to be significant if not adequately managed.

5.4.2.4.2. Operation Phase

No Type 1 or Type 2 cumulative impacts are considered likely during the operational phase.

5.4.3. Mitigation Measures

5.4.3.1. Potential Mitigation Measures

A range of mitigation measures will be required to offset the potential impacts upon soil and groundwater associated with the Project, particularly where major impacts have been identified. The potential mitigation measures for soil and groundwater related impacts are provided below in Table 5-46.

Table 5-46: Soil and groundwater impacts and potential mitigation measures

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
CONSTRUCTION PHASE								
1	Soil Erosion	Land clearance	Project site	Minor negative	– Appropriate measures shall be implemented by personnel – Stabilisation of bare soils – Implementation of wheel cleaning by vehicles leaving the site – Ensuring appropriate stormwater management procedures implemented	– Not applicable	– Not applicable	– Yes
2	Soil and groundwater contamination	Accidental leakages and spills	Project site and surrounding areas	Major negative	– Promotion of best practice management measures on site; ▪ Groundwater shall not be used on-site for any construction activities ▪ Appropriate bunding of all chemical and hazardous waste storage areas and generators ▪ Avoidance and minimisation of spills, leaks etc.	– Abu Dhabi Specification (ADS) for Soil Contamination – The Dutch Groundwater Target and Intervention Values 2009	– Please refer to **Section 3.3.3** and **Section 3.3.4**	– Yes
3		Mobilisation of existing contamination during excavations	Project site and surrounding areas	Moderate negative	– Avoidance of, or remediation within, any areas containing potential contamination	– Abu Dhabi Specification (ADS) for Soil Contamination – The Dutch Groundwater Target and Intervention Values 2009	– Please refer to **Section 3.3.3** and **Section 3.3.4**	– Yes
4		Dewatering activities or accidental release of effluents during disposal activities	Project site and surrounding areas	Major negative	– Promotion of best practice management measures in regard to dewatering – If dewatering is required, a dewatering permit from EAD shall be obtained – Ensure that the dewatering water is tested prior to disposal into the environment and implementation of treatment where required	– Abu Dhabi Specification (ADS) for Soil Contamination – The Dutch Groundwater Target and Intervention Values 2009	– Please refer to **Section 3.3.3** and **Section 3.3.4**	– Yes
5	Generation of sanitary effluents	Sanitary facilities for construction workers	Project site	Moderate negative	– Promotion of best practice management measures on site – Avoidance and minimisation of spills, leaks etc.	– Abu Dhabi Specification (ADS) for Soil Contamination – The Dutch Groundwater Target and Intervention Values 2009 – Recommended Standards for Treated Wastewater reuse and Discharge to Land in Abu Dhabi Emirate	– Please refer to **Section 3.3.3** and **Section 3.3.4**	– Yes
OPERATION PHASE								
6	Soil and groundwater contamination	Inappropriate storage and/or use of hazardous materials and waste	Project site	Moderate negative	– If hazardous material is stored within the Project, hazardous waste shall be appropriately stored and clearly labelled and managed – Waste management shall follow best practices for waste storage and collection	– Abu Dhabi Specification (ADS) for Soil Contamination – The Dutch Groundwater Target and Intervention Values 2009	– Please refer to **Section 3.3.3** and **Section 3.3.4**	– Yes

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
						– Executive Order of Federal Law No. (24) Regulation for Handling Hazardous Materials, Hazardous Wastes and Medical Wastes and the Federal Law No. 12 of 2018 on the Integration of Waste Management		
7		Improper design or inadequate maintenance of stormwater run-off	Project site and surrounding areas	Moderate negative	– Proper stormwater network design to ensure that all risk of contamination from run-off water is reduced and/or avoided during the completion of the final stormwater drainage system	– Abu Dhabi Specification (ADS) for Soil Contamination – The Dutch Groundwater Target and Intervention Values 2009	– Please refer to **Section 3.3.3** and **Section 3.3.4**	– Yes
8		Emergencies or malfunction of wastewater treatment facilities	Project site	Moderate negative	– Proper wastewater network design to ensure that all risk of contamination from spillages are appropriately managed	– Abu Dhabi Specification (ADS) for Soil Contamination – The Dutch Groundwater Target and Intervention Values 2009	– Please refer to **Section 3.3.3** and **Section 3.3.4**	– Yes
9	Structural damage	Seismic activity	Project site	Major negative	– Ensure buildings and roads are designed appropriately to avoid any structure damages from events such as earthquakes, in accordance with ADNOC standards	– ADNOC Guidelines for Architectural Engineering for Onshore/Offshore Buildings (2019); – ADMA-OPCO Codes of Practice for Plant Design – Part 7: Civil (2012); – ADMA-OPCO Codes of Practice for Plant Design – Part 8: Structural (2012); and – ADMA-OPCO Interim Earthquake Safety – Precautions & Procedures (2013).	– Not applicable	– Yes

5.4.3.2. Selected Mitigation Measures

5.4.3.2.1. Construction Phase

Soil Erosion

Prior to construction, an Erosion Control Plan along with best practice management measures on-site shall be implemented as part of the CESMP which will include the following measures:

- Avoidance of activities that will mobilise soils before or during the wet season;
- Minimisation of clearance of existing vegetation and removal of existing topsoil;
- Stabilisation of bare soils on the site damping down or covering with gravel;
- Implementation of wheel cleaning for construction traffic leaving the site;
- Identification of natural drainage channels and implement control measures, such as screens or sedimentation basins to reduce sediments leaving the site; and
- Appropriate stormwater management procedures to be implemented.

Construction Activities resulting in accidental leakages and spills

In order to avoid and minimise the risk and likelihood of contamination on-site, the following measures shall be implemented and incorporated within the CESMP prepared for the Project by the EPC Contractor, which promotes on-site environmental good practice:

- Where and if, groundwater quality does not meet the acceptable standards, water will not be reused, but will be stored in temporary holding tanks before being removed by a licenced wastewater contractor;
- Adequate hazardous waste and hazardous material management facilities and practices;
- Potentially hazardous material to be used away, as far as practical, from high risk areas;
- Any hazardous substances to be substituted with safer alternatives;
- No discharge or overflow of sanitary waste on site. Chemical toilets will be installed at each Project site to provide adequate containment facilities for the construction workforce. The chemical toilets will be emptied and sanitary effluents removed by an approved tanker on a regular basis;
- Fuel storage tanks to be located above ground and be fully bunded with an impermeable barrier;
- Regular vehicle and equipment maintenance to be undertaken in hard-standing areas with isolated drainage and oil-interceptors;
- Vehicle and equipment refueling to be undertaken in hard-standing areas with isolated drainage and oil-interceptors – where this is not possible drip-trays must be used;
- Spill clean-up kits to be readily available on site and staff trained in their appropriate use;
- Spills to be cleaned up immediately and any waste materials generated, including excavated soils, must be disposed of appropriately as hazardous waste;
- Environmental incident reports to be prepared for any spills on site;
- Appropriate housekeeping precautions to be implemented to prevent construction workers from having contact with potentially contaminated soils;

- Construction workers to be required to wear appropriate personal protective equipment (PPE) and to have undertaken adequate training / awareness;
- Appropriate stormwater management procedures to be implemented to ensure that contaminants are not mobilised into the wider environment; and
- Washout from concrete mixing plant or from cleaning ready-mix concrete lorries is contaminated with cement and therefore is highly alkaline. This should not be allowed to enter the marine environment and should be re-used on site where possible or disposed of appropriately.

Mobilisation of existing contamination

As far as practically possible, the Project will avoid contaminated areas (if detected), both known and suspected. Initial soil sampling undertaken by Nautica in 2021 (41) (85) (84) did not identify any contamination, although the potential remains for unidentified pockets of contamination to be present within the Project area particularly given the proximity of each of the land-based Project sites to adjacent industrial facilities.

In the event of suspected contaminated soils and groundwater being located within the Project site, depending on significance of contamination, hazardous soil and groundwater remediation measures will be implemented by the EPC Contractor to remove the suspected contaminated soil, aggregates and groundwater from site, which will reduce the risk of mobilisation during construction.

The CESMP will include an excavated materials management plan. This will describe how uncontaminated and contaminated materials will be dealt with (excavated, temporarily stockpiled and stored and disposed) during construction.

Contamination from dewatering and disposal of effluents

During intrusive soil and groundwater surveys undertaken by Nautica in 2021 (41) (85) (84) no groundwater was encountered within the Project site and therefore it is considered that the groundwater table at Mirfa and Shuweihat is low. Therefore, the requirement for dewatering is therefore not understood at this stage. Nevertheless, the EPC Contractor will be required to apply and receive a dewatering permit from EAD if dewatering is required.

Control measures shall be taken for testing effluent to ensure compliance with EAD ambient marine water quality standards prior to discharge to ensure no impact to the environment occurs. Where exceedances of the standards are recorded, appropriate treatment measures must be implemented prior to discharge.

Contained areas for washing out and cleaning plant, concrete batching plant or ready-mix lorries will be established, and wash-waters will be collected for reuse or appropriately treated where required and safely disposed off-site.

General

In addition, the following general best practice measures are also recommended to be implemented:

- Training material on proper management of hazardous waste to be kept on record, along with signatures of workers who have been trained. Only these workers are authorised to handle hazardous waste on site;
- All hazardous liquid materials will be stored in a container of sufficient strength and structural integrity to ensure that it is unlikely to burst or leak in its ordinary use;
- Incompatible hazardous materials must be segregated and stored separately, e.g.: flammable liquids will be segregated from caustic / acidic materials, if relevant;

- Storage, handling and disposal of fuels, oils, lubricants and other potentially harmful chemicals (and their containers) will be undertaken under proper supervision in accordance with manufacturer's instructions;
- Storage areas will be clearly marked and signed with regard to the quantity and hazardous characteristics of the materials stored (Material Safety Data Sheets);
- Containers will be stored, in designated areas that are isolated from surface water drains, open water and are bunded to contain any spillages;
- Emergency spillage kit will be located at strategic locations and in proximity of the main storage areas and the refuelling area;
- Leaking or empty oil drums will be removed to the hazardous waste storage area to be treated or disposed of via approved waste disposal contractors; and
- Water used for dust damping should come from a source that will not risk causing contamination to soil or groundwater.

Bulk Storage

- The content of any tank will be clearly marked on the tank, and a notice displayed requiring that the valves and trigger guns be locked when not in use;
- All containers will be securely stored and labelled, so that appropriate remediation action will be taken; and
- All tanks will be located on a drip tray of sufficient size and bunded with a capacity of at least 110% of the tank capacity.

Handling and Refuelling

- Prior to commencing work involving handling materials, all personnel will be familiar with the relevant hazardous properties and instructed on the relevant emergency procedures;
- Appropriate Personnel Protective Equipment (PPE) will be issued to relevant personnel;
- Designated personnel will be trained in the use of Emergency Spill Kits;
- Any refueling operation will be supervised and will take place over appropriately sized drip trays;
- All hoses and valves will be checked for wear and tear; and
- All hoses and valves will be securely locked and stowed away when not in use.

Transportation and Maintenance

- Contractors responsible for transporting waste materials to/from the site will be suitably qualified and possess a license from relevant Competent Environmental Authority;
- A transportation document will be created in order to establish a chain of custody using multiple signed copies to demonstrate that the material was transported and received by the final disposal facility in the correct manner;
- All hazardous materials will be labelled, and external signs will be provided on vehicles in accordance with the United Nations Transport Guidelines;
- Plant and vehicles will be well maintained to avoid leakages;
- No vehicles will be serviced on-site;

- All hazardous wastes will be separated from general waste in a designated, well signed area to avoid cross contamination;
- All workers will be sufficiently trained to accurately identify and separate waste streams to prevent cross contamination of waste stores;
- Hazardous waste storage areas will be maintained and regularly inspected and audited to highlight any leaks or spills; and
- All hazardous wastewater should be collected and disposed of to a licensed facility by an appropriately licensed and authorised contractor.

5.4.3.2.2. Operational Phase

The key measures for preventing contamination during the operational phase will be designed into the Project. This includes appropriate designs in relation to the following:

- Appropriate containment systems around storage tanks (e.g. fuels, oils etc.);
- Leak detection facilities;
- Fire prevention measures; and
- Appropriate storm water management systems.

Contamination from inappropriate storage and/or use of hazardous materials and waste

- Storage, handling and disposal of fuels, oils, lubricants and other potentially harmful chemicals (and their containers) will be undertaken under proper supervision in accordance with manufacturer's instructions;
- Hazardous chemicals and materials stored at the site should be appropriately stored in secure, bunded compounds and located on an impervious surface. The storage areas will need to be clearly labelled and have MSDS maintained and available;
- Details and properties for each material should be clearly detailed which include its hazard (poisonous, corrosive, flammable), prohibitions on its disposal (dumpster, drain, sewer) and the recommended disposal method (recycle, sewer, burn, storage, landfill); and
- Systems for acceptance of potentially hazardous goods;
- Ensuring appropriate loading / packaging of hazardous goods;
- Ensuring that all potentially hazardous materials are appropriately labelled and licensed for transport;
- Containers will be stored, in designated areas that are isolated from surface water drains, open water and are bunded to contain any spillages;
- Emergency spillage kit will be located at strategic locations and in proximity of the main storage areas and the refueling area;
- Ensure adequate maintenance of plant and infrastructure pipelines to reduce the risk of leaks and potential pollution of water bodies during operation;
- Relevant design guidelines for waste storage and collection strategy must be adhered to;

- The content of any tank will be clearly marked on the tank, and a notice displayed requiring that the valves and trigger guns be locked when not in use;
- Regular vehicle and equipment maintenance to be undertaken in hard-standing areas with isolated drainage and oil-interceptors;
- Vehicle and equipment refueling to be undertaken in hard-standing areas with isolated drainage and oil interceptors – where this is not possible drip-trays must be used;
- Emergency Response Procedure should be in place and all employees aware of their responsibilities;
- Spill clean-up kits to be readily available on site and staff trained in their appropriate use;
- Spills to be cleaned up immediately and any waste materials generated, including excavated soils or aggregates, must be disposed of appropriately as hazardous waste;
- Fire prevention measures and leak detection systems shall be implemented for certain type of hazardous and dangerous materials;
- The correct rolling stock with appropriate safety and protection systems is in use;
- Development of an Emergency Response Procedure, based upon appropriate risk assessments such as hazard and operability studies (HAZOPS) and, if relevant, studies relating to fire and explosion risk;
- Provision of awareness training for all employees including management, office staff and technical staff on pollution prevention and control techniques and best practices;
- Wider dissemination of Emergency Response Procedure if appropriate, e.g. to Civil Defence and potentially affected communities;
- Appropriate design of the foul sewer network to ensure that the risk of contamination is reduced and/or avoided; and •
- Operational sewage flow shall be appropriately designed, based on the expected work force, as well as being appropriately maintained in order to avoid sewage spills.

The design and construction of the facility, as well as the adoption of best practice operations detailed within an OEMP should significantly limit the risk of pollution.

Other measures in relation to personnel safety, housekeeping and security, on-site awareness training and emergency preparedness policies are also essential. Such measures will form part of the OEMP with the overall aim of avoiding incidences which may lead to potential contamination issues. Such measures will include, *inter alia*:

- To protect and promote health and safety issues to all staff and personnel on-site;
- To minimise exposure to potential hazards and safety issues and reduction in risk from injury and health risk;
- To minimise impacts on the environment from the plant activities taking into account the necessary balance between economic efficiency, energy requirements and environmental protection;
- Promote good practice measures in terms of health and safety to comply, as a minimum, with law and policy requirements;
- Provide appropriate security measures to ensure that any potential issues that may result in contamination are avoided;

- Promote appropriate safety zoning to the hazards that may be present and to ensure that any spillages or incidents are avoided;
- Provide emergency response procedures to any potential incidents to ensure that contamination incidents are controlled if they occur;
- Provision of written standard operating procedures for all processes and appropriate document control;
- Provision of awareness training for all employees including management, office staff and technical staff on pollution prevention and control techniques and best practices;
- The establishment of daily checklists for plant and office areas to confirm cleanliness and adherence to proper storage and security. Specific employees should be assigned specific inspection responsibilities and given the authority to remedy any problems found;
- Continuous monitoring and reporting of the plants' performance should be undertaken in order to establish baseline conditions and whether conditions are improving or deteriorating; and,
- Regular reviews of emergency response procedures should be undertaken, including a contingency plan for spills, leaks, weather extremes etc.

Contamination from Stormwater Run Off

As part of the stormwater drainage system, it must be ensured that that all risk of contamination from run-off water is reduced and/or avoided during the completion of the final stormwater drainage system. Measures include, but are not limited, to the following:

- Proof bunded cases for oil storage;
- Caged area for hazardous waste;
- Bunded areas for any equipment that imply the use of hazardous material; and
- Water / oil separator in the drainage system, etc.

The stormwater drainage system must be designed to ensure that runoff of hydrocarbons and sediments are removed from stormwater prior to discharge to the marine environment. This is likely to include the following measures:

- Provision of oil / water separators to remove oils and hydrocarbons; and
- Provision of settlement systems or sand traps to remove suspended solids.
- Regular maintenance of oil / water sediments and sand traps associated with stormwater run-off outfalls will also be required.

Contamination from wastewater treatment facilities

The Project Proponent will be responsible for the design of the water treatment systems and will therefore ensure that in case of emergencies, raw sewage overflow will not be released into the environment. Further details of the design will be provided in the OESMP. In addition, it is recommended that at the Project initial months of operation, water testing shall be taken within all components of the water treatment plant to ensure all Project effluents meet the applicable standards for discharge to the network.

Structural Damage

The seismicity risk at the Project site is of low to moderate risk however, all buildings and roads shall be designed appropriately to avoid any structure damages from events such as earthquakes, in accordance with the following ADNOC standards:

- ADNOC Guidelines for Architectural Engineering for Onshore/Offshore Buildings (2019);
- ADMA-OPCO Codes of Practice for Plant Design – Part 7: Civil (2012);
- ADMA-OPCO Codes of Practice for Plant Design – Part 8: Structural (2012); and
- ADMA-OPCO Interim Earthquake Safety – Precautions & Procedures (2013).

5.4.3.3. Mitigation Measures to Address Cumulative Impacts

It is anticipated that with the development of an SWMP by the EPC Contractor(s) in accordance with the above requirements, together with a requirement for adherence to the EAD permitting process and implementation of specific measures to ensure that both construction controls (e.g. through the development of a CESMP) will ensure that cumulative effects during construction will be controlled.

No further mitigation measures are required for the operation phase.

5.4.3.4. Mitigation Measures to Address Residual Impacts

Following the implementation of the selected measures, the anticipated residual impacts are shown in Table 5-47 below.

Table 5-47: Soil and groundwater residual impacts

Description of the Impacts	Impact Significance –Prior Mitigation Measures	Residual Impact Significance – Following Mitigation Measures
Construction Phase		
Soil Erosion	Minor negative	Negligible
Contamination of soil and groundwater as a result of construction activities	Major negative	Minor negative
Mobilisation of existing contamination	Moderate negative	Minor negative
Contamination from dewatering and disposal of effluent	Major negative	Minor negative
Generation of sanitary effluents	Moderate negative	Minor negative
Operation Phase		
Contamination from inappropriate storage and/or use of hazardous materials and waste	Moderate negative	Minor negative
Contamination from stormwater run-off	Moderate negative	Minor negative
Contamination from wastewater treatment facilities	Moderate negative	Minor negative
Structural damage	Major negative	Minor negative

5.4.4. Monitoring Program

5.4.4.1. Monitoring Program for Compliance with Selected Mitigation Measures

5.4.4.1.1. Dewatering

The EPC Contractor will be responsible for the ongoing monitoring of dewatering effluent discharges. Appropriate NOCs must be obtained prior to any dewatering effluent discharge into the water drains. If authorisation and permits are granted by DM for the discharge of the dewatering effluent into surface water network, it is expected that the contractor will need to implement a monitoring and reporting programme in order to ensure compliance with the permit. The following methodology will apply for the testing of groundwater effluent discharges:

- An appropriately accredited laboratory will be engaged by the EPC Contractor to conduct the water quality sampling and testing;
- Samples of groundwater will be tested prior to the commencement of dewatering operations against the relevant standards;
- Samples from the dewatering settling tank will then be tested against the recommended standards on a monthly basis;
- If any pollutant levels exceed the prescribed standards then dewatering will cease entirely, and contaminated dewatering effluent will be:
  - Tankered and transported off site to a sewage treatment plant; or
  - Treated on site to a suitable quality for discharge or re-use.

5.4.4.1.2. Hazardous Materials

A visual assessment of the chemical and hazardous material usage areas, delivery areas and store areas should take place on a daily basis involving the following:

- Inspect containers to ensure they are all in good condition with no leaks or signs of corrosion;
- Take immediate action if any spills are seen;
- Make sure all containers are adequately and clearly labelled with all information required;
- Monitor activities on site (such as vehicle and machinery refuelling) which have the potential to result in spills and environmental health impacts;
- Check that spill prevention is actively being enforced on site; and
- Check that site personnel wear adequate PPE when working with chemicals and hazardous materials.

5.4.4.1.3. Record Keeping

Accurate records relating to chemicals and hazardous materials should be undertaken on a monthly basis or when a new chemical or hazardous material is required. The following information should be kept up to date for each chemical and hazardous material:

- Material Safety Data Sheets (MSDS);
- Quantity in store;
- Quantity used per month; and

- Responsibility Details.

Such information should be made available to Emergency crews in case of an emergency event or accident.

A transportation document must be created to establish a chain-of-custody using multiple signed copies to show that all hazardous materials were transported and received by the disposal facility in the correct manner (such as intact, non-leaking labelled containers, licensed transporter, correct handling).

5.4.4.2. Monitoring Program for Cumulative Impacts

It is considered that the monitoring measures specified above would be sufficient to ensure that cumulative effects are monitored.

5.4.4.3. Monitoring Program for Residual Impacts

It is considered that the monitoring measures specified above would be sufficient to ensure that all residual effects are monitored.

5.5. Marine Ecology

This section of the ESIA includes an assessment of the existing marine ecology conditions present within the vicinity of the Project site.

The baseline conditions have been determined through surveys undertaken by Fugro in 2021 and supplemented by additional surveys undertaken by WKC in 2022. Results relating to marine water quality are summarized in **Section 5.2**. The full results of these surveys are presented within **Appendix 2.4**. The baseline conditions have then been used to inform the assessment of potential impacts upon marine ecology. Lastly, mitigation measures have been developed to ensure that appropriate controls are in place during the development of the Project to minimise impacts to acceptable levels.

5.5.1. Description of the Environment

5.5.1.1. Baseline Methodology

5.5.1.1.1. Overview

The baseline conditions have been determined via two sources:

- Existing marine environmental baseline survey (MEBS) are available for significant sections of both route corridors, undertaken by Fugro in 2021 on behalf of ADNOC. The data is recent and therefore considered applicable for consideration within this ESIA; and
- Additional MEBS data has been collected by WKC during April and May 2022, due to key data gaps identified by Mott MacDonald within the Gap Analysis Report (34).

The below subsections provide a summary of the MEBS conducted by Fugro for Route 1 and Route 2. Full details are provided in **Appendix 2.4**.

5.5.1.1.2. Fugro Surveys – 2020 (63)

In order to characterise the marine ecology baseline conditions in terms of benthic habitats and epifauna and communities, ten transect routes at Route 1 were surveyed between 14th April and 20th June 2020 and eleven transects at Route 2 were surveyed between 3rd April and 30th June 2020.

During the survey, video and still footages were collected via the use of Subsea Technology and Rentals SeaSpyder Nano underwater camera, which was deployed approximately 0.5m above the seabed to enable an approximate field of view of 1m of the target marine features.

The video and photographic data were then analysed by experienced Fugro marine biologists/taxonomists. Habitats were classified in accordance with habitat classifications set out in Marine Life of the Emirate of Abu Dhabi (MLEAD) (92) and Environment Agency – Abu Dhabi habitat classifications (93). Epifauna were identified to the lowest taxonomic level possible and their sensitivities assessed.

The transect locations of each route are illustrated in **Section 5.2.**

5.5.1.1.3. WKC Surveys – 2022

Overview

Methodologies used to conduct the marine survey are taken and or adapted from the following survey standards:

- The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA): Standard Survey Methods for Key Habitats and Key Species in the Red Sea and Gulf of Aden;
- Australian Institute of Marine Science (AIMS): Survey Manual for Tropical Marine Resources;
- Regional Organization for the Protection of the Marine Environment (ROPME): Manual of oceanographic observations and pollutant analyses methods (MOOPAM); and
- Seagrass-watch: Manual for Mapping & Monitoring Seagrass Resources by Community (Citizen) Volunteers (McKenzie et al 2003).

The marine surveys were conducted over a single seasonal visit by qualified marine biologists/marine scientists at specific chosen locations within the impacted marine environment. The purpose of the surveys is to characterise the marine ecology of the Project site and surrounding areas as described below:

- Benthic Habitat: Habitat description, current health status; distribution and abundance of each habitat and community type;
- Benthic infauna: Sampling for infauna identification and enumeration;
- Fishes: Surveys to identify fish species composition and relative abundance;
- Marine Mammal and Reptiles: Encounters of either marine mammal (whale, dolphins and porpoises) and or marine reptiles (sea snakes, turtles) will be noted with species identified if possible; and
- Underwater Noise: Underwater noise characterization in terms of natural and anthropogenic sounds (soundscape) as well as passive acoustic monitoring (PAM) for marine mammals.

The methodologies to assess all the above is further detailed in the below sections.

Project Survey Areas

Following the Fugro surveys undertaken in 2021 and as mentioned in **Section 2.4.1**, a Scoping Letter was issued to EAD which identified gaps within the Fugro surveys, principally the Fugro surveys did not cover the shallower nearshore areas for both Route 1 and Route 2 or the area within MMBR crossed by the Route 1. Furthermore, following completion of the Fugro surveys, Route 1 was amended and therefore additional baseline data was required to take account of this amended route, not covered by the previous surveys.

The Scoping Letter set out the planned additional surveys required to provide a complete baseline for this Project ESIA. Due to the large area and scope of work, the surveys have been separated into nearshore areas and offshore areas. The additional surveys undertaken by WKC were undertaken in five main areas, as follows:

- Nearshore areas and route within MMBR not included within Fugro surveys:
  - **Route 1 – Mirfa Landfall Area**: the surveys were conducted on the 7th and 8th of April 2022;
  - **Route 1 – Mirfa Nearshore Area within and near MMBR**: the surveys were conducted on the 5th and 8th of April 2022;
  - **Route 2 – Shuweihat Landfall Area**: the surveys were conducted on the 3rd and 4th of April 2022;
- Offshore areas not covered in Fugro surveys due to change in route locations:
  - **Route 1 – Zakum Clusters Route 1A & 1B re-routing Area**: the surveys were conducted between 19th and 23rd May 2022.

Figure 5-57 to Figure 5-65 below show the location of all survey stations monitored by WKC in order to complete this Project marine ecology baseline.

Results of the marine ecology study are outlined in the sections below and results relating to marine water and sediment quality study are presented in **Section 5.2**. The full results of these surveys, including detailed methodologies followed, are presented within **Appendix 2.4.**

Drift and Towed Drop Down Video (DDV) Transect Surveys Methodology

Marine ecology surveys are critical to understanding the distribution and abundance of marine habitats and associated marine flora and fauna. For this Project, this has been undertaken through transect surveys along the proposed cable routes employing Towed Underwater Video System (TUV) or what is commonly referred to as Drop-Down Video camera (DDV) system (able to capture benthic footages, both still imageries and videos). This methodology has been successfully employed on a number of projects and has proven a valuable technique to allow for greater coverage over a shorter timeframe. Note however that such survey approach only provides qualitative information on the ecological features of the sites.

The DDV surveys are non-diver lead and require the use of an underwater video system operated from the survey vessel and typically towed at slow speed or allowed to drift with prevailing currents to capture video footage of the benthic environment along the proposed cable routes for documenting the marine habitat, fauna and flora encountered. For the towed DDV transect survey, the underwater camera system is towed at low speed (0.5-1.5kts) along the transect paths between pre-selected GPS points.

In addition, on some areas of interest along and adjacent to the route, the towed DDV has been allowed to drift with prevailing currents. In this approach, the towed DDV was allowed to drift for five minutes or for a maximum of 250 meters allowing the current to dictate the movement of the underwater camera system.

Real-time analysis of the encountered benthic communities was undertaken by marine biologists / scientists on-board the vessel as footage is projected 'live' onto the display screen. The recorded video footages were again reviewed on completion of the field surveys in a laboratory for a more detailed analysis of the benthic communities present on site.

The DDV transects were surveyed in all the additional Project survey areas as shown in Figure 5-57, Figure 5-59 and Figure 5-61.

Photoquadrat Survey Methodology

To generate quantitative data from the marine benthic surveys, five photo quadrats were taken at each sampling location along the DDV transect routes (for both towed and drift transects). Where sensitive habitats like corals or seagrasses were observed during the DDV transects, a photo-quadrat sample were taken. The photoquadrat survey was undertaken using a system comprising a steel photoquadrat framer (with 0.5m x 0.5m quadrat) designed to be used with a GoPro camera. This photoquadrat framer was lowered onto the seabed where the attached high-definition camera is programmed to capture at least five representative still photographs per transect. The benthic species composition as well as percentage covers was calculated from data gathered from the analysis of the still footage.

The photoquadrats were taken during the DDV transects surveys, therefore their locations are the same as the DDV transects survey stations shown in Figure 5-57, Figure 5-59 and Figure 5-61.

Benthic Infauna Survey Methodology

Samples were collected using a 0.025m^2 Van Veen grab. The samples were assessed for viability before sieving through a 500 μm stainless steel sieve and subsequent fixation with buffered formalin and Rose Bengal Stain. Infauna identification and enumeration were conducted by WKC, in-house, by an experienced marine biologist.

For infauna assessment, diversity indices, such as number of species, abundance, species richness and Shannon-Wiener (loge) diversity index, were calculated. These indices consider the number of different species and the richness of each species to determine how each species contributes to the diversity within each sample.

The benthic infauna samples were taken during the sediment sampling transects surveys therefore their locations are the same as the sediment sampling survey stations shown in Figure 5-11 to Figure 5-13 within **Section 5.2**.

Fish Survey Methodology

To supplement the current knowledge on the fish species composition, field surveys were undertaken to provide additional information on the fish species present in the project area. The surveys were done through Baited Remote Underwater Video (BRUV) systems. This method delivers non-lethal sampling across a wide range of habitats and depths throughout the site and provides a quantitative (estimates relative abundance, for example) assessment to supplement the qualitative fish data from the DDV samples. The BRUV system is a simple set up of a square frame with a pole extending one meter from the camera to the bait. These stationary, seafloor camera systems record species attracted to the bait or swimming within the camera field of view. They are particularly suitable for observing fish although other marine life is sometimes recorded. A BRUV was deployed at each monitoring site for a minimum of one hour.

The BRUV were deployed in all the additional Project survey areas as shown in Figure 5-58, Figure 5-60 and Figure 5-62.

Marine Mammals and Reptiles Survey Methodology

In addition to data on the marine mammals and reptiles that may be gathered through the captured footage from the underwater camera systems (both DDVs and BRUVs), information on the marine mammals, reptiles and pelagic birds were supplemented by incidental observations from the survey vessel throughout the duration of the marine ecology baseline survey. On any sighting of marine mammals and reptiles, the GPS position and time of the sighting was recorded along with an identification and or photograph of the animal, if possible, and description of behaviour at the time of the recording.

Underwater Noise Survey Methodology

Overview

Sound is described as the effect a vibrating object has on its surrounding environment (94). These vibrations create sound pressure waves that travel through a medium. The sound pressure waves alternately compress and decompress the molecules in the medium as the sound wave travels. The compressions and decompressions associated with sound waves are detected as changes in pressure by biological hearing structures (e.g. ear in humans) as well as by listening devices like a hydrophone. As water is much denser than air sounds travels faster and has good propagation abilities (95). Due to the enhanced properties of water for sound travel many marine animals have developed auditory capabilities and use sound to overcome the challenges of living in the sea.

Underwater sounds are generated by a number of natural sources including waves, rain, thermal vents, seismic events and biological sources. Anthropogenic noise can be from seismic surveys, pile driving, dredging and shipping noise. A diagram showing the noise level (intensity) and frequency of common types of noise in the marine environment is shown below Figure 5-56.

Ambient noise is the combination of many different sounds, each differing in behaviour, spatially and temporally (96). While there can be many sources of ambient noise the main components are from sea surface noise (wind, wave and rain noise), biological noise (fish, mammals and invertebrates), natural seismic/geoacoustic noise and traffic noise (97).

Marine Mammals have evolved complex sound production and hearing abilities which they use to sense and communicate underwater where visibility is often limited (98). Cetacean sounds can generally be divided into different categories like clicks (echolocation), burst-pulses (communication) and whistles/moans (communication)

(98). Concern for the effects of increased anthropogenic noise on marine mammals has increased in the last few decades with regulators and industry considering what the impact of various noises are on marine mammals (99). While some high intensity noises from seismic surveys can potentially cause direct physical harm to marine mammals, the effects of lower intensity sounds like shipping can also cause masking impacting the mammals ability to communicate and echolocate which in turn can effect behaviour and biology.

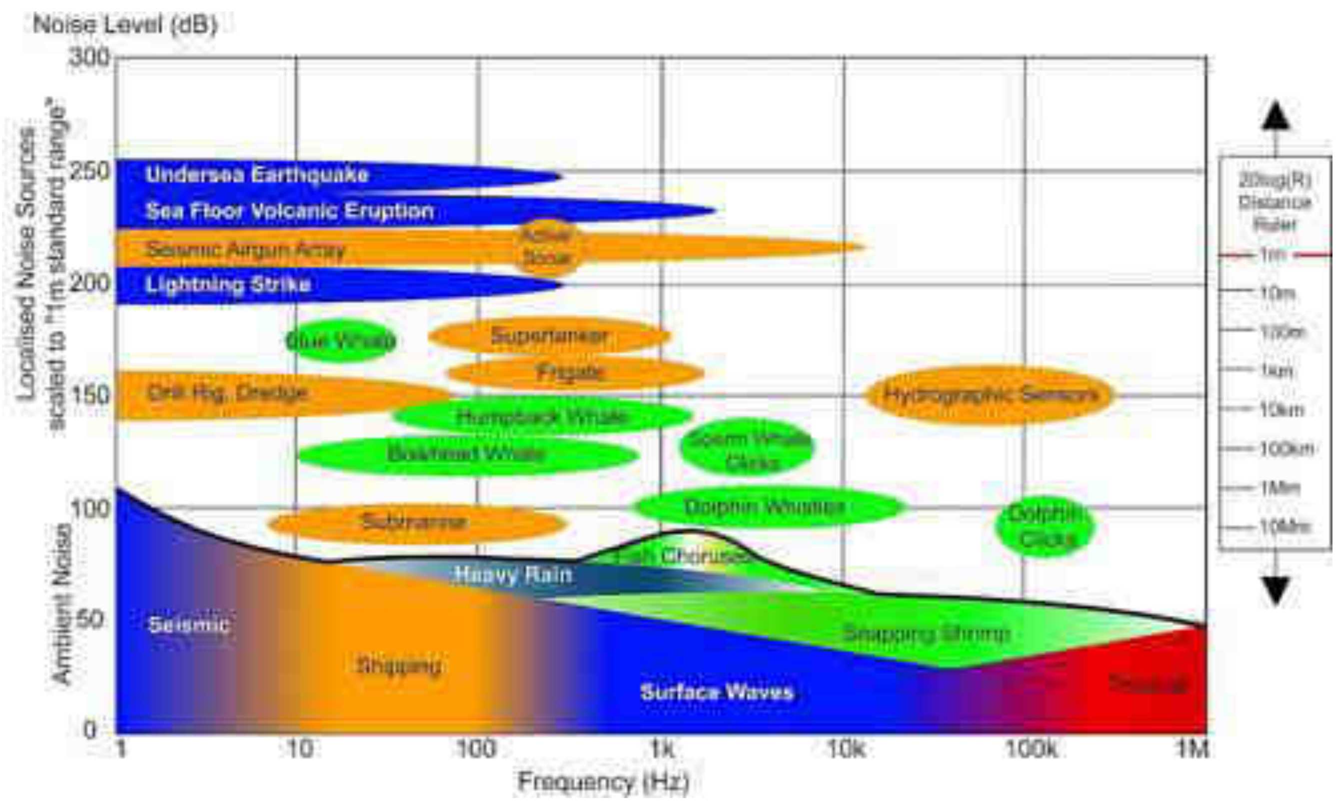


Figure 5-56: Noise level and frequency of sound in the marine environment (100)

Study Approach

The aims of the study were to determine a baseline of underwater noise in the project location including both natural and anthropogenic sounds (soundscape) and for Passive Acoustic Monitoring (PAM) for Marine Mammals. The study focused on sound pressure in the water column.

Underwater noise measurements were collected at five locations at Route 1 on the 7th and 8th of April 2022 (see Figure 5-63 to Figure 5-65) in accordance with the Good Practice Guide No.133: Underwater Noise Measurement (96). A 60-minute recording was taken at each location during daytime (07:00 to 17:00). The equipment was deployed on a mooring system with the hydrophone positioned around mid-depth for each location which ranged from 5-10m depending on location and tide state. PAM was conducted to monitor for vocalising marine mammals. Observations of potential sources of noise were noted during each deployment. Data was analysed to provide information on the noise characteristics of each location as well as any biological sounds recorded.

Equipment used for the study was a TR-Porpoise acoustic recorder fitted with a calibrated Geospectrum M36-900 hydrophone. The device was set to record at a sampling rate of 96 KSPS and sensitivity of -154.4 dB re 1V/µPa. PAM was conducted using PAMGuard64 software, while the data was visualised into spectrograms on Raven Pro 2.0.3 and analysed in dBWav 1.3.4. The data was calibrated in the software using the known recording sensitivity (96).

Conditions on both days was calm with little to no wind as detailed as follows:

- On the 7th April:
  - wind speed was 3-6 mph during the morning (8 AM to 1 PM) and increased to a maximum of 14 mph by 4 PM (101);
  - the high tide was at 7:14am and the low tide was at 3:39pm;
- On the 8th April:
  - wind was between 3-5 mph in the morning and increased to 16mph by 3 PM in the afternoon (102);
  - high tide was at 7:54am low tide at 4:39pm (103).

Figure 5-57: DDV Survey Sites along Route 1 – Mirfa Landfall

Figure 5-58: BRUV locations along Route 1 – Mirfa Landfall

Figure 5-59: DDV Survey Sites along Route 2 – Shuweihat Landfall

Figure 5-60: BRUV Locations along Route 2 – Shuweihat Landfall

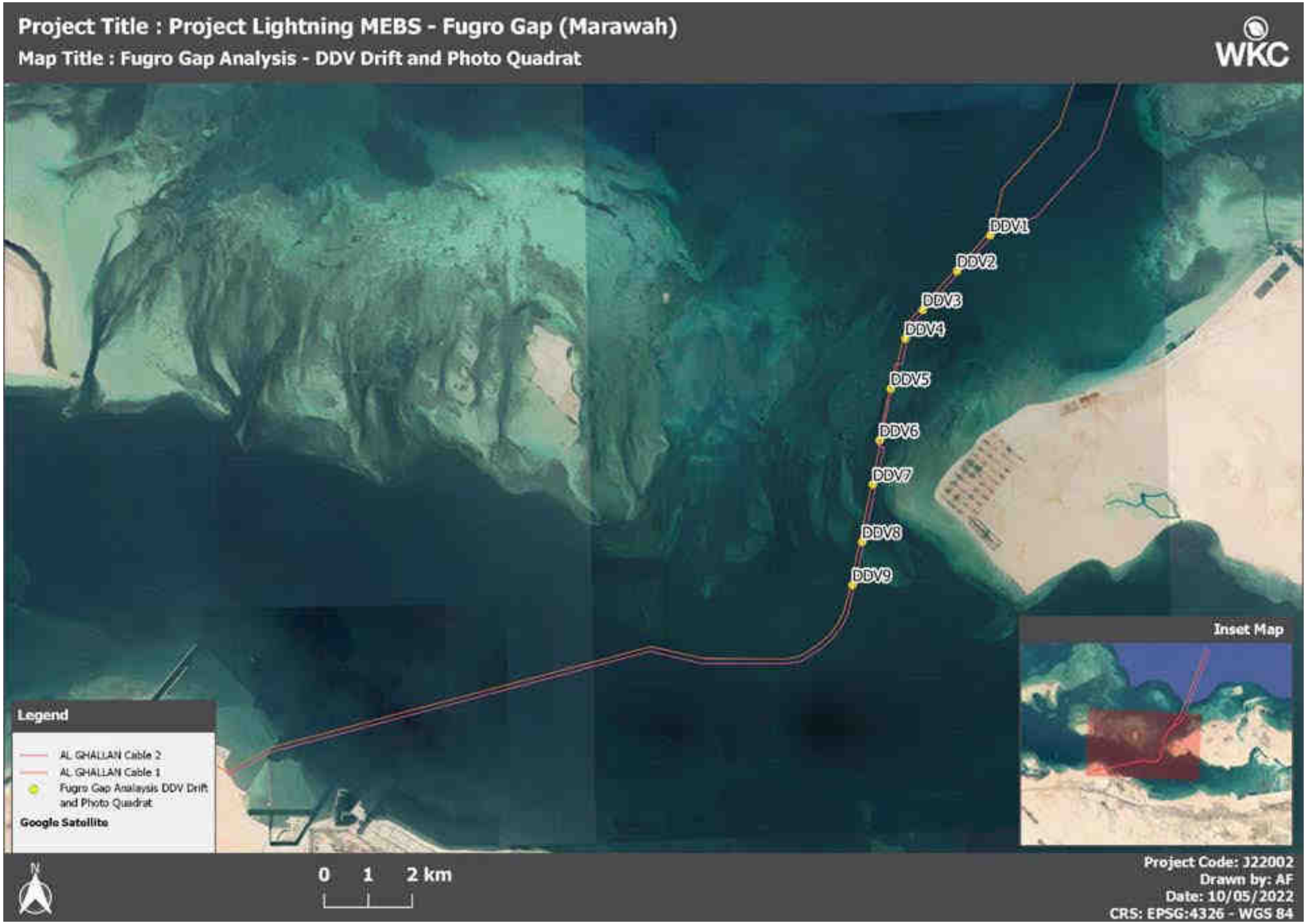


Figure 5-61: Sampling Locations along Route 1 – MMBR

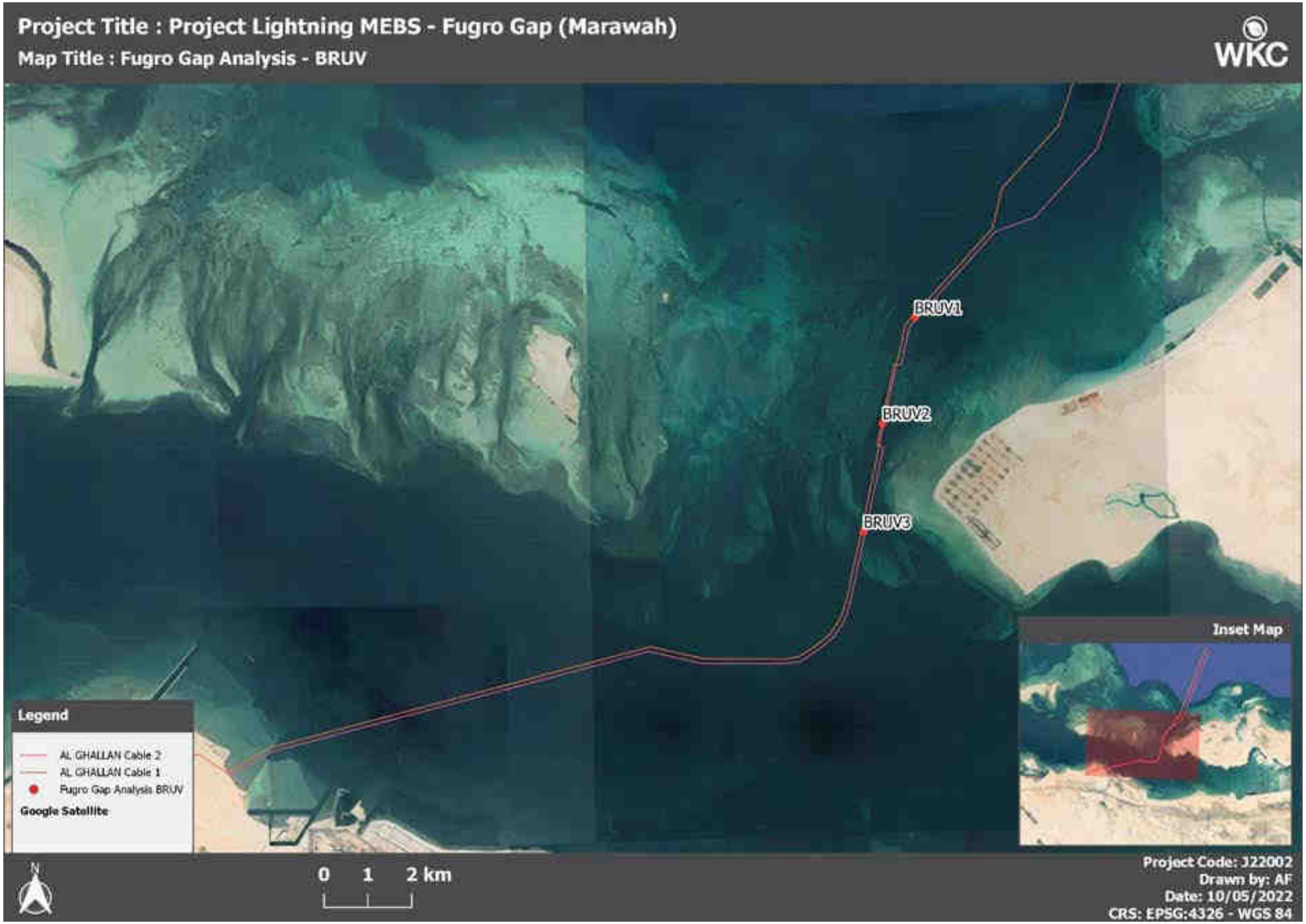


Figure 5-62: BRUV Locations along Route 1 – MMBR

Figure 5-63: Underwater noise monitoring along Route 2 –Shuweihat Landfall

Figure 5-64: Underwater noise monitoring along Route 1 (Mirfa Landfall)

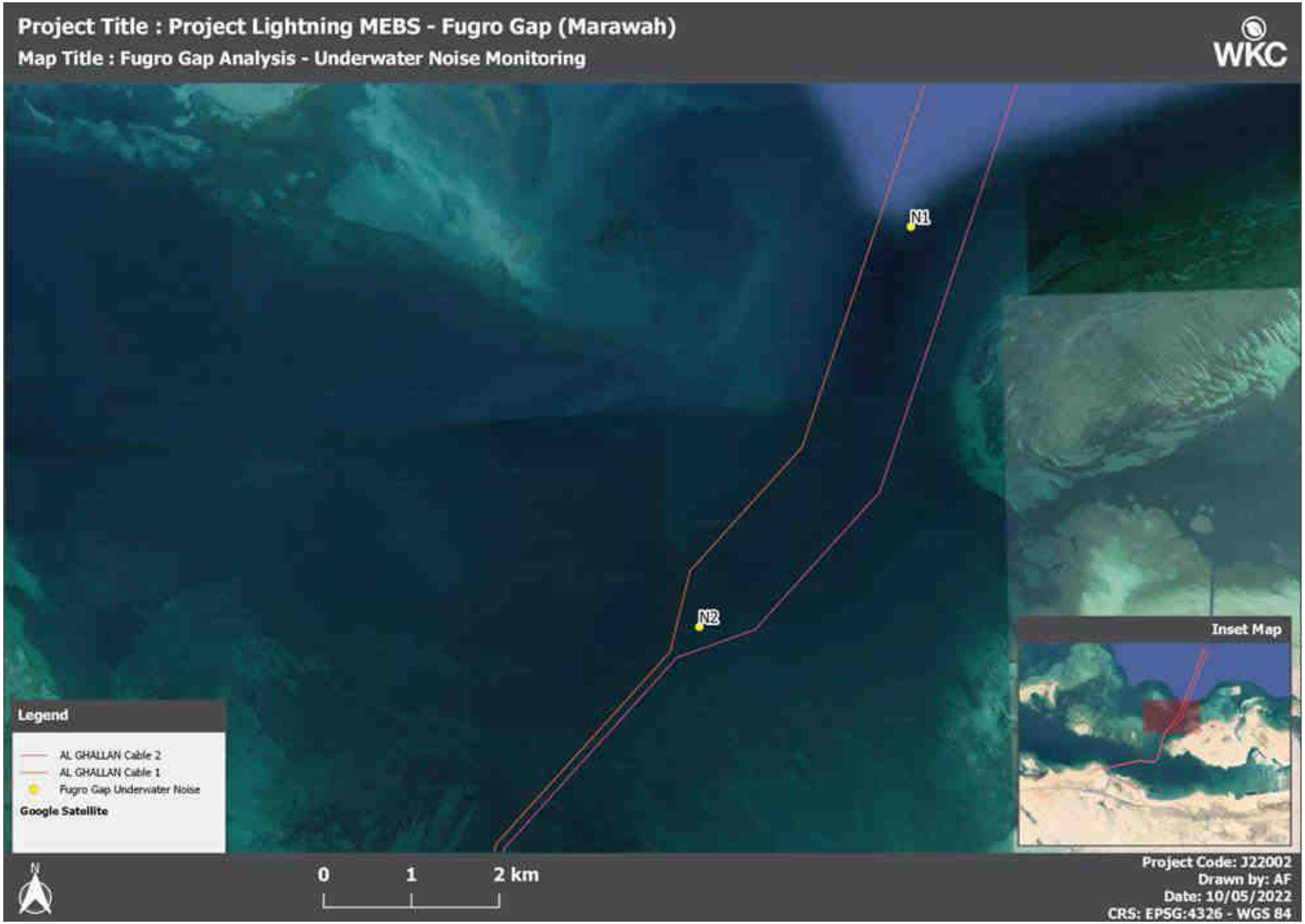


Figure 5-65: Underwater noise monitoring at supplemental sampling along Route 1 – MMBR

5.5.1.2. Baseline Conditions

5.5.1.2.1. Overview

The marine environment surrounding the Project site comprises an extensive seabed with mixed habitat of seagrass, corals, hard-bottom and sandy bottom with exposed intertidal area during low tide void of any vegetation. In some areas, bivalve and algal beds are present. There are also intermixed zones of seagrass and algae recorded. Portions of the Route 1 had dredged seabed with a pronounced dredged wall colonised by invertebrates and corals with aggregations of multiple species of reef associated fishes. The shoreline on the landfall side is generally composed of fine to coarse sandy beach. There are mangroves stands close to Route 1 at Mirfa and within the footprint of Route 2 at Shuweihat. Mangroves have been assessed in detail within the terrestrial ecology chapter in **Section 5.6.**

Macro-algae recorded during the surveys predominantly comprise of *Padina boergeseni* and *Avrainvillea amadelpha* and sargassum species. Seagrasses recorded in the survey area were represented by three different species, *Halodule uninervis, Halophila stipulacea,* and *Halophila ovalis*, sometimes occurring together in mixed beds. These species are typically the dominant species found in the Arabian Gulf.

Seagrass contributes to the oxygenation of seawater and provides a food source for a number of species, including Dugong, turtles and juveniles of many commercially important fish species. Seagrass also plays a significant role in the stabilisation of sediments and trapping of organic particulates.

Marine epibenthic fauna identified in the Project vicinity are noted to be generally broad and sporadic and comprised a mix of sponges, molluscs, invertebrates and species that comprise fouling communities.

Locally, coral reef habitats are recorded in the Shuweihat coastal areas forming reefs and solitary colonies growing on hard-bottom seabed at Route 1 and Route 2. Species of coral recorded included *Favia* spp and *Porites* spp among others.

Five species of turtles have been recorded in the waters of the UAE. These are the Hawksbill (*Eretmochelys imbricata*), Green (*Chelonia mydas*), Loggerhead (*Caretta caretta*), Olive Ridley (*Lepidochelys olivacea*) and Leatherback (*Dermochelys coriacea*). The two predominant turtle species typically recorded are Hawksbills and Green Turtles. These two species are known to nest within the UAE. The Hawksbill turtle (*Eretmochelys imbricata*) is recorded on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species as ‘critically endangered’ while the Green turtle is classified as ‘endangered’. Both species were recorded to be present in the area but Route 1 – Mirfa was observed to have high population of these species.

Indo-Pacific humpback dolphin (*Sousa plumbea*) and Indo-Pacific bottlenose dolphins (*Tursiops sp.*) are known to be present in the area. Historic sightings of dugongs (*Dugong dugon*), which are considered vulnerable by IUCN and protected by EAD, have also been noted utilising the habitat as evidence of grazing tracks are seen on seagrass beds and actual sighting of the species. Dugongs, dolphins, and porpoises in the area are assessed in previous studies to be resident species within the MMBR. Large vertebrates like sharks and rays were also observed during the surveys.

5.5.1.2.2. Fugro Baseline Survey Results

Route 1

This section provides a summary of a MEBS undertaken by Fugro on behalf of ADNOC. These data have been supplied by ADNOC to Anthesis specifically for the Project and the results are summarised below.

With reference to the Marine Life of the Emirate of Abu Dhabi (MLEAD) (92) and Environment Agency – Abu Dhabi habitat classifications (93), a total of three distinct marine habitats were identified during the transect surveys distributed throughout the Route 1 areas. The habitats observed across the survey area were classified as follows:

- ‘Sublittoral mixed deposit’ (SLMXD)/"13,000 - Hard Bottom";
- ‘Sublittoral sand deposit’ (SLSED)/"14,000 - Unconsolidated Bottom”; and
- ‘Seagrass bed’ (SLSED)/"‘12,000 seagrass bed".

The location of transects and habitats identified are illustrated in Figure 5-66 and Figure 5-67 below.

‘Sublittoral mixed deposit’ (SLMXD)/“13,000 - Hard bottom” habitat comprised mainly flat substratum of calcarenite (cemented sand), covered by a veneer of sand sediment, with occasional coral outcrops mainly including finger corals (*Porites sp*.) and boulder corals (*Faviidae*);

‘Sublittoral sediment’ (SLSED)/“14,000 – Unconsolidated bottom” habitat comprised predominantly of sand sediment, with varying proportions of gravel and shell and coral fragments.

‘Seagrass bed’/“12,000 - Seagrass bed” habitat comprised predominantly of sand sediment, colonised by varying densities of the seagrasses including *Halodule uninervis*, *Halophila ovalis* and *Halophila stipulacea*.

Sessile epifauna identified included the following:

- Sponges (Porifera);
- Ascidians (*Phallusia nigra*, Didemnum sp.);
- Faunal turf (Bryozoa/Hydrozoa);
- Hydroids (Hydrozoa);
- Sea cucumber (Holothuroidea);
- Shells (Bivalvia);
- Fanshell (*Pinna muricata*);
- Pearl oyster (Pinctada sp.); and
- Hammer oysters (Malleus sp.).
- Mobile epifauna included the following:
- Snails (Gastropoda);
- Cone shells (Conidae);
- Sea urchins (Echinoidea including *Echinometra mathei);*
- Long spined sea urchins (*Diadema setosum*);
- Sand dollar (Clypeasteroidea sp);
- Pencil urchins (*Phyllacanthus imperialis*);
- Starfish (Asteroidea including Linckia sp., *Astropecten polyacanthusphragmorus*), brittlestars (Ophiuroidea including possible Ophiothela sp.);
- Hermit crabs (Paguroidea);
- Crabs (Decapoda) including decorator crab (Majoidea); and
- Shrimps (Caridea).

Some seaweeds and algal turf, including peacock weed (*Padina boergesenii*) and coralline algae (*Corallinales*), were occasionally observed across the survey area.

Fish fauna was diverse and included, yellowband angel fish (*Pomacanthus maculosus*), emperor fish (*Lethrinus sp.*) including the pink ear emperor fish (*Lethrinus lentjan*), snapper (*Lutjanus sp*.) including blackspot snapper

(*Lutjanus fulviflamma*), orange spot grouper (*Epinephelus coioides*), doublebar bream (*Acanthopagrus bifasciatus*), Arabian monocle bream (*Scolopsis ghanam*), black-streaked monocle bream (*Scolopsis taeniatus*), anchovies (*Clupeiformes*), cardinal fish (*Apogonidae*), and goby (*Gobiidae*).

Route 2

As with the Route 1 above, the surveyed areas within Route 2 comprises of three distinct marine habitats including the following habitats:

- ‘Sublittoral mixed deposit’ (SLMXD)/"13,000 - Hard Bottom";
- ‘Sublittoral sand deposit’ (SLSED)/"14,000 - Unconsolidated Bottom”; and
- ‘Seagrass bed’ (SLSED)/"‘12,000 seagrass bed".

The location of transects and habitats identified are illustrated in Figure 5-68 to Figure 5-70 below.

‘Sublittoral mixed deposit’ (SLMXD)/"13,000 - Hard Bottom" comprised mainly of flat substratum of calcarenite (cemented sand) with occasional coral outcrops including finger corals (*Porites* sp.), boulder corals (*Coscinaraeidae* and *Faviidae*), plate corals (*Turbinaria sp*.), dead boulder corals and shell beds of pearl oysters (*Pinctada* sp.). The calcarenite was generally covered by a veneer of sand sediment.

‘Sublittoral sand deposit’ (SLSED)/"14,000 - Unconsolidated Bottom” comprised mainly flat substratum of sand and gravelly sand with occasional shell deposits and coral rubble fragments.

‘Seagrass bed’/"‘12,000 seagrass bed" comprised mainly flat substratum of sand and gravelly sand with occasional shell deposits and coral rubble fragments. Seagrasses (i.e., *Halophila ovalis* and *Halophila stipulacea*) were present in moderate abundance.

Associated with the corals within this habitat were sessile epifauna of encrusting and branching sponges (*Porifera*) and ascidians (*Tunicata* including *Phallusia nigra* and possibly *Didemnum* sp.).

Shell beds (*Bivalvia*) included largely pearl oysters (*Pinctada sp*.), but hammer oysters (*Malleus sp*.) were also occasionally observed. Hydroids (*Hydrozoa*), coralline algae (*Corallinales*), peacock weed (*Padina boergesenil*), macroalgae, algal turf (*Chlorophyta*) were also present.

Errant invertebrates included brittlestars (*Ophiotela sp*.), sea urchins (*Echinometra mathei*), long-spined sea urchins (*Diadema sp*.), conid shells (*Conidae*) and dorid nudibranchs (*Nudibranchia*), sand dollar (Clypeasteroidea), worm tubes (Polychaeta), dorid nudibranchs (Nudibranchia) and hermit crabs (Paguridoidea).

Fish recorded on site during the surveys included yellowstripe scad (*Selaroides leptolepis*), sordid rubberlip (*Plectorhinchus sordidus*), yellow spotted trevally (*Carangoides fulvoguttatus*), Arabian monocle bream (*Scolopsis ghanam*), yellow fin hind (*Cephalopholis hemistiktos*), cardinal fish (*Apogonidae*), yellowbar angelfish (*Pomacanthus sp*.), and pearly goatfish (*Parupeneus margaritatus*). Gobies (*Gobiidae* including *Cryptocentrus sp* and *Valenciennea sp*.) were sporadically observed in this habitat.

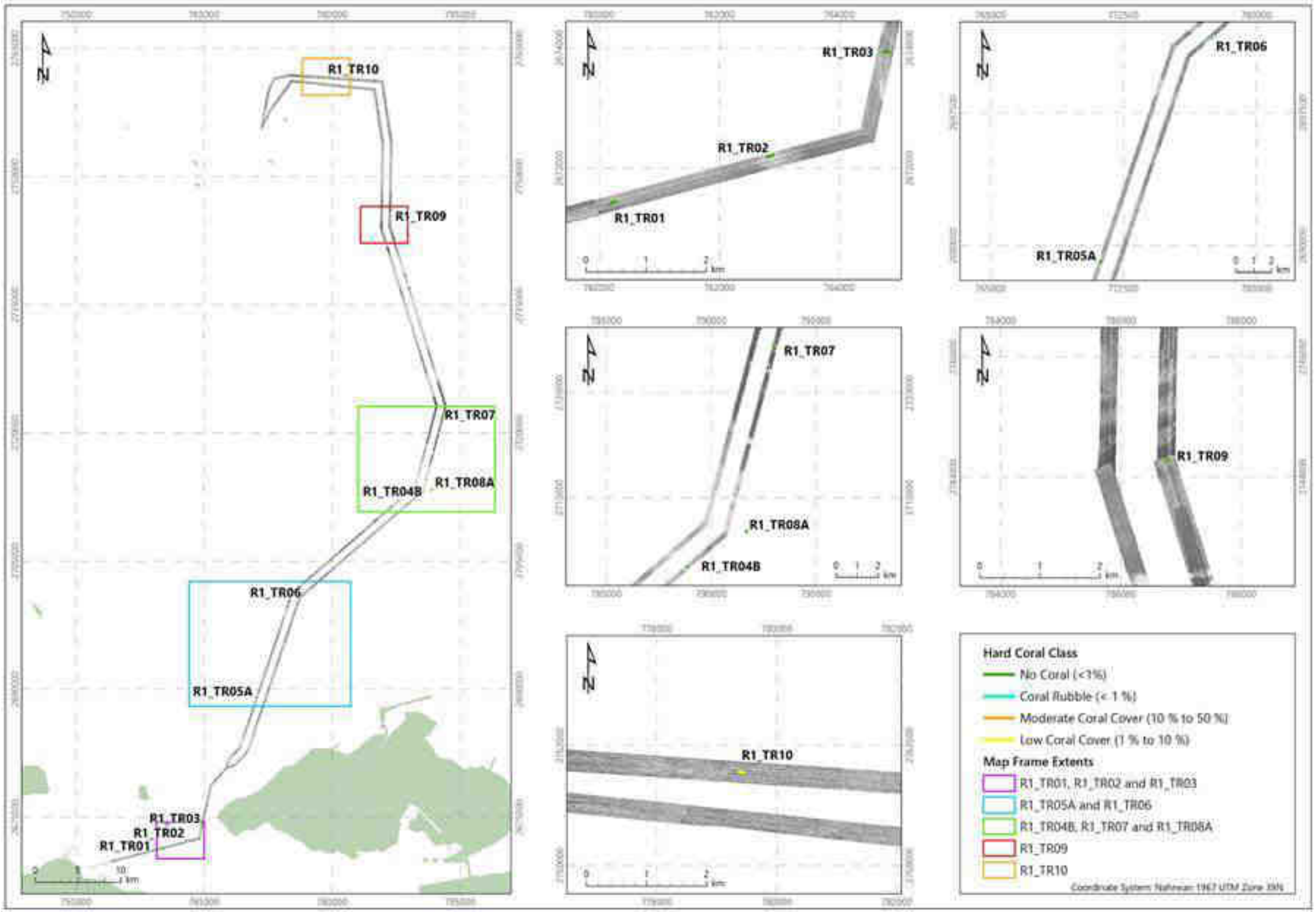


Figure 5-66: Completed environmental transects showing hard coral assessment results along Route 1 (65)

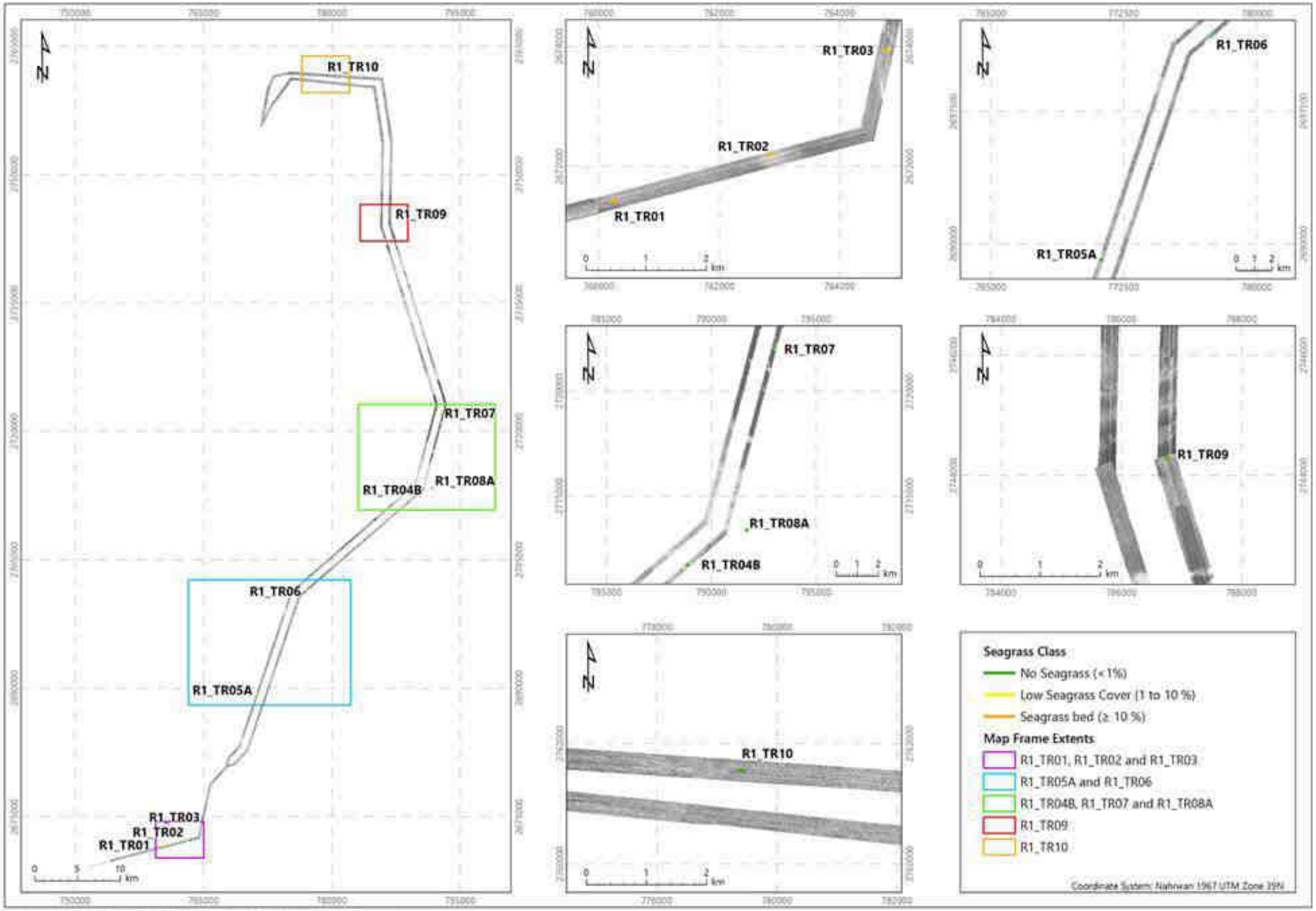


Figure 5-67: Completed environmental transects showing seagrass assessment results along Route 1 (65)

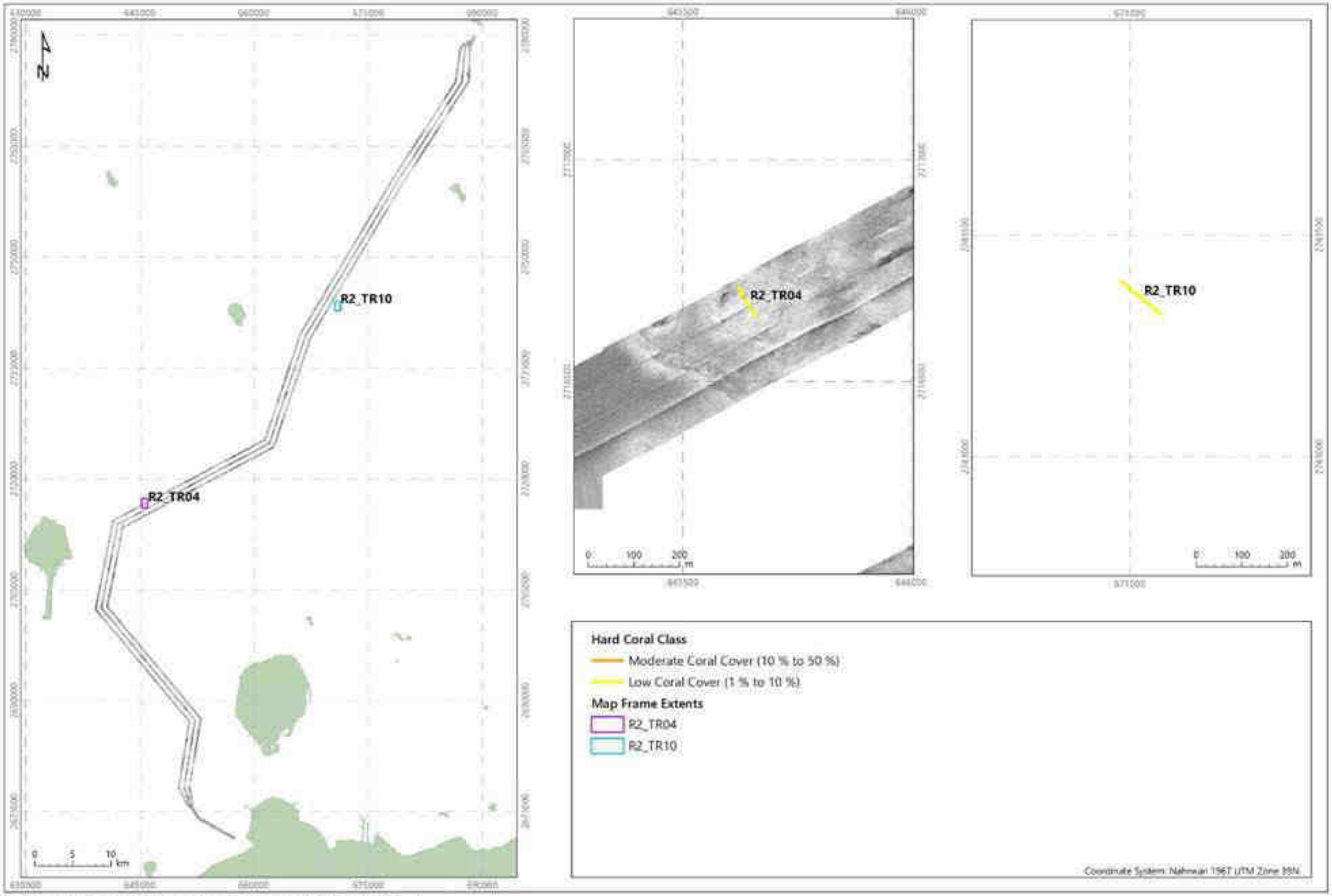


Figure 5-68: Completed transects showing hard coral assessment results along Route 2 (64)

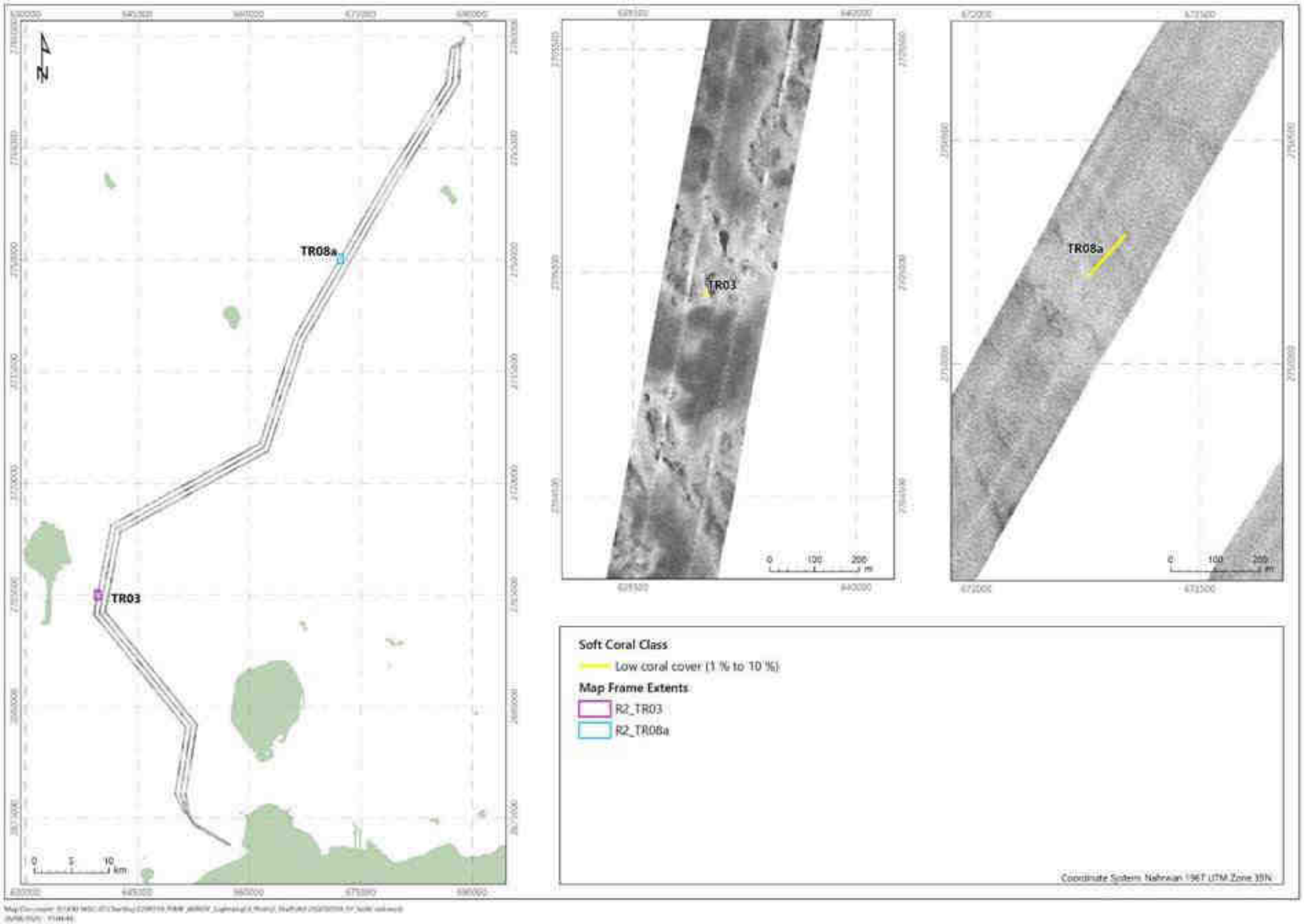


Figure 5-69: Completed transects showing soft coral assessment results along Route 2 (64)

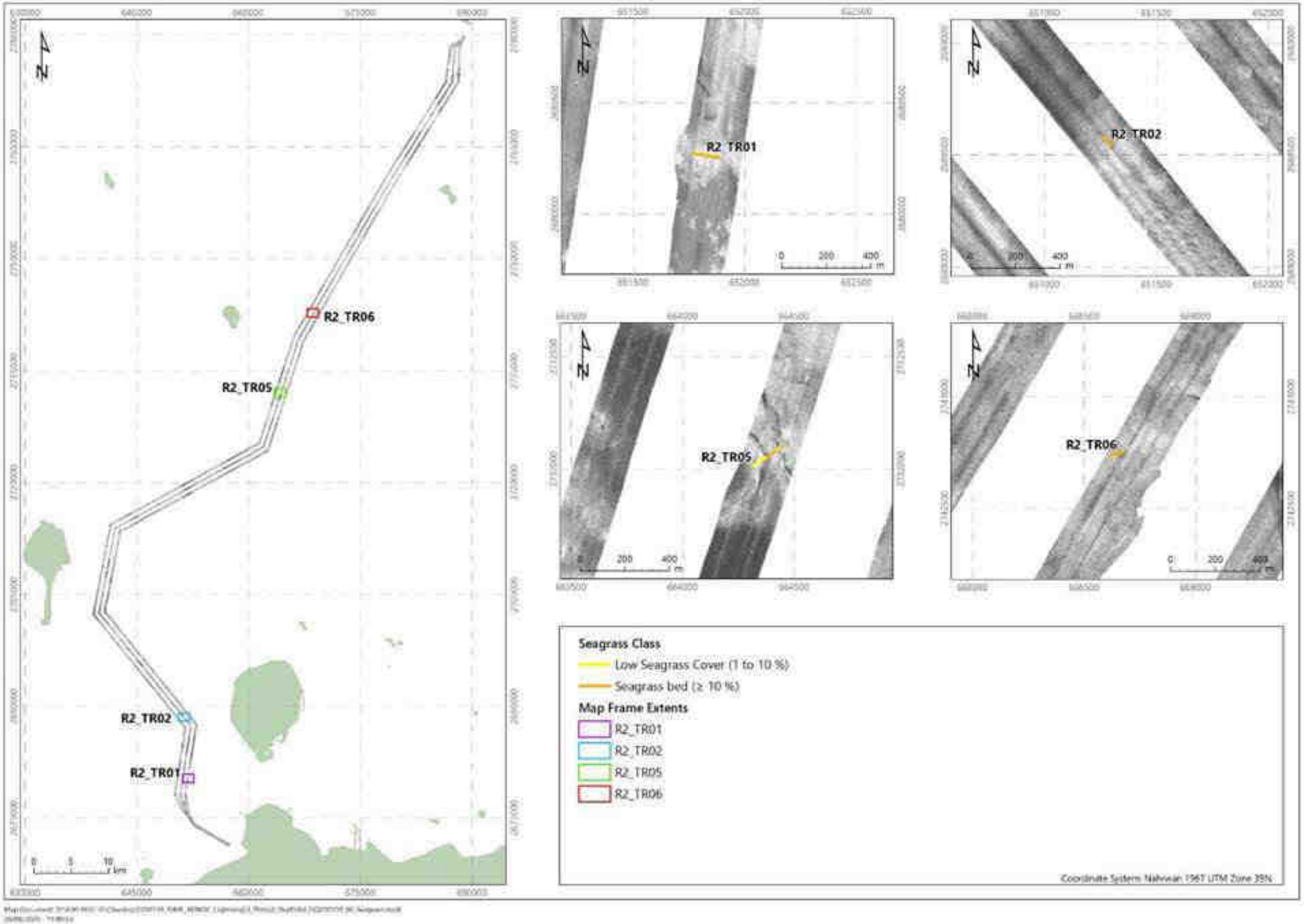


Figure 5-70: Completed environmental transects showing seagrass assessment results along Route 2 (64)

5.5.1.2.3. WKC Marine Ecology Baseline Survey Results

This section provides supplemental information on the marine ecological environment surrounding the Project areas within both Route 1 and Route 2 including the nearshore landfall areas, focusing on habitats and species which are known to exist in the area.

Route 1 – Mirfa Landfall

Benthic Habitat

The marine habitats identified across the study area were classified using the Environment Agency Abu Dhabi (EAD) Habitat Classification (104) and Marine Ecological Classification Standard (CMREC) Scheme. Based on the results of the marine ecology surveys, five core habitat types are present in the survey area which includes the following:

- Unconsolidated Bottom: 14000;
- Hard Bottom:13000;
- Dredged Seabed: 16100;
- Seagrass Bed: 12000; and
- Macroalgae communities: 13010.

The distribution of different habitats within the entire Route 1 (that is, up to the assessment area coverage) is provided in Figure 5-71 and the habitat map at the Route 1 - Mirfa Landfall and surrounding areas is shown in Figure 5-72. Specific DDV photo captures for the different benthic habitats found during marine ecology surveys are presented in Figure 5-73 to Figure 5-80.

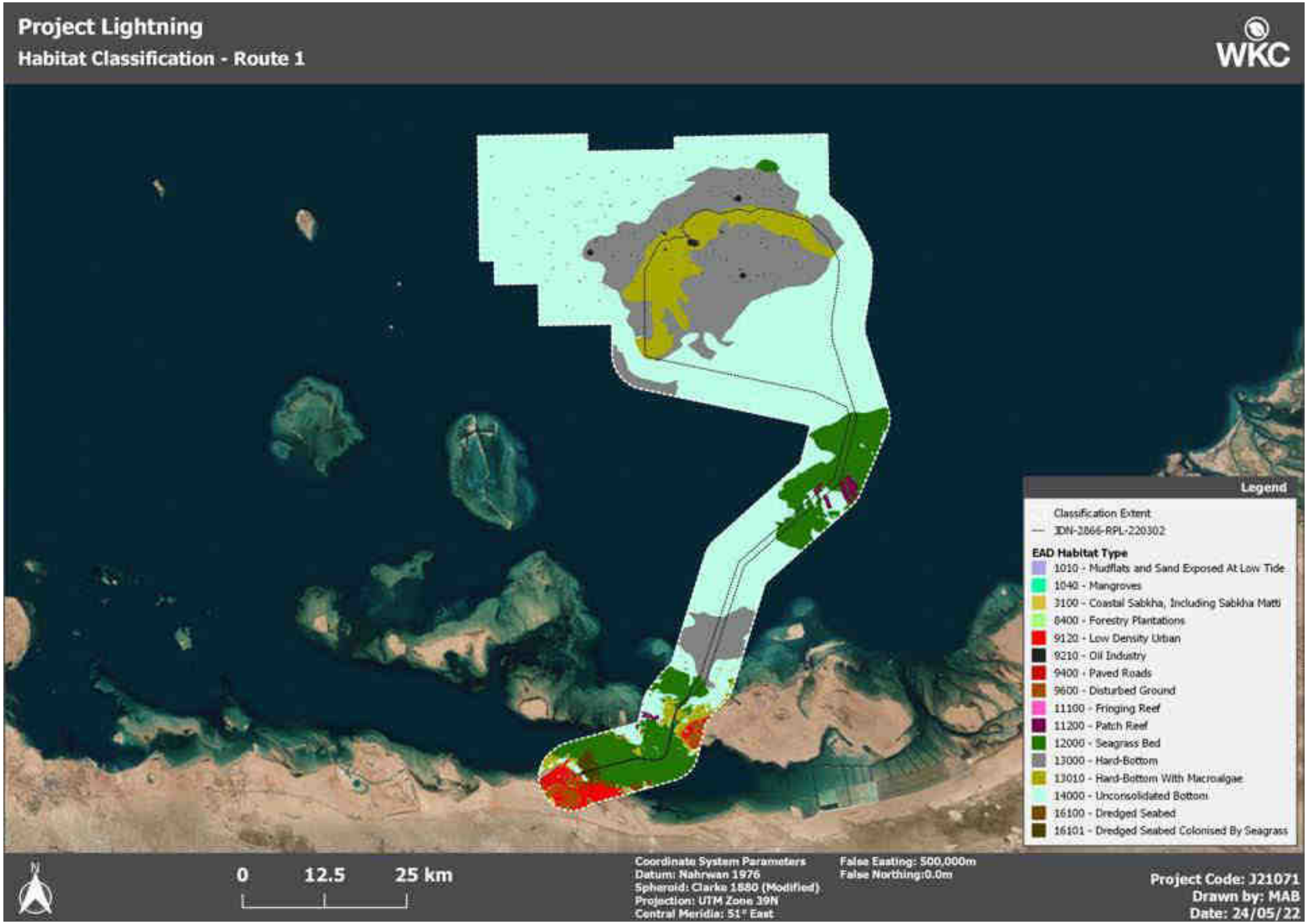


Figure 5-71: Overall habitat map along Route 1

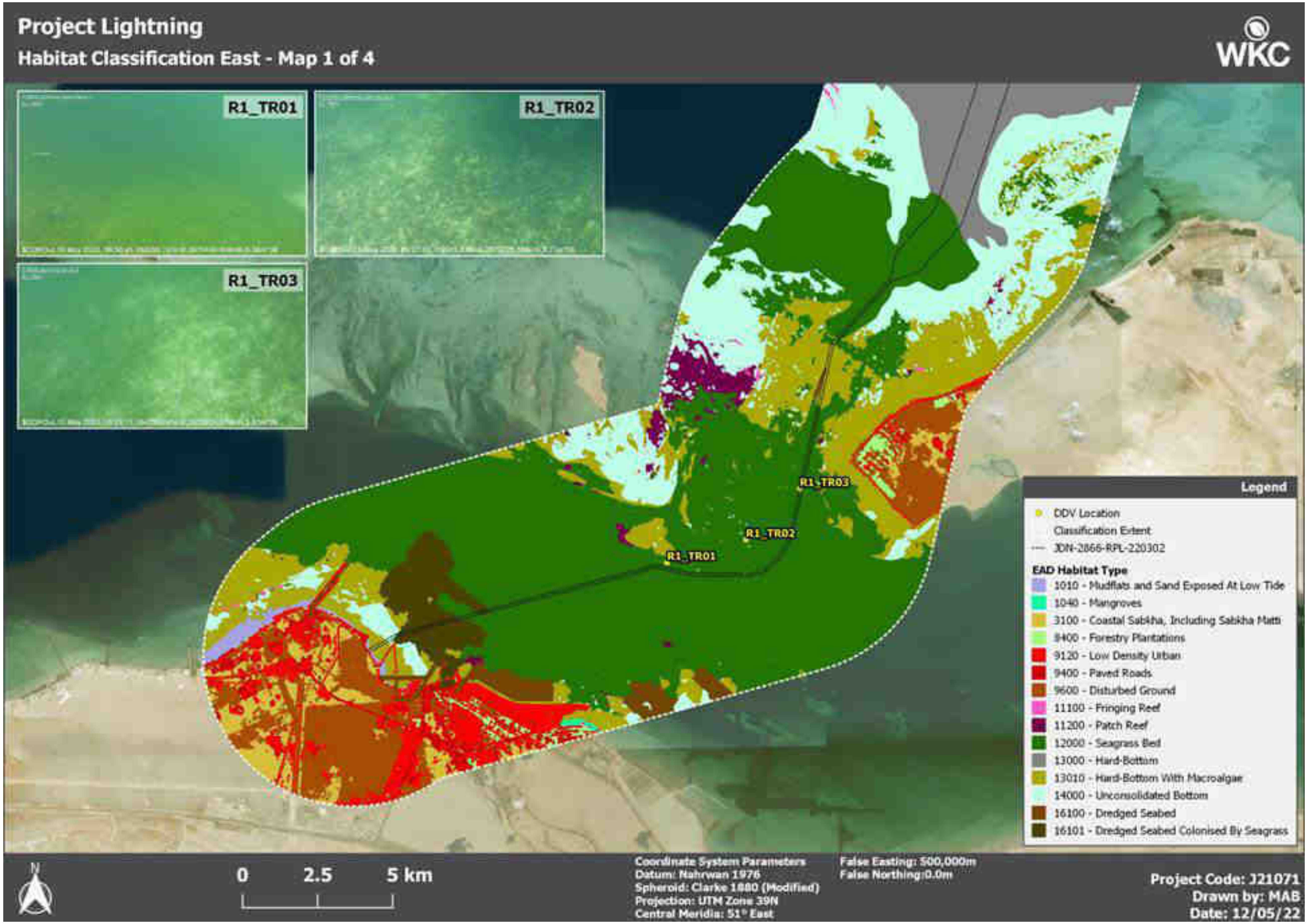


Figure 5-72: Habitat map along Route 1 – Mirfa Landfall

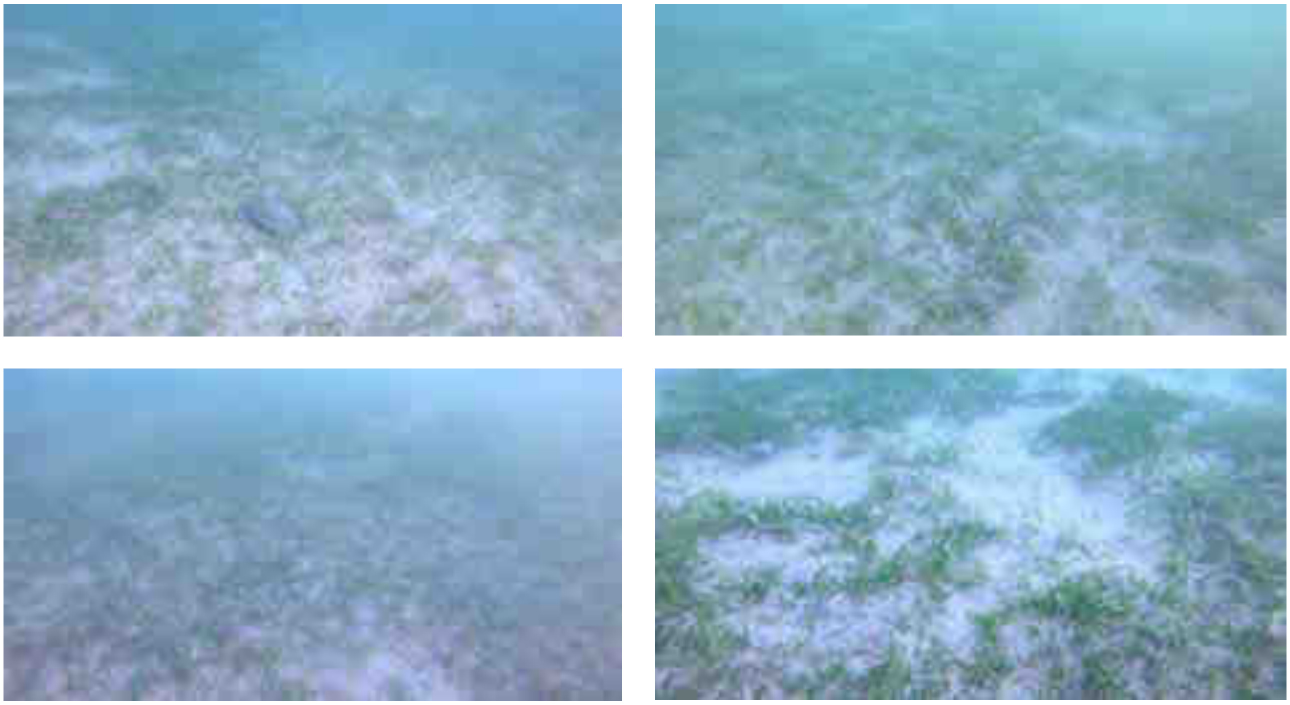


Figure 5-73: Benthic habitat along Route 1 – Mirfa Landfall (DDV1)

Figure 5-74: Benthic habitat along Route 1 – Mirfa Landfall (DDV2)

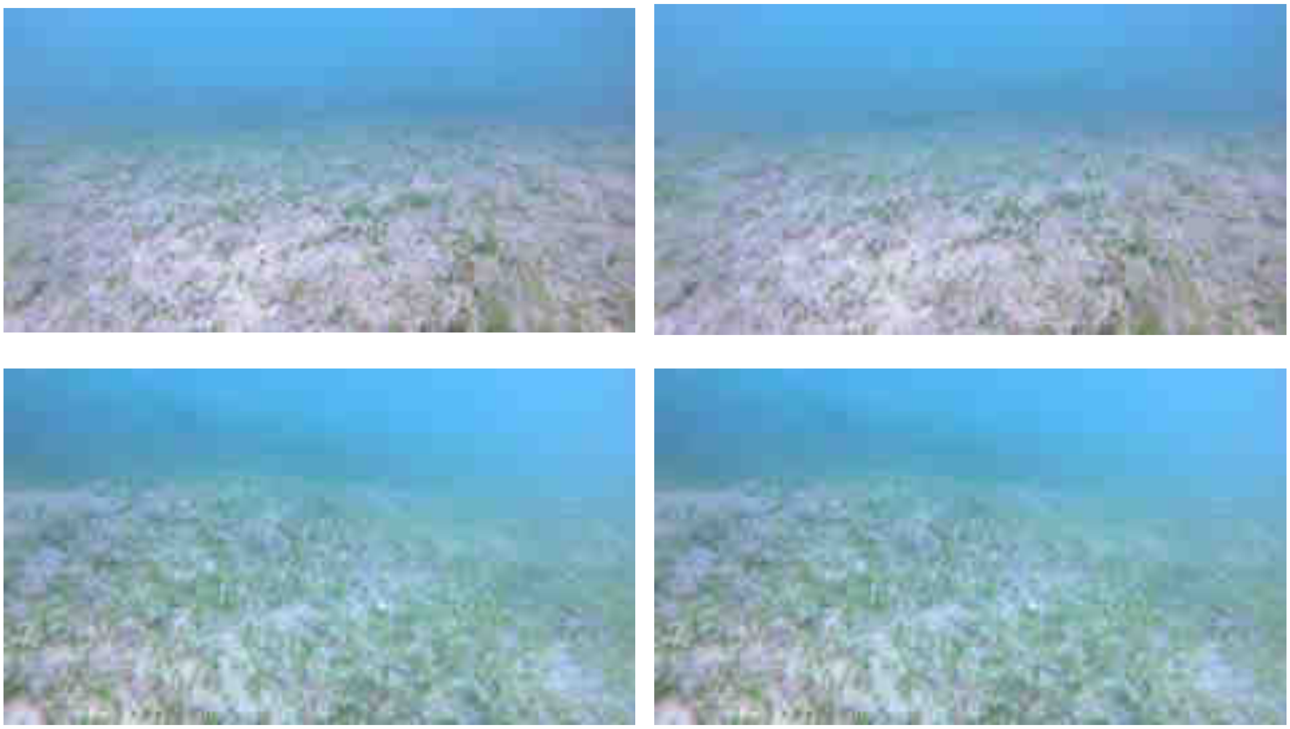


Figure 5-75: Benthic habitat along Route 1 – Mirfa Landfall (DDV3)

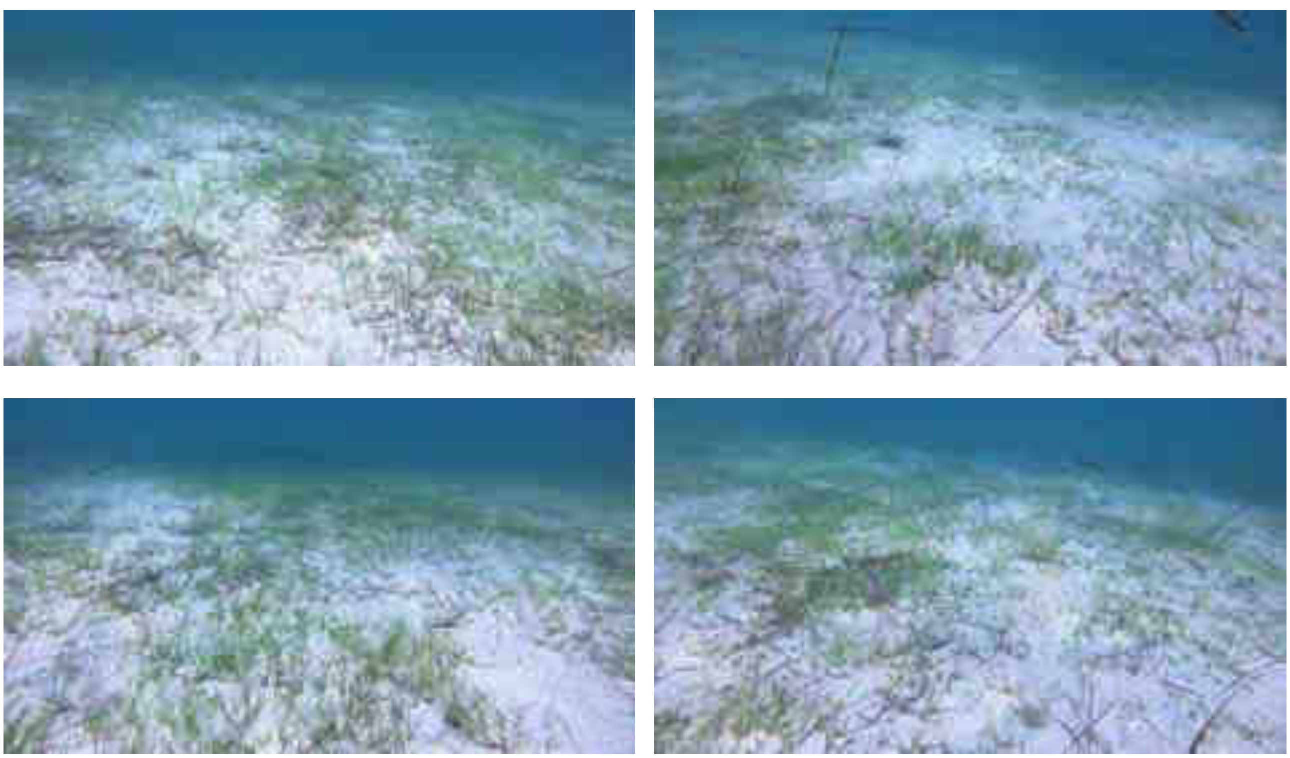


Figure 5-76: Benthic habitat along Route 1 – Mirfa Landfall (DDV4)

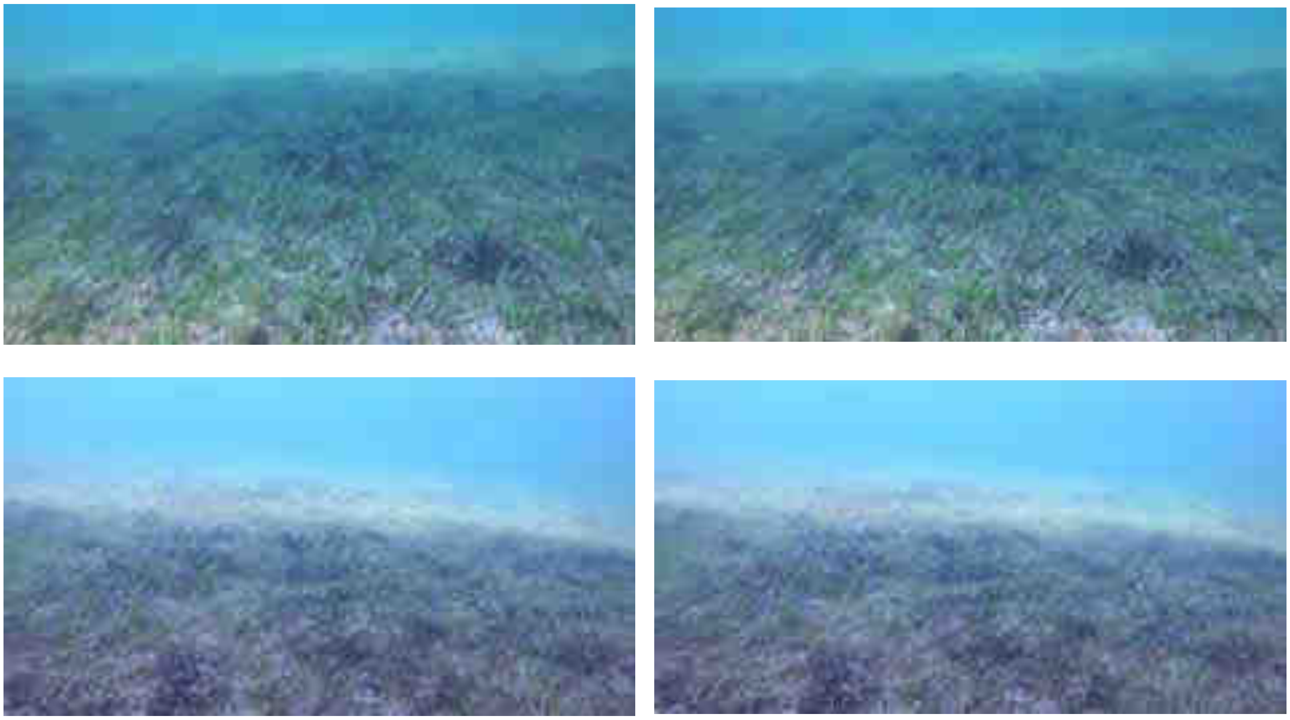


Figure 5-77: Benthic habitat along Route 1 – Mirfa Landfall (DDV5)

Figure 5-78: Benthic habitat along Route 1 – Mirfa Landfall (DDV6)

Figure 5-79: Benthic habitat along Route 1 – Mirfa Landfall (DDV7)

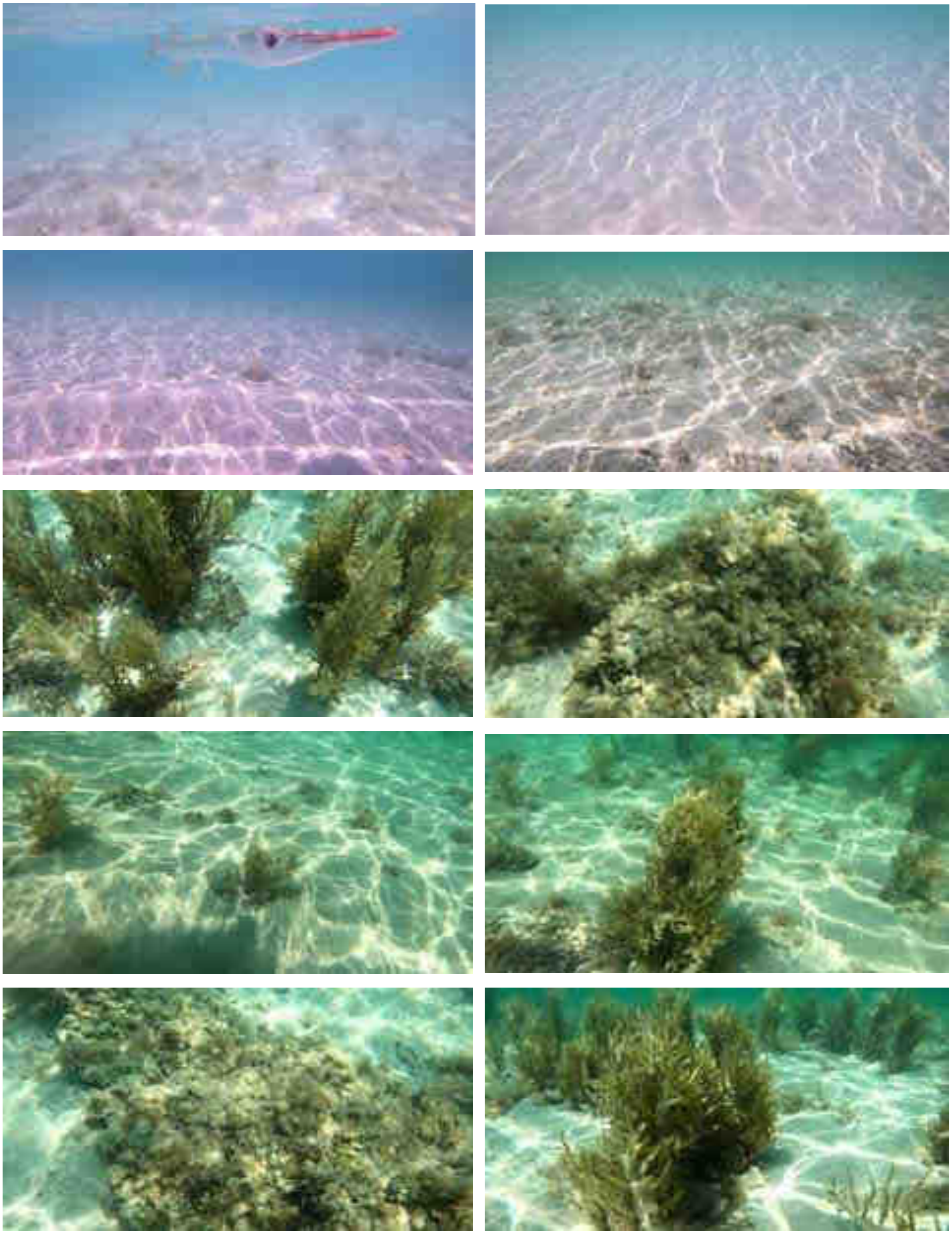


Figure 5-80: Benthic habitat along Route 1 – Mirfa Landfall (Towed Transect)

Based on the assessment of the captured still images, the characteristic benthic habitats found throughout the surveyed areas include mostly seagrass, seagrass with macro-algae, and sandy areas as detailed in Table 5-48. These habitat types including associated flora and fauna are further discussed in the following sections.

Table 5-48: Benthic habitat along Route 1 – Mirfa Landfall from analysed photoquadrats

Photo Quadrat Number	Seagrass (%)	Sand (%)	Hardbottom (%)	Rubble and Shells (%)	Macro Algae (%)	Total (%)
PQ1	100	0	0	0	0	100
PQ2	100	0	0	0	0	100
PQ3	100	0	0	0	0	100
PQ4	93.7	0	0	0	6.3	100
PQ5	100	0	0	0	0	100
PQ6	100	0	0	0	0	100
PQ7	0	100	0	0	0	100

Unconsolidated Bottom

The unconsolidated bottom habitat at nearshore shallow areas is characterized by fine sand to sandy sediments. In areas where isolated hardbottom is available it was noted that growth of macro algae (e.g. *Sargassum* sp.) and fouling epiphytic organisms was present (Figure 5-81). These open areas of sand are sometimes defined and not heavily colonised by seagrass or algae largely due to wave movement that is demonstrated by ripple patterns in the sand.

These areas contain a lower abundance of marine life as fish and invertebrates prefer the more productive and sheltered environment provided by nearby seagrass and macroalgae beds. There were no subsea exposed hardbottom substrate or corals in the area surveyed. However, pelagic fishes and large vertebrates such as turtles and rays may be seen in these habitats as they move between their foraging areas.

Figure 5-81: Unconsolidated bottom (sandy)

Hard Bottom

The area found to have extensive hardbottom substrate is located on the east side of the channel between Salahah island and Al Jirab island. The hard bottom benthic characteristics shows extensive cover of molluscan bivalves and other fouling species. The habitat is terminated on the west by a dredge channel and a dredge wall, with heavy colonies of bivalves. With a feature like this, it is possible that small coral colonies might be present but no extensive corals were found other than old dead reef structures.

Dredged Seabed

A dredged channel is located at the end of the towed transect, extending to a wider area which is assumed to be a borrow area rather than a planned navigational channel. The extent of this dredged bed is shown in the habitat map developed for the area (see Figure 5-72). The seabed comprising of fine silt to mud is colonised by seagrasses mixed with macroalgae. The dredged seabed is low-lying compared to the surrounding undredged areas which may become sediment traps accumulating mainly fine sands. Where this occurs, whilst dredging activities are typically known to remove a layer of deposits which constitutes a habitat for benthic organisms that may result in general reduction of biomass in marine ecosystems, such occurrence may also be considered to provide a distinct opportunity for other marine communities to colonise and use.

Seagrass Beds

Seagrasses are well represented throughout the survey area. Seagrass habitats ranged from dense seagrass meadows, see Figure 5-82, to sparse seagrass patches (see Figure 5-73 to Figure 5-80). It should be noted that the seagrass meadows in the surveyed areas are dense, healthy, and very extensive. For the sparse seagrass growths observed in the area, given favourable conditions, such assemblages can quickly develop and establish seagrass beds. Seagrasses are important as these habitats are considered ecosystem engineers, due to their ability to modify the existing unconsolidated bottom into a distinct habitat. Apart from this, seagrass are important habitats for foraging wildlife. During the survey, grazing marks of dugong were noted providing evidence that the area is used by this important threatened (i.e., Vulnerable in both the Abu Dhabi (105) and the IUCN Red Lists (106)) species as a foraging ground. In addition, the frequent recordings of sea turtles (through DDVs, BRUVs and incidental sightings) were recorded in this area further indicating the importance of the seagrass habitat in this area in supporting species of conservation importance both nationally and internationally.

There were three species of seagrasses identified in the area, which includes *Halophila stipulacea*, *Halophila ovalis* and *Halodule uninervis*. These species are adept at colonising areas of unconsolidated bottom due to fast propagation rates and tolerance to varying environmental conditions.

Figure 5-82: Seagrass bed, *Halodule uninervis*

Seagrasses not only provide important foraging areas for marine wildlife as the sediments trapped within the seagrass beds are also known to support a greater diversity and abundance of benthic fauna, much greater than what open sand substrates are able to support (107). This includes many commercially important species such as fish, shrimps, and oysters which utilise seagrass beds as nursery and foraging grounds.

As seagrass expands, it creates an environment that is more productive and more habitable thus encouraging more diverse marine life. Seagrasses also provide a variety of ecosystem functions. The rhizome and root system of a seagrass bed stabilises loose sediment and organic materials. This leads to improved water clarity and reduced erosion. Furthermore, seagrasses are highly productive photosynthetic plants and as such, they contribute significant amounts of oxygen that become available for consumption by other marine life.

Seagrasses are also known to sequester carbon and are thus effective in storing blue carbon, which has become increasingly prevalent in discussions on climate change mitigation. Through the process of photosynthesis, seagrasses sequester large amounts of atmospheric carbon dioxide that is ultimately stored in the sediment. Due to their wide distribution, seagrasses are the largest source of blue carbon storage in the UAE (108). Seagrass beds are considered more valuable as they encourage a greater diversity of marine organisms and provide more beneficial ecosystem services.

Macroalgae Communities

Significant macroalgae communities was observed in several areas within the survey sites, comprising of a mono species bed or mixed with of unconsolidated bottom structures and seagrass beds. An example of macroalgae meadow at the survey area is presented in Figure 5-83. This macroalgae community covers a wide area and contains many large macroalgae plants including a variety of species mainly from the groups Chlorophyta (green algae) and Phaeophycean (brown algae).

Macroalgae are more tolerant of pollutants and compete with seagrass for space and resources. Macroalgae meadow play a similar ecological role as seagrasses in that they provide shelter and foraging opportunities for marine creatures. However, unlike seagrasses, macroalgae are less effective at stabilising sediments and storing carbon (109).

Figure 5-83: *Sargassum* sp.

Dredged Wall

Dredging typically produces deep, flat area of seabed bordered by an often steep sided slope (dredged wall) up to the original depth (110) of which marine benthic formations are created. The dredged wall can be vertical or rapidly inclining in orientation. Although not particularly ecologically valuable habitat when initially created, through time these walls support a rich and diverse species assemblage, mainly fouling community. As water currents move along these structures, scouring may happen creating crevices and crannies as well as exposing hard substrates. These hard structures undergo benthic community succession and could develop into a diverse habitat with sponges, corals, algae, bivalves, among others.

Oftentimes along this dredge wall is a diverse aggregation of reef associated fish species. An ecologically developed dredge wall can be a proxy to a coral reef since a rich biomimicry substrate formation can be achieved.

Benthic Community (Flora and Fauna)

Table 5-49 provides a summary of the habitats investigated for benthic communities through DDV. The various benthic flora and fauna species associated with the natural benthic substrates observed through the survey methods are further discussed in the following sections.

Table 5-49: Benthic community observations along Route 1 – Mirfa Landfall

Sampling Location	Seagrass	Macro-algae	Description
DDV1	X	X	Rich seagrass meadow
DDV2	X		Rich seagrass meadow
DDV3	X	X	Rich seagrass meadow
DDV4	X		Rich seagrass meadow
DDV5	X		Rich seagrass meadow
DDV6	X	X	Rich seagrass meadow

Sampling Location	Seagrass	Macro-algae	Description
DDV7	X		Rich seagrass meadow

Seagrasses

Three species of seagrass were identified in the Project Site, *Halophila stipulacea*, *Halophila ovalis* and *Halodule uninervis* whilst both species were widely distributed, *H. uninervis* appears to be the dominant species. These seagrasses are three species that are known to thrive in Arabian Gulf, largely due to the high salinity and high temperatures experienced (111). An example of seagrass meadow in the study area is presented in Figure 5-84.

Seagrass distribution is limited by sediment type, wave action, and light availability. *H. ovalis* and *H. uninervis* prefer soft sediments including sand and mud. The root system spreads throughout the sediment to anchor above ground shoots and leaves of the plant. As such, seagrasses prefer sheltered environments and cannot tolerate high wave energy. Light availability is influenced by depth and water clarity and is required by seagrass for photosynthesis. While these species are considered relatively hardy, they are sensitive to pollution and physical disturbances. Therefore, the presence of seagrass indicated stable marine conditions and high environmental quality (112).

Figure 5-84: Seagrass meadow with filamentous algae

H. stipulacea, H. ovalis and *H. uninervis* are widely distributed in tropical areas and are listed as Least Concern by the IUCN Red List. *H. ovalis* is characterised by a round leaf shape and is commonly known as spoon grass or paddle weed. *H. uninervis* is characterised by long, thin leaf blades like many terrestrial grasses. Both species are primary food sources for dugong and sea turtles (113).

Invertebrates

Various invertebrate species were observed in the rock wall area including sea urchins, gastropods, bivalves, sponges, and tunicates. In addition, burrows in seagrass beds provide evidence of invertebrate habitation, however, species identification was not possible in these areas. A summary of macroinvertebrates observed in the study area is provided in Table 5-50.

Table 5-50: List of invertebrates found along Route 1 – Mirfa Landfall

Common Name	Scientific Name
Collectors Sea Urchin	*Tripneustes sp.*
Long Spined Sea Urchin	*Diadema setosum*
Sponge	*Demospongiae*
Tunicate	*Phallusia nigra*
Sea Snail	*Cerithriidae sp.*
Pearl Oyster	*Pinctada radiata*

Sponges

Sponges are the simplest multi-cellular organism in the animal kingdom. Despite their simplicity, they are very diverse in size, structure, and colour. Sponges can be found in all marine environments with many species associated with coral reefs. Their primary functional role is in nutrient cycling, particularly silicon and nitrogen. They also act as sediment stabilisers and aid in reef creation through substrate consolidation [16]. Small marine organisms including juvenile fish and invertebrates benefit from the microhabitat provided by sponge aggregations. Small organisms are known to live inside and around sponges, utilising them for protection and as a food source.

Bivalves

Bivalves belonging to the Family Spondyllidae, which often dominate some areas of the Arabian Gulf, were recorded in the surveyed areas. These organisms attach to hard substrate and would heavily colonize an area forming a mat or bed. These are filter feeders, collecting food from seawater. These bivalves are primary feeders, filtering in organic materials and prefer to grow in areas with strong currents aiding in their feeding. This invertebrate plays an important role in nutrient regulation and benthic structure engineering.

Other bivalves are burrowing and solitary individuals, living among seagrasses and coral reef areas. An example is the pearl oyster (*Pinctada* sp.) which was noted to be present in the survey area.

Fishes

Based on the results of sampling using BRUVs, DDVs and incidental recordings by marine biologists from on-board the vessels, fish species recorded on site included Spotted eagle ray, Four lined therapon, Grunts, Tawney shark. Figure 5-86 and Figure 5-87 provides sample captured still footages of marine species at survey location BRUV 1 and BRUV 2 at Route 1, respectively. The species list is presented in Figure 5-85 below. Among the fish species recorded, only the Honeycomb Whipray or Coach whipray (*Himantura undulata*) is listed as a threatened species (i.e., Endangered) by the IUCN in their most recent global assessment (106).

Figure 5-85: Fish species list generated by BRUV

Common Name	Scientific Name	BRUV 1	BRUV 2
Small-Scaled Terapon	*Tripneustes sp.*	X	X
King Mackerel	*Diadema setosum*		X
Honeycomb Whipray	*Demospongiae*	X	

Figure 5-86: Fish and other species recorded through BRUV1 installed at Route 1 – Mirfa Landfall

Figure 5-87: Fish and other species recorded through BRUV2 installed at Route 1 – Mirfa Landfall

Four lined Terapon

Four lined Terapon (*Pelates quadrilineatus*) aggregates in small school oftentimes found in near shore seagrass areas. The species were recorded on BRUV deployments in two occasions at R1 – Mirfa land fall. They feed on small fish and invertebrates. These species are not a sought after fish among commercial fishermen.

Gobies

This fish species often found on dug sand which the use as protection against predators. These often feed on small crustaceans and polychaetes. During the surveys they are commonly observed during the deployment of DDV camera.

Orange Spotted Trevally

The orange spotted trevally (*Carangoides bajad*) is relatively common species along the UAE coastline. These trevallies usually congregate in schools Trevally play an important ecological role as midwater meso-predators, feeding on small fish and invertebrates. The IUCN Red List categorizes *C. bajad* as Least Concern due to their wide global distribution. The orange spotted trevally is commercially important species in the UAE. In 2016, Abu

Dhabi reported *C. bajad* landings of 143 tons (114). This species is overexploited in the UAE and therefore areas that host juveniles, such as this location, are of great importance.

Grunt

Grunt is moderately sized fish feeding on shrimps, crustaceans, and molluscs. This fish is characterized with strong jaw able to break shells of crabs and bivalves. Habitat preferred are mangroves, reefs, and hardbottom benthic structures. They are predated by large fish barracuda and sharks. It may evade predators by blending it colour with the environment.

Silver Biddy

Silver biddy has protrusible jaws that may be used to gather infauna worms in sandy and seagrass habitats. Although home range can be within mangroves and coral reef areas, and they swim as schools. It is common in the waters of UAE and are not a target fish for commercial fishermen but may be caught as a bi catch in net-based fishery.

Reticulate Whipray or Coach Whipray

Reticulate whipray or Coach whipray (*Himantura uarnak*)[4] is a cartilaginous fish widespread in the Indo-Pacific in the Eastern and Western Indian and Western Central Pacific Oceans from South Africa to the Philippines (106). During the survey, these rays were documented on two occasions with BRUV. These fishes are ovoviviparous and gives birth to a few live young pups. The ray can be identified with dark dorsal coloration with patterned white spots and with a plain white on the ventral side. Small fish bivalves and crustaceans are the common prey for this demersal feeder. They are predated upon by several shark species such as hummer head, white tip, bull shark etc. This species is listed as "Endangered" by the IUCN (106) and are protected in the great barrier reef where efforts to conserve the species includes breeding in captivity. This species is currently not assessed locally and nationally in the UAE although it has been assessed as part of the regional assessment for the Arabian Sea and adjacent waters spearheaded by the EAD (115). Based on this assessment, this species experiences significant declines in the eastern part of the region due to the intense and increasing fishing pressure but only limited mortality is recorded in the western part (for example the Gulf) where it also remains common. Based on the above, the species is assessed as a Vulnerable species (115).

Benthic Infauna

Sediments were collected in Route 1 – Mirfa Landfall with eight infauna samples. A total of 49 distinct taxa (family/genus/species) were recorded and identified at an average of 15.75 taxa per sample. The highest total abundance was recorded in R1-Inf8 with 94 individuals whilst lowest in R1-Inf4 CNTR with 34 individuals. On the other hand, the highest species richness (S) was recorded at R1- Inf8 with 24 taxa whilst R1-Inf4 CNTR was the lowest with 7 taxa. The summary of species identified, and enumeration are provided in Table 5-51.

Table 5-51: Infauna list and enumeration within Route 1 – Mirfa Landfall

Taxa	Sampling Locations								Total
	R1-Inf1	R1-Inf2	R1-Inf3	R1-Inf4 CNTR	R1-Inf5	R1-Inf6	R1-Inf8	R1-Inf9	
Amphipoda									
Ampelisca spp.	3	4	4		4	13	13	9	**28**
Caprella sp.						6			**6**
Ceradocus sp.		1	5						**6**

[4] Also called Honeycomb Whiptail Ray or Honeycomb whipray.

Taxa	Sampling Locations								Total
	R1-Inf1	R1-Inf2	R1-Inf3	R1-Inf4 CNTR	R1-Inf5	R1-Inf6	R1-Inf8	R1-Inf9	
Urothoe sp.						3			**3**
Anthozoa									
Actiniaria sp.	1								**1**
Cumacea									
Cumopsis sp.			6		1	4	3	1	**15**
Decapoda									
cf *Diogenes* sp.					1		1	5	**7**
Echinodermata									
Asteroidea	1								**1**
Ophiuroidea	1	1							**2**
Foraminifera									
Peneroplis sp.	13	2							**15**
Mollusca									
Barbatia sp.							1		**1**
Mitrella blanda		1			1		2	3	**7**
Rhinoclavis sp.		3					2	5	**10**
Tellina sp.		1							**1**
Umbonium vestiarium							7	10	**17**
Nematoda									
Nematoda gen. spp.	2				1	1	1		**5**
Ostracoda									
Ostracod gen.spp.	2								**2**
Polychaeta									
Capitellidae	1	3	4	6					**14**
Chrysopetalidae (*Chrysopetalum* sp.)	4					1			**5**
Cirratulidae			4	1			2		**7**
Dorvilleidae *(Dorvillea* sp.)	17		1						**18**
Eunicidae							2	2	**4**
Flabelligeridae (*Pherusa* sp.)	1	2			1				**4**
Flabelligeridae (*523rad asp.*)		9							**9**
Glyceridae (*Glycera* sp.)		2			2	1	4	2	**11**

Taxa	Sampling Locations								Total
	R1-Inf1	R1-Inf2	R1-Inf3	R1-Inf4 CNTR	R1-Inf5	R1-Inf6	R1-Inf8	R1-Inf9	
Hesionidae	1				2		16	1	**20**
Lumbrineridae	1	2	3	1	8		7		**22**
Magelonidae (*Magelona* sp.)						1			**1**
Maldanidae	1						7	2	**10**
Nephtyidae (*Nepthys* sp.)			2	3					**5**
Nephtyidae (*Aglaophamus* sp.)							3		**3**
Nereididae (*Nereis* sp.)	1						5		**6**
Oenidae	1			2					**3**
Opheliidae (*Armandia* sp.)					1			7	**8**
Opheliidae (*Ophelina* sp.)					1			1	**2**
Orbiniidae	1	4	1	4					**10**
Paraonidae (*Aricidea* sp.)	6		2	17	5	1	5	1	**37**
Phyllodocidae						1			**1**
Pilargidiidae		1					1	1	**3**
Polynoidae							1		**1**
Sabellidae			1		3	2	3		**9**
Serpulidae (*Hydroides* sp.)	1								**1**
Spionidae (*Aonides* sp.)			1						**1**
Spionidae (*Prionospio* spp.)			13		2		4	2	**21**
Syllidae (*Exogone* sp.)	1							1	**2**
Syllidae (*Syllis* spp.)						11	1	2	**14**
Trichobranchidae (*Terebellides* sp.)			1						**1**
Sipuncula									
Golfingia sp.					2		1	1	**4**
Tanaidacea									
cf *Apseudes* sp.	2				1		2		**5**
Total	**62**	**36**	**48**	**34**	**36**	**45**	**94**	**56**	**389**

The infauna community was dominated by Polychaeta comprising 61% of the total number of individuals, followed by Amphipoda (16%), see Figure 5-27. The most abundant polychaete species were *Aricidea* sp., Lumbrineridae, *Prionospio* spp.) and Hesionidae with 37, 22, 21, and 20 individuals, respectively. On the other hand, the most abundant species of Amphipoda was *Ampelisca* spp. with 50 individuals, which occurred in all samples except in R1-Inf4 CNTR. It should be noted that other polychaete species were numerically dominant in some samples: Dorvillea sp. in R1-Inf1; *Brada* sp. in R1-Inf2; and *Syllis* sp. in R1-Inf6. In addition, gastropod species (*Umbonium vestiarium*) dominated the sample in R1- Inf9. Sample photos of the most abundant taxa are provided in Figure 5-89 to Figure 5-96.

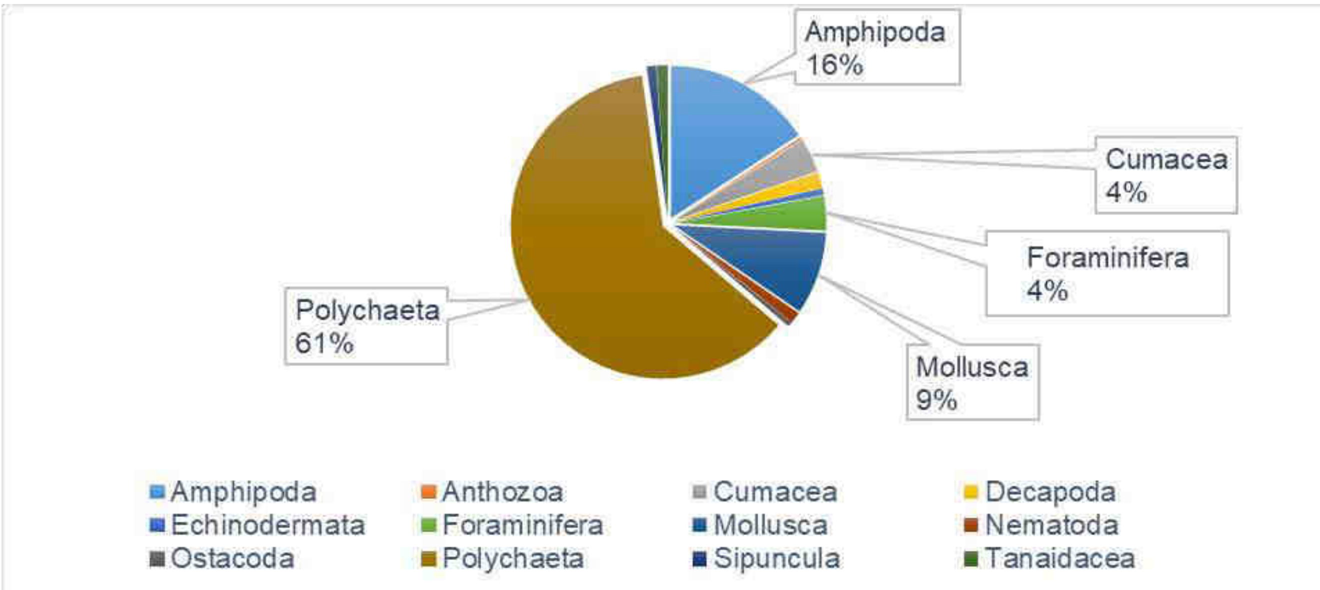


Figure 5-88: Infauna species composition within Route 1 – Mirfa Landfall

The diversity indices have been computed and the summary of the results is provided in Table 5-52. Diversity was found highest at location R1-Inf8 (H=2.814; 1-D=0.9199) and lowest at location R1-Inf4 CNTR (H=1.493; 1-D=0.692), as shown in Table 6-11. The infauna community in R1-Inf9 had the second-highest diversity index (H=2.548; 1-D=0.8992) compared to R1-Inf1 (H=2.429; 1-D=0.8585), although R1-Inf1 recorded the greatest number of recorded taxa. This can be explained by taxa that were being more evenly distributed in R1-Inf9.

Table 5-52: Infauna diversity index within Route 1 – Mirfa Landfall

Biodiversity Parameters	R1-Inf1	R1-Inf2	R1-Inf3	R1-Inf4 CNTR	R1-Inf5	R1-Inf6	R1-Inf8	R1-Inf9
Taxa_S	21	14	14	7	16	12	24	18
Individuals	62	36	48	34	36	45	94	56
Simpson_1-D	0.8585	0.8827	0.8698	0.692	0.8935	0.8217	0.9199	0.8992
Shannon_H	2.429	2.389	2.312	1.493	2.498	2.013	2.814	2.548
Evenness_e^H/S	0.5406	0.7788	0.721	0.6356	0.7601	0.624	0.6947	0.7099

Locations R1-Inf1 and R1-Inf4 have the lowest computed values for evenness index, with 0.5406 and 0.6356 respectively. Such values are indicative of uneven species distribution and this was evidenced by the dominance of a single taxa, namely *Dorvillea* sp. at R1-Inf1 and *Aricidea* sp. at R1-Inf4 location. In contrast, species distributions were found relative even at locations R1-Inf2 (0.7788) and R1-Inf5 (0.7601) as no particular taxa dominated (in terms of numbers).

The abundance, composition, and diversity of infauna are influenced by different factors including organic/microbial pollution, sediment grain size, wave action, water quality, and habitat types. It should be noted that no single factor is associated with the pattern of the infauna community. The diversity index revealed that species richness could be high but low in abundance or high abundance but low species richness. The infauna community explored in this Project was taken near or within reef and seagrass areas, and presence of unconsolidated bottom with sandy to silty sedimentary structure. The composition of infauna present in the samples was relatively diverse and representative of the habitats in which they were collected. Taxa observed were mainly associated with low pollution and healthy macrofaunal communities.

Figure 5-89 to Figure 5-96 illustrate the most common taxa identified through the Project study area.

Figure 5-89: Amphipoda *(Ampelisca* sp.)

Figure 5-90: Paraonidae (*Aricidea* sp.)

Figure 5-91: Hessionidae

Figure 5-92: Dorvilleidae *(Dorvillea* sp.)

Figure 5-93: Spionidae (*Prionospio* sp.)

Figure 5-94: Syllidae (*Syllis* sp.)

Figure 5-95: Flabelligerdae (*Brada* sp.)

Figure 5-96: Chrysopetallid*ae (Chrysopetalum* sp.)

Marine Mammals and Reptiles

The results of the marine mammals and reptile surveys, including incidental observations, from 5th to 9th of April 2022 are presented in the overall distribution map of species sighting in Figure 5-97.

Turtles

During the survey at Route 1 (Mirfa) Landfall, significant sea turtle activity was observed. The predominant marine turtle species found in the UAE are the hawksbill turtle (*Eretmochelys imbricata*) and the green turtle (*Chelonia mydas*). Both species are known to use the UAE coastline for foraging and nesting with primary foraging habitat including shallow coastal areas near coral reefs and seagrasses. While it was previously believed that green turtles do not nest within the UAE, green turtle nests have been confirmed at Sir Bu Nair Island [18].

The IUCN Red List categorizes the hawksbill turtle as Critically Endangered and the Green Turtle as Endangered (106). This is due to significant and continuous global population decline. The main causes of reduced populations are over exploitation, incidental fishing mortality, and degradation of marine habitat and the nesting habitat.

Because of the high presence of turtles in the area, the survey team established three vantage points in order to ascertain the population level of the species. Vantage points are fixed observation stations with a 25-minute observation duration.

A green sea turtle was documented at BRUV 2. Images from these recordings show that an individual turtle was attracted by the BRUV bait. At the same survey a total of 82 other turtle sightings (including those taken from the established VPs) were noted. During observation period, all sightings of turtles are counted during the episode of the turtle's surface breaks when breathing. The results are as follows, VP1 with 24 counts (See Figure 5-98), VP2 with 10 (See Figure 5-99) and VP3 with 11 counts (See Figure 5-100). This observation provides an indication that the area has high turtle population density.

Sample photographs of turtles taken during the survey are presented in Figure 5-101.

Figure 5-97: Marine species observations along Route 1 – Mirfa Landfall

Figure 5-98: MMRO observation Vantage Point 1

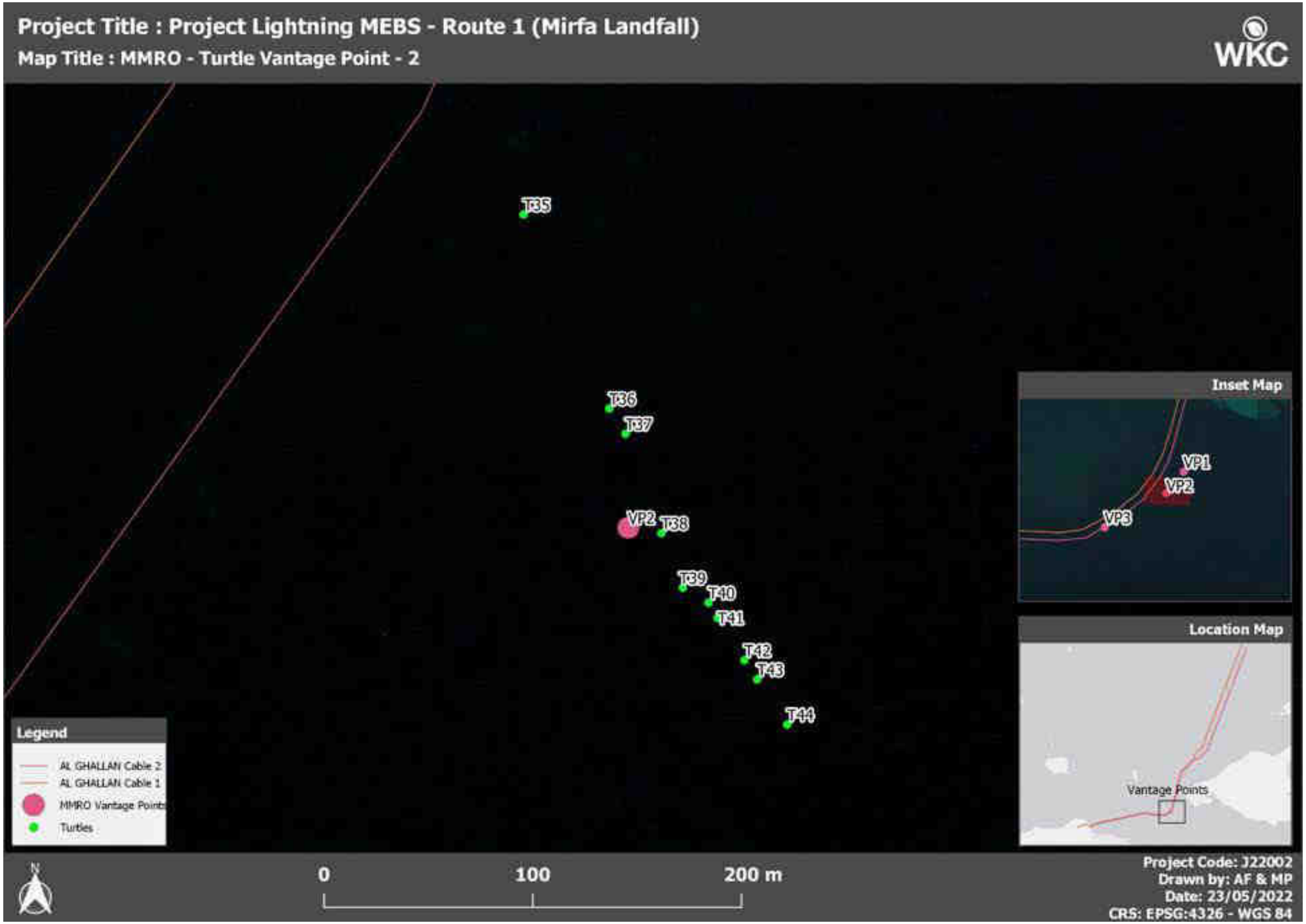


Figure 5-99: MMRO observation Vantage Point 2

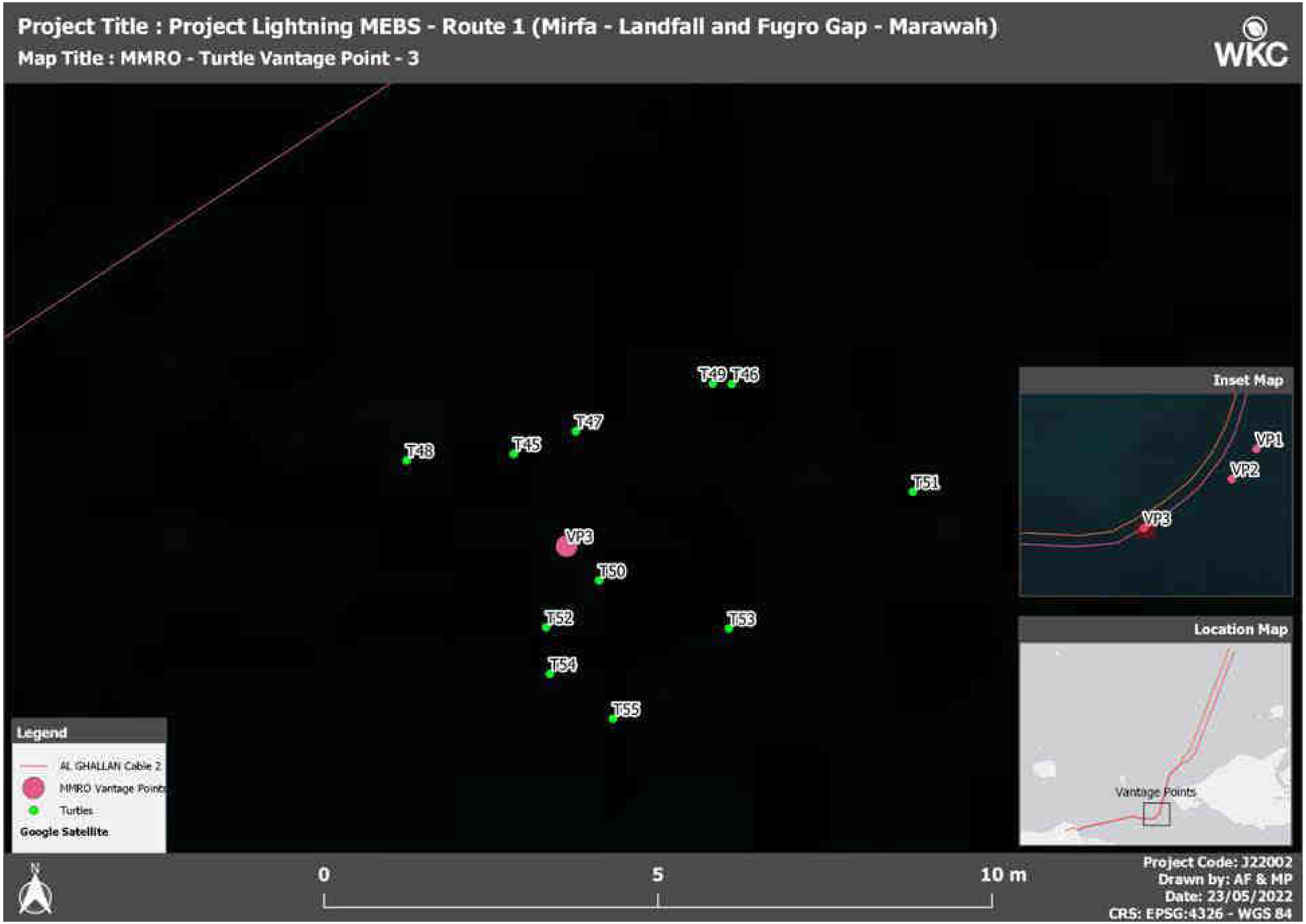


Figure 5-100: MMRO observation Vantage Point 3

Figure 5-101: Observed marine turtle sample photos within Route 1 – Mirfa Landfall

Marine Mammals

The team documented a number of marine mammals during the survey, one undetermined species (potentially Dolphin species), refer to the location of sighting as mapped in Figure 5-97. Note that no photograph was able to be taken of the following observed species at the time of the survey.

<u>Incidental Sightings</u>

Another ray species was documented from a vessel during the conduct of transects surveys. The location was nearshore of the Mirfa landfall route. Note that a stingray was also recorded by the BRUV system deployed on site at location BRUV 2 in Route 1 – Mirfa Landfall. In addition, a number of bird species were also recorded along the Route 1 – Mirfa landfall including cormorants, gulls and terns as shown in Figure 5-102.

Figure 5-102: Observed seabirds sample photos within Route 1 – Mirfa Landfall

Underwater Noise

Underwater noise was inferred on recordings undertaken at various measurement locations within Route 1 as summarized in Table 5-53.

Table 5-53: Summary table of underwater recordings and boat sightings

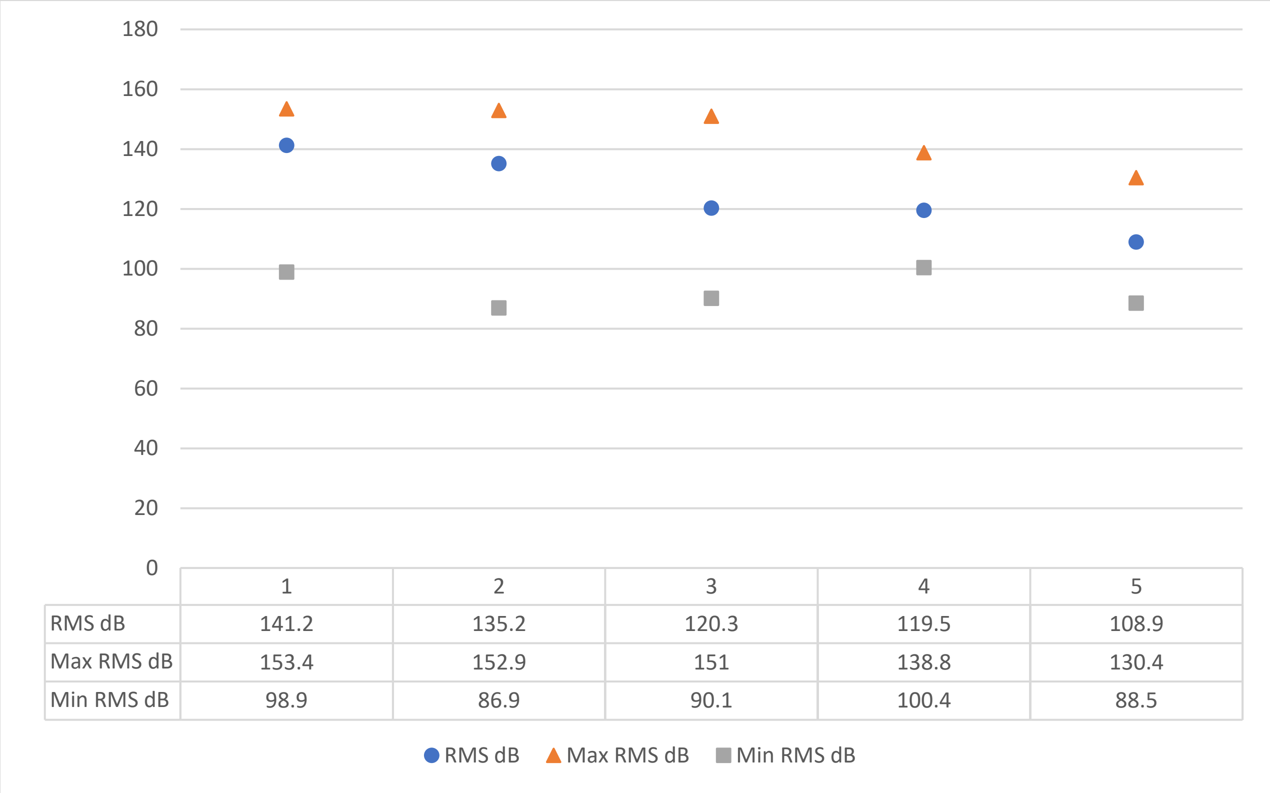
Location	Date	Depth	Deployed	Retrieved	Number of boats recorded
1	08/04/2022	10m	09:53	11:08	1
2	08/04/2022	8m	11:27	12:23	1
3	08/04/2022	5m	14:30	15:58	2
4	07/04/2022	6m	08:36	10:05	3
5	07/04/2022	9m	11:06	12:29	2

<u>Noise Analysis per Recording / Soundscape</u>

Sound analysis was conducted or the full duration of each recording (Table 5-54). Recordings were clipped at the beginning and end to eliminate any sounds from the survey vessel. The data shows that Mean and Max Sound Pressure Levels (SPL) root mean squared (RMS) in dB was highest at Location 1 and decreasing to be lowest at location 5. Mean RMS ranged from 141.2 dB at location 1 to 108.9 dB at location 5. The maximum and minimum RMS ranged from 88.5 at location 5 to 153.4 dB at location 1. See graphical representation in Figure 5-103. Overall soundscape is represented in Figure 5-104.

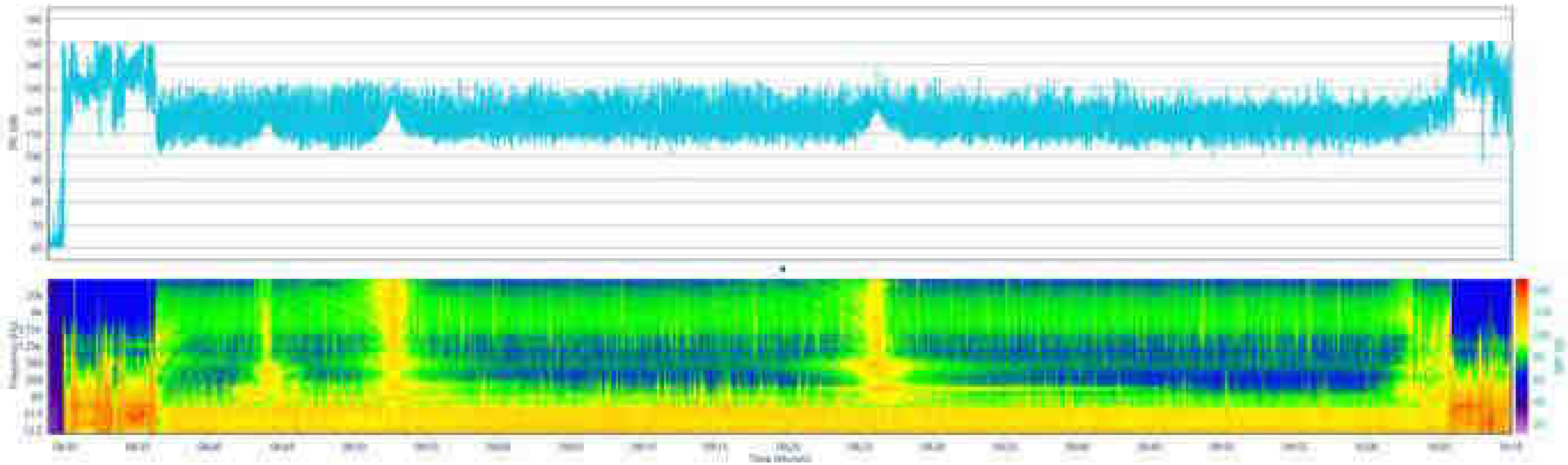
Table 5-54: Noise analysis for each recording

Location	Start Time	End Time	RMS dB	Max RMS dB	Min RMS dB	90% dB	50% dB	10% dB	Peak dB	SEL dB
1	08/04/2022 09:54	08/04/2022 11:07	141.2	153.4	98.9	147.1	119.2	110.8	155	177.6
2	08/04/2022 11:34	08/04/2022 12:22	135.2	152.9	86.9	122.9	99.1	92.3	154.8	169.6
3	08/04/2022 14:35	08/04/2022 15:55	120.3	151	90.1	120.9	109.8	101	154.6	157.1
4	07/04/2022 08:40	07/04/2022 10:00	119.5	138.8	100.4	122.7	116.6	110.9	154.4	156.3
5	07/04/2022 11:13	07/04/2022 12:24	108.9	130.4	88.5	112.7	105.1	97.9	147.4	145.2



	1	2	3	4	5
RMS dB	141.2	135.2	120.3	119.5	108.9
Max RMS dB	153.4	152.9	151	138.8	130.4
Min RMS dB	98.9	86.9	90.1	100.4	88.5

Figure 5-103: Graph indicating the mean, maximum and minimum RMS dB per recording



Key:

1 – Deployment

2, 3 and 4 – Boat Noise

5 – Retrieval

Figure 5-104: Soundscape for Mirfa Noise 4 illustrated in dBWav software showing sound levels (top) and spectrogram (bottom)

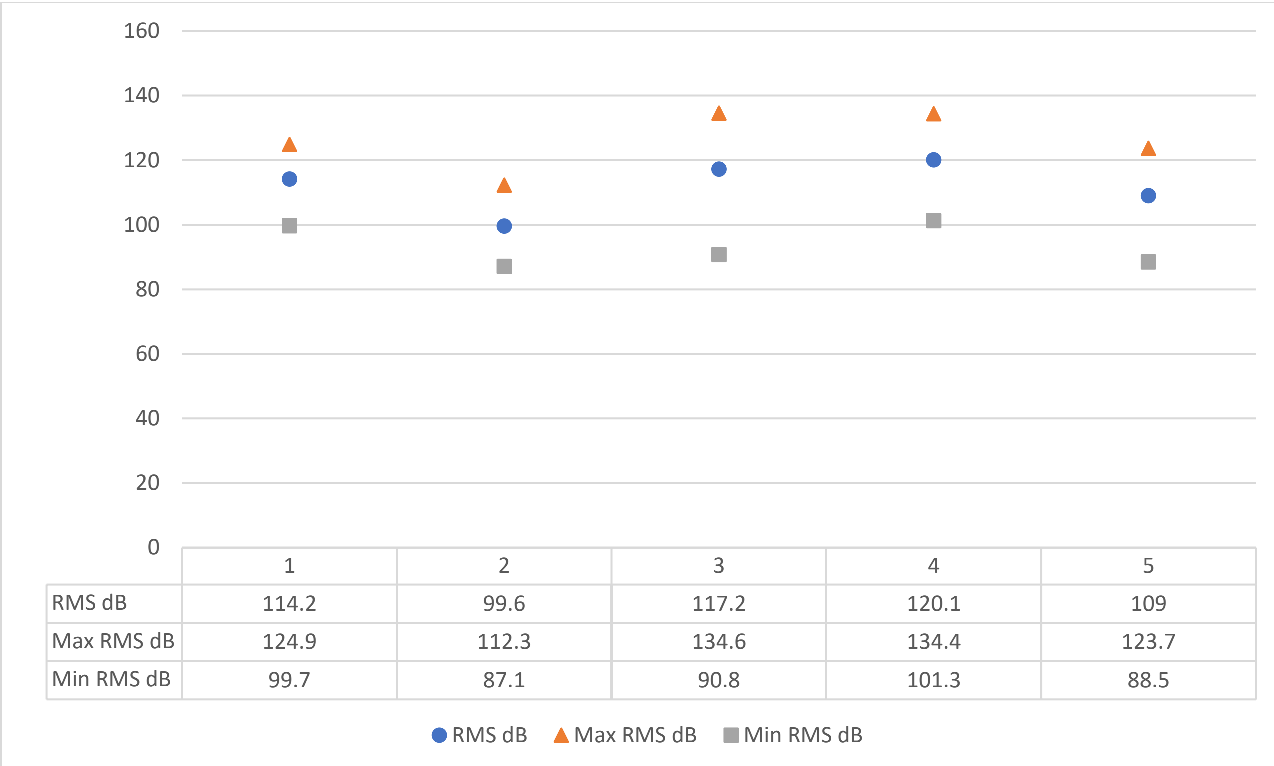
Sources of Noise and Ambient Noise Analysis

Ambient Noise Analysis

During each recorded a clip was selected to analyse the ambient noise. The clip was chosen during the recording when no anthropogenic noises (e.g., boats) were recorded. Each clip was analysed and is presented in table and chart form below (Table 5-55 and Figure 5-105). Ambient background noise was similar across the sampled locations being slightly higher at locations 3 and 4 with location 2 being the lowest. Mean RBS ranged from 99.6 dB at location 2 to 120.1 dB at location 4. A Spectrogram of ambient noise at location 3 is provided in Figure 5-106. This graph shows sound along time (x-axis) with sound shown in frequency (y-axis), the colour indicates sound level with higher sounds lighter in colour and dark indicating no sound.

Table 5-55: Noise analysis of ambient conditions for each recording

Recording	Start Time	End Time	RMS dB	Max RMS dB	Min RMS dB	90% dB	50% dB	10% dB	Peak dB	SEL dB
1	08/04/2022 10:28	08/04/2022 10:32	114.2	124.9	99.7	117.2	112.9	107.9	154.4	137.6
2	08/04/2022 12:08	08/04/2022 12:12	99.6	112.3	87.1	103.1	96.9	91.5	136.3	123
3	08/04/2022 14:46	08/04/2022 14:56	117.2	134.6	90.8	121	109.9	101.3	154.4	144.9
4	07/04/2022 09:00	07/04/2022 09:22	120.1	134.4	101.3	123.4	117.2	111.5	154.4	151.3
5	07/04/2022 11:30	07/04/2022 11:48	109	123.7	88.5	112.9	105.4	98.3	142.8	139.4



	1	2	3	4	5
RMS dB	114.2	99.6	117.2	120.1	109
Max RMS dB	124.9	112.3	134.6	134.4	123.7
Min RMS dB	99.7	87.1	90.8	101.3	88.5

Figure 5-105: Chart showing ambient mean, maximum and minimum RMS dB of background noise for each recording

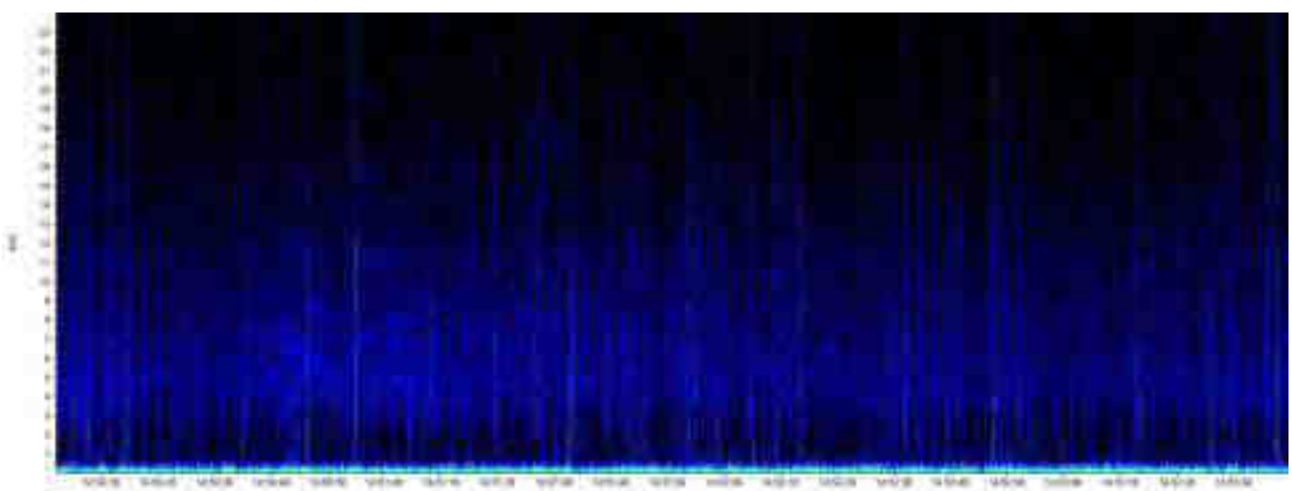


Figure 5-106: Spectrogram example of ambient noise at Location 3 illustrated in raven lite software

Sources of Noise

A number of sources of noises were identified during the study and have been analysed below Table 5-56 with images of the spectrograms provided in Figure 5-109 to Figure 5-110. At location 1 during the survey a regular series of pulses was recorded and most likely from a seismic or geological survey being conducted in the area. The pulses occurred approximately every 13 seconds. The pulses were predominantly low frequency <4 kHz reaching a max RMS of 125.3 dB.

Table 5-56: Analysis of specific noise sources

Description	Location	Duration (sec)	RMS dB	Max RMS dB	Min RMS dB	90% dB	50% dB	10% dB	Peak dB	SEL dB
Series of Pulses	1	38.2	117	124.6	104.1	120	115.6	110.4	149.1	132.9
Single Pulse	1	0.8	121.4	125.3	116.4	125.3	121.8	116.8	143.7	119.8
Boat	4	146.5	121.4	133.3	108.5	124.5	119.4	113.8	154.3	143.1
Invertebrate Click	4	0.8	124.6	127.8	120.7	127.8	124.3	123.1	132.8	123.1

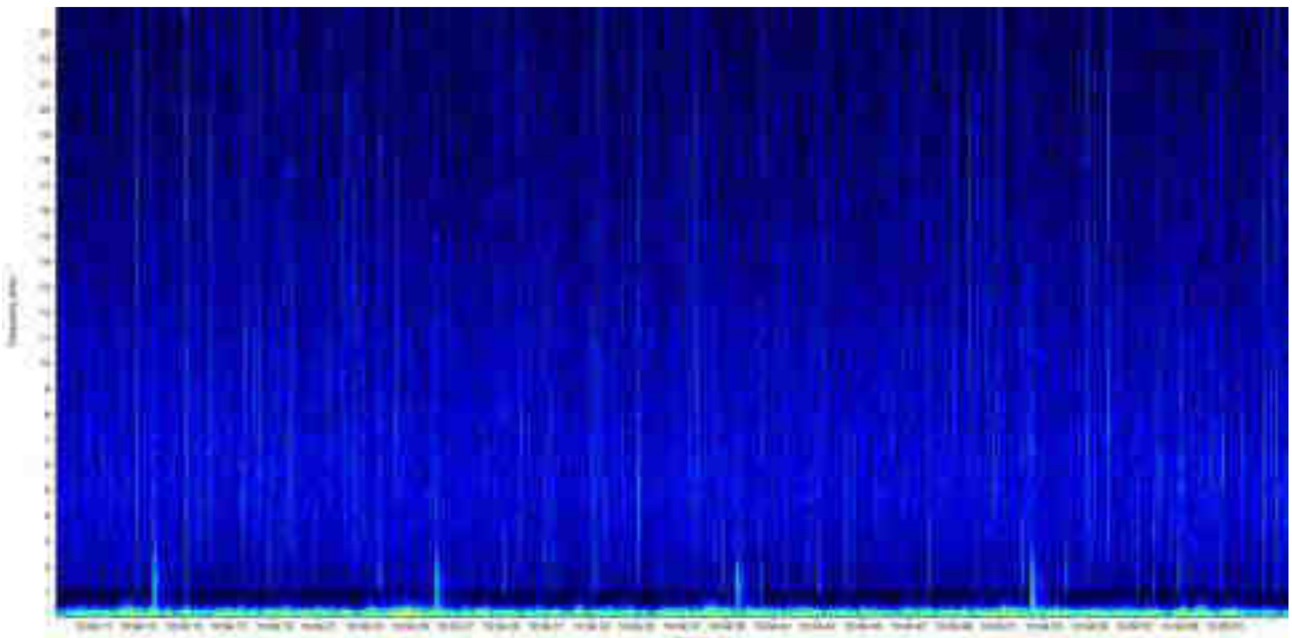


Figure 5-107: Series of pulses at Location 1

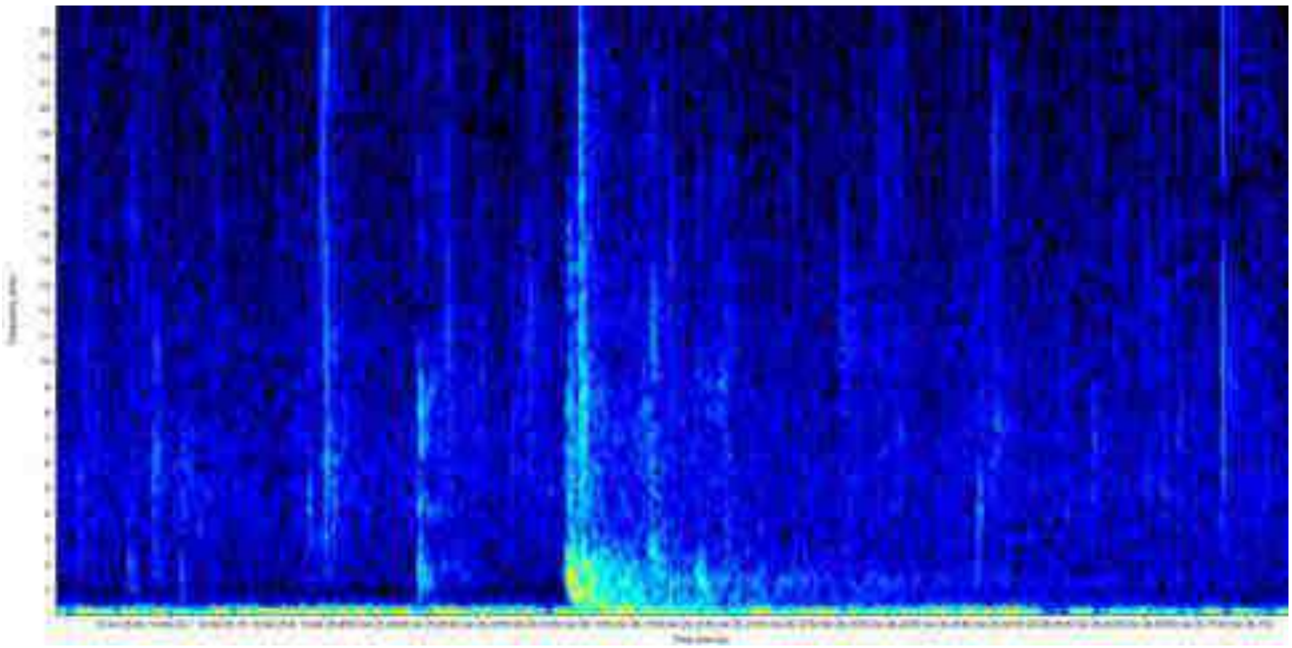


Figure 5-108: Detailed spectrogram of single pulse at Location 1

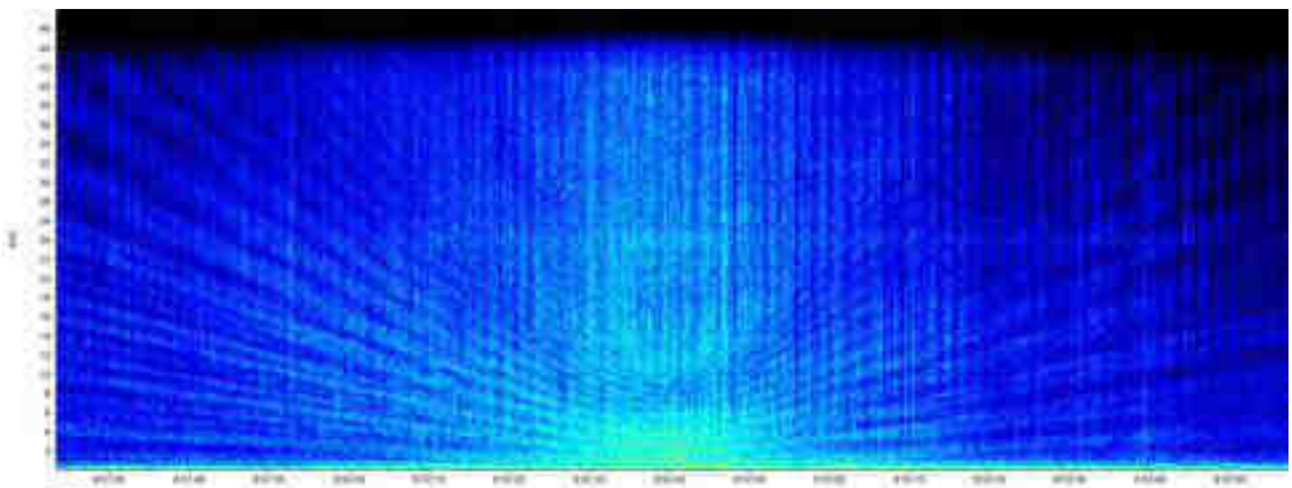


Figure 5-109: Spectrogram boat at Location 4

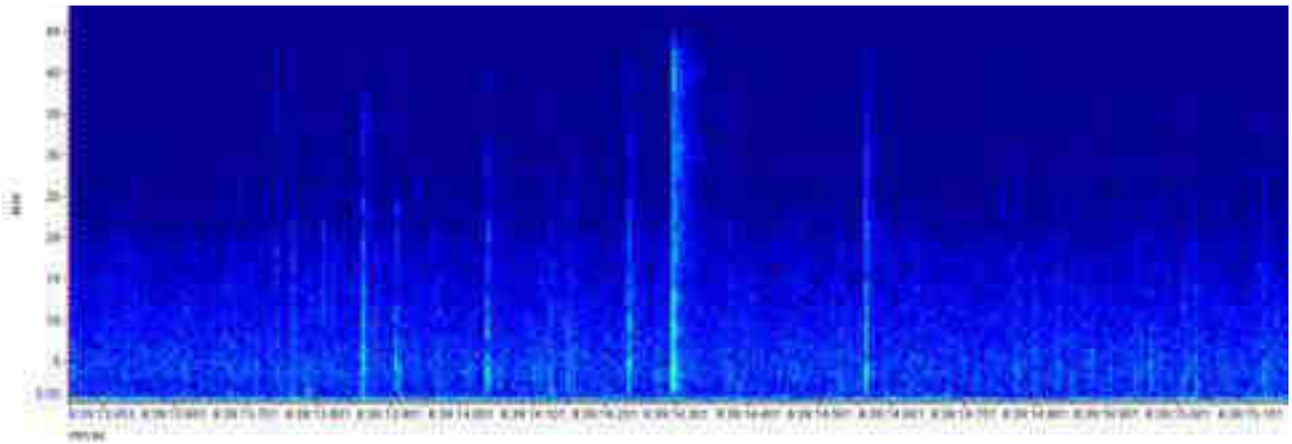


Figure 5-110: Spectrogram of invertebrate clicks at Location 4

Boat traffic was recorded at each location and an example of a boat pass is shown from location 4 (Figure 5-109). A boat passing recorded a max RMS of 133.3 dB and a peak of 154.3 dB. The spectrograms of boat noise (Figure 5-109) showed that peak sound levels were generally between 0 – 16 kHz, which overlaps the bandwidth which are known with dolphin communication (Figure 5-56) and indicates that increased boat traffic could have a masking effect on local dolphin populations.

The ambient background noise at each location was marked with invertebrate clicking and a sample from location 4 was included for analysis. The clicks recorded a maximum RMS of 132.8 dB with a mean RMS of 124.6 dB. The clicks showed a wide range in frequency from 0 to approximately 44 kHz.

Marine Mammals

Indo-Pacific humpback dolphin (*Sousa plumbea*) and Indo-Pacific bottlenose dolphins (*Tursiops sp.*) are known to be present in the area. Historic sightings of dugongs (*Dugong dugon*), which are considered vulnerable by IUCN and protected by EAD, have also been noted utilising the habitat as evidence of grazing tracks are seen on seagrass beds and actual sighting of the species. Dugongs, dolphins, and porpoises in the area are assessed in previous studies to be resident species within the MMBR.

During the survey both dolphin and Dugong were observed, however the dolphin could not be identified to species level (Figure 5-97).

During the Passive Acoustic Monitoring vocalisations were identified at locations 2, 3 and 5. The vocalisations were short whistle and moan type. At location 2 a series of short whistles were recorded (Figure 5-111). The whistles were short concave shaped in the 5-6 kHz range. At location 3 a longer moan was recorded (Figure 5-112). The moan was longer in duration around 2 seconds with an ascending contour from around 1.5 kHz to 4 kHz. A further series of moans was detected later in the recording at location 3 with a slightly descending shape but in a similar frequency range (Figure 5-113). A series of whistles/moans were detected at location 5 (Figure 5-114). The chorus lasted 10 seconds and was between 3-4 kHz.

No direct information for the hearing threshold of Indian Ocean Humpback dolphins were available (116), but information is available for the Indo-Pacific Humpback dolphin (*Sousa chinensis*) species which would be expected to be similar. Bottlenose dolphins produce whistles in the range of 0.8-24 kHz while Indo-Pacific Humpback Dolphin produce whistles in the range of 1.2-16 kHz (117). Dugong can produce short duration barks with a frequency of 0.5 to 22 kHz with a median frequency of 1.2kHz and short duration (126 ms) and long duration (1737 ms) calls with a frequency around 4 – 4.5 kHz (118).

The identification of the species making the vocalisations could not be determined and could be either dolphin or dugong as these species can produce a range of sounds within the frequencies recorded.

The vocalisations recorded during the survey and known hearing ranges are within the range of boat noise (119). This indicates that increased boat traffic has the potential to mask communication in dolphins and dugongs.

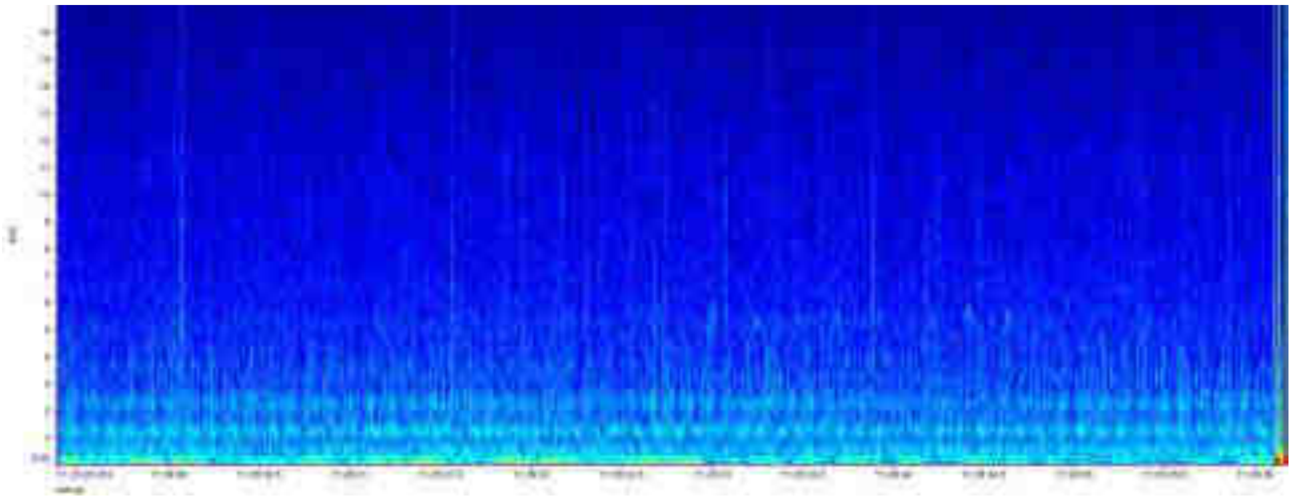


Figure 5-111: Series of short whistles at Location 2

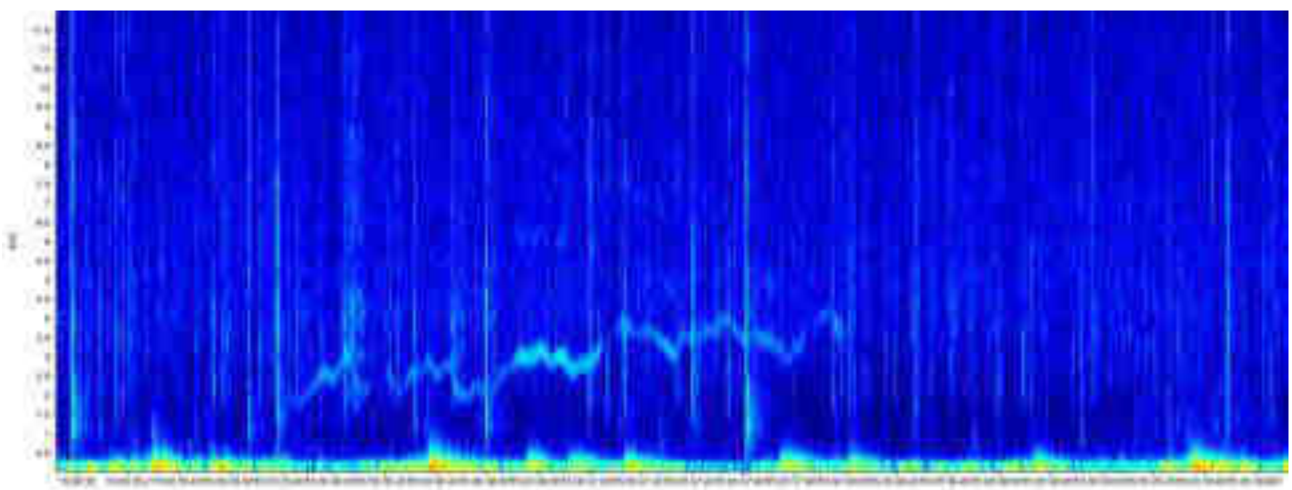


Figure 5-112: Moan type vocalisation at Location 3

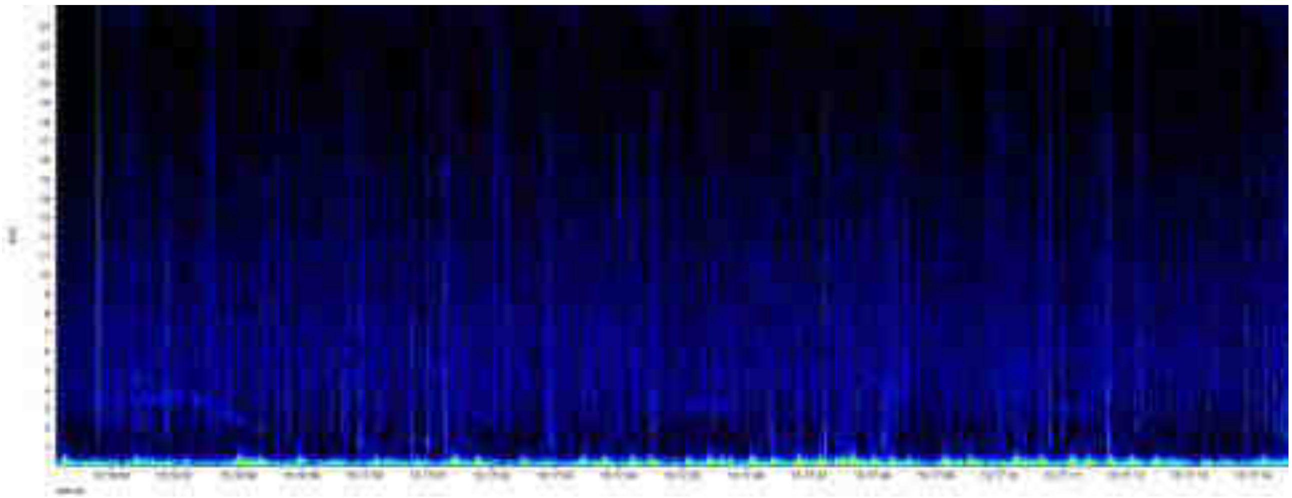


Figure 5-113: Series of moans at Location 3

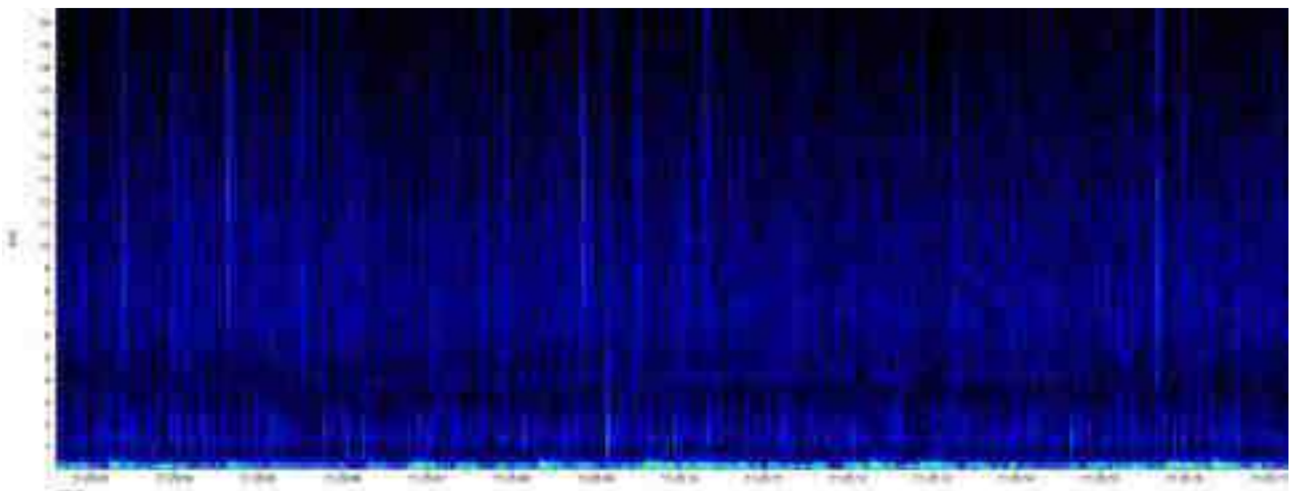


Figure 5-114: Series of moans at Location 5

Route 1 – Mirfa Nearshore Area within and near MMBR

Benthic Habitat

The overall habitat map for Route 1 which traverses areas of the MMBR is provided in Figure 5-71. Based on the results of the marine ecology surveys, four core habitat types are present in the survey area which includes the following and that which are shown in Figure 5-115:

- Unconsolidated Bottom: 14000;
- Dredged Seabed: 16100;
- Seagrass Bed: 12000; and
- Macroalgae communities: 13010.

Specific DDV photo captures for the different benthic habitats found during marine ecology surveys are presented in Figure 5-116 to Figure 5-124.

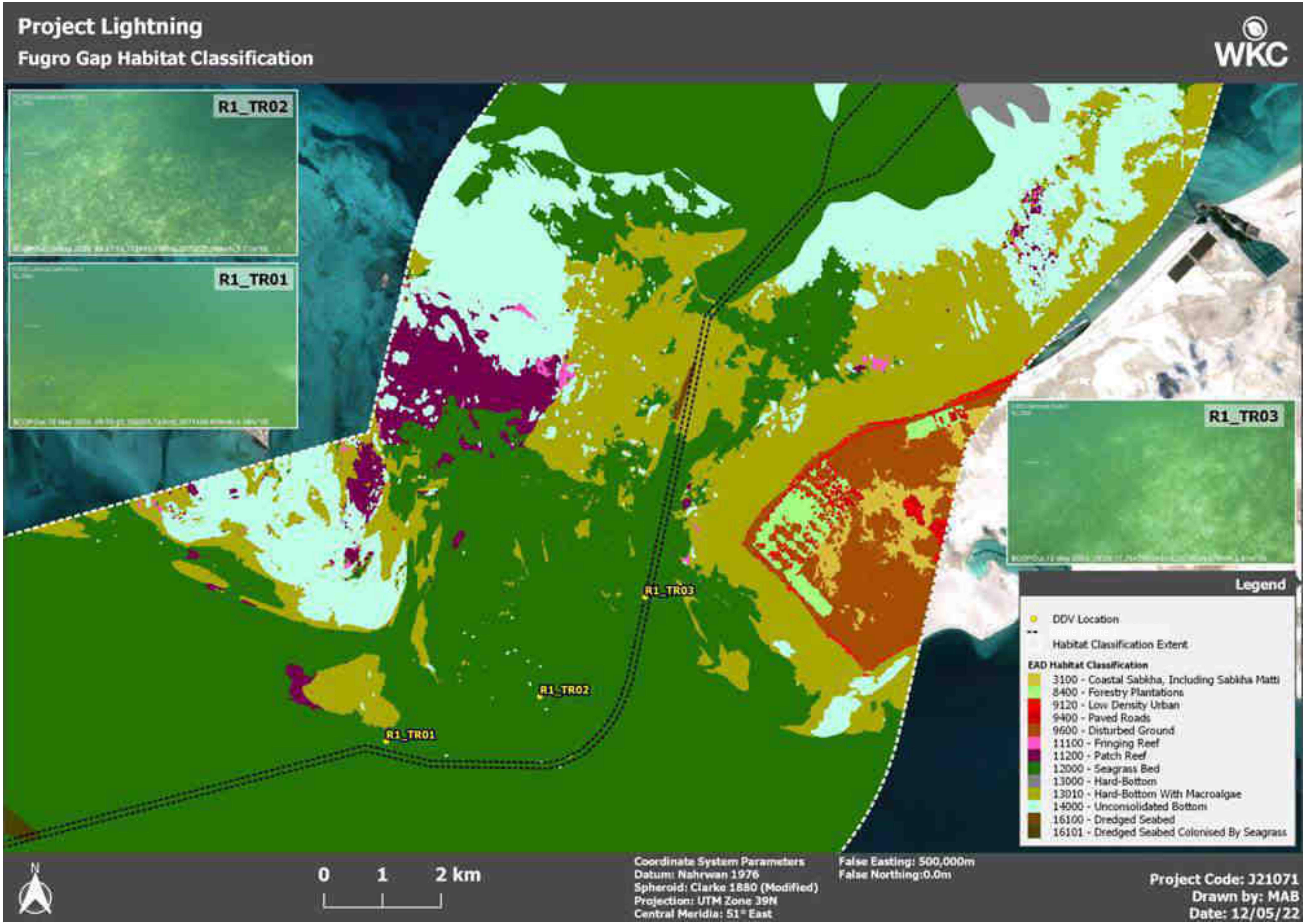


Figure 5-115: Habitat map along Route 1 – MMBR

Figure 5-116: Benthic habitat along Route 1 – MMBR (DDV1)

Figure 5-117: Benthic habitat along Route 1 – MMBR (DDV2)

Figure 5-118: Benthic habitat along Route 1 – MMBR (DDV3)

Figure 5-119: Benthic habitat along Route 1 – MMBR (DDV4)

Figure 5-120: Benthic habitat along Route 1 – MMBR (DDV5)

Figure 5-121: Benthic habitat along Route 1 – MMBR (DDV6)

Figure 5-122: Benthic habitat along Route 1 – MMBR (DDV7)

Figure 5-123: Benthic habitat along Route 1 – MMBR (DDV8)

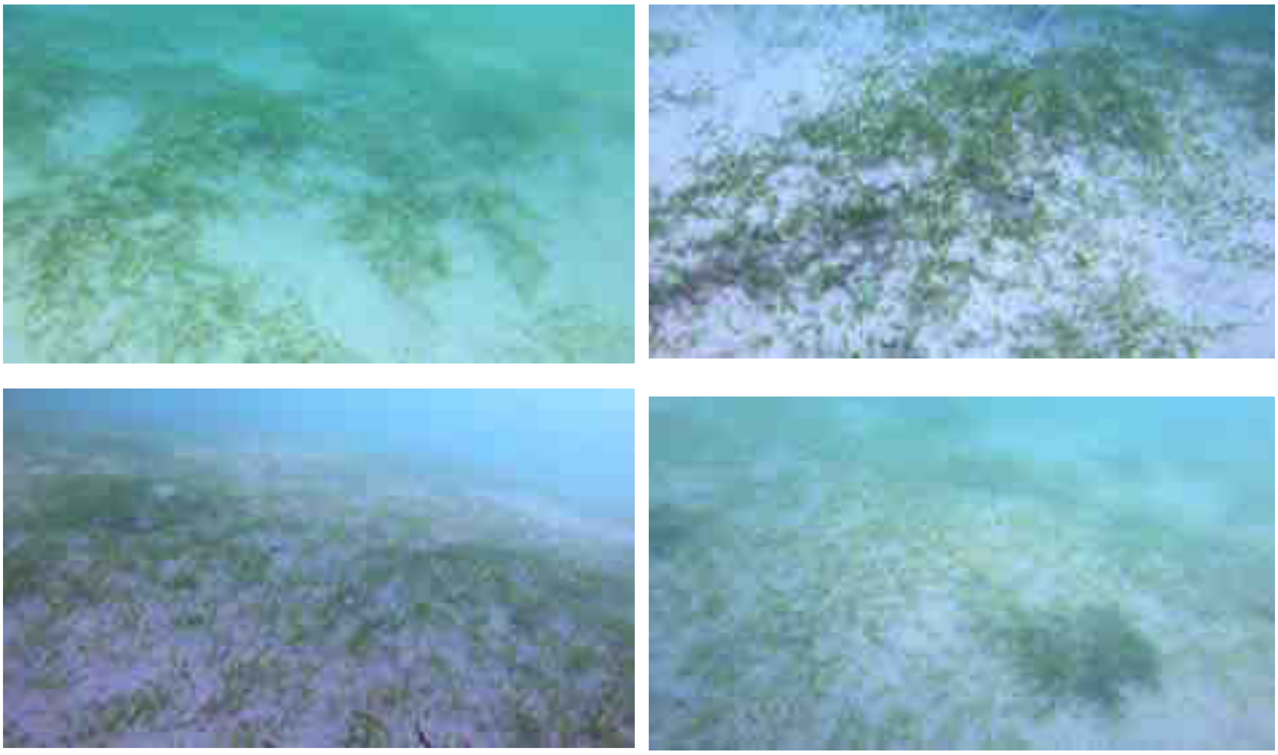


Figure 5-124: Benthic habitat along Route 1 – MMBR (DDV9)

Based on the assessment of the captured still images, the characteristic benthic habitats found throughout the surveyed areas include mostly seagrass, seagrass with macro-algae, and sandy areas as detailed in Table 5-57. These habitat types including associated flora and fauna are further discussed in the following sections.

Table 5-57: Photo quadrat results along Route 1 – MMBR

Photo Quadrat Number	Seagrass (%)	Sand (%)	Hardbottom (%)	Rubble and Shells (%)	Macro Algae (%)	Total (%)
PQ1	100	0	0	0	0	100
PQ2	78.65	20.1	1.25	0	15	100
PQ3	100	0	0	0	0	100
PQ4	0	10.93	89.06	0	0	100
PQ5	0	0	100	100	0	100
PQ6	0	0	64.06	0	35.93	100
PQ7	0	100	0	0	0	100
PQ8	0	100	70	0	0	100
PQ9	73	24	3	0	0	100

Unconsolidated Bottom

The unconsolidated bottom habitat in this area is characterized by coarse sand often intermixed with shells fragments and rubble, see Figure 5-125. These open areas of sand are sometimes defined and not heavily colonised by seagrass or algae largely due current movement that is demonstrated by ripple streak patterns in the sand. These areas contain a lower abundance of marine life as fish and invertebrates prefer the more productive and sheltered environment provided by nearby seagrass and macroalgae and hard bottom areas.

Figure 5-125: Unconsolidated bottom (sandy)

Dredged Seabed

A dredged channel is located on a water way, extending the Mirfa channel trough between a shoal and an island going north to Al Ghallan Island (Route 1). An example of Dredged Seabed in the Project area is presented in Figure 5-126. The current navigational channel provides vessel access to landing craft and private boats. DDVs and sediment analysis in this area confirmed substrate typical of dredged seabed. The sediment ranges from a sand to coarse sand substrate. Areas of this dredged channel is devoid of marine invertebrates including bivalves, sponges, algae, and corals.

Figure 5-126: Dredged seabed

Seagrass Bed

Seagrasses are well represented throughout the survey site. Areas range from dense seagrass meadows to sparse seagrass patches. Grazing marks made by dugong are found in the seagrass bed of this area, Figure 5-127. The three species identified were *Halophila stipulacea*, *Halophila ovalis and Halodule uninervis*. These species are adept at colonising areas of unconsolidated bottom due to fast propagation rates and tolerance to varying environmental conditions. The seagrass beds are often inter-mixed with macro algae and sparse sponges.

Figure 5-127: Seagrass bed

This ecologically valuable habitat provides foraging for many organisms including endangered species such as sea turtles and dugongs. Sand sediments within seagrass beds support a greater diversity and abundance of benthic fauna than open sand substrates (107). Many commercially important species such as fish, shrimps, and oysters also utilise seagrass beds as nursery and foraging grounds.

The rhizome and root system of a seagrass bed stabilise loose sediment and organic materials. This leads to improved water clarity and reduced erosion. Seagrasses are highly productive photosynthetic plants and as such, they contribute significant amounts of oxygen that become available for consumption by other marine life.

Macroalgae Communities

Significant macroalgae meadows were observed in several areas within the survey site, comprising of a mono species bed or mixed with seagrass beds. An example of macroalgae meadow at the survey area is presented in Figure 5-128. This macroalgae community covers a wide area and contains many large macroalgae plants including a variety of species are present mainly from the groups Chlorophyta (green algae) Rhodophyta (Red algae) and Phaeophyceae (brown algae). *Sargassum sp.* Was observed to be a dominant species in certain sites of the surveyed area.

Figure 5-128: Macroalgae bed

Dredged Wall

In general, marine benthic formations are created after dredging activities. Formation of habitat typical commenced at the walls of the dredging footprint. The wall can be vertical or rapidly inclining in orientation. As water current move along these structures, scouring may happen creating crevices and crannies as well as exposing hard substrates. These hard structures undergo benthic community succession and will develop into a diverse habitat with sponges, corals, algae, bivalves etc. The dredge wall was seen along DDV location.

Oftentimes along this dredge wall is a diverse aggregation of reef associated fish species. An ecologically developed dredge wall can be a proxy to a coral reef since a rich biomimicry substrate formation can be achieved. During the survey bivalves is the dominant marine invertebrate observed.

Hardbottom

During the survey hardbottom substrates were observed in various areas of the bay. An examples hardbottom habitats are presented in Figure 5-129. This habitat type is devoid of seagrasses and has a well-defined boundary. In addition, sessile marine organisms were noted to colonise the substrate like macro algae, corals, tunicates, and bivalves. Hard bottom substrates provide opportunity for coral growth thus considered an important natural marine habitat. This habitat also provide stability to the seabed that will facilitate continuity of benthic colonization until climax community is achieved.

Figure 5-129: Example of hardbottom

Benthic Community (Flora and Fauna)

Table 5-59 provides a summary of the habitats investigated through DDV. The various benthic flora and fauna species as well as the natural benthic substrate observed through the survey methods are also included in the table below. Table 5-58 below identifies the invertebrates species observed with Route 1 – MMBR study area.

Table 5-58: Invertebrate species observed at Route 1 - MMBR

Common Name	Scientific Name
Collectors Sea Urchin	*Tripneustes sp.*
Long Spined Sea Urchin	*Diadema setosum*
Sponge	*Demospongiae*
Tunicate	*Phallusia nigra*
Sea Snail	*Cerithriidae sp.*
Pearl Oyster	*Pinctada radiata*
Bivalves	*Chlamys livida*
Blue Swimmer Crab	*Portunus pelagicus*

Table 5-59: Benthic community observations along Route 1 – MMBR

Sampling Location	Unconsolidated Bottom (Sandy)	Seagrass	Corals	Macro-algae	Bivalve Bed	Hard Bottom	Description
DDV1		X		X			Rich seagrass meadow intermixed with macroalgae with population of pearl oysters. Grazing tracks seen produced by dugong.
DDV2		X		X			Rich seagrass meadow intermixed with macroalgae with population of pearl oysters. Grazing tracks seen produced by dugong.
DDV3		X		X			Rich seagrass meadow intermixed with macroalgae with population of pearl oysters. Grazing tracks seen produced by dugong.
DDV4	X	X		X	X	X	A Mosaic of Hard bottom with seagrass colonizing open sand patches, corals and coral structures were observed
DDV5			X	X	X	X	Bivalve beds and Hardbottom with rocks colonized by bivalves. A coral and coral structures were observed
DDV6			X	X	X	X	Hardbottom with bivalve beds and macro algal community. Coral and coral structures were observed
DDV7	X						Hard sand bottom
DDV8	X						Sandy bottom with shell fragments
DDV9	X	X					Seagrass bed with open patches of sand

Fishes

A fish study was undertaken using Baited Remote Underwater Video (BRUVs). Most species identified were pelagic and reef-associated fishes. A number of these species are considered commercially important in the UAE.

Fish species that were identified during the survey includes the grouper, kingfish and orange spotted trevally. Table 5-60 provides a list of all species identified at each survey location. Also, there is a high population of blue swimmer crab observed in the area. BRUV recorded low number of fish and species at the time of the survey. These habitat types (Hardbottom and Seagrass) typically provide shelter and foraging opportunities.

Table 5-60: Summary of fish species in supplemental survey areas along Route 1 – MMBR

Common Name	Scientific Name	Site		
		BRUV1	BRUV2	BRUV3
Yellow Bar Angelfish	*Pomacanthus maculosus*		X	
Orange Spotted Grouper	*Ephinephelus cocoides*		X	
Ehrenberg Snapper	*Lutjanus ehrenbergii*		X	
Orange Spotted Trevally	*Carangoides bajad*	X	X	
Grunt	*Haemulon plumierii*		X	
Two Bar Seabream	*Acanthopagrus bifasciatus*		X	
Silver Biddy	*Gerres subfasciatus*		X	
Blue Swimmer Crab	*Portunus pelagicus*			X
Reticualte Whipray	*Himantura uarnak*	X		

Sample photographs from BRUV systems deployed at Route 1 – MMBR are presented in Figure 5-130 and Figure 5-132. Refer to preceding sections (Route 1 – Subsection on Fishes) for further notes on the fish species observed along Route 1 – Landfall.

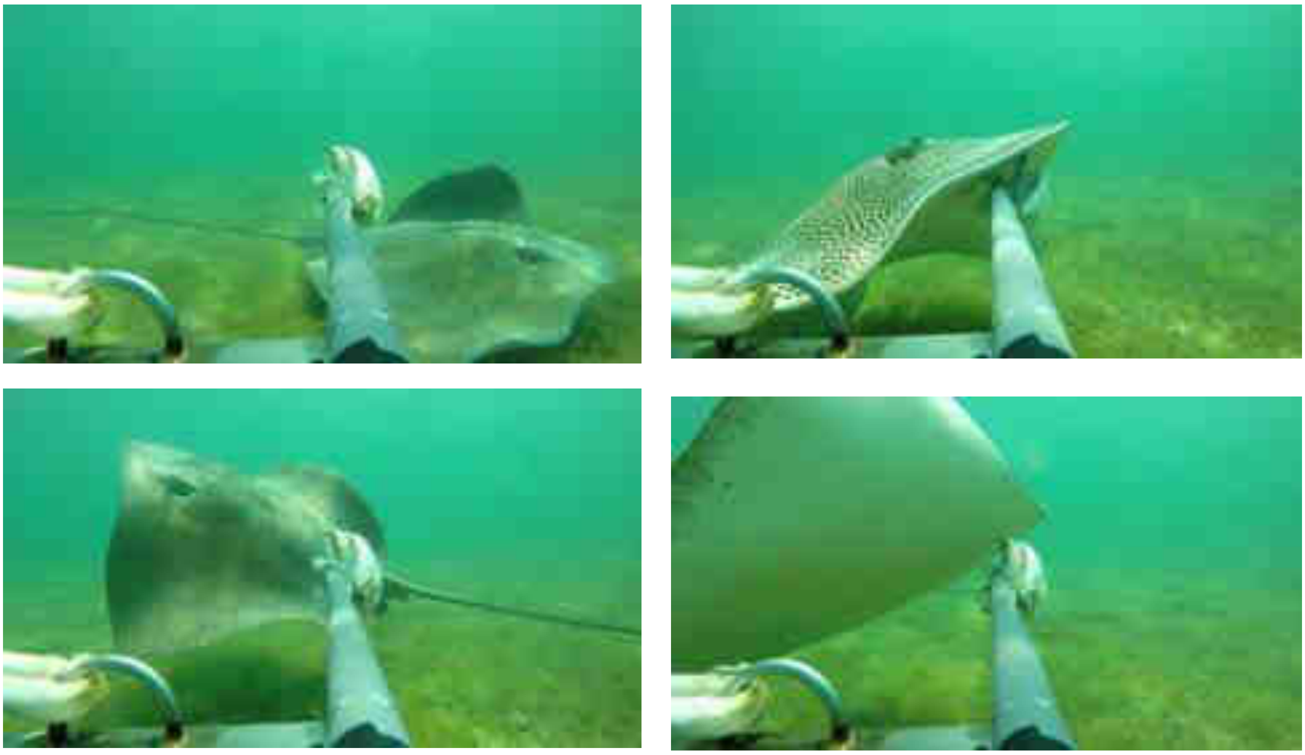


Figure 5-130: Fish and other species recorded through BRUV1 installed at Route 1 – MMBR

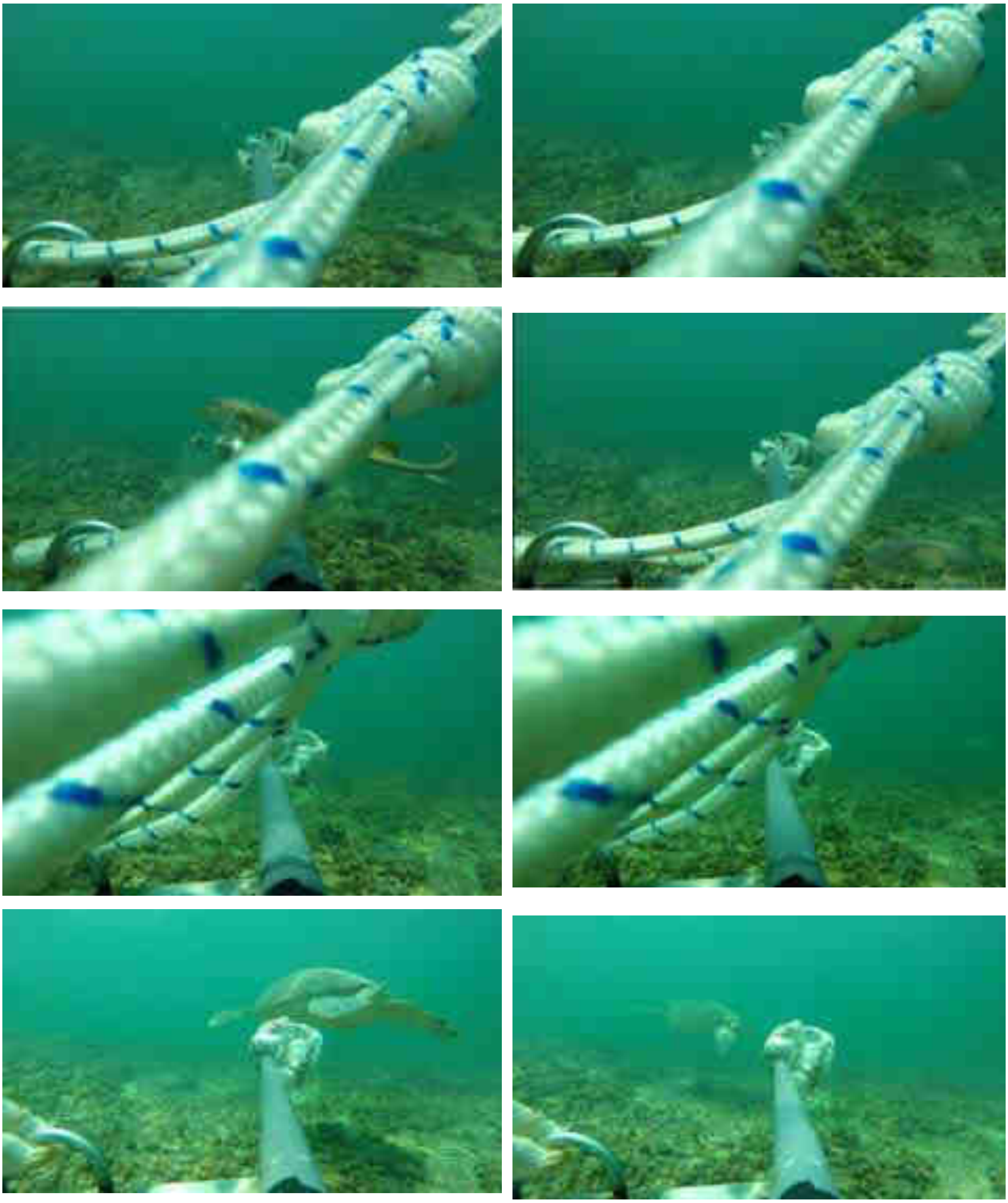


Figure 5-131: Fish and other species recorded through BRUV2 installed at Route 1 – MMBR

Figure 5-132: Fish and other species recorded through BRUV3 installed at Route 1 – MMBR

<u>Crustaceans</u>

Blue Swimmer Crab

Blue swimmer crabs are bright blue in colour with spots of white on the carapace with size of around 8 inches when adult. These crabs stay buried under the sand in most time but wander among seagrass and sandy areas to feed. Being omnivores, they feed on bivalves, fish, and macro algae. They are commercially important and constantly harvested by both recreational and commercial fishermen.

This species is prolific and fast growing but are overexploited in other countries. Blue Swimmer Crabs in other regions are protected with varying degree fishery management policies.

Marine Mammals and Reptiles

Marine Mammal and Reptiles condition at Supplemental Sampling Areas -Route 1 – MMBR survey points were discussed together with the MMRO Route 1 – Mirfa Landfall survey.

Underwater Noise

Please refer to the discussion on underwater noise in the section above for Route 1 – Mirfa Landfall survey which covers the MMBR area.

Route 1 – Zakum Clusters Route 1A & 1B re-routing Area

Benthic Habitat

The marine habitats identified across the Route 1 – Zakum Clusters study area are illustrated in Figure 5-133 were classified using the Environment Agency Abu Dhabi (EAD) Habitat Classification (104) and Marine Ecological Classification Standard (CMREC) Scheme. Based on the results of the marine ecology surveys, three core habitats were present in the area:

- Patch Reef: 11200;
- Hardbottom: 13000; and
- Unconsolidated Bottom: 14000.

The offshore survey was conducted at the site from 19th to 23rd of May 2022 and revealed that the benthic community was mainly hardbottom with coarse to fine sandy particles made up of calcium carbonate rocks, coral rubble, molluscan shells, sparse coral colonies and dead coral structures. Unconsolidated bottom areas have also been recorded. The hardbottom areas are mostly located within the Zakum oil and gas fields whilst unconsolidated bottom areas are recorded mostly outside the fields. The location map is shown in Figure 5-13.

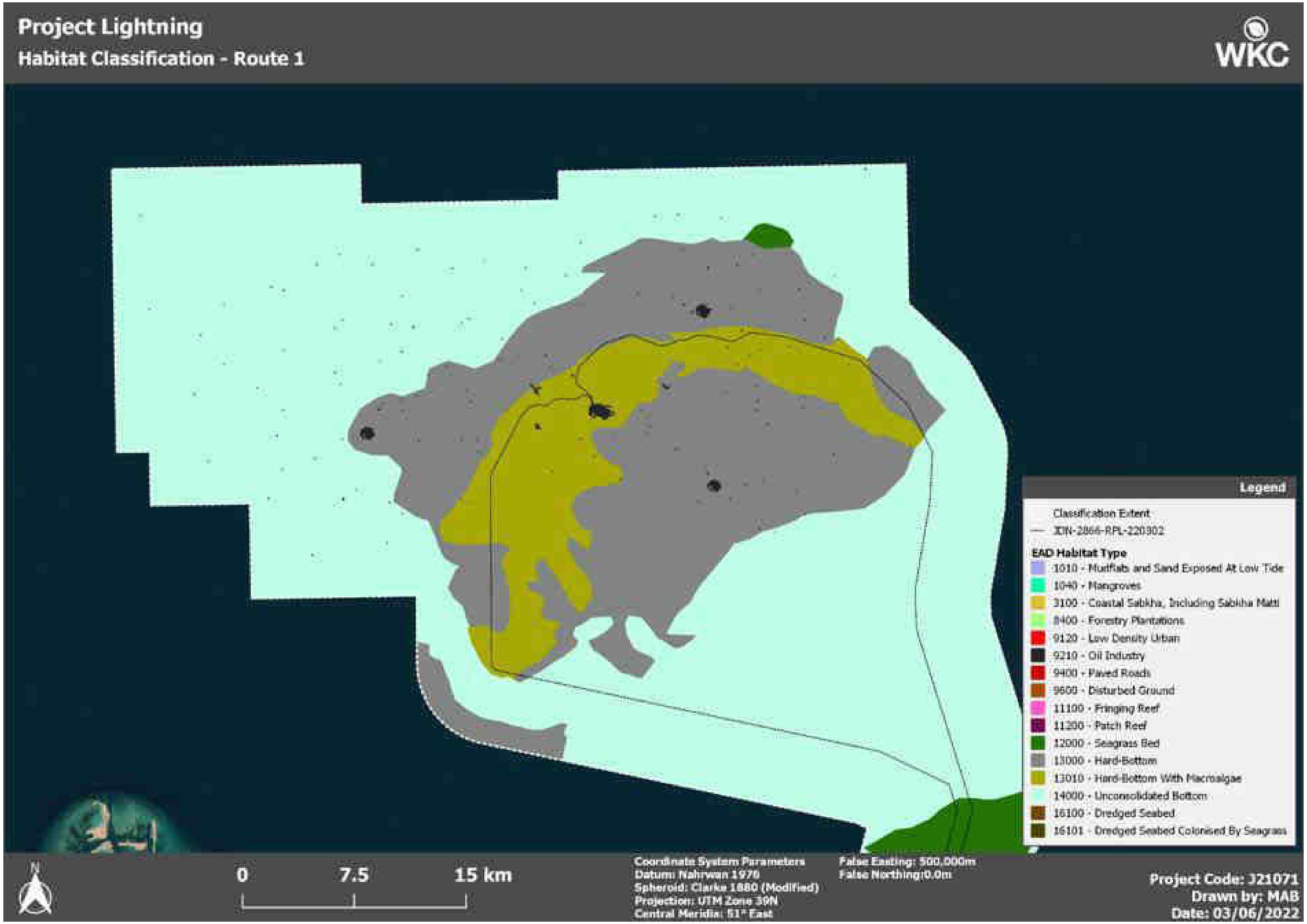


Figure 5-133: Habitat map along Route 1 – Zakum Clusters rerouting

Figure 5-134: Hardbottom benthic habitat along Route 1 – Zakum Clusters (DDV1)

Figure 5-135: Hardbottom with bivalves bed and sparse coral colonies benthic habitat along Route 1 – Zakum Clusters (DDV2)

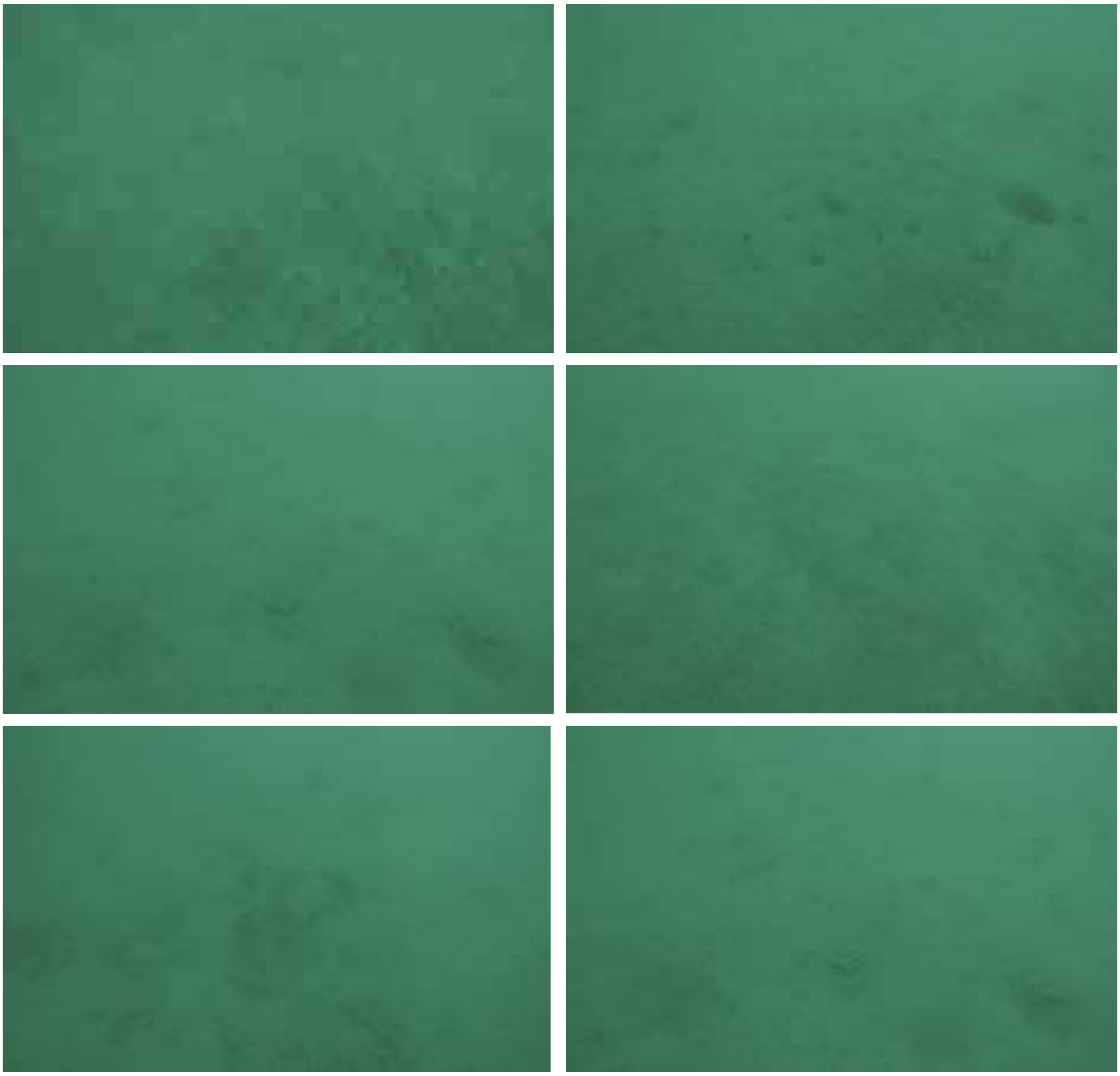


Figure 5-136: Unconsolidated bottom with sea pens (contracted) benthic habitat along Route 1 – Zakum Clusters (DDV3)

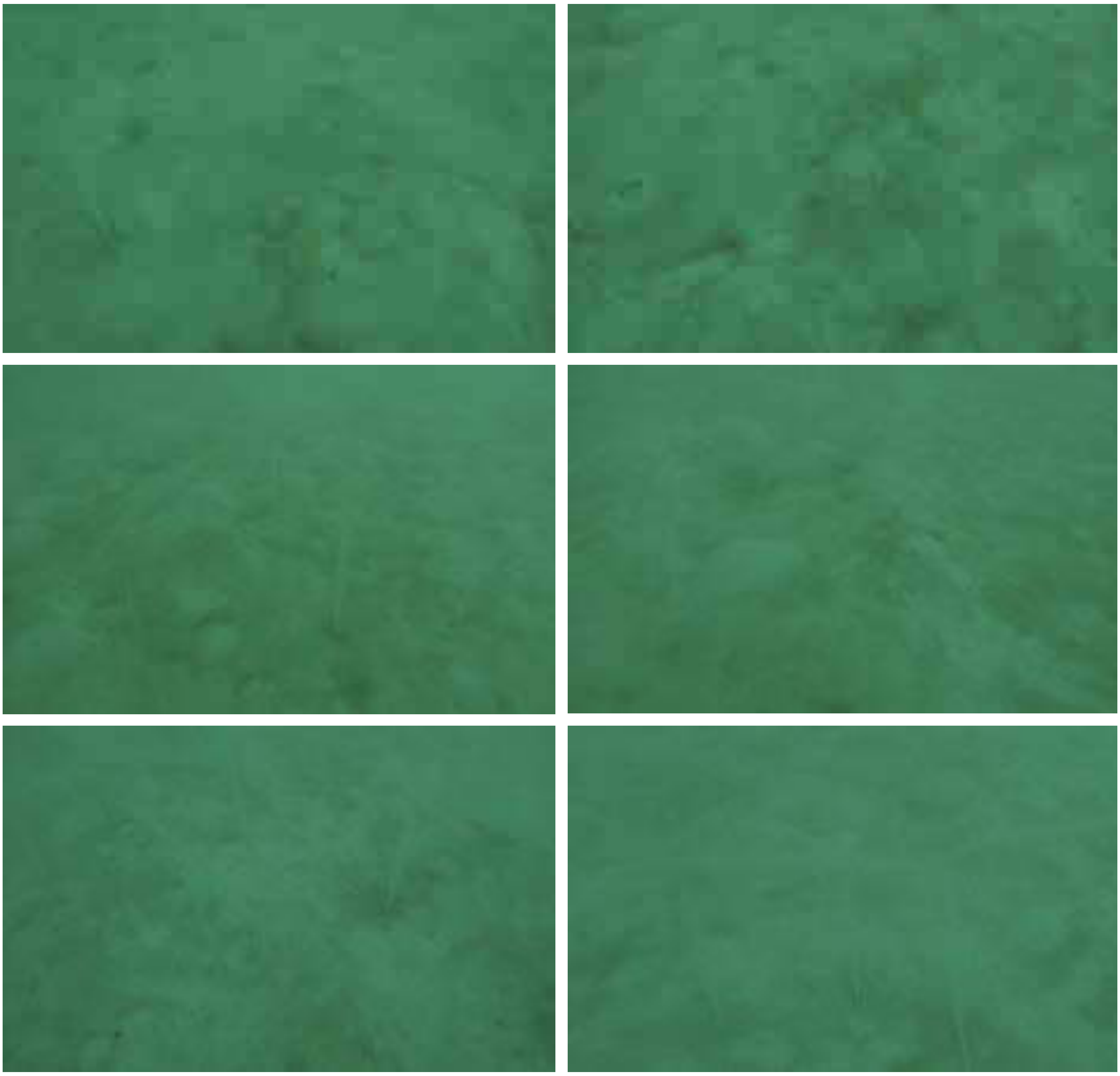


Figure 5-137: Unconsolidated bottom with sea pens benthic habitat along Route 1 – Zakum Clusters (DDV4)

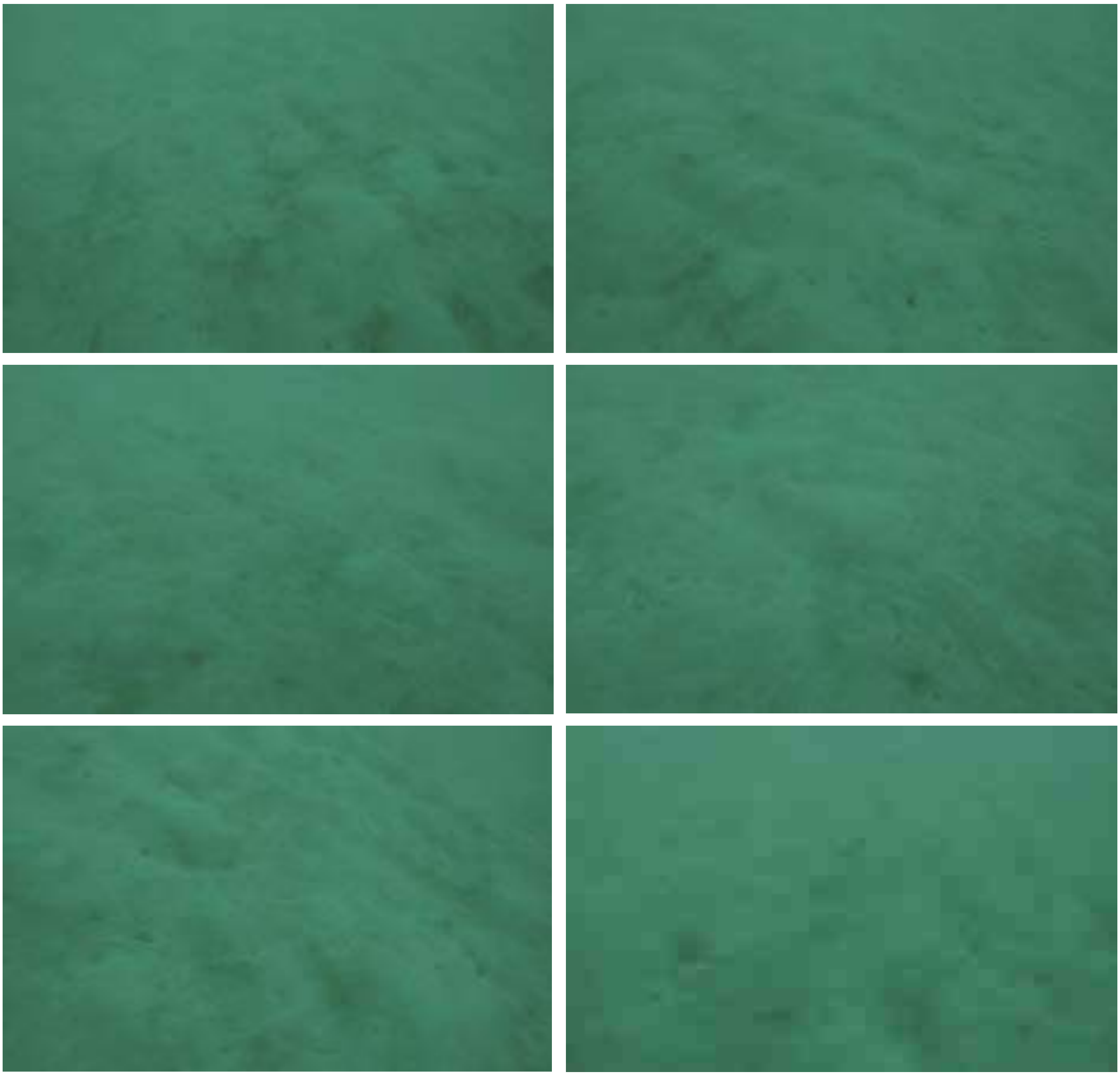


Figure 5-138: Unconsolidated bottom with sea pens benthic habitat along Route 1 – Zakum Clusters (DDV5)

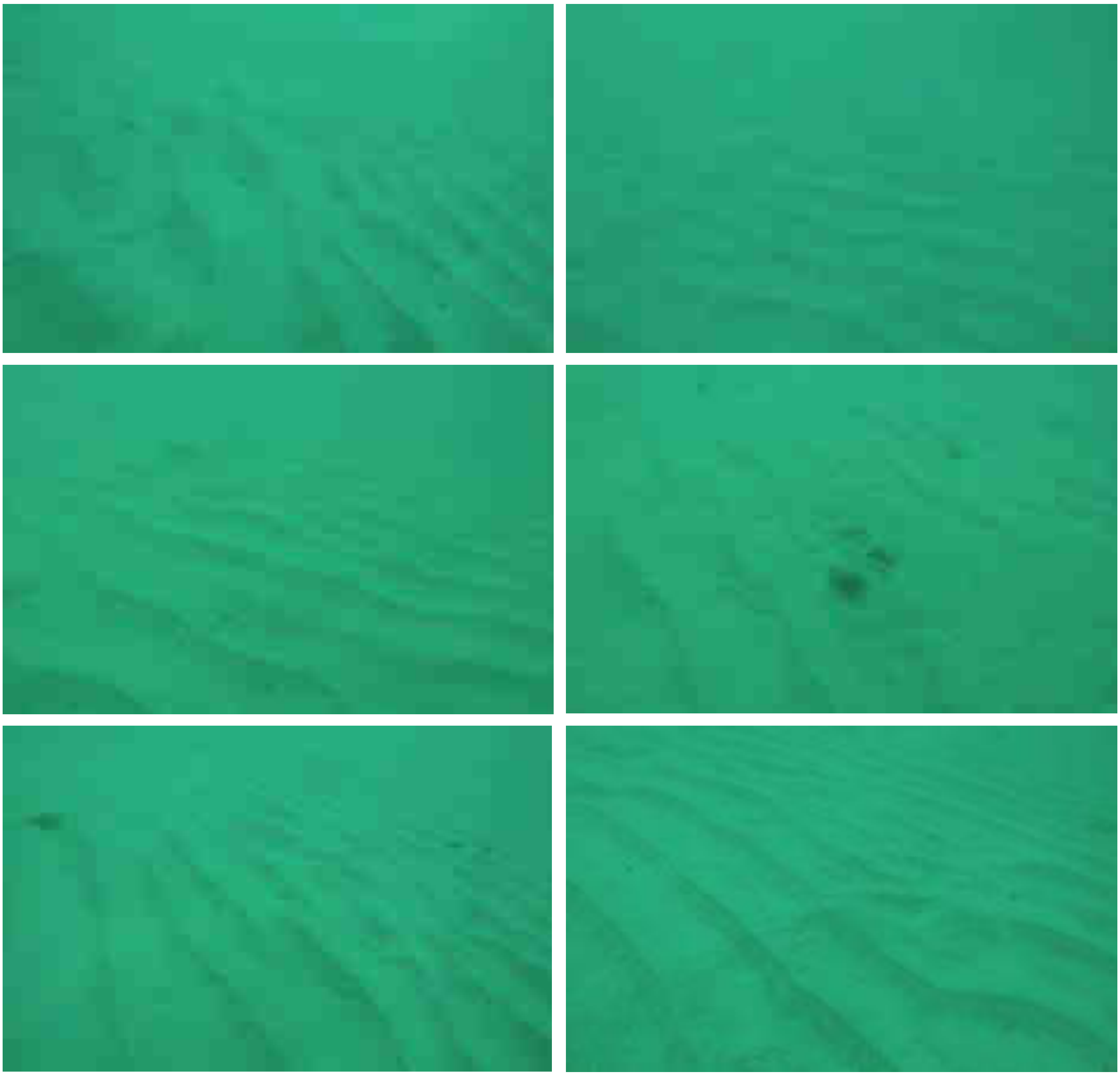


Figure 5-139: Unconsolidated bottom (sandy) benthic habitat along Route 1 – Zakum Clusters (DDV6)

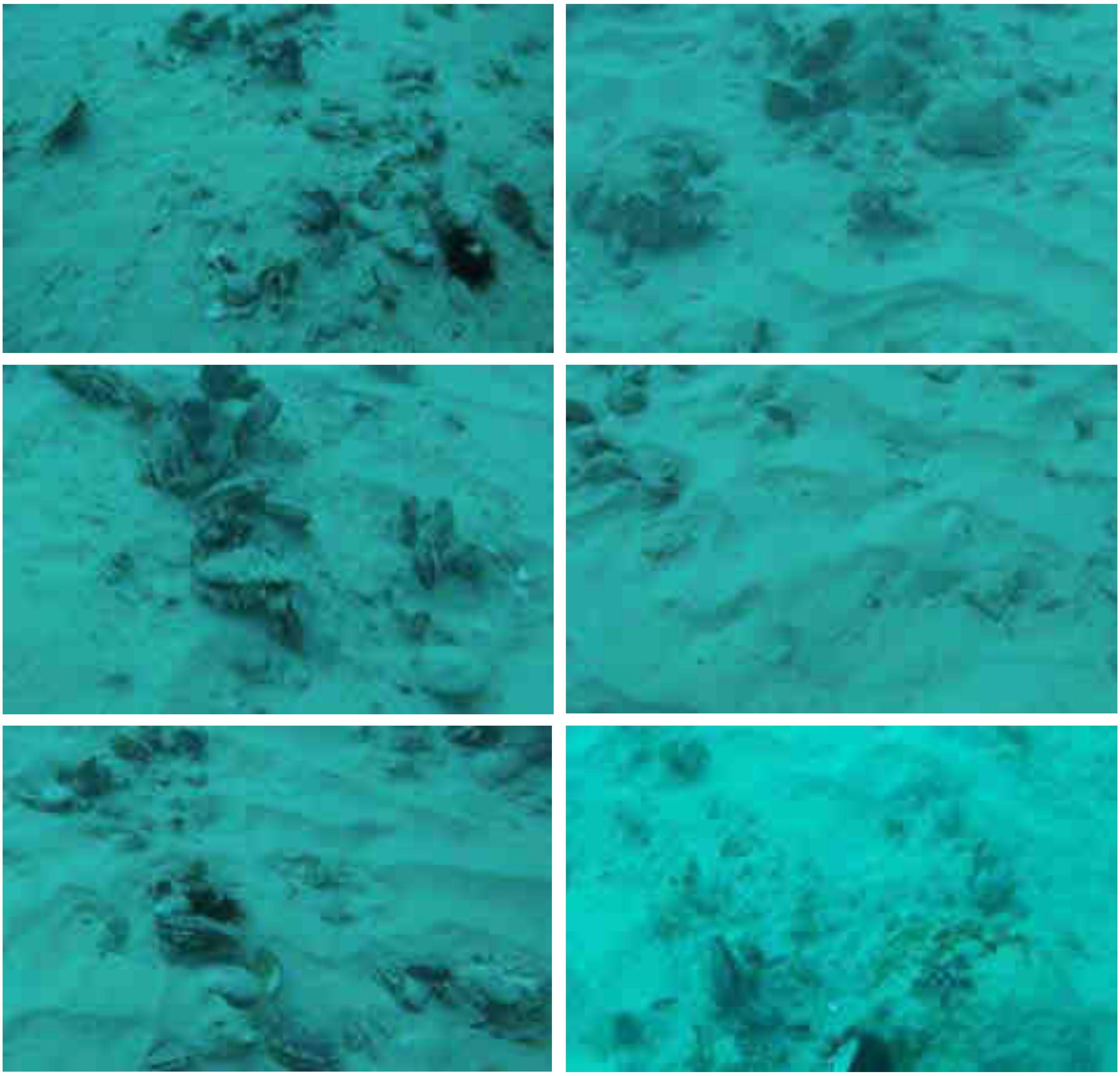


Figure 5-140: Hardbottom with bivalve bed and dead coral with algae benthic habitat along Route 1 – Zakum Clusters (DDV7)

Figure 5-141: Hardbottom with bivalve bed, sparse coral colonies and dead coral with algae benthic habitat along Route 1 – Zakum Clusters (DDV8)

Figure 5-142: Hardbottom with bivalve bed, sparse coral colonies and dead coral with algae benthic habitat along Route 1 – Zakum Clusters (DDV9)

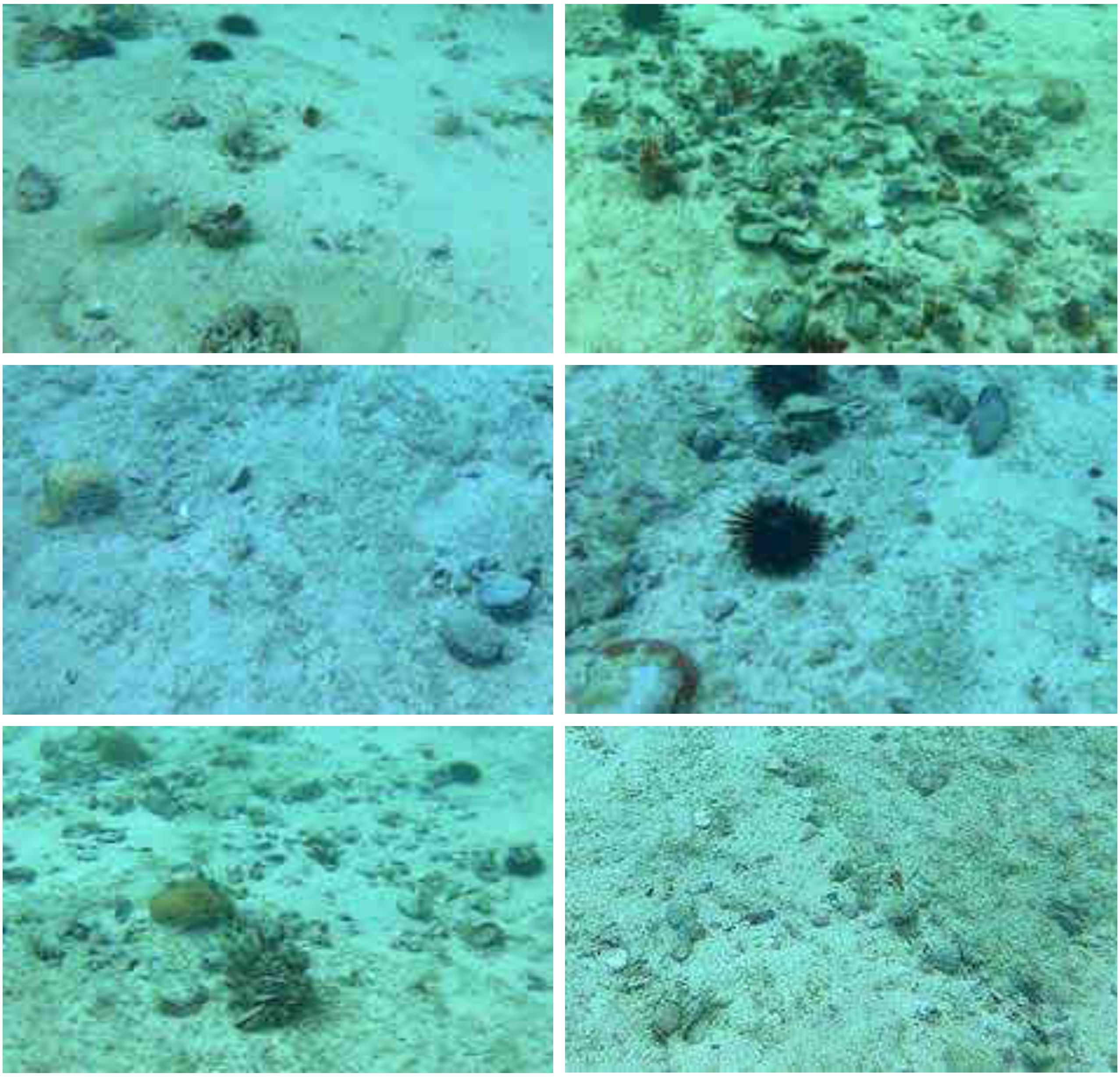


Figure 5-143: Hardbottom with bivalve bed, sparse coral colonies and dead coral with algae benthic habitat along Route 1 – Zakum Clusters (DDV10)

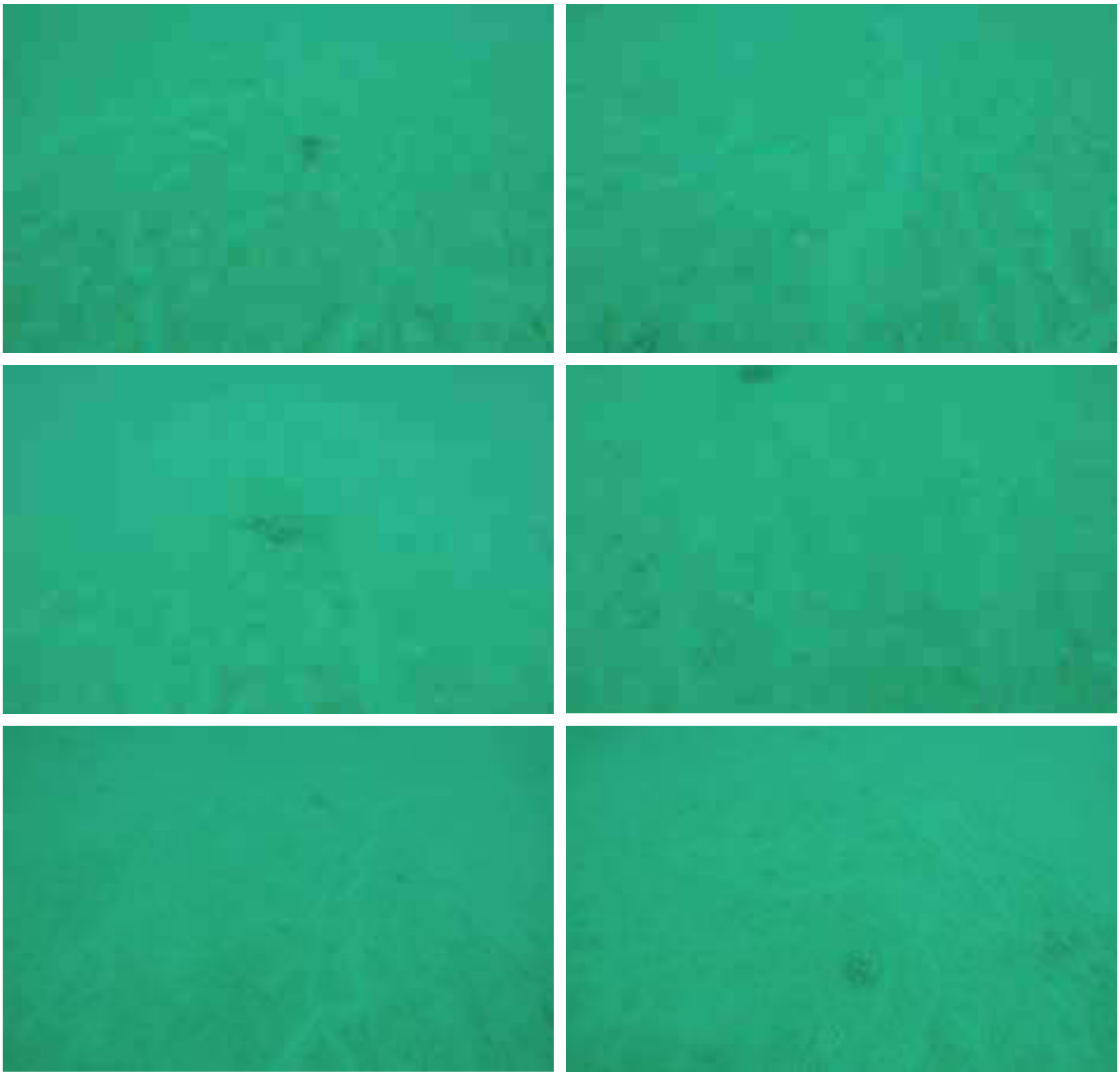


Figure 5-144: Unconsolidated bottom benthic habitat along Route 1 – Zakum Clusters (DDV11)

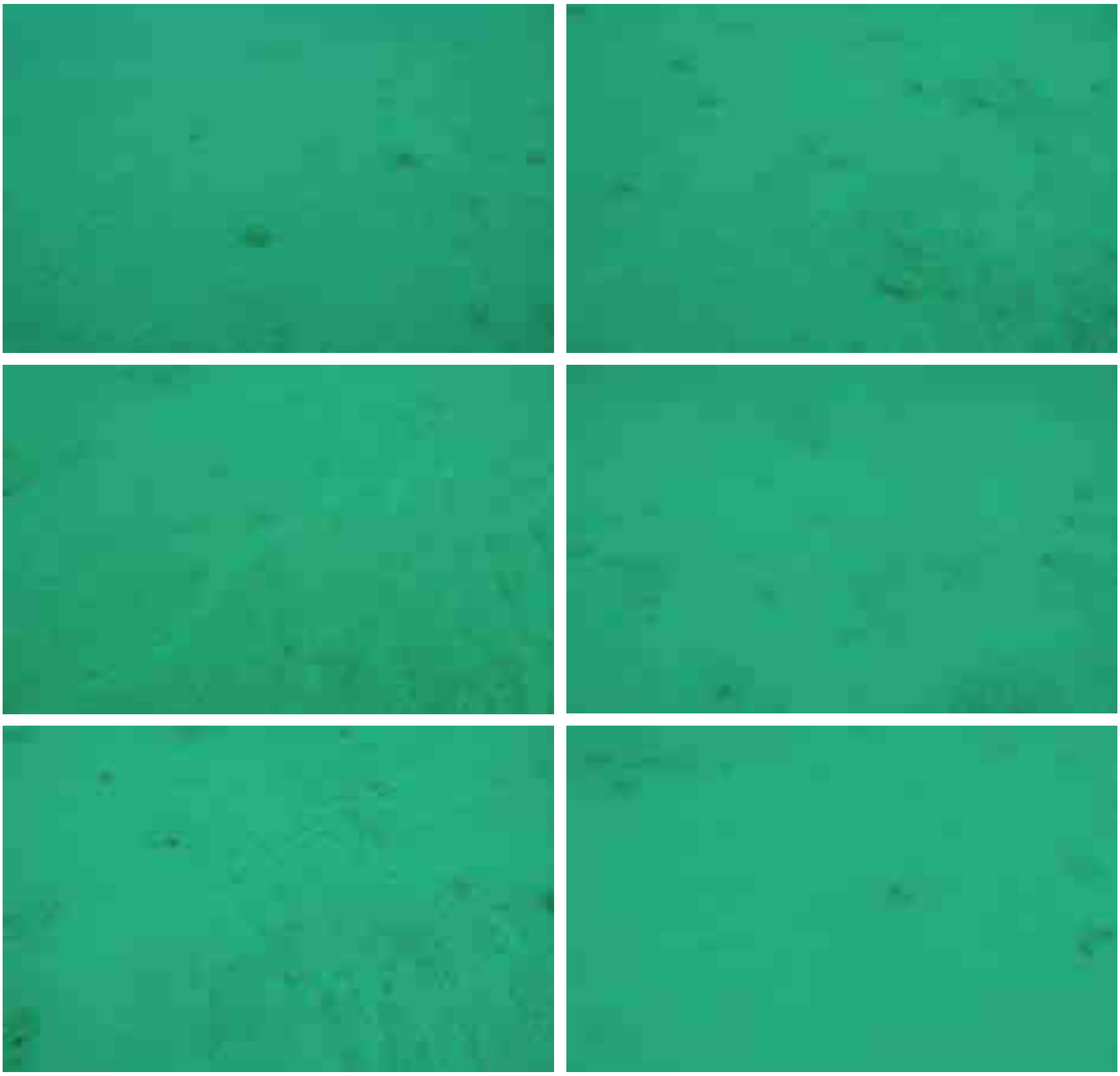


Figure 5-145: Unconsolidated bottom benthic habitat along Route 1 – Zakum Clusters (DDV12)

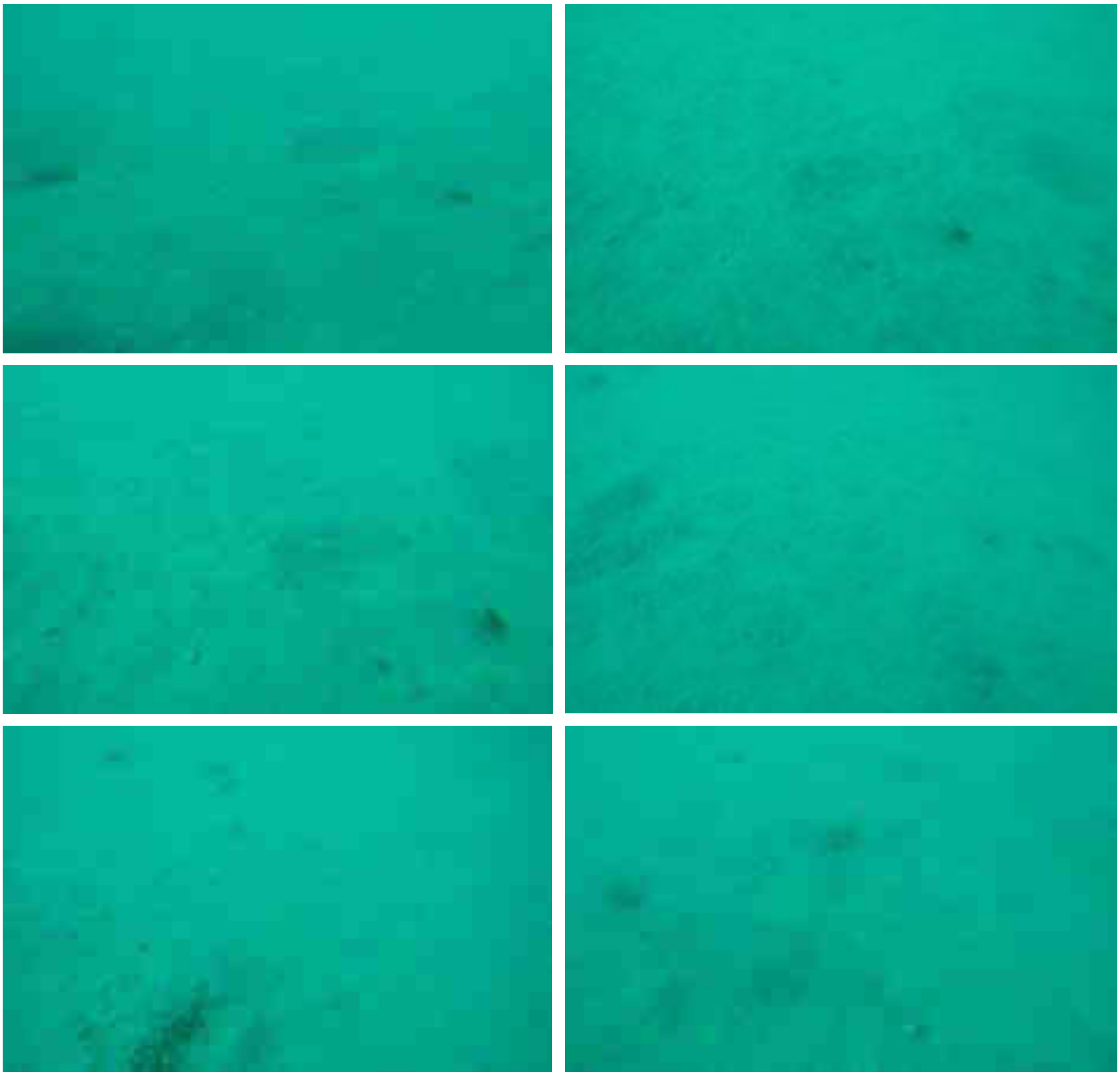


Figure 5-146: Unconsolidated bottom benthic habitat along Route 1 – Zakum Clusters (DDV13)

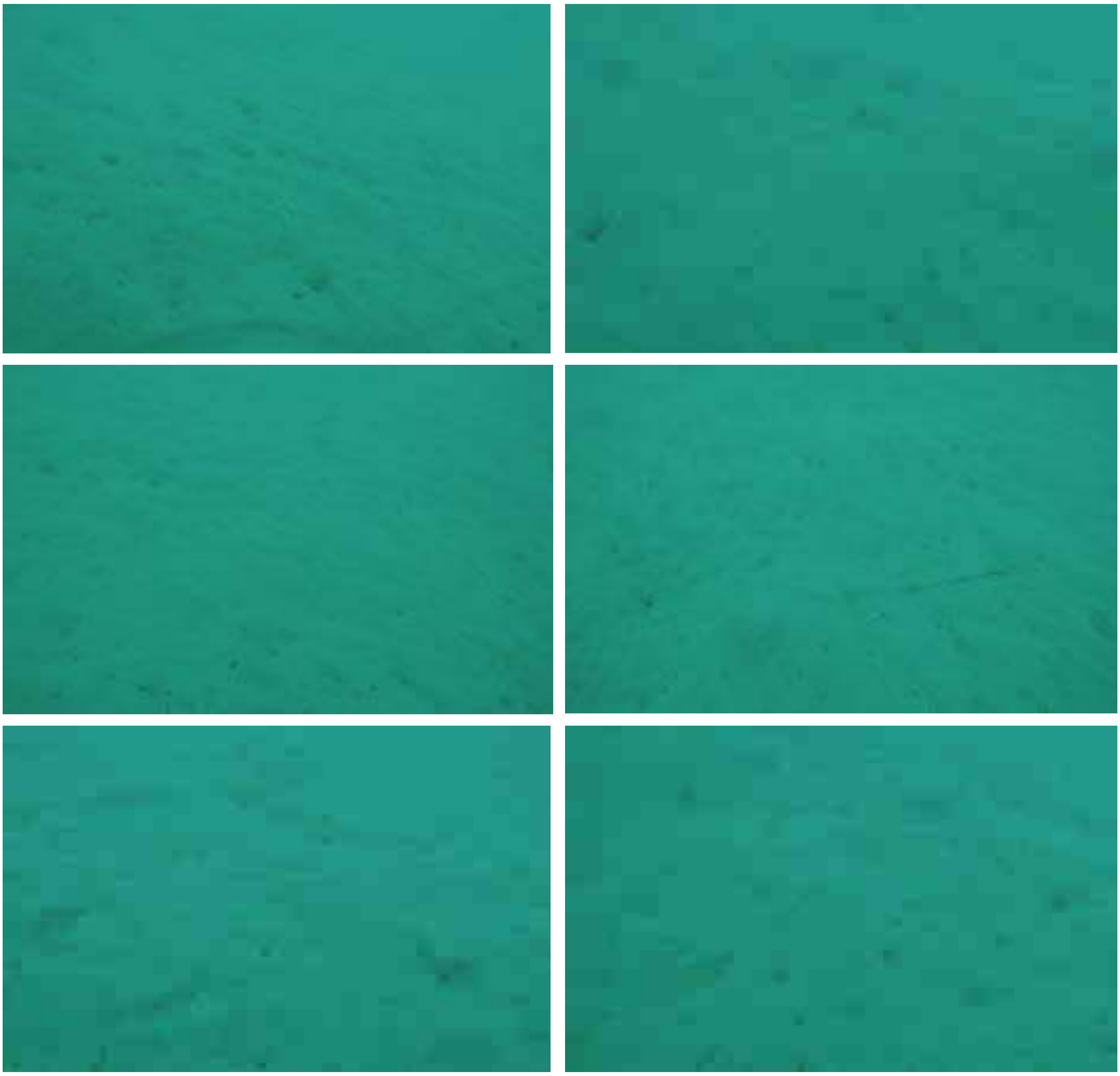


Figure 5-147: Unconsolidated bottom with sea pens benthic habitat along Route 1 – Zakum Clusters (DDV14)

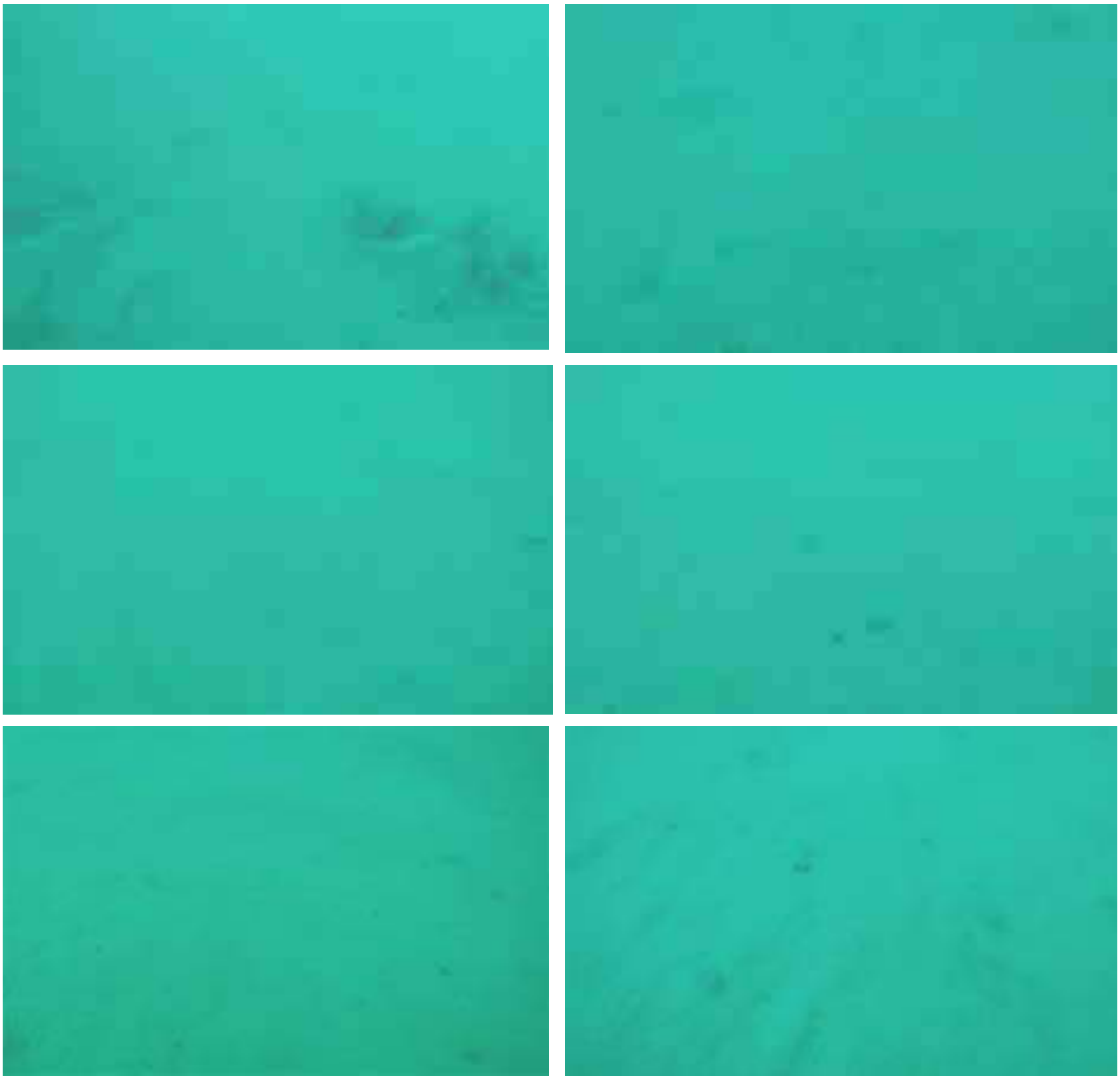


Figure 5-148: Unconsolidated bottom with sea pens (contracted) benthic habitat along Route 1 – Zakum Clusters (DDV15)

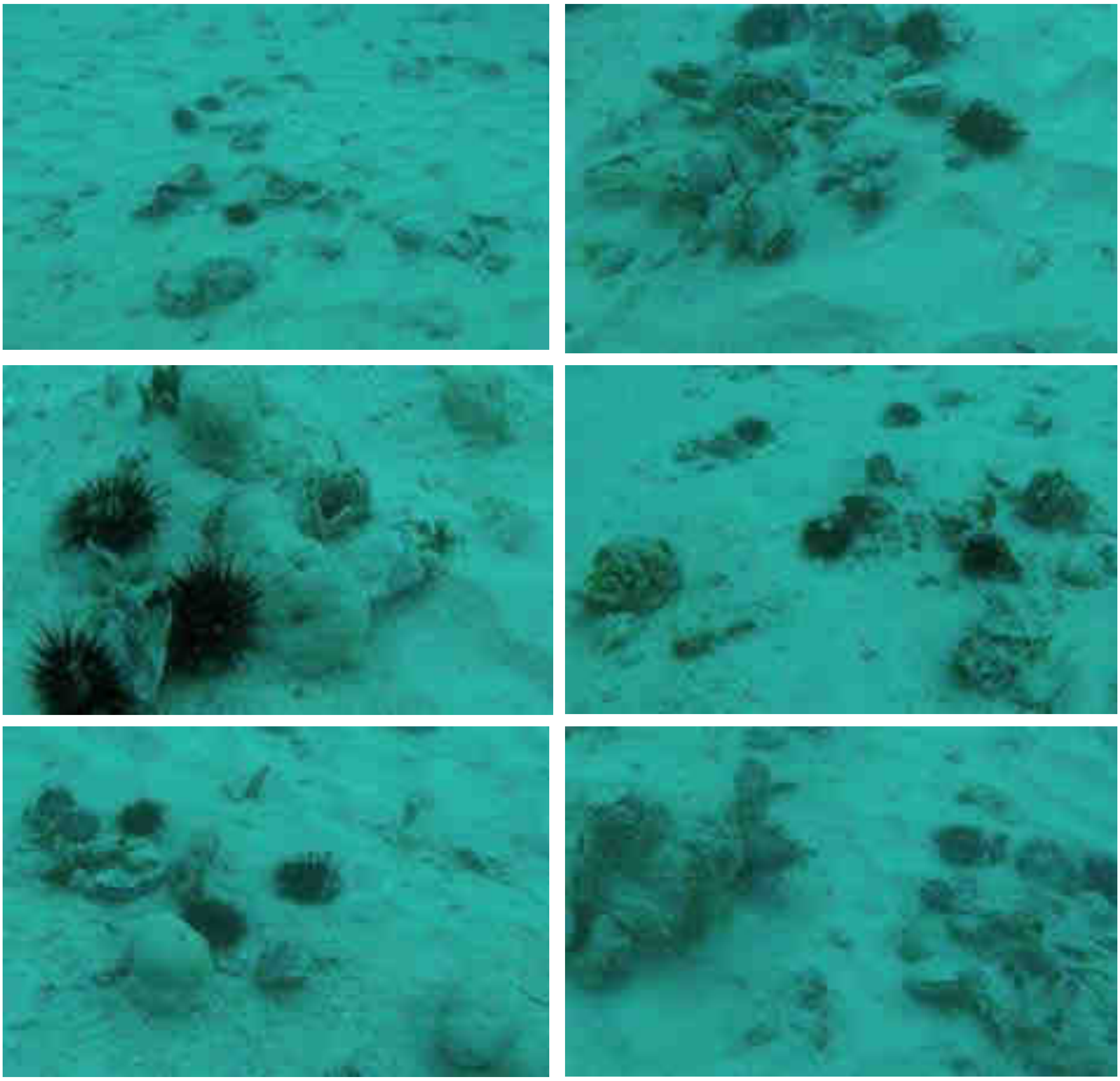


Figure 5-149: Hardbottom with bivalve bed, sparse coral colonies and dead coral with algae benthic habitat along Route 1 – Zakum Clusters (DDV16)

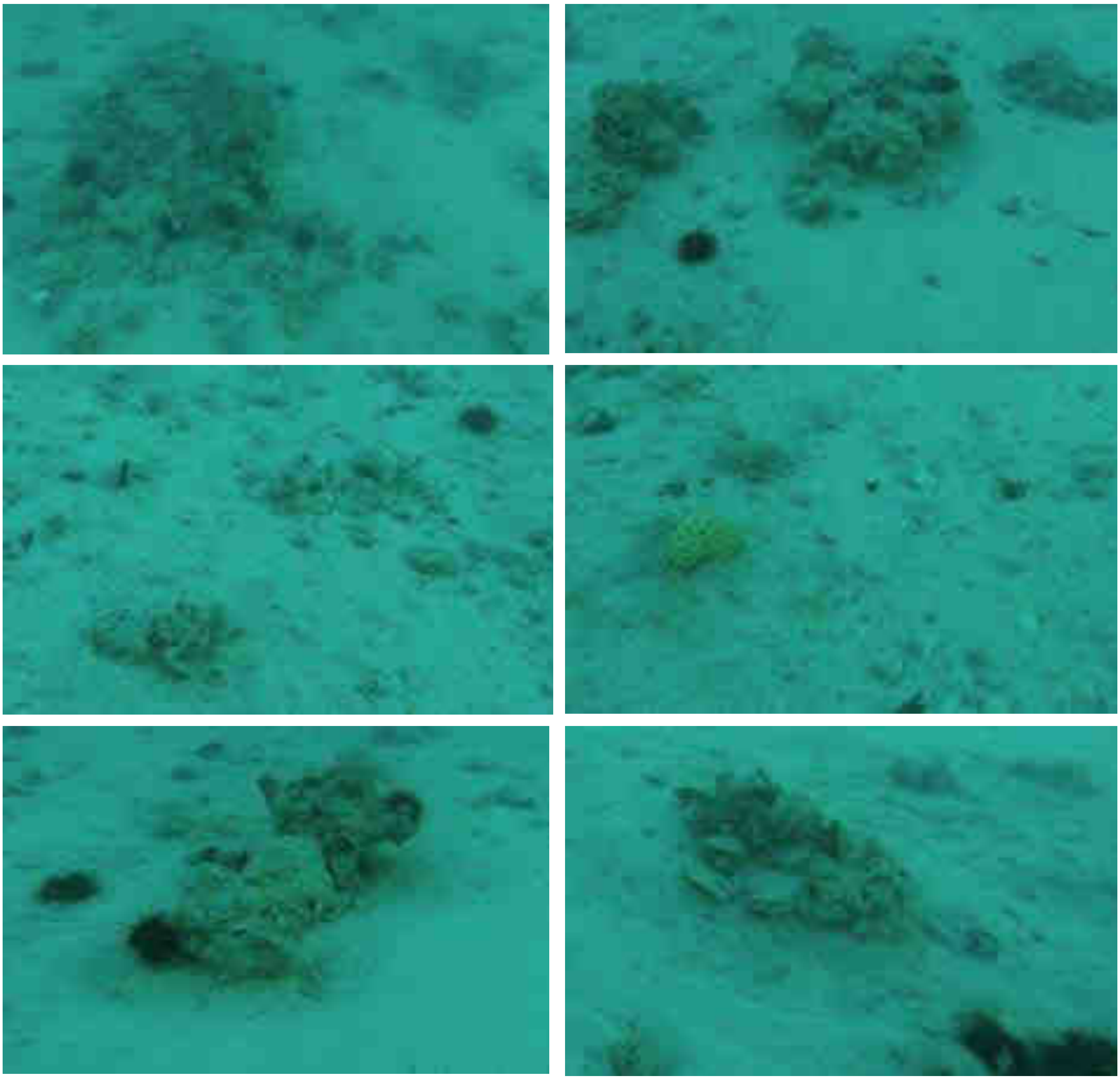


Figure 5-150: Hardbottom with bivalve bed, sparse coral colonies and dead coral with algae benthic habitat along Route 1 – Zakum Clusters (DDV17)

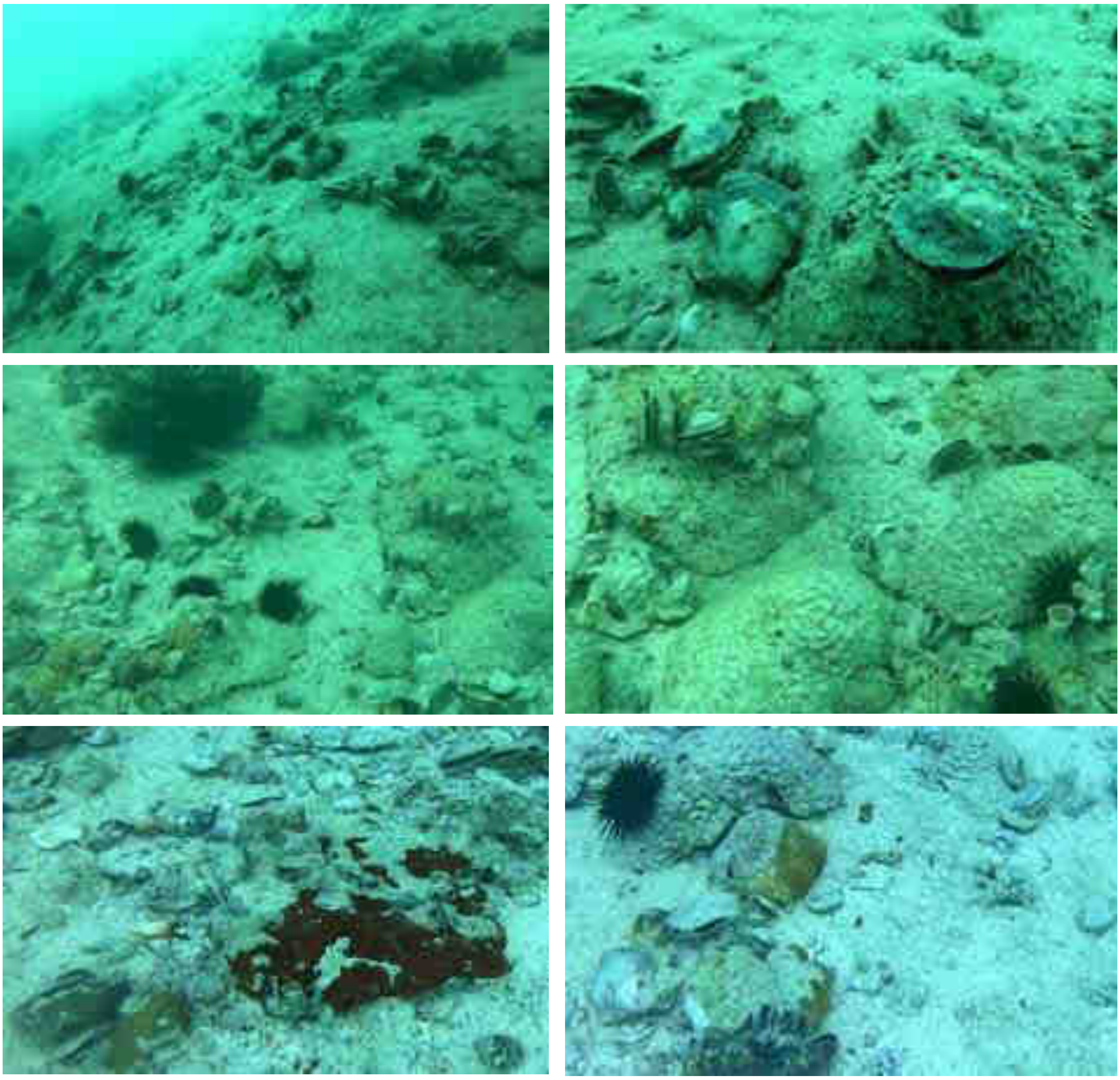


Figure 5-151: Hardbottom with bivalve bed, sparse coral colonies and dead coral with algae benthic habitat along Route 1 – Zakum Clusters (DDV18)

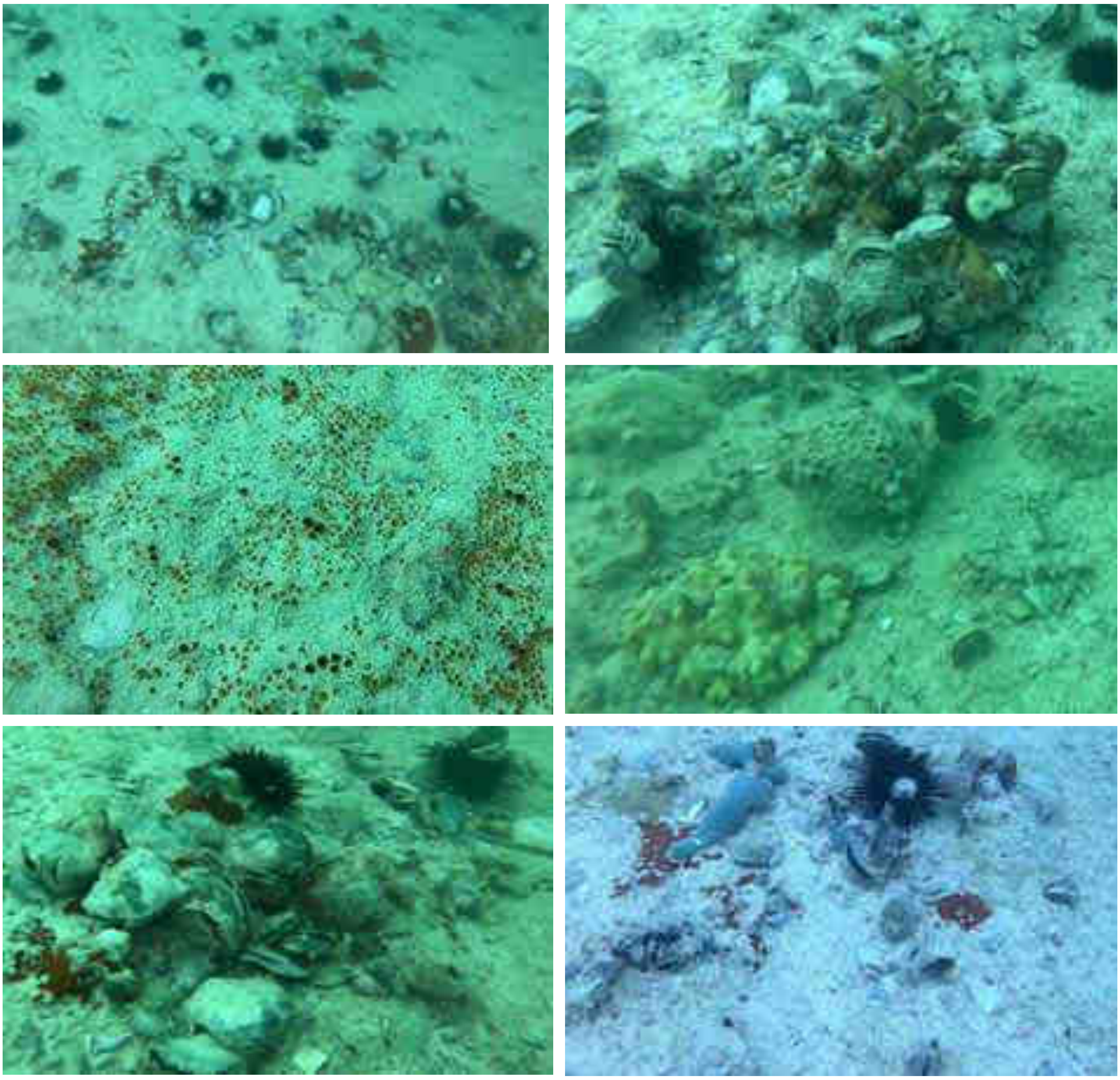


Figure 5-152: Hardbottom with bivalve bed, sparse coral colonies and dead coral with algae benthic habitat along Route 1 – Zakum Clusters (DDV19)

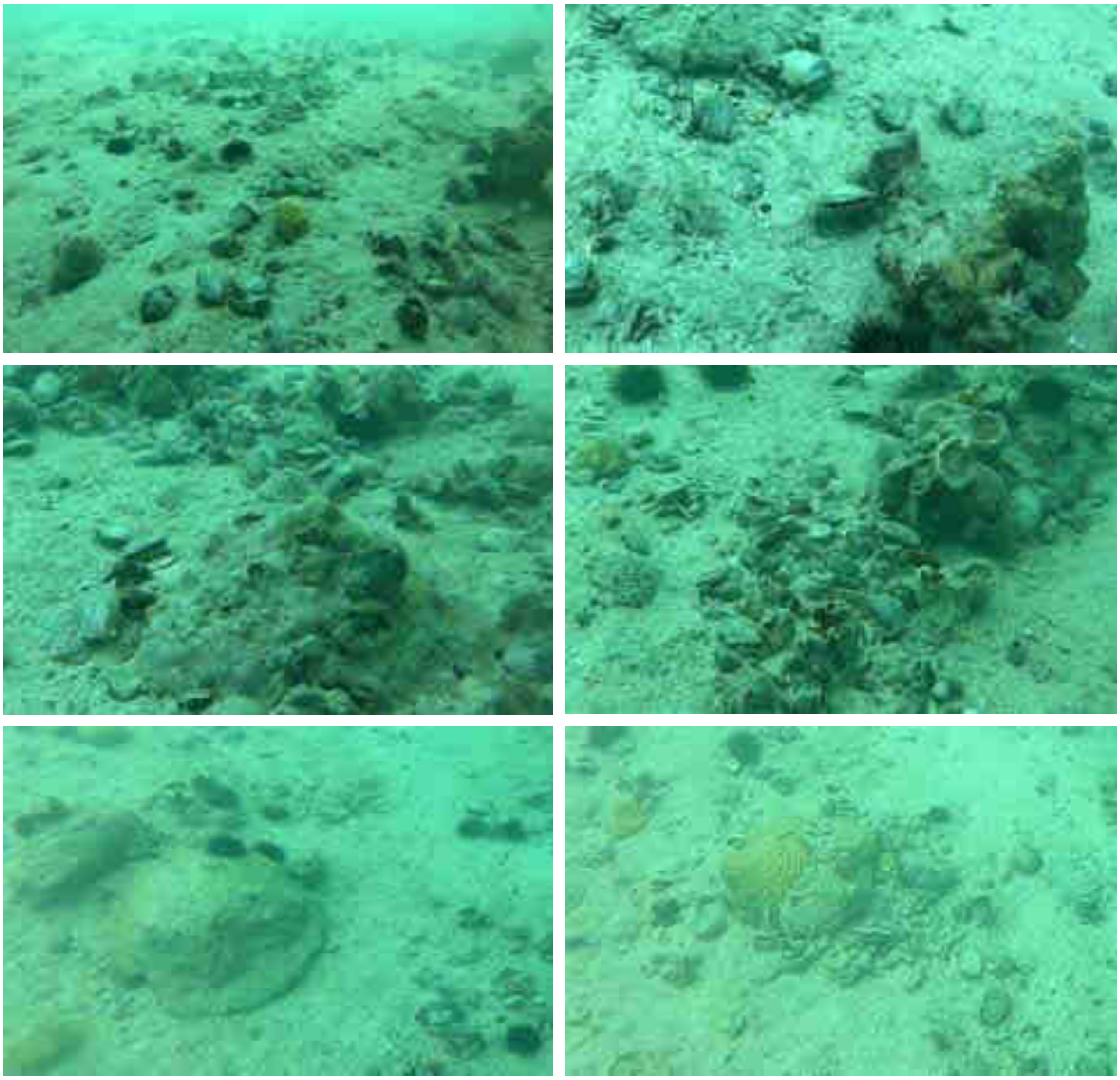


Figure 5-153: Hardbottom with bivalve bed, sparse coral colonies and dead coral with algae benthic habitat along Route 1 – Zakum Clusters (DDV20)

Unconsolidated Bottom

Mainly found on areas outside of Zakum oilfield, unconsolidated bottom habitat was found to be void of macro flora and faunal communities and organisms present are generally confined to burrowing marine organisms, gastropods and infaunal worms. The substrate found on sampling points outside of Zakum field was mud to silt and the unconsolidated bottom found within Mubarraz field sampling points were coarse sand with shell fragments.

Hardbottom

Almost all of survey points within Zakum oilfield was hardbottom. The features of this habitat include sparse young (<5 years old) coral colonies of which the majority was found to be dead, potentially from coral bleaching events. Populations of sea urchin, bivalves and a few sponges were documented during the survey. No massive coral structures were found.

Patch Reef

The coral colonies at Zakum cluster, particularly on areas within the Zakum oilfield, forms a developing patch reef habitat. Coral colony density and distribution are sparse and disjointed. It is assessed that the reef is young (estimated to be less than five years old) and massive coral mortality was seen potentially from coral bleaching. The impact of this mortality is preventing the development of a functional reef, thus the areas reflected on the habitat map were assigned to hard bottom.

Benthic Community (Flora and Fauna)

Table 5-61 below provides a summary of the habitats investigated through DDV. The various benthic flora and fauna species as well as the natural benthic substrate observed through the survey methods are also highlighted.

Fish

There were limited species of fish found during the DDV survey at Zakum clusters as detailed in Table 5-62. The fish tend to congregate in areas where there is hard bottom substrate and some coral and molluscan structures. Of all the species documented, the orange spotted grouper is considered important for fisheries.

Marine Mammal and Reptiles

No marine mammal and turtles were encountered during the survey.

Table 5-61: Summary of substrate type in Route 1 – Zakum Cluster through DDVs

DDV Point	Hardbottom	Unconsolidated Bottom	Rocks, Rubbles, and Molluscan Shells	Corals	Description
DDV1	X		X		Hardbottom with sediment constituent comprised of mostly of coarse-to-fine sand, and complemented with trifling rocks, rubbles and remains of mollusc shell.
DDV2	X		X	X	Hardbottom with rich fouling bivalves (mussel-like) from sand and few coral colonies of *Porites* sp. Also, with the presence of sea urchins (*Echinometra mathei* and *Diadema setosum*) and sponge (cf. *Dysidea* sp.).
DDV3		X			Unconsolidated bottom (silt/mud) with presence of Sea pens (Pennatulacea)
DDV4		X			Unconsolidated bottom (silt/mud) with presence of Sea pens (Pennatulacea)
DDV5		X			Unconsolidated bottom (silt/mud) with presence of Sea pens (Pennatulacea)
DDV6		X			Unconsolidated bottom (sandy)
DDV7	X		X	X	Hardbottom comprised of *Pinctada* spp., remains of dead coral framework, and some colonies with partly alive section. *Echinomerta* mathei is also present.
DDV8	X		X	X	Hardbottom comprised of *Pinctada* spp., remains of dead coral framework, and some colonies with partly alive section. *Echinomerta mathei* and *Diadema setosum* are also present.
DDV9	X		X	X	Hardbottom comprised mainly of Pinctada spp., with few occurring coral colonies of Poritids and Merulinids, and with

DDV Point	Hardbottom	Unconsolidated Bottom	Rocks, Rubbles, and Molluscan Shells	Corals	Description
					the presence of sea urchins (*Echinometra mathei* and *Diadema setosum*) and sponge (cf. *Dysidea* sp.). Previous coral mortality is evident with the incidence of dead corals with algae.
DDV10	X		X	X	Hardbottom comprised mainly of Pinctada spp., with few occurring coral colonies of Poritids and Merulinids, and with the presence of sea urchins (*Echinometra mathei* and *Diadema setosum*) and sponge (cf. *Dysidea* sp.). Previous coral mortality is evident with the incidence of dead corals with algae.
DDV11		X	X		Unconsolidated bottom (mud/silt/sand)
DDV12		X	X		Unconsolidated bottom (mud/silt/sand)
DDV13		X	X		Unconsolidated bottom (mud/silt/sand)
DDV14		X			Unconsolidated bottom (silt/mud) with presence of Sea pens (Pennatulacea)
DDV15		X			Unconsolidated bottom (silt/mud) with presence of Sea pens (Pennatulacea)
DDV16	X		X	X	Hardbottom comprised mainly of Pinctada spp., with few occurring coral colonies of Poritids and Merulinids, and with the presence of sea urchins (*Echinometra mathei* and *Diadema setosum*) and sponge (cf. *Dysidea* sp.). Previous coral mortality is evident with the incidence of dead corals with algae.
DDV17	X		X	X	Hardbottom comprised mainly of Pinctada spp., with few occurring coral colonies of Poritids and Merulinids, and with the presence of sea urchins (*Echinometra mathei* and

DDV Point	Hardbottom	Unconsolidated Bottom	Rocks, Rubbles, and Molluscan Shells	Corals	Description
					Diadema setosum) and sponge (cf. *Dysidea* sp.). Previous coral mortality is evident with the incidence of dead corals with algae.
DDV18	X				Hardbottom comprised mainly of Pinctada spp., with few occurring coral colonies of Poritids and Merulinids, and with the presence of sea urchins (*Echinometra mathei* and *Diadema setosum*) and sponge (cf. *Dysidea* sp.). Previous coral mortality is evident with the incidence of dead corals with algae.
DDV19	X		X	X	Hardbottom comprised mainly of Pinctada spp., with few occurring coral colonies of Poritids and Merulinids, and with the presence of sea urchins (*Echinometra mathei* and *Diadema setosum*) and sponge (cf. *Dysidea* sp.). Previous coral mortality is evident with the incidence of dead corals with algae. Hydroids growing on coral skeleton and on molluscan shells. Crustose coralline algae has also colonised some of the dead coral framework
DDV20	X		X	X	Hardbottom comprised mainly of Pinctada spp., with few occurring coral colonies of Poritids and Merulinids, and with the presence of sea urchins (*Echinometra mathei* and *Diadema setosum*) and sponge (cf. *Dysidea* sp.). Previous coral mortality is evident with the incidence of dead corals with algae. Hydroids growing on coral skeleton and on molluscan shells. Crustose coralline algae has also colonised some of the dead coral framework

Table 5-62: List of fish observed through DDVs

Common Name	Scientific Name	DDV Location																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Bludger	*Carangoides gymnostethus*							X													
Yellow bar Angelfish	*Pomacanthus maculosos*								X	X											X
Orange-spotted Grouper	*Epinephelus coicoides*								X												
Black-streaked Monocle Bream	*Scolopsis taeniatus*															X				X	
Arabian Monocle Bream	*Scolopsis ghanam*																		X		
Goby	Gobiidae								X	X				X							

Note: X denotes the presence of species

Route 2 – Shuweihat Landfall

Benthic Habitat

Based on the results of the marine ecology surveys, four core habitats are present in the survey area as follows:

- Unconsolidated Bottom: 14000;
- Seagrass Bed: 12000;
- Macroalgae communities: 13010; and
- Fringing Reef: 11100.

The distribution of different habitats within the entire Route 2 is shown in Figure 5-154 and the specific habitats found in the Shuweihat Landfall and nearshore areas are provided in Figure 5-155. Specific conditions of the various coral reefs encountered are provided in Figure 5-156 to Figure 5-160. The various snapshots of the benthic communities captured by the DDV systems (Drift Towed) are presented in Figure 5-161 to Figure 5-166.

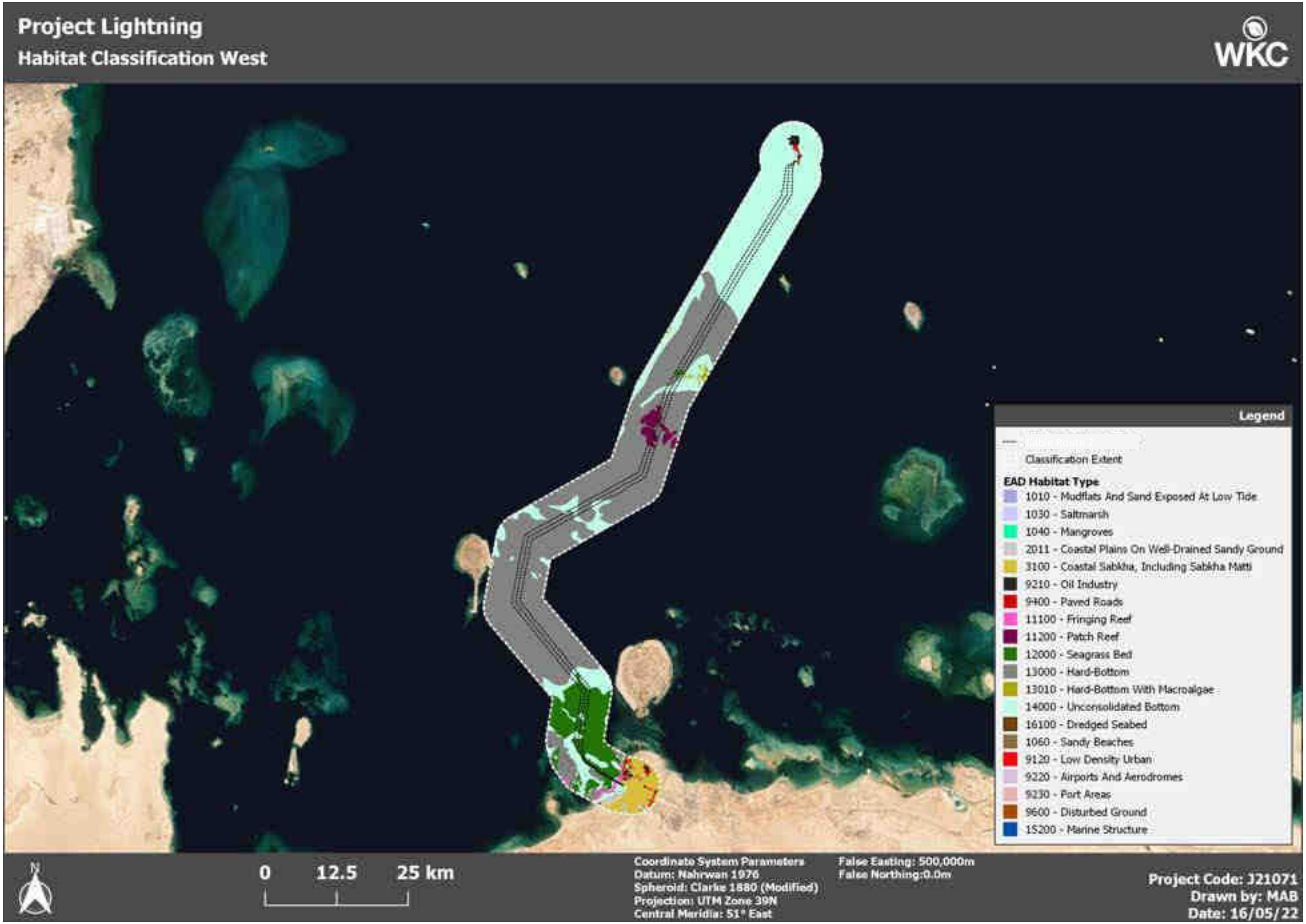


Figure 5-154: Overall habitat map along Route 2

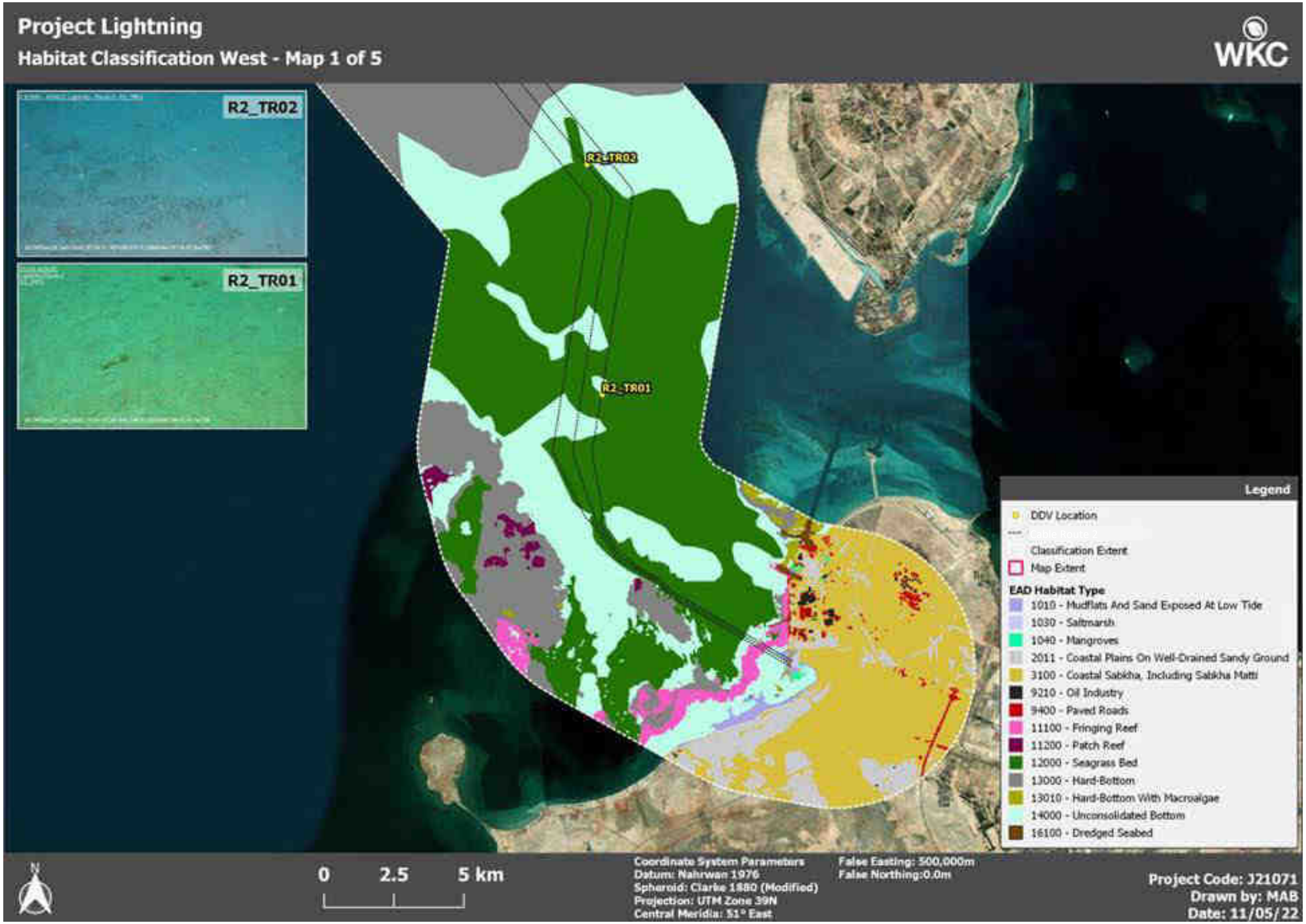


Figure 5-155: Habitat map along Route 2 – Shuweihat Landfall

Figure 5-156: Surviving corals found at the fringing reef along Route 2 – Shuweihat Landfall

Figure 5-157: Fringing reef condition along Route 2 – Shuweihat Landfall (1)

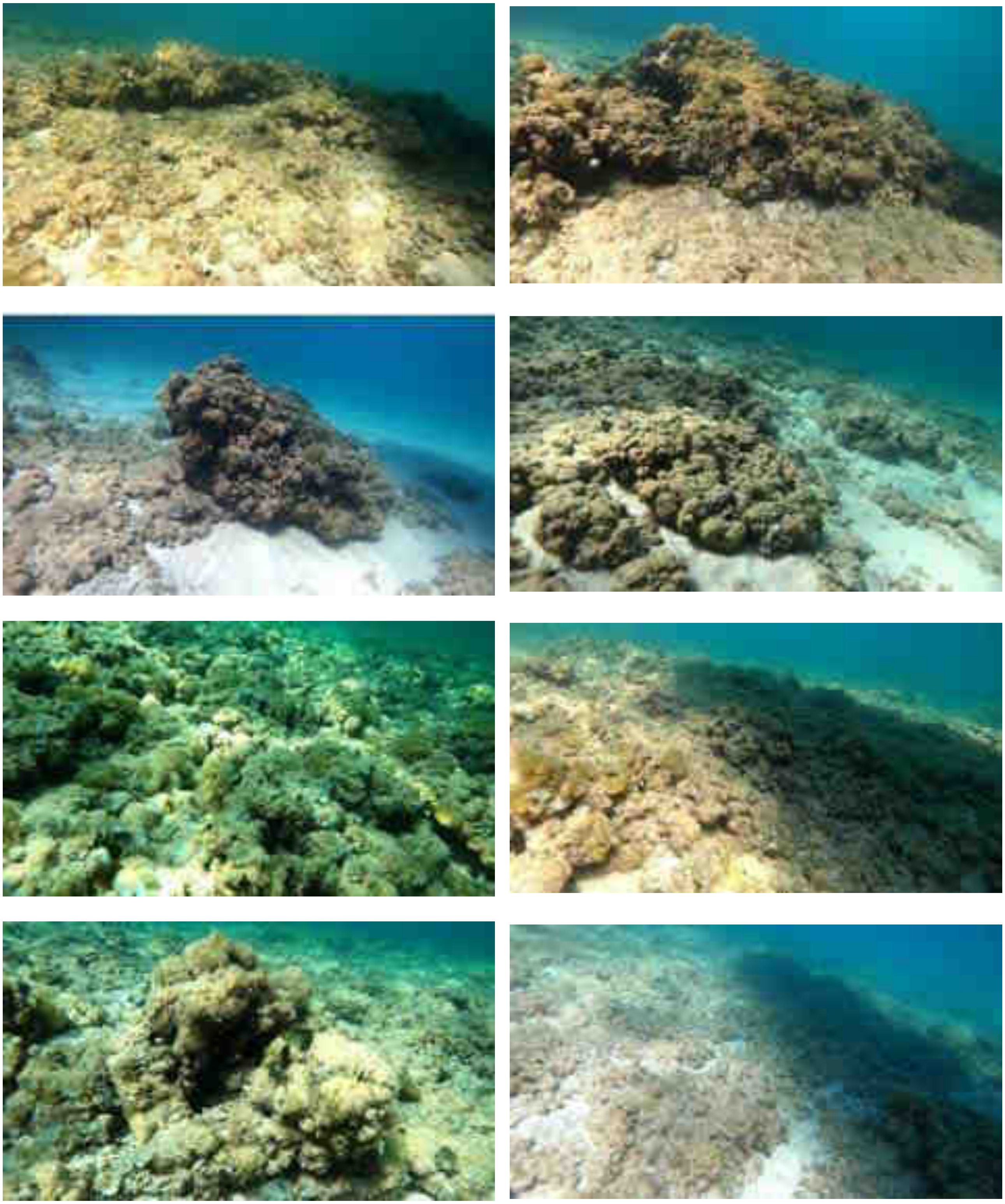


Figure 5-158: Fringing reef condition along Route 2 – Shuweihat Landfall (2)

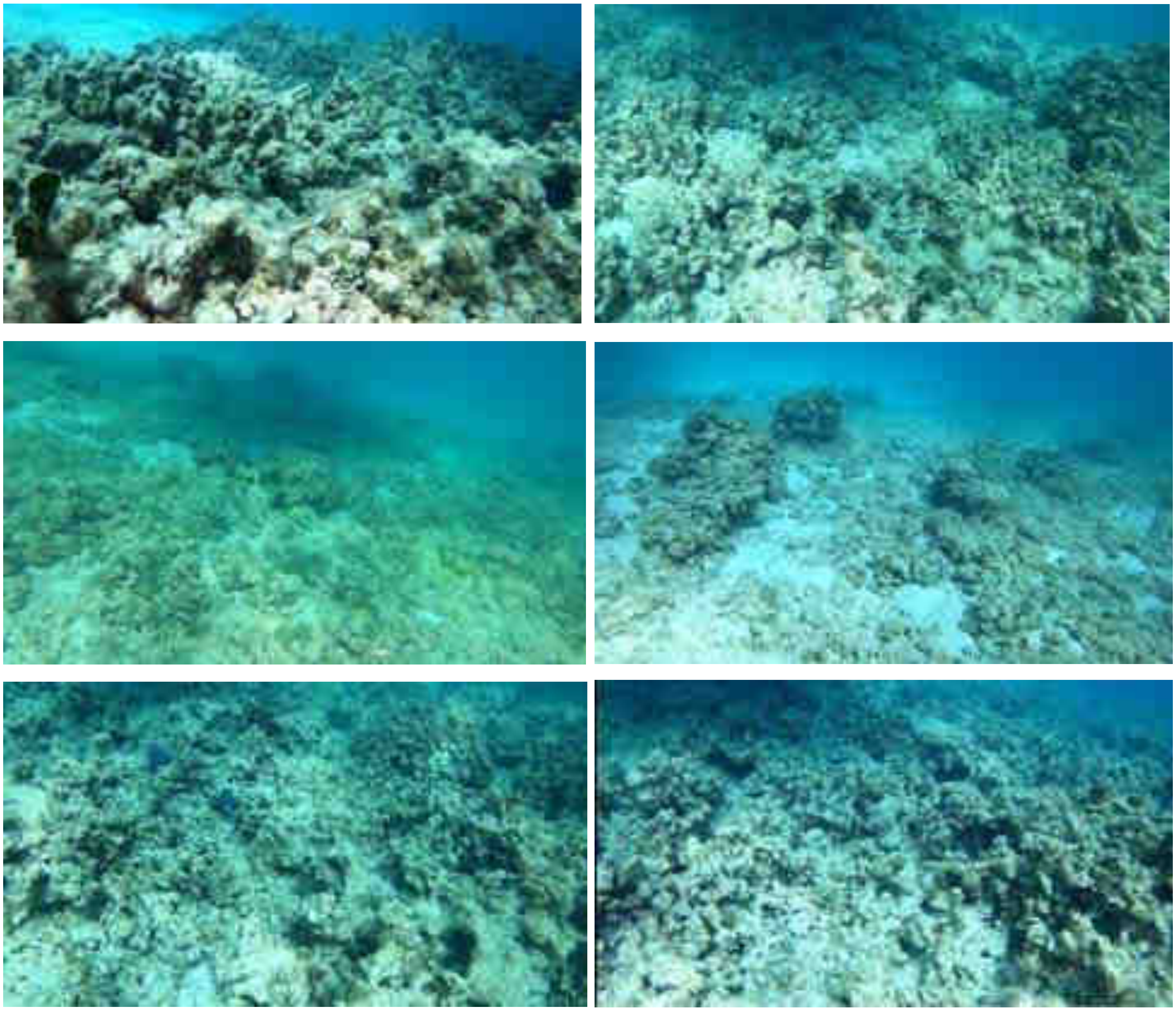


Figure 5-159: Fringing reef condition along Route 2 – Shuweihat Landfall (3)

Figure 5-160: Conditions at the outer border of the fringing reef along Route 2 – Shuweihat Landfall (DDV1)

Figure 5-161: Benthic habitat along Route 2 – Shuweihat Landfall (DDV1)

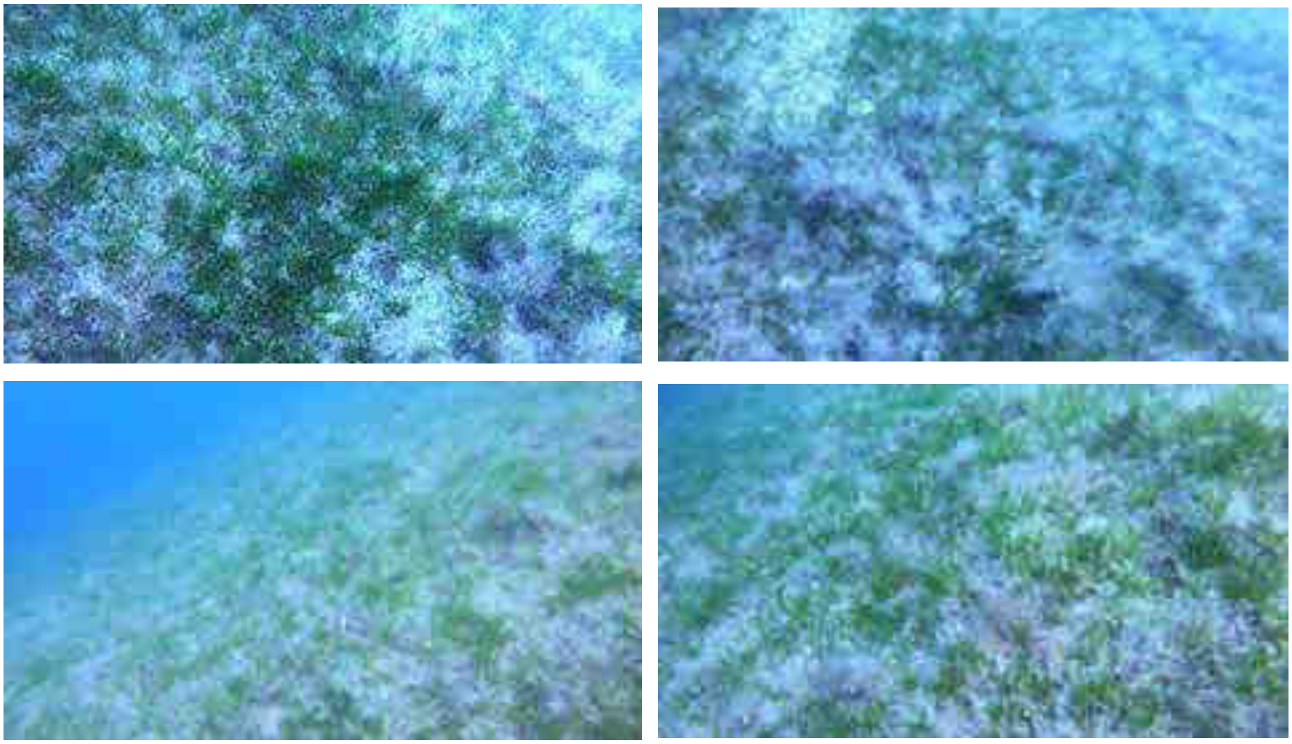


Figure 5-162: Benthic habitat along Route 2 – Shuweihat Landfall (DDV2)

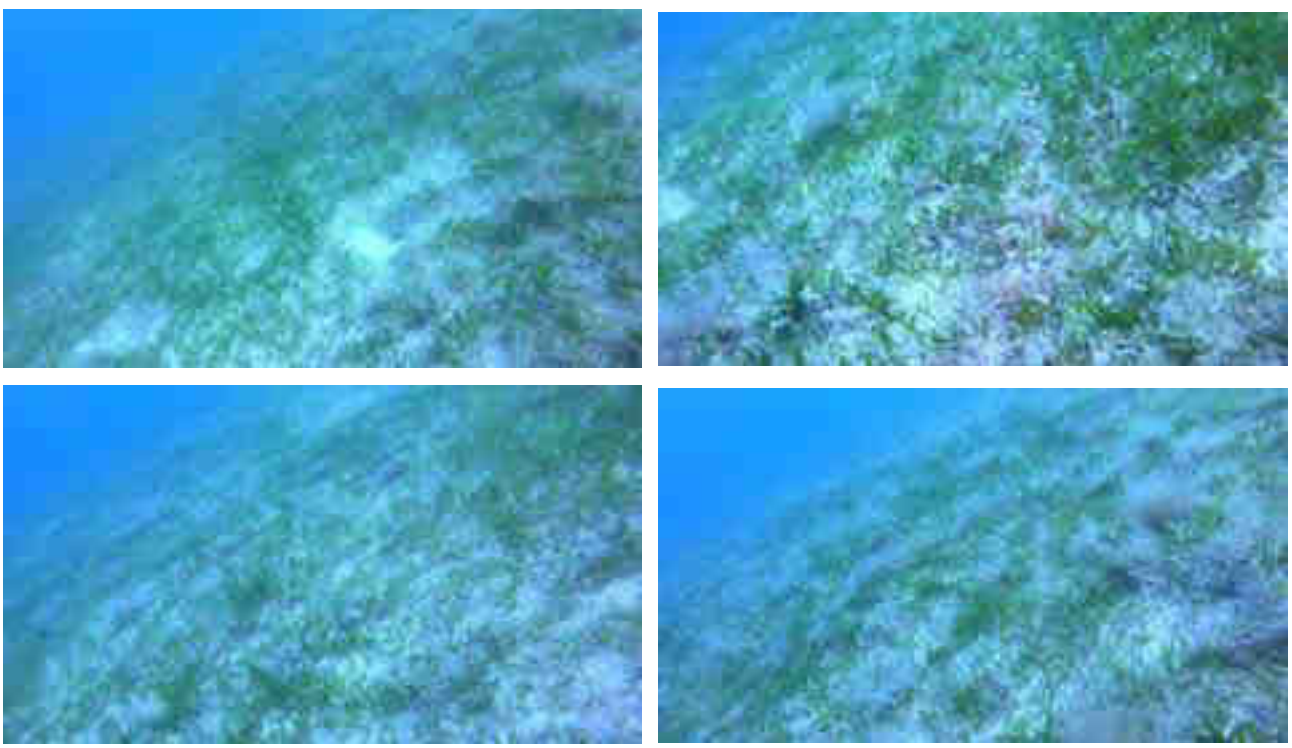


Figure 5-163: Benthic habitat along Route 2 – Shuweihat Landfall (DDV3)

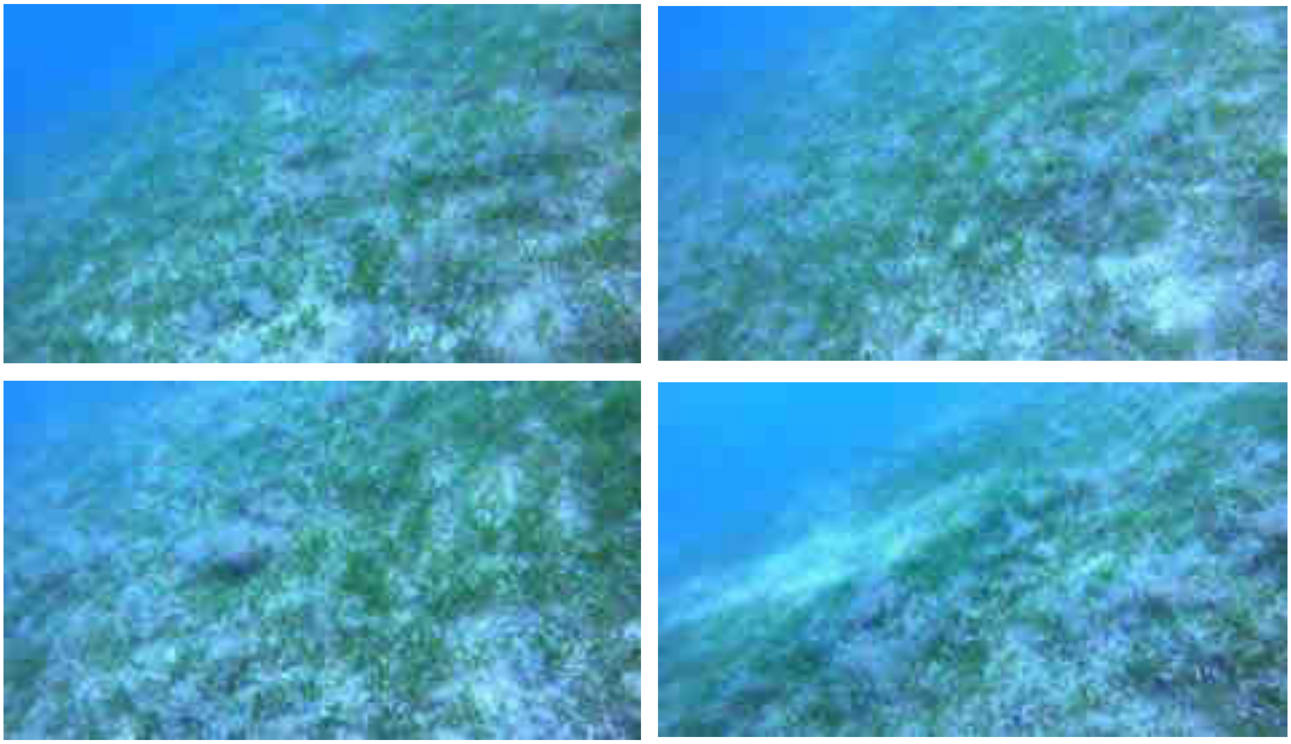


Figure 5-164: Benthic habitat along Route 2 – Shuweihat Landfall (DDV4)

Figure 5-165: Benthic habitat along Route 2 – Shuweihat Landfall (DDV5)

Figure 5-166: Benthic habitat along Route 2 – Shuweihat Landfall (DDV6)

Based on the assessment of the captured still images, the characteristic benthic habitats found throughout the surveyed areas include mostly seagrass, seagrass with macro-algae, and sandy areas as detailed in Table 5-63. These habitat types including associated flora and fauna are further discussed in the following sections.

Table 5-63: Benthic Habitat along Route 1 – Shuweihat Landfall from analysed photoquadrats

Photo Quadrat Number	Seagrass (%)	Sand (%)	Hardbottom/ Fringing Reef (%)	Rubbles and Shells (%)	Macro Algae (%)	Total (%)
PQ1	32.5	62.5	0	5	0	100
PQ2	100	0	0	0		100
PQ3	100	0	0	0		100
PQ4	100	0	0	0		100
PQ5	100	0	0	0	0	100
PQ6	0	57.5	42.5	0	0	100

Unconsolidated Bottom

The unconsolidated bottom habitat in this area is characterized by coarse sand often intermixed with shells fragments and rubbles, see Figure 5-167. These open areas of sand are sometimes defined and not heavily colonised by seagrass or algae largely due wave movement that is demonstrated by ripple patterns in the sand.

Figure 5-167: Unconsolidated bottom (sandy substrate)

These areas contain a lower abundance of marine life as fish and invertebrates prefer the more productive environment seagrass, reefs, and hard bottom areas. On these areas sparse hard substrates sometimes appear and colonized by fouling organisms which may be a combination of ascidians, macro algae, and molluscan bivalves. Sea urchin may sometime be attracted to these benthic structures and aggregate.

Seagrass Bed

Seagrasses are well represented throughout the survey site. Areas range from dense seagrass meadows to sparse seagrass patches particularly on the meadow boundaries (Figure 5-168). The three species identified were *Halophila stipulacea*, *Halophila ovalis and Halodule uninervis*. These species are adept at colonising areas of unconsolidated bottom due to fast propagation rates and tolerance to varying environmental conditions.

Figure 5-168: Seagrass bed mixed with macro algae

Seagrass can quickly develop into established seagrass beds. As ecosystem engineers, their ability to modify the existing unconsolidated bottom into a distinct habitat is related to the scale mass of core seabed present. This habitat provides foraging for many organisms including endangered species such as sea turtles and dugongs. Sand sediments within seagrass beds support a greater diversity and abundance of benthic infauna than open sand substrates (107). Many commercially important species such as fish, shrimps, and oysters also utilise seagrass beds as nursery and foraging grounds.

Seagrasses also provide a variety of ecosystem functions. The rhizome and root system of a seagrass bed stabilises loose sediment and organic materials. This leads to improved water clarity and reduced erosion. Seagrasses are highly productive photosynthetic plants and as such, they contribute significant amounts of oxygen that become available for consumption by other marine life.

Macroalgae Communities

A significant macroalgae meadow mixed with seagrasses was observed in several areas within the survey site, comprising of a mixed with of unconsolidated bottom, reef structures and seagrass beds. An example of macroalgae meadow at the survey area is presented in Figure 5-169. This macroalgae community covers a wide area particularly on the identified fringing reef and contains many large macroalgae plants including a variety of species are present mainly from the groups Chlorophyta (green algae) and Phaeophycean (brown algae).

Figure 5-169: Macroalgae bed filamentous algae mixed with seagrass beds

Fringing Reef

During the survey, a fringing reef was identified nearshore of Shuweihat landfall. The structure observed was developed by corals, but the present state of the reef is very poor and most of the corals observed are dead. There are young colonies of corals seen growing but they are sparse. It is assessed that the live coral density in the fringing reef is very low and estimated to be at <1% of the benthic cover. Under these conditions, the exact densities cannot be determined using the approved survey methods employed. An example of the fringing reef habitats is presented in Figure 5-170. This habitat type is devoid of seagrasses and has a well-defined boundary. In addition, sessile marine organisms were noted to colonise the substrate like macro algae, corals, tunicates, and bivalves. Further discussion on corals and the current conditions are provided further below.

The fringing reef substrates still provide opportunity for coral growth thus considered an important natural marine habitat. This habitat also provide stability to the seabed that will facilitate continuity of benthic succession until climax community is achieved.

Figure 5-170: Example of fringing reef

Benthic Community (Flora and Fauna)

Table 5-64 provides a summary of the habitats investigated through DDV. The various benthic flora and fauna species as well as the natural benthic substrate observed through the survey methods are also included in the table below.

Table 5-64: Benthic community observations within Route 2 – Shuweihat Landfall

Sampling Location	Unconsolidated Bottom (Sandy)	Seagrass	Reef	Macro-algae	Description
DDV 1	X	X			Rich seagrass meadow with population of pearl oysters. Sandy bottom in patches and extended areas. Unconsolidated bottom with hard outcrops colonized by fouling species.
DDV 2		X		X	Rich seagrass meadow mixed with filamentous macro algae
DDV 3		X		X	Rich seagrass meadow mixed with filamentous macro algae.
DDV 4		X		X	Rich seagrass meadow mixed with filamentous macro algae
DDV 5		X	X	X	Defined rich seagrass meadow mixed with filamentous macro algae and areas of dead fringing reef covered with turf algae
DDV 6			X	X	Fringing reef with macro algae

Invertebrates

Various invertebrate species were observed in the area including sea urchins, sea snails, bivalves, sponges, and tunicates. In addition, burrows in seagrass beds provide evidence of invertebrate habitation, however, species identification was not possible in these areas. A summary of macro invertebrates observed is in the study area is provided in Table 5-65.

Table 5-65: List of invertebrates along Route 2 – Shuweihat Landfall

Common Name	Scientific Name
Collectors Sea Urchin	*Tripneustes* sp.
Long Spined Sea Urchin	*Diadema setosum*
Sponge	Demospongiae
Tunicate	*Phallusia nigra*
Sea Snail	Cerithriidae sp.
Pearl Oyster	*Pinctada radiata*

Corals

Coral are colonial organisms found throughout tropical and sub-tropical oceans. Each coral is comprised of hundreds, or thousands of individual animals called polyps. The polyps use tentacles with stinging cells called nematocysts to catch prey that drift past in the water column. However, shallow water corals typically derive most of their energy and nutrients from a symbiotic relationship with photosynthetic single-celled organisms known as zooxanthellae. The zooxanthellae live within the tissues of the coral and photosynthesize to provide the polyps with nutrients such as glucose and amino acids. Many types of corals are ecosystem engineers as they are primarily responsible for reef building. As these corals grow, they produce hard calcium carbonate skeletons, which become the framework of the reef. The complex habitat created by corals provides a range of ecological niches that encourages biodiversity. The examples of current conditions of fringing reefs at the survey sites are presented in Figure 5-171 and Figure 5-172.

Figure 5-171: Dead corals

Figure 5-172: Surviving corals

Evidence of coral bleaching was also observed in locations of the fringing reef. The bright colours exhibited by many corals are caused by zooxanthellae. When corals undergo stress from environmental changes such as increased temperature or pollution the zooxanthellae are expelled, hence the coral turns a bright white colour. This phenomenon is known as coral bleaching. A bleached coral is not dead as the polyps can still obtain energy by feeding on plankton. However, this can only be sustained for a short time before the coral becomes nutrient deficient and starves or is overcome by algae growth. If the environmental stress is reduced, it is possible for the zooxanthellae to recolonise the coral and the polyps may recover. The cumulative impact of persistent bleaching events generally reduces the resilience of corals and leads to a loss of diversity and overall abundance (120).

The other probable cause of coral mortality observed in the Project site was sedimentation. Sediments that are disturbed through wave action settle on and around corals. The sediment particles cause physical damage to the polyp and impede light penetration to the zooxanthellae. This causes the coral to become nutritionally deficient and vulnerable to algae overgrowth.

Corals and algae are constantly competing for space in the reef environment. Healthy corals can fend off algae using stinging cells on the polyp tentacles. However, a coral undergoing environmental stress such as sedimentation is less able to prevent algae growth.

Sea Urchin

The dominant invertebrate observed in the study area were sea urchins. The two species of urchins ((*Tripneustes sp.*) and long spine urchin (*Diadema setosum)*) found in the area. Collector Sea Urchin, *Tripneustes sp*., are algae eaters. They live on open sea bottom and use collected pebbles to conceal themselves from predators. Sea urchin are commercially important in other countries as it is sought for their roe. There is no known direct fishery for this species in the UAE. In the right conditions, these species tend to be prolific and produce hundreds of thousands of eggs which stays in the water column during larval stage.

Sea urchins are ecologically important due to their herbivorous behaviour. Most of their life cycle is spent crawling along hard substrates consuming vast amounts of turf algae, allowing other organisms, such as corals, to settle and propagate. Shrimps and small fishes are often seen sheltering amongst the spines of sea urchins. This provides protection from predators and a food source as the spines trap food particles floating in the water column. Sea urchins are also associated with parasitic snails that adhere to the urchin’s body to absorb fluids and nutrients.

Sponges

Sponges are the simplest multi-cellular organism in the animal kingdom. Despite their simplicity, they are very diverse in size, structure, and colour. Sponges can be found in all marine environments with many species associated with coral reefs. Their primary functional role is in nutrient cycling, particularly silicon and nitrogen. They also act as sediment stabilisers and aid in reef creation through substrate consolidation (121). Small marine organisms including juvenile fish and invertebrates benefit from the microhabitat provided by sponge aggregations. Small organisms are known to live inside and around sponges, utilising them for protection and as a food source.

Bivalves

The dominant bivalves, found in Shuweihat belongs to the Family Spondyllidae, these organisms attached to hard substrate and would heavily colonized and area forming a mat or bed. They are filter feeders, collecting food from seawater. This invertebrate is important in its role as nutrient regulators and benthic structure engineering.

Other bivalves are borrowing and solitary individuals living among seagrasses and coral reef areas. An example is the pearl oyster (*Pinctada sp*.) which was noted to be present in the survey area.

Crustaceans

Blue swimmer crabs are bright blue in colour with spots of white on the carapace with size of around 8 inches when adult. These crabs stay buried under the sand in most time but wander among seagrass and sandy areas to feed. Being omnivores, they feed on bivalves, fish, and macro algae. They are commercially important and constantly harvested by both recreational and commercial fishermen. Note that a Blue Swimmer Crab (*Portunus pelagicus*) was captured in one of the BRUV systems (BRUV 3) deployed on site.

This species is prolific and fast growing but are overexploited in other countries. Blue Swimmer Crabs in other regions are protected with varying degree fishery management policies.

Fishes

A fish study was undertaken using Baited Remote Underwater Video (BRUVs) as presented in Table 5-66. Most species identified were pelagic and reef-associated fishes. A number of these species are considered commercially important in the UAE.

Fish species that were identified during the survey includes the grouper, kingfish and orange spotted trevally. Table 5-66 provides a list of all species identified at each survey location. Also, there is a high population of blue swimmer crab observed in the area. BRUV recorded low number of fish and species at the time of the survey. These habitat types (Hardbottom and Seagrass) typically provide shelter and foraging opportunities for a variety of marine species.

Table 5-66: Summary of fish species within Route 2 – Shuweihat Landfall

Common Name	Scientific Name	Site	
		BRUV1	BRUV3
Yellow Bar Angelfish	*Pomacanthus maculosus*		X
Orange Spotted Grouper	*Ephinephelus coioides*		X
Ehrenberg Snapper	*Lutjanus ehrenbergii*		X
Wrasse	*Halichoeres sp.*		X
Orange Spotted Trevally	*Carangoides bajad*		X

Common Name	Scientific Name	Site	
		BRUV1	BRUV3
Grunt	*Haemulon plumierii*		X
Two Bar Seabream	*Acanthopagrus bifasciatus*		X
Silver Biddy	*Gerres subfasciatus*		X
King Fish	*Scomberomorus cavalla*	X	
Blacktip Shark	*Carcharinus limbatus*	X	
Giant Sea Catfish	*Arius gigas*	X	
Tawny Nurse Shark	*Nebrius ferrugineus*	X	

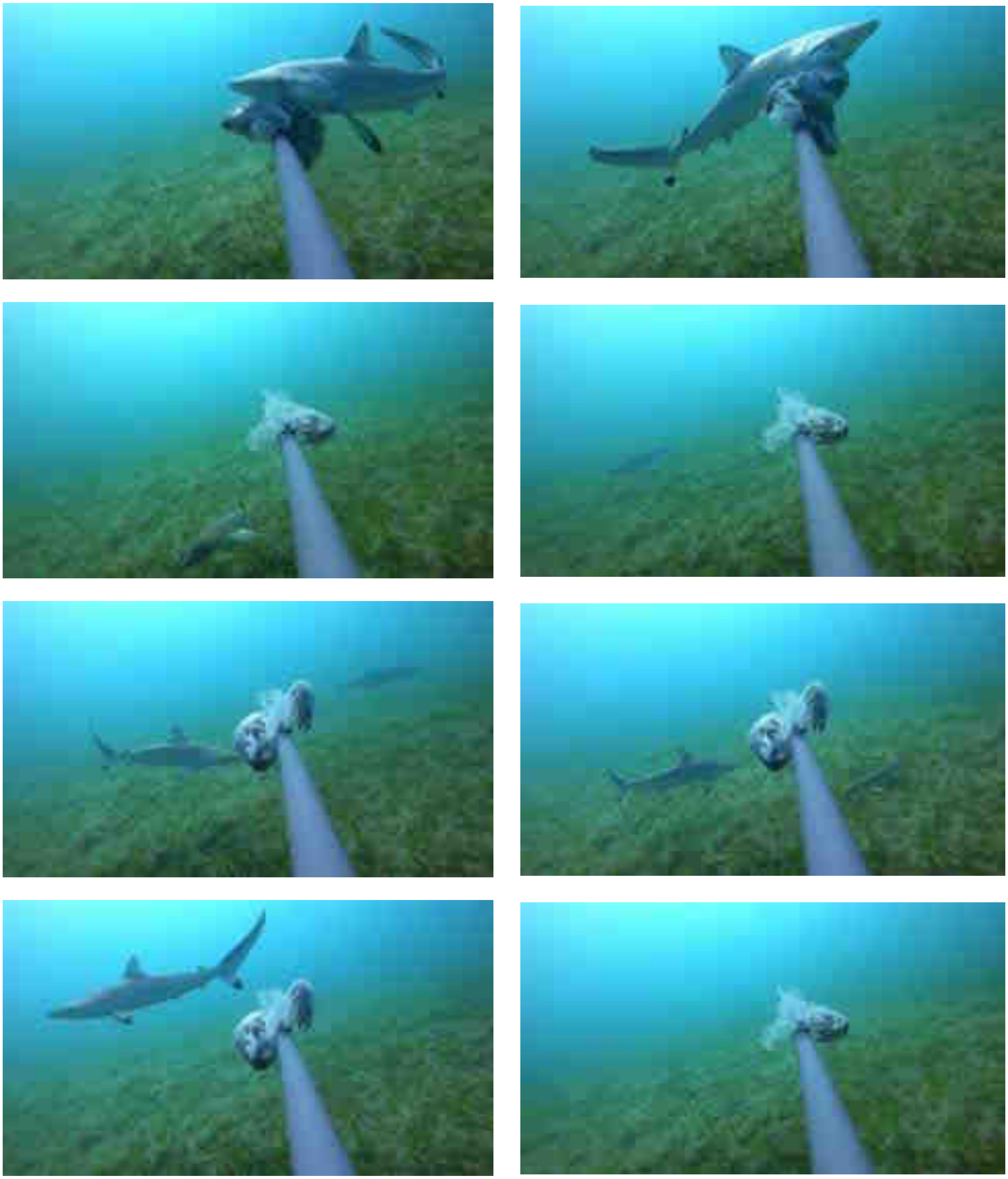


Figure 5-173: Fish and other species recorded through BRUV1 installed at Route 2 – Shuweihat Landfall

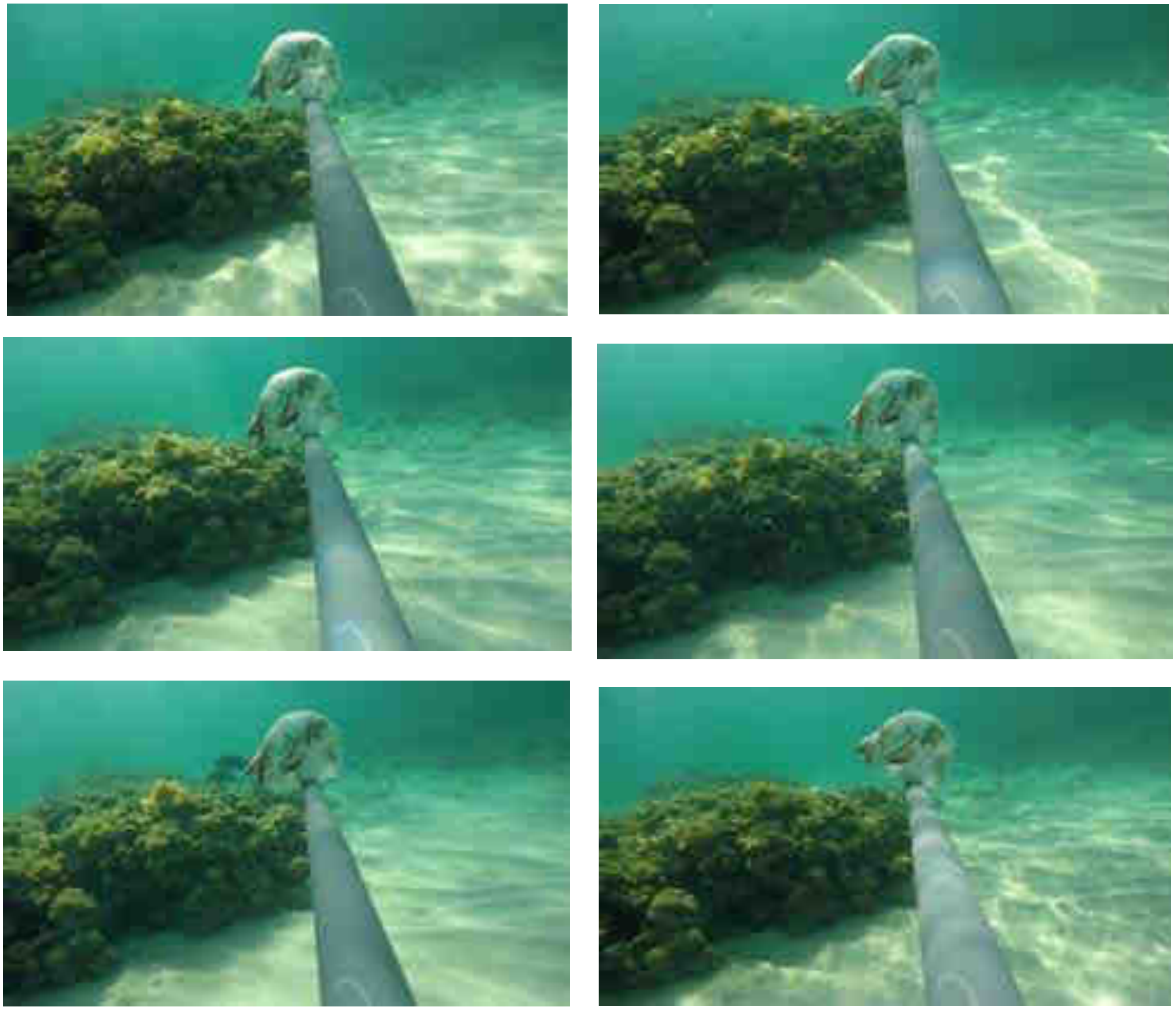


Figure 5-174: Fish and other species recorded through BRUV3 installed at Route 2 – Shuweihat Landfall

Yellow Bar Angelfish

The yellow bar angelfish (*Pomacanthus maculosus*) was commonly found on hard bottom habitat throughout the surveyed area and was captured through the BRUV system deployed at location 3 within Route 2. This species of angelfish is specific to the Arabian Peninsula and East Africa. Usually congregating in pairs or small schools, these fish establish a home range associated with rocky outcrops or reef areas. Mated pairs are highly territorial and are often seen driving other fish away. *P. maculosus* are occasionally caught by artisanal fishers for consumption and are valued as an aquarium species. The IUCN Red List categorises *P. maculosus* as Least Concern. As seen in other types of angelfish, the juvenile of this species is highly distinct from the adult form. Juveniles are fluorescent blue with black and white bands. As they mature, the colouration gradually changes to the characteristic blue with a single yellow band.

Orange Spotted Grouper

Commonly found in shallow to deep water areas in the region habituating coral reefs and marine structures. Locally known as Hamour, this fish is a sought-after species for fishermen employing hook and line, spear, and fish traps. Hamour is a predatory fish that feeds on smaller fish and crustaceans. Its body shape is elongate and its head is flat, a characteristic of a demersal fish. The fish has a light brown colour with vertical saddle lines along the body and carries brown to orange spots in areas on the body. The maximum weight may reach 15 kilos. They are protogynous hermaphrodites and may change from female to male in their lifetime which is a unique adaptation to preserve reproduction of the species. In the region, the spawning period is documented to be for the month of March to June. This species was recorded in BRUV 3 location within Route 2.

Ehrenberg Snapper and Dory Snapper

The Ehrenberg snapper (*Lutjanus ehrenbergii)* was captured by the BRUV system deployed at Location 3 (BRUV 3). Refer to subsection on fishes for Route 1 results discussed above for further notes on this species.

Orange Spotted Trevally

This species was confirmed to be present in the area through the footages of individuals of this species through the BRUV system installed within location 3 at Route 2 (BRUV 3). Refer to further discussion on this species in the fish survey results for Route 1 above.

Grunt

Footages of individuals of this fish species were captured in location BRUV 3 deployed in Route 2. Further notes on this species are available in the discussion of fish survey results for Route 1 above.

Two-bar Seabream

Individuals of the Two-bar Sea Bream (*Acanthopagrus bifasciatus*) were recorded within the BRUV 3 deployment location in Route 2. This species is found only in the Arabian Peninsula. Seabreams are carnivorous fish, feeding predominantly on benthic invertebrates. It is relatively common in the UAE and is an important commercial species. *A. bifasciatus* is caught by longlines, handlines, trawls, and traps. Current exploitation levels in the UAE are within the estimated safe harvest level. The IUCN Red List has undertaken a regional assessment of *A. bifasciatus* populations in the Arabian Gulf and has categorized this species as Least Concern.

Stripped Terapon

This species was recorded in BRUV 3 location in Route 2.

Silver Biddy

Silver biddy was recorded within Route 2 in BRUV 3 location. For further notes on this species, please refer to fish section in Route 1 discussion of results.

Kingfish

This fish species is one of the fastest swimming fish in the ocean. The fusiform body shape and high forked caudal fins allows it the burst into high speed to capture its prey which are pelagic and semi pelagic fishes. Kingfish is a sought after fish by commercial and sports fishermen. This is one of the most commercially important fish species in the region. This species was recorded at BRUV 1 location within Route 2.

Blacktip Shark

Blacktip Shark is a moderately sized fish feeding on other small sized fish. This fish is a mesopelagic top predator. Habitat preferred are seagrass, reefs, and hardbottom benthic structures where most smaller fish aggregate. Sharks of these species are indicators of a healthy marine ecosystem. IUCN currently lists this shark species as ‘’Vulnerable’’ species (106). This species was recorded within Route 2 in BRUV 1 location.

Giant Sea Catfish

This species of catfish is demersal in its behaviour, similar to its freshwater relatives. The presence of a dorsal third spine differentiates this fish from the freshwater species. This fish feeds on fish and invertebrates on seagrass and unconsolidated bottom sediment substrate. This is not a sought-after fish species among fishermen in the region. This was recorded in BRUV 1 location within Route 2 survey area.

Tawny Nurse Shark

Another shark documented during the deployment of BRUV (BRUV 1 location) is the Tawny Nurse Shark. This fish is demersal and inhabit the seafloor searching for prey. This shark prefers to prey on crabs and small fishes that are associated with reef and seagrasses. This fish is listed as ''Vulnerable'' species as classified by the IUCN.

Benthic Infauna

Benthic infauna analysis showed a total of 354 individuals with an average of 50.6 individuals per sample with the highest abundance at Inf 2 with 107 individuals and lowest at Inf 1 with 20 individuals, see Table 5-67.

Table 5-67: Infauna list and enumeration within Route 2 – Shuweihat Landfall

Taxa	Sampling Location							Total
	R2-Inf1	R2-Inf2	R2-Inf3	R2-Inf4	R2-Inf5	R2-Inf6	R2-Inf7	
Amphipoda								
Ampelisca spp.	1	9	5	4	10	10	6	45
Caprella sp.		1				1		2
Ceradocus sp.		1			1	2		4
Leucothoe sp.					1			1
Urothoe sp.				14	1	1	1	17
Anthozoa								
Actiniaria sp.					1			1
Copepoda								
Calanoid	3							3
Cumacea								
Cumopsis sp.		6	1		1			8
Decapoda								
cf *Diogenes* sp.				1				1
cf *Petrolisthes* sp.						1		1
Echinodermata								
Ophiuroidea		1				2		3
Mollusca								
Acrosterigma sp.		1						1
Bassina sp.	1							1
Niso sp.		1						1
Paphia sp.		1						1
Rhinoclavis sp.	1							1
Tellina sp.	1	5	1	1	1			9

Taxa	Sampling Location							Total
	R2-Inf1	R2-Inf2	R2-Inf3	R2-Inf4	R2-Inf5	R2-Inf6	R2-Inf7	
Mysida								
Gastrosaccus sp.		1						1
Nemertea								
Nemertea gen.spp.						1		1
Platyhelminthes								
Acoelomorpha gen.spp		3			4	1		8
Polychaeta								
Ampharetidae		1					3	4
Capitellidae	1	4						5
Chrysopetalidae (*Chrysopetalum* sp.)		15			2	7	1	25
Dorvilleidae (*Dorvillea* sp.)					6		3	9
Flabelligeridae (*Pherusa* sp.)		6						6
Hesionidae				1	1	1		3
Lumbrineridae			1				1	2
Magelonidae (*Magelona* sp.)	2		10	2				14
Nephtyidae (*Nepthys* sp.)		1	1		5	5		12
Nereididae (*Nereis* sp.)							2	2
Opheliidae (*Armandia* sp.)				1				1
Opheliidae (*Ophelia* sp.)	1	1						2
Orbiniidae				1			2	3
Paraonidae (*Aricidea* sp.)		14		1				15
Phyllodocidae		1				3		4
Pilargidiidae		1						1
Poecilochaetidae	1							1
Polynoidae		6						6
Sabellidae		8				2	2	12
Serpulidae (*Hydroides* sp.)		2			6	4		12
Spionidae (*Aonides* sp.)							1	1
Spionidae (*Prionospio* spp.)	3	5	6		3	6	13	36
Spionidae (*Scolelepis* sp.)							1	1
Syllidae (*Exogone* sp.)	1						3	4
Syllidae (*Syllis* spp.)		3	16	5			12	36

Taxa	Sampling Location							Total
	R2-Inf1	R2-Inf2	R2-Inf3	R2-Inf4	R2-Inf5	R2-Inf6	R2-Inf7	
Trichobranchidae (*Terebellides* sp.)		1						1
Sipuncula								
Golfingia sp.	4	7	5		3		4	23
Phascolion sp.						1		1
Tanaidacea								
cf *Apseudes* sp.		1		1				2
Total	**20**	**107**	**46**	**32**	**46**	**48**	**55**	354

The infauna samples collected belong to 49 distinct taxa (family/genus/species) at an average of 15.1 taxa per sample, see Table 5-68. The highest diversity was 28 taxa at location R2-Inf2 and the lowest was 9 taxa per sample at R2-Inf3.

Table 5-68: Infauna diversity index in Route 2 – Shuweihat Landfall

Biodiversity Parameters	R1-Inf1	R1-Inf2	R1-Inf3	R1-Inf4 CNTR	R1-Inf5	R1-Inf6	R1-Inf 8	R1-Inf 9
Taxa_S	21	14	14	7	16	12	24	18
Individuals	62	36	48	34	36	45	94	56
Simpson_1-D	0.8585	0.8827	0.8698	0.692	0.8935	0.8217	0.9199	0.8992
Shannon_H	2.429	2.389	2.312	1.493	2.498	2.013	2.814	2.548
Evenness_e^H/S	0.5406	0.7788	0.721	0.6356	0.7601	0.624	0.6947	0.7099

As shown in Table 5-68, the Diversity index was found to be highest at location R2-Inf2 (H=2.902; 1-D=0.9279) and lowest at location R2-Inf3 (H=1.78; 1-D=0.7892. The R2-Inf1 infauna community had one of the lowest abundances, resulting in a more uniform distribution of organisms and a higher diversity index as a result. The Evenness index showed that location R2-Inf1 had the highest value of 0.8476 indicating a more even distribution in abundance with location R2-Inf4 having the lowest evenness of 0.475 due to the dominance of Amphipod (*Urothoe* sp.) at this location.

The infauna community was dominated by Polychaeta making up 62% of the total number of individuals. Amphipoda was the next most abundant with 19% and Sipuncula with 7%. Other groups contributed less than 5% to the total number of individuals, see Figure 5-175. The most common species was the amphipod species (*Ampelisca* spp.) with 45 individuals followed by the polychaete species: *Prionospio* spp. (36); *Syllis* sp. (36); and *Chrysopetalum* sp. (25).

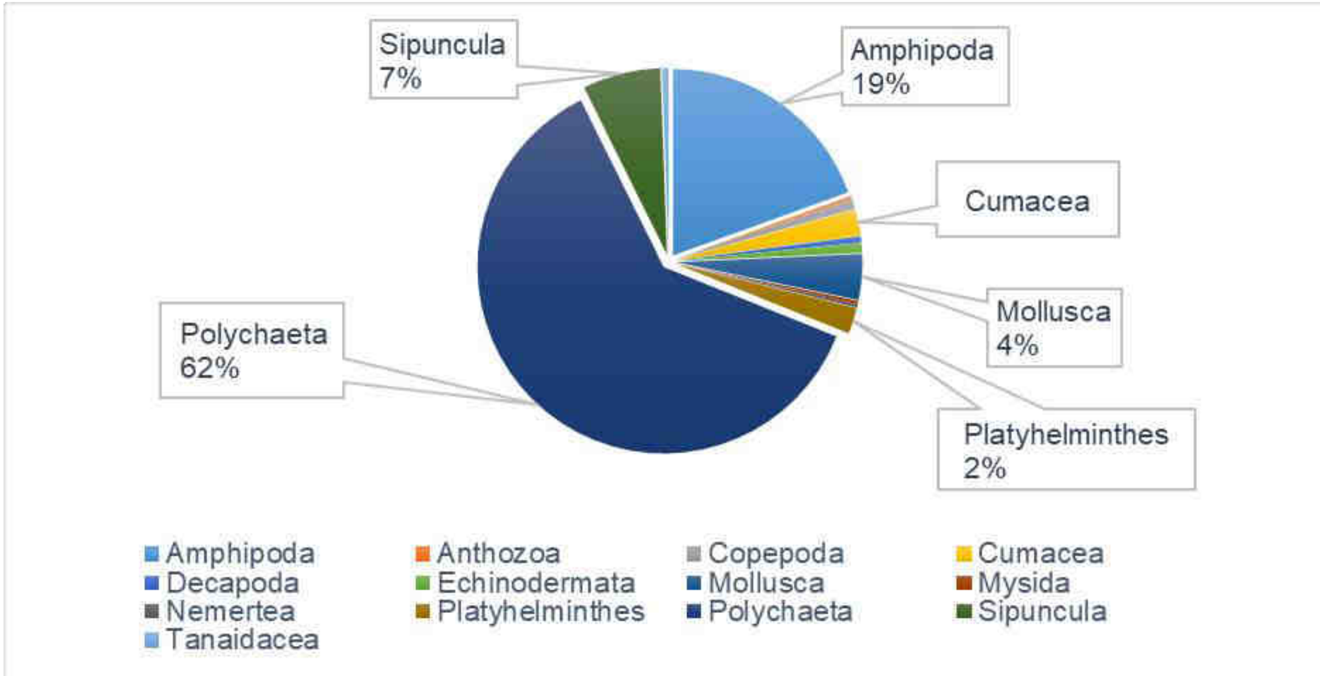


Figure 5-175: Percent composition of benthic infauna in Route 2 – Shuweihat Landfall

The infauna communities found in the samples were diverse and reflective of the unconsolidated substrate and seagrass habitats from which they were taken. The samples were similar throughout the study area, apart from samples with seagrass present and grain size. The taxa that were found were mostly linked to low pollution and healthy macrofaunal populations.

Figure 5-89 to Figure 5-96 illustrate the most common taxa identified through the Project study area.

<u>Marine Mammals and Reptiles</u>

Dolphin

A small pod of dolphins, with an estimated 5-8 individuals was observed during the conduct of the survey. Three observers on board the vessel one of which is JNCC certified MMRO marine biologists. The team noted the dolphin's movement but too far to take photograph documentation. The dolphins were identified as Humpback Dolphins.

The Indian Ocean humpback dolphin, *S. plumbea*, is a humpback dolphin species specific to Africa and the Arabian Peninsula. The most recent investigation estimates an *S. plumbea* population of 701 individuals within Abu Dhabi waters (122). This is the largest reported population in the world. *S. plumbea* have highly specific habitat requirements, only occurring in shallow, near-shore environments. Due to this restricted habitat, *S. plumbea* are highly vulnerable to anthropogenic impacts.

S. plumbea is categorised by the IUCN Red List as ''Endangered''. As with other cetaceans, *S. plumbea* have slow reproduction rates, making populations highly sensitive to anthropogenic induced mortalities. Incidental catch and habitat degradation are the greatest threats to this species as fishing pressure and coastal development has intensified throughout its range.

Turtles

Turtles have been recorded on site through MMRO surveys, and through the BRUVs deployed on site as well as through incidental sightings. During the MMRO surveys, no significant sea turtle activity was observed in the area except for three surface breaks created when turtle takes a breath. Due to the quickness of events during the sightings, no photographic documentation was possible. The number of sightings may be considered low.

The predominant marine turtle species found in the UAE are the hawksbill turtle (*Eretmochelys imbricata*) and the green turtle (*Chelonia mydas*). Both species are known to use the UAE coastline for foraging and nesting with primary foraging habitat including shallow coastal areas near coral reefs and sea grasses.

The IUCN Red List categorizes the hawksbill turtle as ''Critically Endangered'' and the Green Turtle as ''Endangered''. This is due to significant and continuous global population decline. The main causes of reduced populations are over exploitation, incidental fishing mortality, and degradation of marine habitat and the nesting habitat.

5.5.1.3. Critical Habitat Assessment (IFC PS6)

There are two assessed critical habitat that will be impacted by the project, these are seagrass habitat and coral reef habitat (Patch Reef and Fringing Reef). The locations of these critical habitats are shown in Figure 5-71 and Figure 5-154. Further description of these habitats are presented below.

5.5.1.3.1. Seagrass Habitat

Seagrass is present within the Project site along both Route 1 and 2. These habitats are subtidal, ranging from shallow water nearshore to depths of up to 15 meters offshore. The vast meadow is contiguous with patches of open sandy substrates. The EAD description for benthic habitat classification puts at least 10% cover to be assigned as seagrass habitat. Seagrass beds at Route 1 are within the MMBR. At this location, seagrass meadow is healthy, widely spread and dense.

Seagrasses species found in UAE are well represented throughout the survey sites. The three species identified were *Halophila stipulacea*, *Halophila ovalis and Halodule uninervis*. These species are adept at colonising areas of unconsolidated bottom due to fast propagation rates and tolerance to varying environmental conditions such as salinity and temperature.

During the survey, Dugong and its grazing marks were seen and evidence that the area is used by this important vulnerable species as a foraging ground. Also, studies showed that dugong are residents of the MMBR and the wider seagrass bed outside of the MMBR is within their home range. There is an estimated 3,000 dugong individuals within the 1,500 square kilometres of seagrass bed in the UAE but most sightings of dugong are within the MMBR. Although not on the endangered list, the species is an important indicator of seagrass ecological health and the quality marine ecosystem since Dugongs are highly seagrass dependent species.

Sea turtles found in the Project area were of high density indicating that seagrass in this area is an important support to the ecology of these endangered species. Only two species were seen with the majority being Green Turtle which is classified as endangered globally by IUCN but classified as vulnerable locally. Hawksbill turtles were also spotted during the survey. The species being calssified as ''critically endanged'' globally by IUCN. The high diversity of marine flora and fauna on seagrass beds makes it an ideal foraging grounds for turtles. Also, the shoreline areas around the islands and mainland of the MMBR and even Shuweihat are used as nesting grounds for turtle and these nearby seagrass areas provides nourishment for this important period of the turtle's reproduction cycles. Sharks and Rays were also present and documented during the survey in both Route 1 and Route 2. The shark species include Blacktip Reef Shark and the Tawny Nurse Shark, both of which are classified as vulnerable by IUCN and on two occasions during the BRUV deployment a Honeycomb Whipray was documented, which is an endangered species as classified by IUCN globally. The high diversity of marine fauna on the seagrass beds provided feeding opportunities for Blacktip Reef Shark, which is an apex predator, and the Tawny Nurse Shark and the Honeycomb Whipray being demersal feeders that predates on sessile or otherwise slow-moving organisms inhabiting the seagrass bed structure.

Sandy areas within seagrass beds support a greater diversity and abundance of benthic fauna than open sand substrates (107). Species such as fish, shrimps, and oysters also utilise seagrass beds as nursery and foraging grounds and some of these species are both ecologically and commercially important. This habitat service directly helps the existing fisheries industry in the area, although there is only limited fishing activity allowed within the

MMBR, the surrounding zones outside of its boundary stand to benefit for the increase of fish stocks produced by the resource management employed.

Seagrass habitat creates an environment that is more productive and habitable thus encouraging more diverse marine life to live within. The habitat also provides a variety of ecosystem functions and services. The rhizome and root system of a seagrass bed stabilises loose sediment and organic materials. This leads to improved water clarity and reduced erosion. Seagrasses are highly productive photosynthetic plants and as such, they contribute significant amounts of oxygen that become available for consumption by other marine life.

Seagrasses also have significant blue carbon sequestration potential, which has become increasingly prevalent in discussions on climate change mitigation. Through the process of photosynthesis, seagrasses sequester large amounts of atmospheric carbon dioxide that is ultimately stored in the sediment. Due to their wide distribution, seagrasses are the largest source of blue carbon storage in the UAE (108). Seagrass beds are considered more valuable as they encourage a greater diversity of marine organisms and provide more beneficial ecosystem services.

5.5.1.3.2. Coral Reef Habitat

Coral Reef habitat are areas characterised by a substrate largely constructed by the reef-building activities of corals and associated organisms. Within the Project site, two of this type of coral structure were found: a fringing reef at Shuweihat landfall and three areas of patch reef offshore along both Route 1 and Route 2. The present state of the fringing reef at Shuweihat Landfall can be assessed to be in critical health condition as most of the corals are dead. The reef structure is now heavily colonised by algal species and bivalves. The surviving young colonies of corals seen to be present are sparse and estimated to be <1% in density. Locally, EAD still classifies these areas as critical habitat with the justification confined in the fact that the fringing reef structure was developed by coral species and the reef continues its limited ecological function despite its present state. The fringing reef structure will continue provide opportunity for coral colonization and growth thus considered an important natural marine habitat. Also, this habitat provide stability to the seabed and protection of shorelines from strong waves and currents therefore preventing sediment erosion that could impact the seagrass community nearby.

The coral patches found along the cable routes are assessed to be young colonies and estimated to be <5 years old. The reef pattern is disjointed and the inter colony spaces are distinct and wide in some areas. These corals are growing on hardbottom substrates with populations of bivalves, sponges, urchins, gastropods, macroalgae, and ascidian species. Reef associated fish were also seen foraging on corals and rock outcrops with fouling species. The species documented are common in the region like Arabian yellow bar angelfish, Ehrenberg's snappers, Four lined Terapon and Gobies. Orange Spotted Trevally and Orange Spotted Grouper (Hamour) are fish of commercial importance in the region were also documented.

The coral species within the Arabian Gulf region are unique in the sense that ambient condition ranges are found to be beyond the normal levels. The tolerances exhibited by these coral species could be useful for science specially with the increasing global temperatures. Recent increases of temperature in the Gulf have resulted in massive coral bleaching and mortality. As an example, 90+ % of Acropora coral species are now dead from the 2017 high temperature event. The coral species documented during the surveys were Porites, Favia and Platygyra. This indicate that diversity is low and the species might be the only ones left that can tolerate the high salinity and wide temperature ranges in the Gulf. The remaining coral standing stocks is seen as the only source of coral gametes that will introduce new recruits in otherwise barren hardbottom substrates during annual coral spawning event. This reduces the ability of the reef to recover and expand.

Coral reefs are areas of high biodiversity and productivity, one square kilometre coral reefs can produce 15 tons of fish per year if properly managed.

Species Classification and Dependency on Critical Habitat

Species found to be dependent on the critical habitat identified on the Project areas are assessed and presented in Table 5-69.

Dugong is highly dependent on seagrass beds, with an IUCN classification of Vulnerable for both global and local categories. It is also listed on the EAD red list as vulnerable. The survey team sighted both individual animals and grazing tracks on seagrass beds. Green and Hawksbill turtle were found in high density aggregations, also indicating high dependency on seagrass beds. Green turtles are classified as Vulnerable and Hawksbill turtle is classified as Endangered by IUCN and the EAD red list. Other marine mammals like Indo-pacific Finless Porpoise and Indian Ocean Humpback dolphins, which are also present in the Project area both have Endangered status by IUCN and the EAD red list. The humpback dolphin was further categorized by IUCN as Endangered globally, but Finless Porpoise was classified as Vulnerable. For Chondrichthyes species the Tawny Nurse sharks (Vulnerable) and the Honeycomb Whipray (Endangered) are known demersal feeders on seagrass beds, although could be present in open patches of sandy bottom substrate and hard bottom habitat. A more mid water predator that was documented during the survey on seagrass beds was the Blacktip Reef shark which is categorized as Vulnerable by IUCN globally and by local IUCN standards. The species have a wider home range which includes feeding on reefs and open water.

Coral reef mainly attracts associated fish species like Angelfish, Wrasses, Cardinals and Damsel fishes to name a few. Some species are known to be classified as ‘’Endangered’’ by IUCN (local), these are the Blue-barred Parrot fish and the Clark’s Anemone fish. The rapid decline of coral cover in the Gulf has resulted in a decrease in the fish’s population. The survey did not note the presence of these species, but efforts are being implemented to save the species by applying conservation techniques. An important resident of coral reefs in the region is the Orange Spotted Grouper known as ‘’Hamour’’, this species is heavily exploited in UAE by the fishing community. The decline of this species population is not only due to fisheries but also the massive loss of coral habitat which the fish is associated with. Efforts to conserve the species has listed ‘’Hamour’’ to be vulnerable under local IUCN category. Sharks and Rays often visit the reef areas for feeding and refuge. The dependency of these fishes with a healthy coral reef areas is very important for the balance of the marine ecosystem.

It is concluded that both seagrass and coral reef habitats would qualify as critical habitats in accordance with IFC Performance Standard 6.

Table 5-69: Critical habitat and species classification

Habitat	EAD Classification	Species	IUCN Global	IUCN Local	EAD Red List	Endemic or Restricted Range	Migratory or Congregatory Species	Highly Threatened and/or Unique	Key Evolutionary Processes	IFC Classification
Seagrass	Critical	Dugong (*Dugong dugon*)	Vulnerable	Vulnerable	Vulnerable	Yes	No	Yes	No	Critical
		Green Turtle (*Chelonia mydas*)	Endangered	Vulnerable	Vulnerable	Yes	Yes			
		Hawksbill Turtle (*Eretmochelys imbricata*)	Endangered	Endangered	Endangered	Yes	Yes			
		Indo-Pacific Finless porpoise (*Neophoceana phocaenoides*)	Vulnerable	Endangered	Endangered	Yes	No			
		Indian Ocean Humpback dolphin (*Sousa plumbea*)	Endangered	Endangered	Endangered	No	No			
		Blacktip Reef shark (*Carcharhinus melanopterus*)	Vulnerable	Vulnerable	-	Yes	No			
		Honeycomb Whipray (*Himantura undulata)*	Endangered	-	-	Yes	No			
		Tawney Nurse Shark (*Nebrius ferrugineus*)	Vulnerable	Vulnerable	-	Yes	No			
Fringing Reef		Hawksbill Turtle (*Eretmochelys imbricata*)	Critical	-	Endangered	No	Yes			
		Orange Spotted Grouper (*Epinephelus coioides*)	Least Concern	Vulnerable	-	No	No			
		Blue-barred Parrotfish (*Scarus ghobban*)	Least Concern	Endangered	-	Yes	No			
		Clark's Anemone fish (*Amphipion clarkii*)	Least Concern	Endangered	-	Yes	No			
		Green Turtle (*Chelonia mydas*)	Endangered	Vulnerable	Vulnerable	Yes	Yes			
Patch Reef		Hawksbill Turtle (*Eretmochelys imbricata*)	Critical	-	Endangered	No	Yes			
		Orange Spotted Grouper (*Epinephelus coioides*)	Least Concern	Vulnerable	-	No	No			
		*Blue-barred Parrotfish (*Scarus ghobban*)	Least Concern	Endangered	-	Yes	No			
		*Clark's Anemone fish (*Amphipion clarkii*)	Least Concern	Endangered	-	Yes	No			
		Green Turtle (*Chelonia mydas*)	Endangered	Vulnerable	Vulnerable	Yes	Yes			
		Blacktip Reef shark (*Carcharhinus melanopterus*)	Vulnerable	Vulnerable	-	Yes	No			
		Tawney Nurse Shark (*Nebrius ferrugineus*)	Vulnerable	Vulnerable	-	Yes	No			

*Species not seen during the survey

5.5.1.3.3. Summary of Baseline Conditions

Marine Ecology at Route 1 including MMBR and Zakum Clusters Area

The benthic habitat analysis identified the area is classified as Seagrass Bed with substantial macroalgae intermixed. Seagrass colonisation was extensive throughout the sand areas of the survey site. Seagrass beds are classified as critical habitat in EAD CMERC standards. There was no extensive Coral cover noted along the survey line.

Fish species were abundant on the seagrass areas. Species observed during the survey are all associated with seagrass and demersal, highlighting the survey was the video capture of Honeycomb Whiptail which is considered endangered by the IUCN.

Sea turtles were observed on multiple occasions through incidental sighting and VP observations. There is a high turtle population as counted during records of surface breaks. Their presence may indicate that the turtles could be resident area, although, no direct study has been conducted to determine if these turtles are residents or transitory.

The green turtle (*Chelonia mydas*) and the hawksbill turtle (*Eretmochelys imbricate*) were directly documented within the Project site. The IUCN Red List categorises the green turtle as Endangered and the hawksbill turtle as Critically Endangered. Marine turtles are protected, and UAE law and conservation efforts should be implemented to protect these species in this area.

There was single sighting of a dolphin species currently of undetermined species as identification during sighting was not possible. There were sightings of solitary Dugong on two occasions. The species were elusive, and no photo documentation was possible. Presence of Dugong along the survey line is highly possible as grazing marks were noted on the seagrass beds. This species is categorised by the IUCN Red List as Vulnerable.

At Zakum Clusters, three core habitats (hard bottom, unconsolidated bottom and patch reef) were found along the survey route and surrounding areas. The hard bottom habitat is mainly found inside the Zakum oilfield, and the unconsolidated bottom (fine silt and mud) are outside of the oilfields. Inside Mubarraz oilfield, mainly unconsolidated bottom was found but mainly comprised coarse sand particles with shell and coral fragments. The Patch reef habitat is a forming reef of young coral colonies but is sparse and widely distributed on the hard bottom substrate inside Zakum oilfield. The species identified include *Porites*, *Favia* and *Platygyra*, indicating that the diversity is low and recruitment was from narrow spawning periods. This assessment is based on the age distribution of corals in the area which is estimated to be <5 years old. No old reef or structurea were found and the majority of the young colonies are dead, potentially as a result of a bleaching event brought about by high temperatures during summer.

Fish species identified were mainly reef associated demersal fish and presence of commercially important species were also noted. During the deployment of DDV, fish species identified include reef associated Arabian Yellow Bar Angelfish, Gobies and Breams. Commercially important Orange Spotted Grouper was also observed.

No marine mammals or turtles were encountered during the survey.

An overall Habitat map generated for Cable Route 1 based on the survey results and remote sensing is presented in Figure 5-176.

Marine Ecology at Route 2

Route 2 (Shuweihat) Landfall Marine Environmental Baseline Study was conducted between 3rd to 4th of April 2022. The findings of the baseline survey are summarised below.

There are two critical habitat types - seagrass and fringing reef - found along the survey route and surrounding area. The seagrass bed is healthy and seen as an extensive meadow with a wide distribution. All three (3) species of seagrass found in the UAE was documented to be present. These are *Halodule uninervis, Halophila ovalis* and *halophila stipulacea* indicating a climax community. The meadow is often seen intermixed with macro algae and sponges.

A fringing reef is located nearshore along Route 2, near to the Shuweihat Power Plant. The condition of the reef is poor with sparse young coral colonies. The reef is covered with turf algae and other fouling species such as ascidians, bivalves and sponges. Although the health condition of the reef is poor, it still continue to function as refuge and feeding areas of multiple species of reef associated fish as well as wave protection of the inner intertidal areas.

Fish species identified were both reef associated demersal fish and the presence of commercially important species were also noted. During the fish study, Blacktip shark and Tawny Nurse Shark were documented. The presence of these species indicates a healthy marine ecosystem as sharks can be used as indicator species for a healthy marine system.

Sea turtles were observed on three occasions through records of surface breaks for breathing. The three (3) sightings were brief, and no photos could be taken and therefore, species identification was not possible. As presence and numbers could not be concluded, it is not clear if the turtles are resident in the area.

A pod of dolphins was observed within the survey site. The dolphin species was identified as Indian Ocean humpback dolphins (*Sousa plumbea*). Approximately 5 to 8 individuals were observed, *S. plumbea* have highly specific habitat requirements, only occurring in shallow, near-shore environments. Due to this restricted habitat, *S. plumbea* are highly vulnerable to anthropogenic impacts, thus, this species is categorised by the IUCN Red List as Endangered.

Habitat Map for Cable Route 2 as a result of the survey and remote sensing is presented in Figure 5-177.

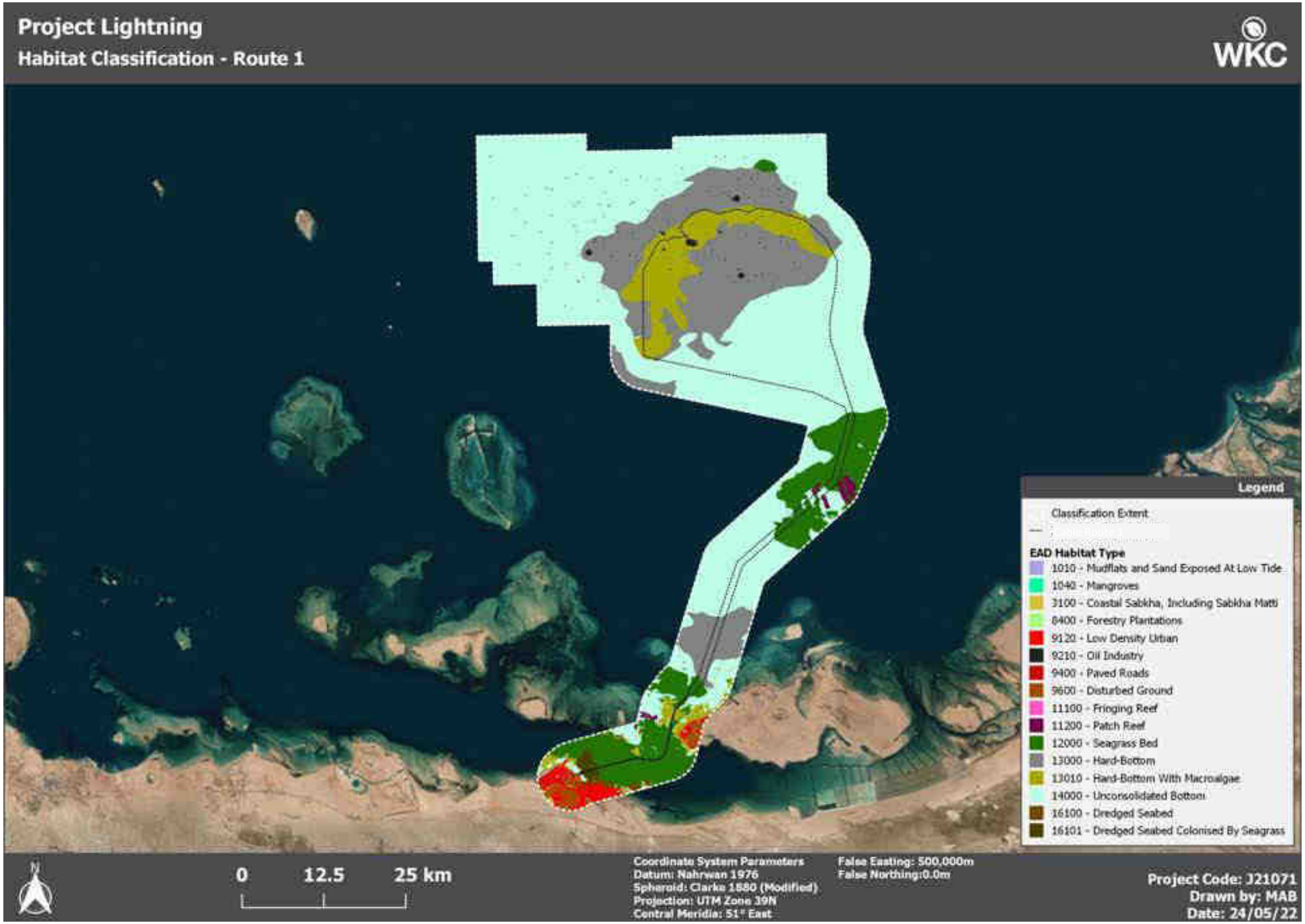


Figure 5-176: Cable Route 1 habitat map

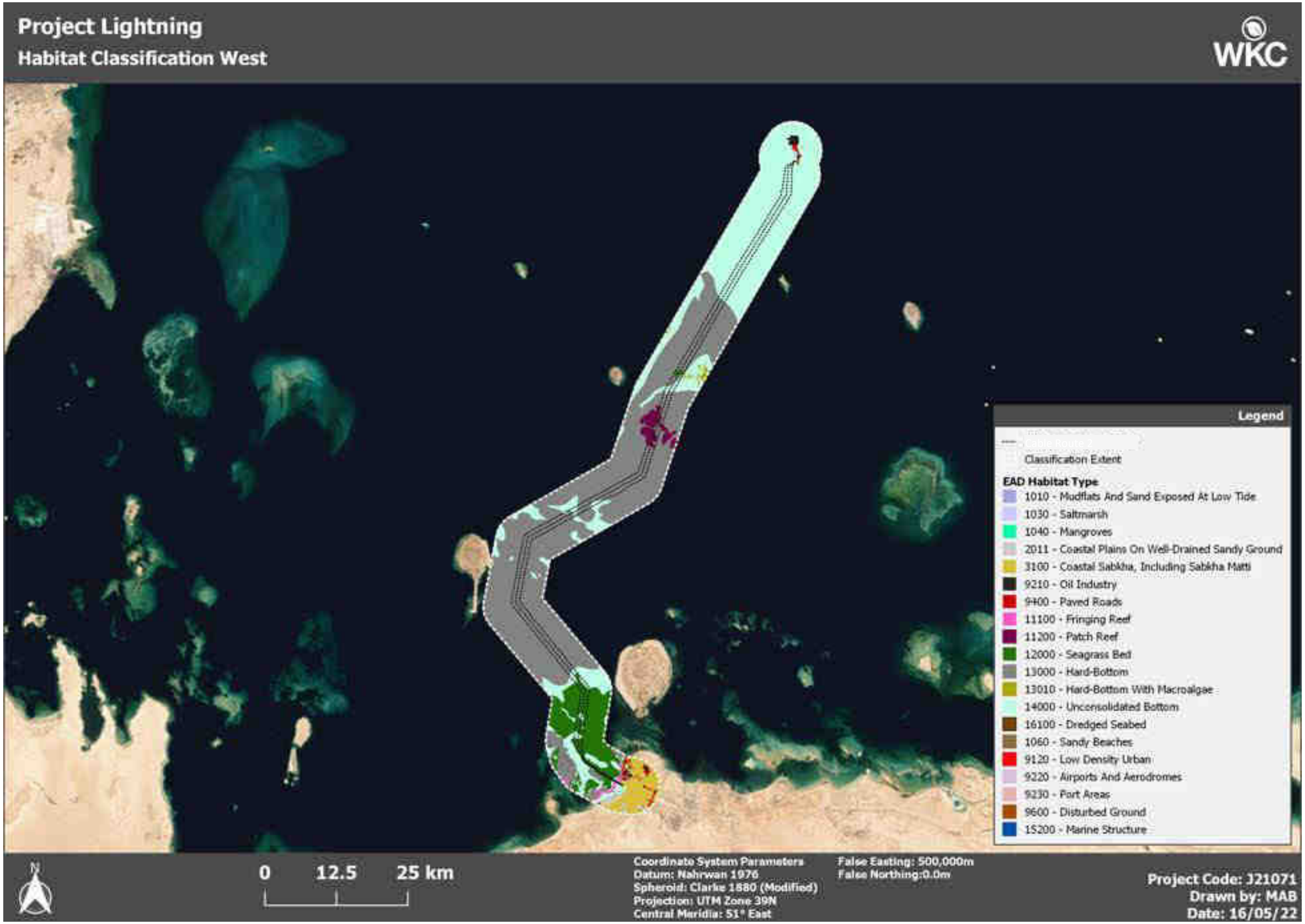


Figure 5-177: Cable Route 2 habitat map

Commercial Fish Species (Route 1 and Route 2)

Commercial fisheries in the UAE have grown rapidly over the last decade. Growing populations and increased tourism have greatly escalated the demand for seafood and aquarium fish. EAD reports there are at least thirteen species of fish that are currently exploited at unsustainable levels in the UAE. The UAE Sustainable Fisheries Program is currently being implemented to gain a greater understanding fish stocks and implement management strategies to achieve a sustainable fishery by 2030 (123).

Of the overexploited species, three have been observed within the Project site. The diverse habitat within the Project site, including the presence of corals, bivalve beds, and seagrass, provides an environment that attracts these valued species. These critical areas provide feeding grounds, nesting areas, and nursery habitats. The presence of commercially important species highlights the significance of reef habitats in the Gulf region.

Table 5-70 provides a list of the commercially important fish species that have been identified during surveys. This also includes various statistics provided by EAD (114). Of the commercially important species observed within the Project site, Hamour (*Epinephelus coioides*) is the most valuable.

Table 5-70: Summary of commercial fish species observed within Route 2 – Shuweihat Landfall

Common name	Species Name	Average Price per kilo 2016 (AED)	Total landings Abu Dhabi 2016 (megatons)	Status (Year of Assessment)
Orange Spotted Trevally	*Carangoides bajad*	29.0	143	Overexploited (2014)
Hamour	*Epinephelus coioides*	45.5	609	Overexploited (2014)
Ehrenberg Snapper	*Lutjanus ehrenbergii*	19.0	53	Underexploited (2009)
Yellow Bar Angelfish	*Pomacanthus maculosus*	-	-	Underexploited (2007)
Two Bar Seabream	*Acanthopagrus bifasciatus*			

In 2016, Abu Dhabi reported 609 megatons of Hamour landed with an average price of 45.5 AED per kilo. This species is currently exploited beyond sustainable limits. The Orange spotted trevally, Talang Queen fish, and Ehrenberg snapper are on low abundance throughout the survey site as assessed through BRUV and DDV transects. These species are commercially important and various fishery is active within the region.

Underwater Noise

Route 1 including MMBR Area

Sound analysis was conducted or the full duration of each recording to describe the seascape at each location. The data shows that Mean and Max Sound Pressure Levels (SPL) root mean squared (RMS) in dB was highest at Location 1 and decreasing to be lowest at location 5. Mean RMS ranged from 141.2 dB at location 1 to 108.9 dB at location 5. The maximum and minimum RMS ranged from 88.5 at location 5 to 153.4 dB at location 1.

During each recorded a clip was selected to analyse the ambient noise. The clip was chosen during the recording when no anthropogenic noises were recorded. Ambient background noise was similar across the sampled locations being slightly higher at locations 3 and 4 with location 2 being the lowest. Mean RBS ranged from 99.6 dB at location 2 to 120.1 dB at location 4.

A number of sources of noises were identified during the study including anthropogenic pulses, boat noise and biological clicks. At location 1 during the survey a regular series of pulses was recorded and most likely from a seismic or geological survey being conducted in the area. The pulses occurred approximately every 13 seconds. The pulses were predominantly low frequency <4 kHz reaching a max RMS of 125.3 dB.

Boat traffic was recorded at each location and an example of a boat pass was used at location 4. A boat passing recorded a max RMS of 133.3 dB and a peak of 154.3 dB. The spectrograms of boat noise showed that peak sound levels were generally between 0 – 16 kHz, which overlaps the bandwidth which are known with dolphin communication and indicates that increased boat traffic could have a masking effect on local dolphin populations.

The ambient background noise at each location was marked with invertebrate clicking and a sample from location 4 was included for analysis. The clicks recorded a maximum RMS of 132.8 dB with a mean RMS of 124.6 dB. The clicks showed a wide range in frequency from 0 to approximately 44 kHz.

During the Passive Acoustic Monitoring, vocalisations were identified at locations 2, 3 and 5. The vocalisations were short whistle and moan type. At location 2 a series of short concave whistles were recorded in the 5-6 kHz range. At location 3 a longer moan was recorded around 2 seconds in duration with an ascending contour from around 1.5 kHz to 4 kHz. A further series of moans was detected later in the recording at location 3 with a slightly descending shape but in a similar frequency range. A series of whistles/moans were detected at location 5 with the chorus lasting 10 seconds and was between 3-4 kHz.

No direct information for the hearing threshold of Indian Ocean Humpback dolphins was available, but information is available for the Indo-Pacific Humpback dolphin (*Sousa chinensis*) species which would be expected to be similar. Bottlenose dolphins produce whistles in the range of 0.8-24 kHz while Indo-Pacific Humpback Dolphin produce whistles in the range of 1.2-16 kHz. Dugong can produce short duration barks with a frequency of 0.5 to 22 kHz with a median frequency of 1.2kHz and short duration (126 ms) and long duration (1737 ms) calls with a frequency around 4 – 4.5 kHz.

The identification of the species making the vocalisations could not be determined and could be either dolphin or dugong as these species can produce a range of sounds within the frequencies recorded.

5.5.2. Environmental Impact Prediction and Evaluation

5.5.2.1. Marine Ecology Sensitive Receptors

Sensitive receptors are defined as those features of the environment that are of value to the functioning of the natural systems, i.e., areas or elements of ecological, landscape, or heritage value, species, habitats and ecosystems, soil, air, and water bodies, or socio-economic value including human receptors. As noted in **Section 3.9.2,** the assignment of receptor sensitivity can be made in consideration of existing designations and quantifiable data. Table 5-71 provides the criteria that were used to establish the environmental value of sensitive receptors or resources during the impact assessment process for marine ecology.

Table 5-71: Criteria for defining the values of marine ecology receptor or resources

Value (Sensitivity)	Criteria
High	The receptor is protected (designated) by international law or recognized internationally as an important resource with high importance and rarity.
Medium - High	The receptor is protected by national law and is important for national and regional biodiversity and is subject to species/habitat action plan.
Medium	The receptor is locally or nationally important for nature conservation and contributes to the selection of local/national MPAs and/or helps maintain the viability of the wider ecosystem.
Low - Medium	The receptor is part of a local nature conservation designation or reserve and whilst not considered to have a key ecosystem role is nevertheless a component part of a healthy and productive broader ecosystem.
Low	The feature is commonly occurring and widespread throughout the UAE and is not recognised through any nature conservation designation mechanisms.

Based on the above criteria, the sensitivity of marine ecology sensitive receptors identified in the Project site and surrounding areas are detailed in Table 5-72.

Table 5-72: Marine ecology sensitive receptors

Sensitive Receptor	Receptor Class Value	Justification
Critical habitats, e.g., seagrasses within Route 1, including those within the MMBR and fringing reef within the nearshore section of Route 2	*High*	The general area traversed by Route 1 and Route 2 supports dense and healthy seagrass beds, particularly the nearshore alignments at Route 1 which encompasses areas within the MMBR and Route 2. Seagrass habitats are considered critical habitats in the UAE which is under continued threat from coastal development and marine activities particularly dredging and reclamation. Seagrass is a vital habitat providing valuable services to fish species, especially as foraging areas for Green Turtle and Dugong. Seagrass is also considered a 'Blue Carbon' habitat type due to its ability to sequester and store carbon. The sensitivity of the seagrass habitats within the Project areas is therefore considered to be **High**.
Critical habitats (e.g., coral reefs) in offshore areas within Route 1 and Route 2 and environmentally sensitive habitat (e.g., hard bottom with macroalgae) and hard bottom habitats – All areas	*Medium - High*	The coral reef areas (e.g., Patch Reef and Fringing Reef habitats) are located within nearshore areas as well as approximately midway (offshore) through the alignments of Route 1 and Route 2. With other smaller areas of coral reef identified scattered in other surrounding areas. Coral is considered a critical habitat in the UAE and is under continuous threat from coastal development, dredging and reclamation and as a result of climate change. Coral is a habitat architect providing habitat for many diverse species of fish (including the most economically important species within the Arabian Gulf) and providing foraging areas for the Hawksbill Turtle.

Sensitive Receptor	Receptor Class Value	Justification
		The coral found within the Project areas were largely dying or dead, although young colonies of corals were noted. Macroalgae (including those on hard bottom habitats, i.e., hard bottom with macroalgae which were found in the Project areas) can often seasonally compete with seagrass and often forms a mixed habitat where neither species can attain dominance. Macroalgae community are considered to be an environmentally sensitive habitat in the UAE due to the services provided for nursing fish and juvenile turtles. The habitat is also a secondary food source for Dugong and Green Turtle, along with many other species. Hard bottom areas comprise of substrates that provide opportunity for coral growth and thus considered to be an important natural marine habitat. This habitat is also known to stabilise the seabed thereby facilitating continuity of benthic colonization until climax community is achieved. In consideration of the above, the sensitivity of such habitats is considered to be **Medium – High**.
Marine mammals, reptiles and fishes	*High*	A rich collection of marine species including mammals, reptiles and species were recorded throughout the surveyed areas and are often in association with the healthy habitat assemblage on site. Among the species recorded included some of the most threatened species locally, nationally, regionally and internationally, and thereby considered of high conservation importance, and some of great economic significance (e.g., fishes). This includes the Dugongs, marine sea turtles, among others. A number of these are described below. Dugongs (*Dugong dugon*) are known to have historically inhabited the coastline of the entire UAE in large numbers. However, they have been extirpated from the majority of the coastline due to historic hunting and disturbance caused by coastal development and marine traffic. Dugongs are known to frequently forage around the seagrass habitats around MMBR and the surrounding areas and a number of individuals have been recorded during recent surveys. Hawksbill Turtle (*Eretmochelys imbricata*) were recorded around the Project areas in significant numbers historically and during the surveys conducted as part of this Project. Hawksbills are listed as Critically Endangered by the IUCN. Hawksbill turtles feed on coral and hard-bottom habitats, both of which are found extensively throughout the Project areas. Overall, the sensitivity of the marine mammals, reptiles and fishes, represented by the threatened species known to frequent the areas, is considered to be **High**.
All other habitats, e.g., unconsolidated bottom,	*Low*	A number of less valued natural and non-natural or man-made habitats and the associated benthic communities are distributed

Sensitive Receptor	Receptor Class Value	Justification
and man-made or non-natural habitats, e.g., dredged seabed and associated benthic infauna and other communities and species		throughout the Project areas. Examples include the unconsolidated bottom habitat that mainly consists of loose sediment and sand not heavily colonised with seagrass, macroalgae, or other epifauna species. The soft sediment can host several infauna species that are important bottom feeders. Another example is the hard bottom substrate which is often the result of strong current action removing sediment from the underlying bedrock. The exposed rock is colonised by a varying extent by algae, sponges, soft coral, hard coral, and carious fouling organisms. The habitat does support a wide variety of fauna. Such habitats support a number of benthic communities that are considered to be common locally and regionally. The overall sensitivity therefore is considered as **Low**.

5.5.2.2. Construction Phase Impacts

Potential impacts to the marine environment resulting from the Project construction phase can be summarised as follows:

- Localised direct loss of marine habitat and associated individual organisms and colonies;
- Indirect impacts to habitats such as erosion, sedimentation, alteration or damage resulting in loss of habitat or degradation of existing conditions;
- Potential disturbance to marine mammals and reptiles due to noise pollution;
- Potential impact to marine fauna due to possible collision risks with marine vehicles; and
- Potential for localised contamination events to occur.

5.5.2.2.1. Impacts on Benthic Marine Habitats

Local Direct Loss of Benthic Marine Habitats

The Project will involve dredging/trenching through an area of natural, and relatively pristine habitats, some of which are classified as critical or environmentally sensitive and therefore considered of medium-high to high value. Although mitigation measures may be implemented to reduce impacts to marine habitats, marine habitats directly within the construction footprint will be inevitably lost.

Based on the calculation of the footprints of the various activities in the Project area, for Route 1 a total area of approximately 451 ha will be impacted for the cable laying and approximately 1,713 ha for the disposal areas (132 ha at the North Disposal Area and 1,580 ha at the South Disposal Area), as described in Table 4-12. In addition, a total of approximately 315 ha within Route 2 (Table 4-13) will be potentially impacted, resulting in a total impact area of 767 ha for cable laying activities and approximately 1,713 ha allocated as disposal areas.

Overlays of the Project layout on the habitat maps developed for the Project through remote sensing and verified through ground-truthed data of marine features from the surveys, shows the extent of marine habitats directly impacted. These habitats include seagrass, macroalgae, hard structured habitats like fringing and patch reefs, and other natural habitats including hardbottom habitats. These habitats within the direct footprint of the construction activities will therefore be potentially lost and / or permanently altered as shown in Figure 5-178 for Route 1 and Figure 5-179 for Route 2. The habitats impacted at the disposal areas are shown in Figure 5-180. The areas of each habitat type impacted are provided in Table 5-73 below.

Table 5-73: Marine habitat loss calculations

Habitat Code	Habitat Type	Sensitivity	Area (ha)
Route 1			
11200	*Patch Reef*	*Medium – High*	6.07
12000	*Seagrass Bed*	*High*	312.44
13000	*Hard-bottom*	*Medium – High*	17.48
13010	*Hard-bottom with Macroalgae*	*Medium – High*	46.14
14000	*Unconsolidated Bottom*	*Low*	37.37
16100	Dredged Seabed	*Low*	2.52
16101	Dredged Seabed colonised by Seagrass	*Low*	35.13
Route 2			
11100	*Fringing Reef*	*Medium – High*	4.02
11200	*Patch Reef*	*Medium – High*	5.79
12000	*Seagrass Bed*	*High*	89.38
13000	*Hard-bottom*	*Medium – High*	135.30
13010	*Hard-bottom with Macroalgae*	*Medium – High*	0.14
14000	*Unconsolidated Bottom*	*Low*	80.91
North Disposal Area			
12000	*Seagrass Bed*	*High*	132.12
South Disposal Area (Worst case scenario)			
12000	*Seagrass Bed*	*High*	1,580.45

Areas within the direct footprint of the trenching activities include critical habitats like seagrass beds and coral reefs which are highly valued as well as less valued habitats including unconsolidated bottom, hard-bottom with macroalgae and hard-bottom habitats. Macroalgae communities are considered by the EAD to be a sensitive habitat in Abu Dhabi Emirate and have been identified to provide nursery habitat for fisheries and juvenile turtles (124). The habitat is also closely associated with coral reef and seagrass communities. As with most of the marine habitats in the region, habitat of this type is threatened by coastal development, reclamation, and dredging activities.

Sessile benthic marine fauna present within the hard-bottom habitat recorded during baseline surveys included corals in different life-stages (mostly juvenile) although, density and abundance of the recorded coral species were low. Although not dominant in the area and not of sufficient coverage to be considered a reef, the presence of coral indicates the habitat is productive. This sparse coral colony distribution is aggravated by coral mortality, particular in Zakum Clusters areas and two other offshore patch reefs. The fringing reefs at Shuweihat were found to be largely dead, although still functions as a reef structure where associated fish come for feeding and refuge. The fringing reef also acts as barrier to protect neighbouring habitat like seagrass from sedimentation caused by erosion from nearby sandy shallow intertidal areas.

Seagrass habitats in the Project areas, particularly within the areas traversed by Route 1 and particularly within the MMBR, are highly productive and important areas for some of the worlds most threatened marine species occurring in the Arabian Gulf including the Dugong and other mammals as well as sea turtles. The loss of seagrass as a result of the Project, which may potentially impact a total area of approximately 80ha in total, is assessed to be temporary as seagrasses are known to easily recover in a short period of time of approximately one year. The trenching activity involved as part of the Project will be undertaken over a relatively narrow width such that the surface area to volume ratio is low which will limit the impacts on the overall extent of the seagrass beds. Considering that majority of the seagrass habitat losses are deemed temporary, and the habitats are likely to recover and reestablish once works have been completed and no further substantial and intrusive activities are anticipated directly within the cable alignment, the impact severity is determined to be *low*. Post project monitoring will apply scientific measurements to document the recovery rates that will occur.

The trenching activity however will be over a route that is anticipated to irreversibly impact the fringing reef at Shuweihat (which is in very poor condition) and the hard bottom habitat along the supplemental sampling areas at Route 1 in MMBR (areas not surveyed by Fugro) as well as the other coral structures (e.g., offshore coral reefs), benthic habitat and communities within the direct footprint of the Project. Impacts to these medium-high valued habitats are therefore considered to be of *medium* severity.

The impacts therefore are as follows:

- For high valued habitats including seagrass beds along the route alignment including the North Disposal Area, impacts will be of **moderate negative** significance;
- For high valued habitats including seagrass beds within the South Disposal Area (because of the much larger area compared to the route alignment and North Disposal Area), impacts will be of **major negative** significance;
- For the coral losses within the fringing reef habitat in Route 2, considered to be of medium-high value, impacts will be of medium severity and impacts will be of **moderate negative** significance;
- For other medium-high valued habitats, such as hard bottom, hard bottom with macroalgae, and patch reefs, the impact significance is considered **moderate negative**; and
- For low valued habitats, such as mainly non-natural habitats as well as unconsolidated bottom, the impact significance is anticipated to be **negligible**.

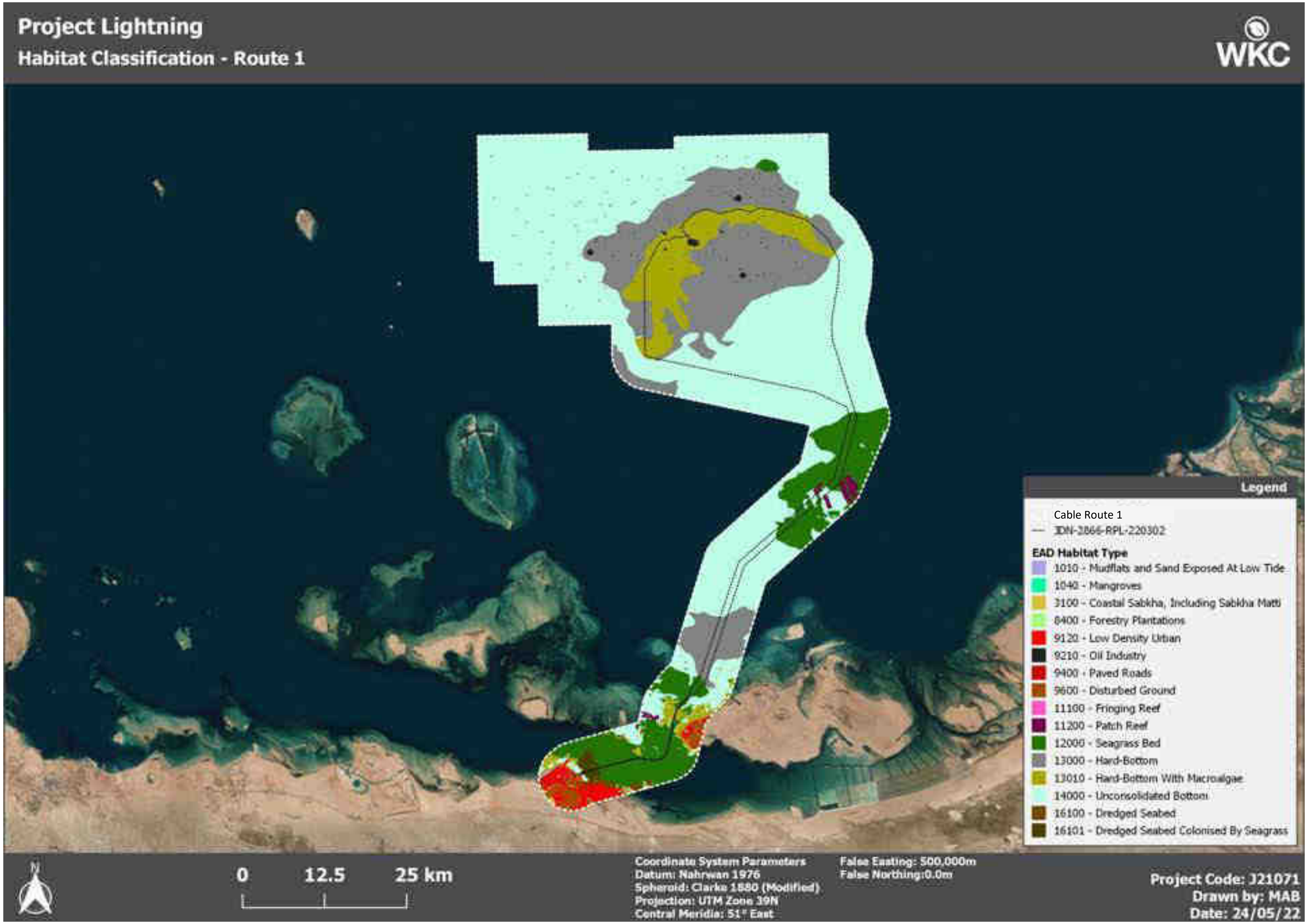


Figure 5-178: Habitat classification for Route 1 (overview map)

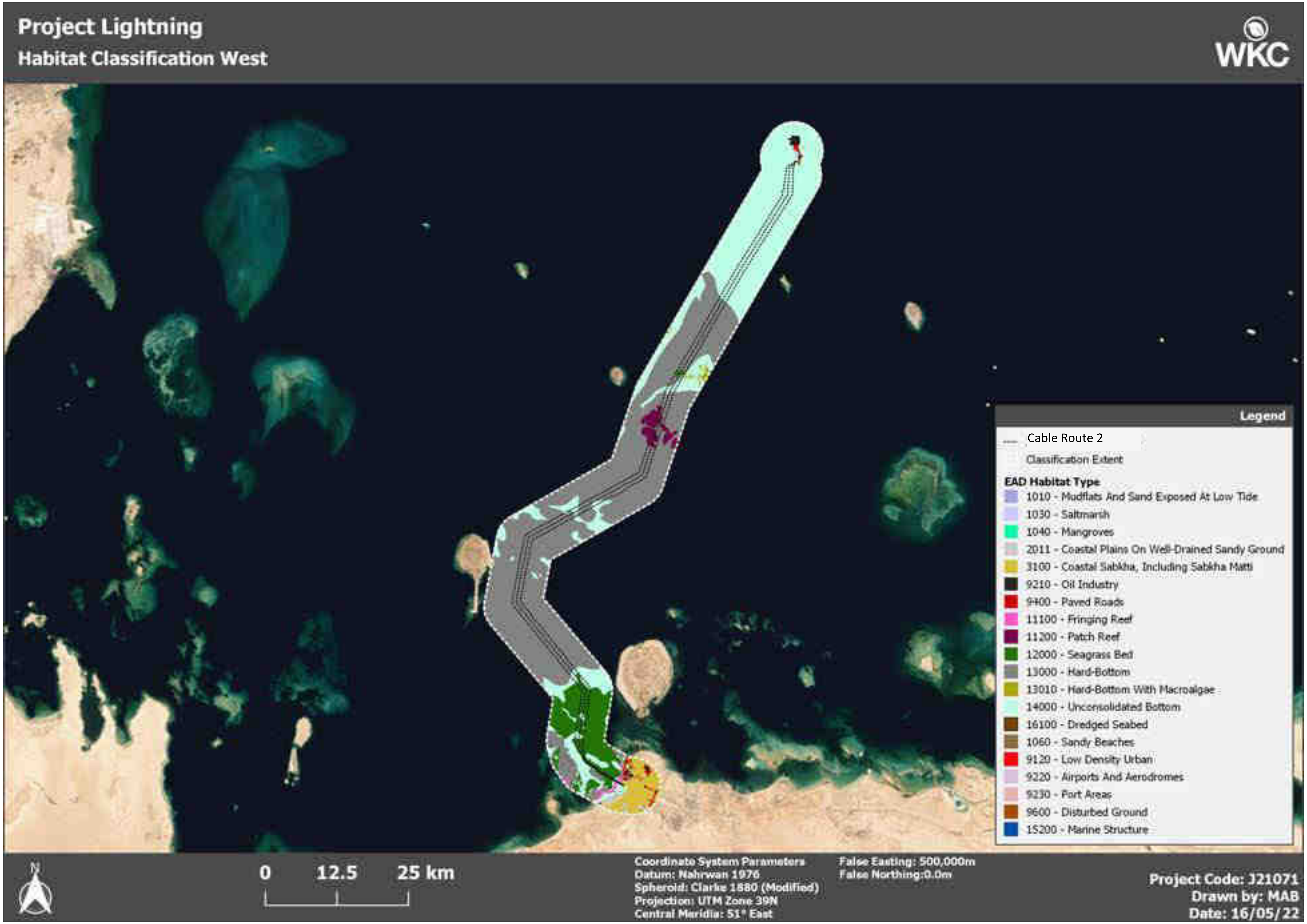


Figure 5-179: Habitat classification for Route 2 (overview map)

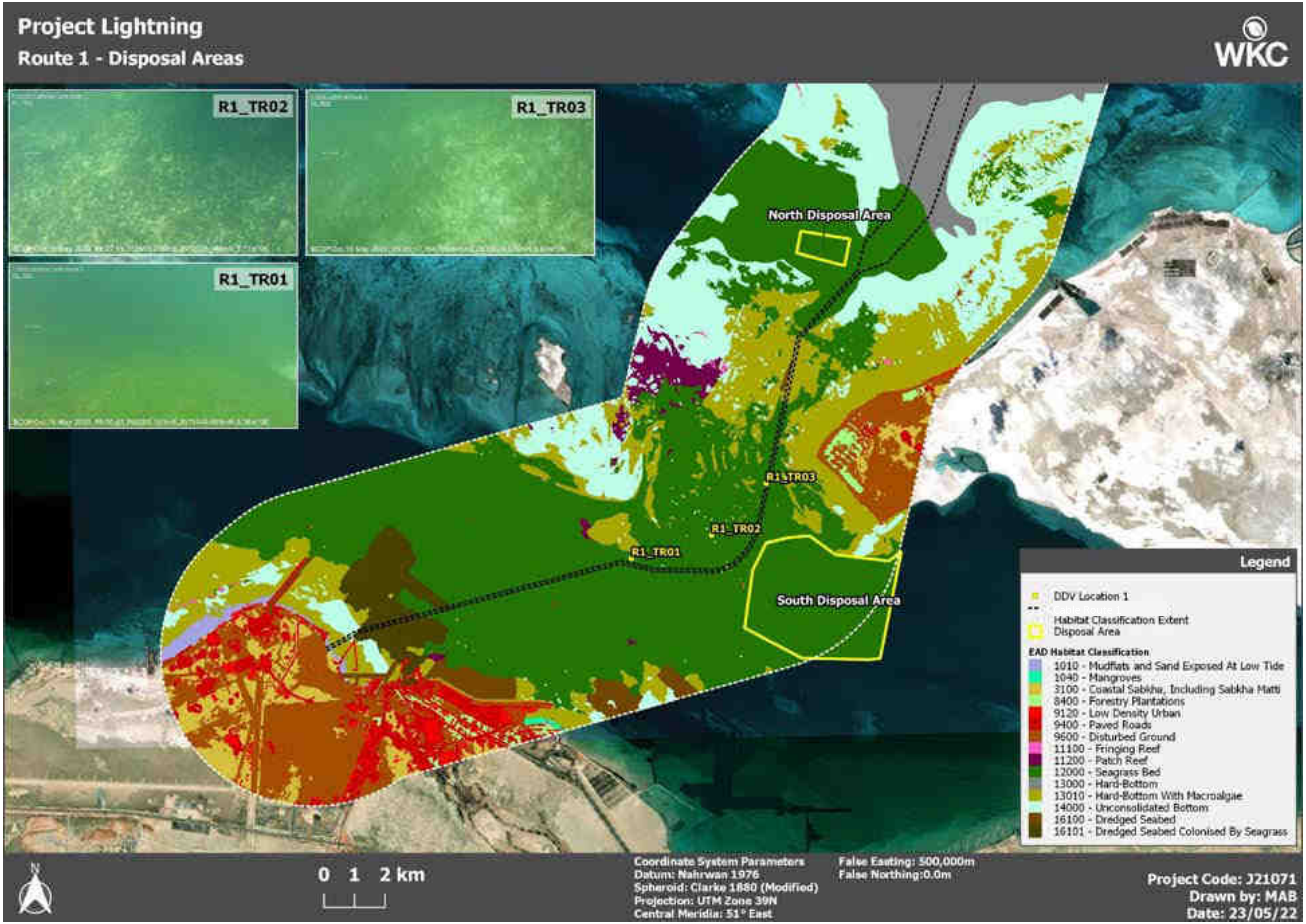


Figure 5-180: Habitats within the disposal areas

Indirect Loss of Localised Marine Habitat and Individual Organisms

Habitats outside of the Project construction footprint will have the potential to be impacted through the dispersion of sediment plumes associated with trenching, either through impacts due to turbidity and reduced water clarity, or through smothering by sediment deposited after suspension.

Turbidity or reduced water clarity is of particular concern to organisms that rely on photosynthesis for energy production including critical habitats such as coral reef and seagrass, and sensitive habitats such as macro-algae communities.

Seagrass beds are considered highly productive ecosystems fulfilling a key role in the coastal zone providing important ecological and economic functions (e.g., importance to fisheries) and ecosystem services. They are highly sensitive marine environments, particularly from reduced water clarity which results in increased turbidity. This is considered as the primary cause of seagrass degradation and global loss as light is one of the key environmental resources for growth and survival of seagrasses (125).

As with other marine organisms, varying sensitivities to increased turbidity or sedimentation of different seagrass species can be observed and are typically dependent on local conditions (125). Whilst the minimum light requirements of seagrasses are reported across a very wide range (i.e., 2.5-3 % surface incident light (SI)), most species are known to require at least 15-25% of SI. For some species, like most *Halophila* sp., as low as 3-8% of SI has been reported as the minimum light requirement. Seagrass beds are able to withstand time periods of limited light availability, they are of course without light for 50% of the time (at night) and are frequently exposed to natural decreases in light availability due to increased turbidity due to storms for example. Studies have shown that *Halophila ovalis* are able to survive for periods up to one month at 0% optimum light conditions, and species of the genus *Halodule* are able to survive up to 3-4 months at 0% optimum light conditions or nine months at 13-15% optimum surface irradiance (126).

Apart from minimum light requirement, the length of time that different species can survive at low light levels is also of importance. It has been clarified in the review by that larger below-ground biomass are better adapted to longer periods of sub-minimal light. In addition, it is worth noting that the seagrass species *Halophila ovalis* has the shortest period of survivability at sub-minimal light. Though it is often difficult to distinguish effects of turbidity (availability of light) and sedimentation (smothering), particularly in the field, several studies have documented degradation of seagrass meadows by smothering due to excessive sedimentation. Critical thresholds of seagrasses for sedimentation range from 2-13 cm/year. In Singapore with consideration to natural background variability in suspended sediment load, seagrass meadows have been assumed to be well adapted to short-term fluctuations in background concentration of 5-10 mg/l such that noticeable change can be stimulated at excess loadings higher than 5 mg/l (127). As such, the impact criteria provided in Table 5-74 can be referenced to provide an indication of the impact severity for increased sediment loading of marine environments.

Table 5-74: Impact severity for suspended sediment concentration on marine habitat (128)

Severity	Definition (excess concentration)
No Impact	Excess suspended sediment concentrations >5 mg/l for less than 20% of the time.
Slight Impact	Excess suspended sediment concentrations >5 mg/l for more than 20% of the time. Excess suspended sediment concentrations >10 mg/l for less than 20% of the time.
Low Impact	Excess suspended sediment concentrations >25 mg/l for more than 5% of the time.
Medium Impact	Excess suspended sediment concentrations >25 mg/l for more than 20% of the time. Excess suspended sediment concentrations >75 mg/l for less than 1% of the time.
High Impact	Excess suspended sediment concentrations >75 mg/l for more than 20% of the time.

This matrix describes the impact of an increase in the suspended sediment concentration above the ambient conditions over a Project's time frame. The overall spread of the turbidity plume during construction is summarised within **Section 5.2**. As per the result of the modelling studies, the unmitigated suspended sediment concentrations are anticipated to meet regulatory criteria for the majority of the time. However, the regulatory criteria may not be sufficient to protect habitats sensitive to increased turbidity. The criteria found in Table 5-74 has been applied to the predicted suspended sediment concentrations for the duration of the dredging works. This is presented in Figure 5-181 for Route 1 and Figure 5-182 for Route 2. See also **Subsection on Numerical Modelling – Dredging Assessment** in **Section 5.2.2.2** for further details of the results.

Overall, concentrations that may result from no impact up to moderate impacts as per the criteria above will extend to surrounding seagrass habitats, to an approximate total area of 236 Ha in Route 1. Moderate impacts are however limited to the immediate areas of the works and majority of the impacted areas will have lower impact effects. In addition, note that the trenching activities only last for a few days at any given area and given that seagrass beds are known to withstand periods of greater than 1 month at 0% optimal light conditions, the overall impacts to seagrass associated with reduced light attenuation is anticipated to be *low* and therefore the impact significance is considered to be **moderate negative**. At Route 2, the impacts representing minor to moderate severities extend only within the immediate areas of the works, limited to the coastal and nearshore areas affecting only very limited seagrass areas. Much of the impacts reaching the seagrass areas in close proximity to the works represents only *slight* effects. The impacts to the seagrass located in nearshore areas of Route 2 is anticipated to be **minor negative.**

Hard corals are known to be sensitive to elevated turbidity levels as photosynthetic processes of the zooxanthellae serving as algal symbionts to these groups are adversely affected by reduced light penetration through the water column (127). In such photosynthetic corals, the symbiont algae are responsible for producing majority of the coral's energy requirements, such that most corals require light to survive (Achituv and Dubinsky, 1990 *in* (129)). In addition, elevated sedimentation levels can clog the corals' feeding and respiratory system (130). High turbidity and sedimentation rates can therefore potentially result not only in direct mortality of the coral, but may also lead to reduced growth, lower calcification rates and reduced productivity, disease susceptibility and regenerative capacities (129). When compounded by natural processes induced stresses, substantial impacts on coral health and declines in live coral cover will likely occur (Field, et al., 2000 *in* (129)).

Studies to determine lethal (acute) and sub-lethal (chronic) turbidity thresholds have been conducted on a number of species. However, the level of sensitivity of the corals is dependent on a number of factors. One factor is the specific characteristics of the corals. For example, with the plate corals like *Pachyseris* sp., such species may be more sensitive to increased sedimentation but least sensitive to light penetration reduction. Conversely, branching corals including *Acropora* sp. show exactly the opposite trend in sensitivity (127). One other factor is the background levels in which the corals are accustomed to. Different regions having varying background conditions will have corals with varying levels of tolerances to suspended sediment levels. As other authors have pointed out as well, species composition of areas may also play an important factor in determining turbidity impacts on corals. It has been shown that reefs subjected to increased sedimentation may be dominated by species that have higher tolerance and are better adapted to such conditions. Erftemeijer, Riegl, Hoeksema, & Todd (2012) provided a comprehensive review and reported that tolerance limits of corals for total suspended matter (or suspended-sediment concentration) may range from <10 mg/l in reef areas not subject to stresses from human activities to >100 mg/l in marginal reefs in turbid nearshore environments. The wide range shows that different species, and corals in different geographic regions, may have different responses to increased amounts and rates of sedimentation. The lowest sediment treatments known so far that caused full colony mortality were TSS levels of 30 mg/l after 12 weeks (131). In general, however, corals are thought to be affected by chronic TSS levels of as low as 10 mg/l (132).

It is also worth noting that impacts due to increases in turbidity during coral spawning is not well documented. Coral spawning within the waters of the UAE is known to occur during April and May in the presence of a full moon (133). Due to the unknown impact during such events, additional mitigation measures will be implemented between March and May if required.

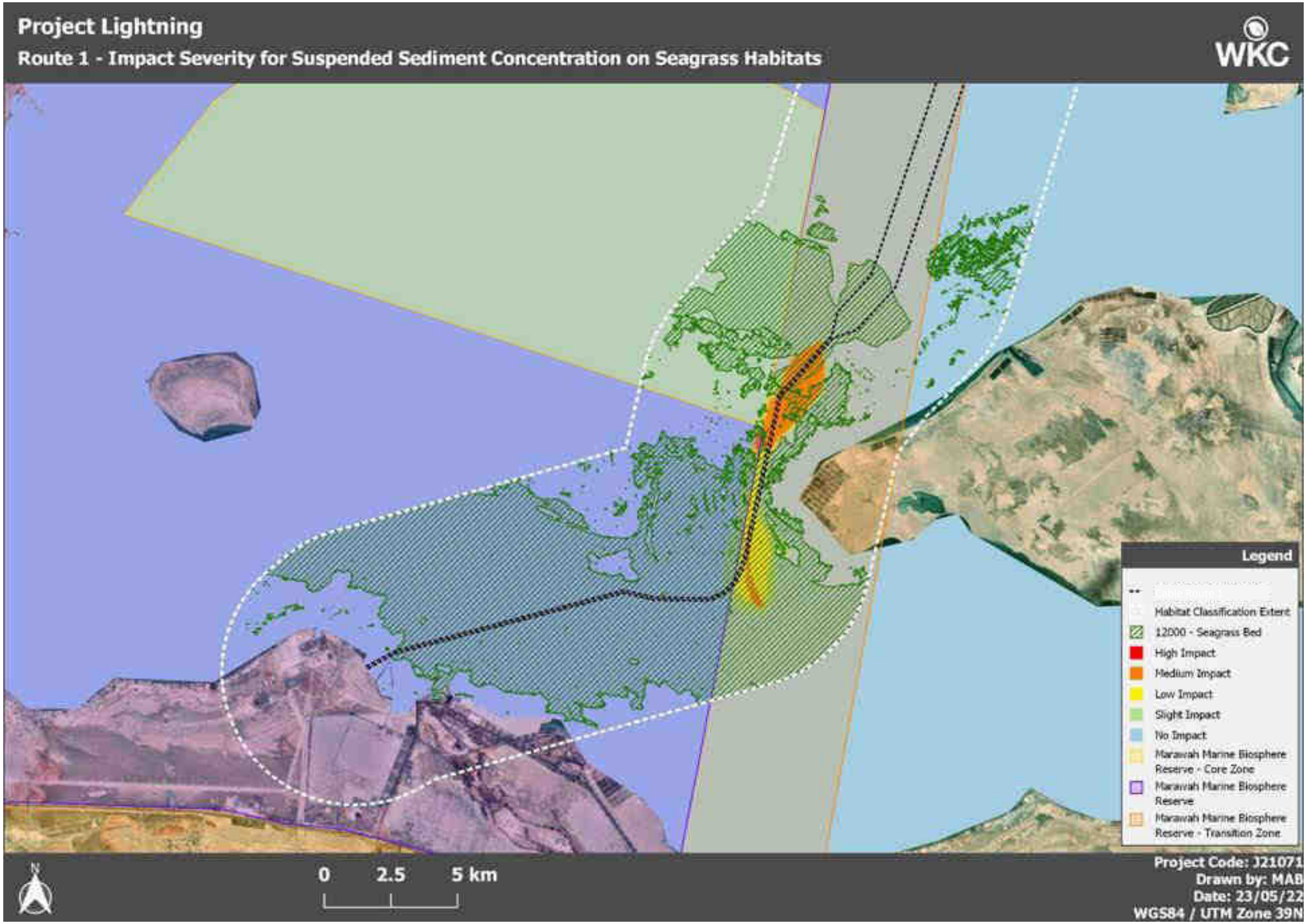


Figure 5-181: Impact severity of suspended sediment on seagrass at Route 1

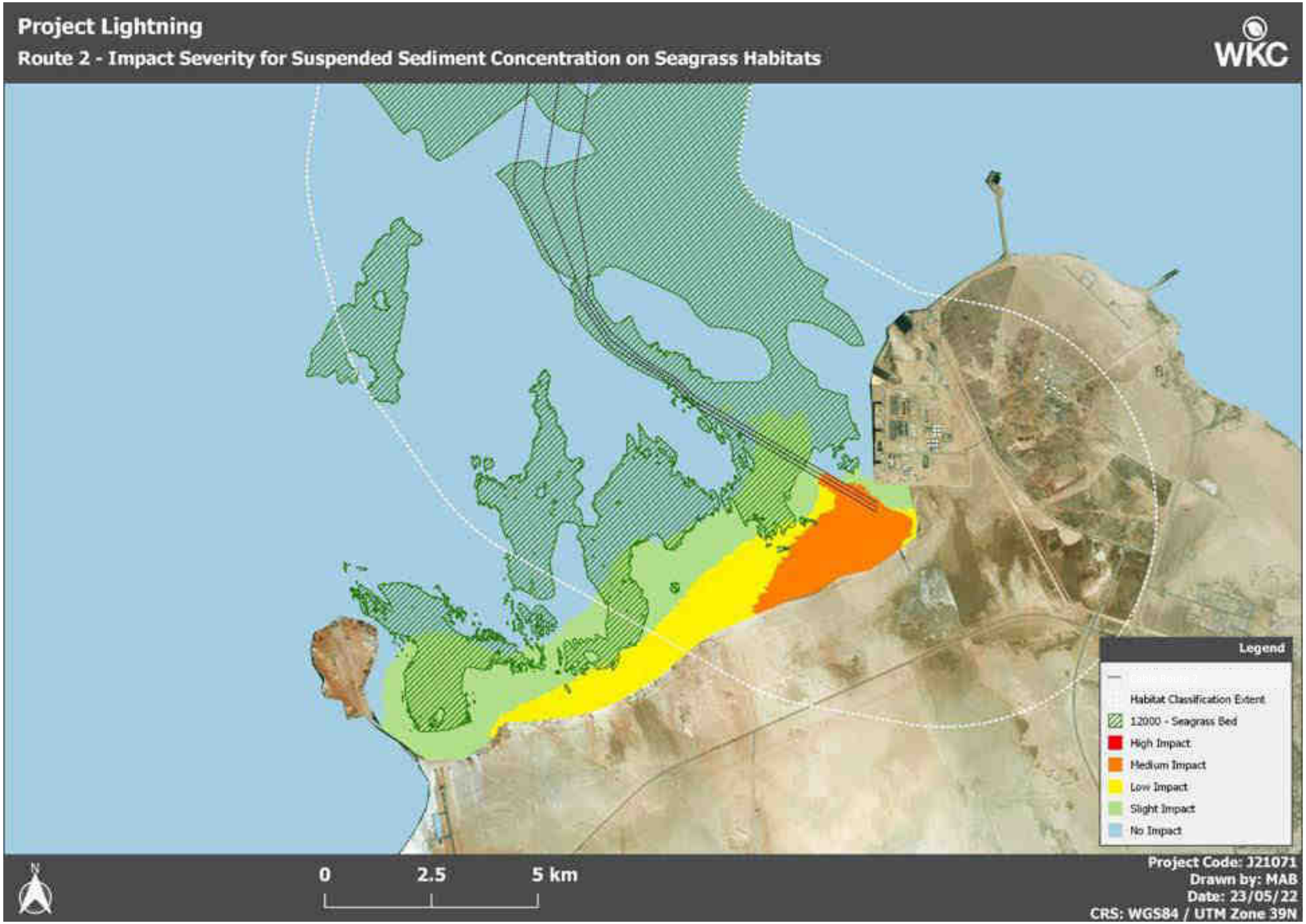


Figure 5-182: Impact severity of suspended sediment on seagrass at Route 2

Note that the impact to corals will depend on both concentration of TSS experienced and the period the coral is exposed for. Therefore, to investigate the long-term turbidity exposure issues for corals, the criteria used in a number of Australian dredging programmes has been referenced. The criteria for these coral impact zones, given in Table 5-75 below, were originally defined through interaction with the Western Australian EPA Science Unit, during the dredging studies for the Chevron Gorgon project at Barrow Island off the Western Australian coast (134).

Table 5-75: TSS impact zone criteria for corals

Variable	Timeframe	Concentration	Time (Cumulative Days)
Zone 1:	**Zone of High Impact**		
TSS	Short	≥25 mg l^{-1}	5 in 15
TSS	Medium	≥10 mg l^{-1}	20 in 60
TSS	Long	≥5 mg l^{-1}	80 in 240
Zone 2:	**Zone of Moderate Impact**		
TSS	Short	≥25 mg l^{-1}	2 in 6
TSS	Medium	≥10 mg l^{-1}	7 in 21
TSS	Long	≥5 mg l^{-1}	20 in 60
Zone 3:	**Zone of Low Influence**		
TSS	Any	≥2 mg l^{-1}	At any time

Note: Exposure for at least six hours during daylight hours was regarded as satisfying the TSS exposure criteria.

The minimum TSS level adopted for the zone of influence (Zone 3) was exposure to 2 mg/l for a day (daylight hours).

Zone 3 (the zone of influence) covers a larger region that the zones of impact but is only an indication of where turbid plumes may be seen at some point during the dredging but, by definition, do not cause any impacts.

Based on the above criteria and based on the extent of impact effects on coral reef habitats as provided in Figure 5-183 for Route 1 and Figure 5-184 for Das Island cable route (Route 2), the impacts at Route 1 will mostly be within the areas immediately next to the trenching activity locations which are at some distance to most of the coral reef locations and only some small patch reefs at the areas within MMBR (Supplemental sampling - areas not surveyed by Fugro) are in close proximity which will potentially experience some *low* impact effects as shown in Figure 5-183. However, areas of coral habitats located at Shuweihat as shown in Figure 5-184 are anticipated to be exposed to suspended sediment of large enough concentrations to result in *medium* magnitude in the majority of areas, although a *high* magnitude may be experienced over a very small peripheral area.

Coral and seagrass habitats are also susceptible to increased levels of sedimentation even over relatively short periods of time. This deposition of sediment can smother the habitats and reduce photosynthetic rate and overall health.

Table 5-76: Impact severity of sedimentation on seagrass in turbid environments

Severity	Definition
No Impact	Sedimentation <0.10 kg/m^2/day (<0.25 mm/day)
Slight Impact	Sedimentation <0.25 kg/m^2/day (<0.63 mm/day)
Minor (Low) Impact	Sedimentation <0.50 kg/m^2/day (<1.25 mm/day)
Moderate (Medium) Impact	Sedimentation <1.00 kg/m^2/day (<2.50 mm/day)
Major (High) Impact	Sedimentation >1.00 kg/m^2/day (>2.50 mm/day)

As noted in the dredging assessment, the trenching and backfilling involved within the construction programme for both Route 1 and Route 2, are sparsely spread both temporally and spatially, such that the statistical analysis of concentrations (e.g., mean and 95th percentile) are indicated conservatively compared to the potential for significant exceedance in AWQOs. Results further show that the exceedances within the AOI for the Das Island Cable Route are expected to occur for over two weeks, whereas within Route 1 AOI, exceedance is generally limited to less than one week, likely due to the faster mixing processes associated with higher current speeds. Furthermore, sediment rates are expected to have the biggest impact in the direct vicinity of dredging works with no impact expected approximately 100 m from dredging works. More moderate sedimentation is expected over a wider area; however, this sedimentation rate (over ambient) is anticipated to be less than 1.2 mm/day. The impact severity therefore that is associated with smothering by deposited sediment is anticipated to be *low*. Overall, the impacts that are considered to be largely of *low* severity is considered to result in a **moderate negative** impact significance due to the *high* valued coral habitats.

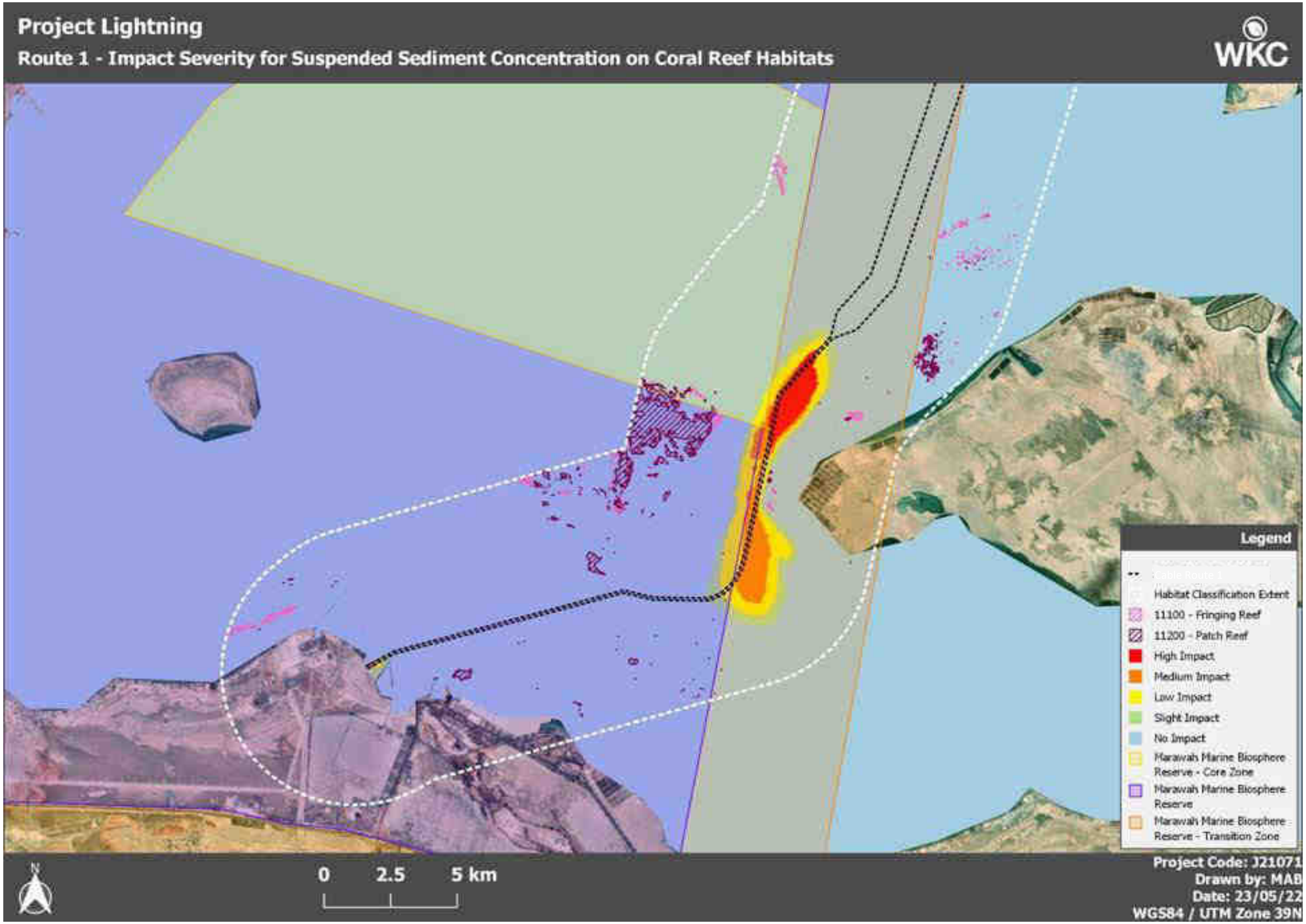


Figure 5-183: Impact severity of suspended sediment on coral reefs along Route 1

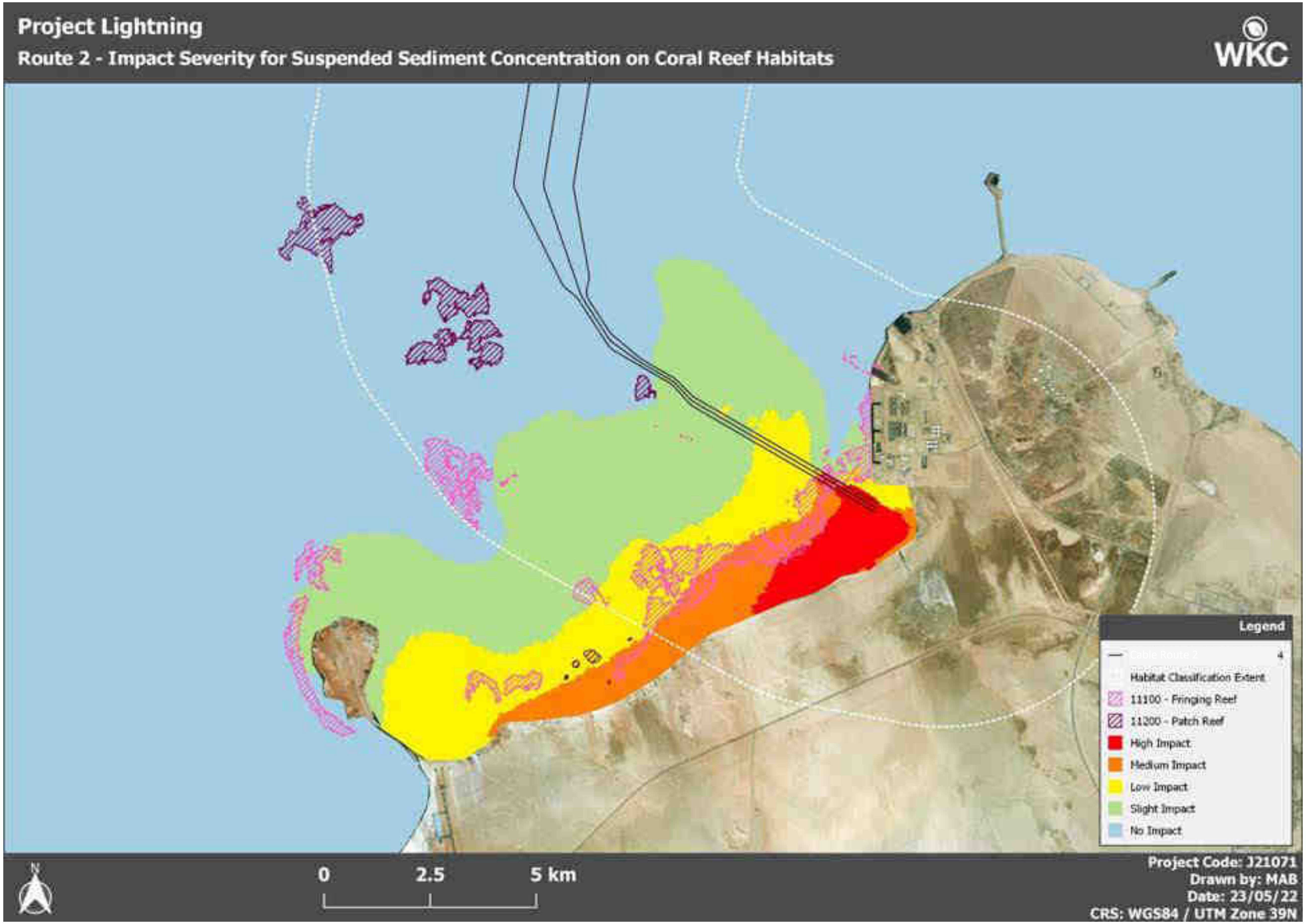


Figure 5-184: Impact severity of suspended sediment on coral reefs along Route 2

Summary of Impacts on Critical Impacts

As a best-case scenario (no requirement of the southern disposal area and the implementation of silt curtains), the Project would result in the temporary loss of 534 ha. (direct) and 1,287 ha. (estimated indirect) of seagrass habitat through dredging and trenching/backfilling activities. As a worst-case scenario (requirement of the southern disposal area and no implementation of silt curtains), the Project would result in the temporary loss of 2,114 ha. (direct) and 2,987 ha. (estimated indirect) of seagrass habitat through dredging and trenching/backfilling activities. It is however assessed that the seagrass will recover within a year after Project completion.

The cable route will also pass through areas that contain patch reefs and fringing reef. As a best-case scenario, the Project would result in the temporary loss of 16 ha. (direct) and 6 ha. (estimated indirect) of patch reef and fringing reef and as a worst-case scenario, the Project would result in the temporary loss of 16 ha. (direct) and 96 ha. (estimated indirect) of patch reef and seagrass habitat.

Details of the calculated estimations are provided in Table 5-77 below.

Table 5-77: Impacts upon critical habitat

Habitat	Sensitivity	Direct Loss (ha)	Indirect Loss (Ha)	Total Expected Loss
Worst Case-Scenario[1]				
Seagrass	Critical	2,114	2,987	**5,101**
Patch Reef	Critical	12	0	**12**
Fringing Reef	Critical	4	96	**100**
Best Case-Scenario[2]				
Seagrass	Critical	534	1,287	**1,821**
Patch Reef	Critical	12	0	**12**
Fringing Reef	Critical	4	6	**10**

Notes:

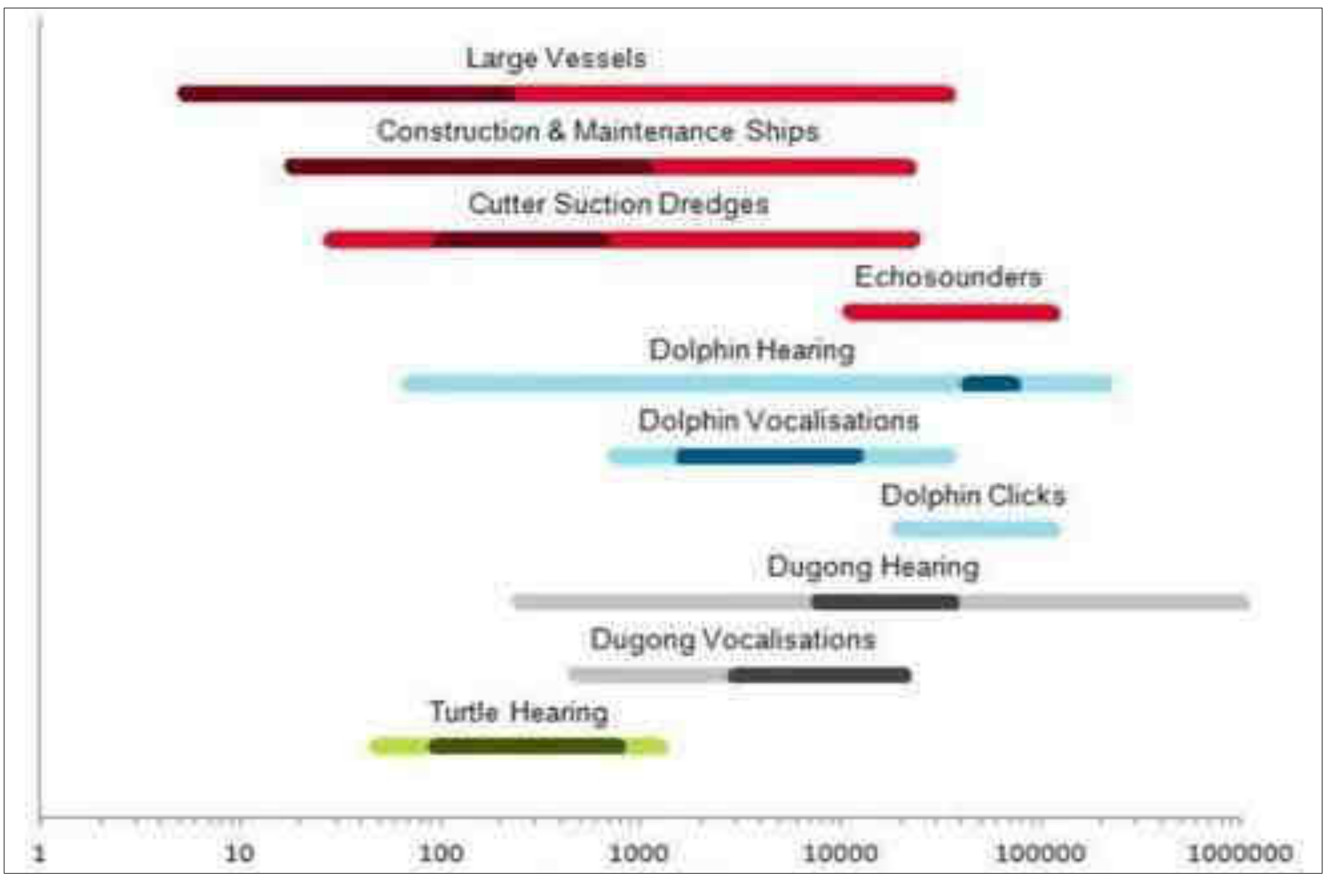
1. Worst case-scenario includes:
   - With the Southern Disposal Area (if found to be required)
   - Without the implementation of mitigation measures: considering 100% mortality in high impact zones and 50% mortality in moderate impact zones
2. Best case-scenario includes:
   - Without the Southern Disposal Area (not expected to be required)
   - With the implementation of mitigation measures: silt curtains deployment. Assumed silt curtains are deployed efficiently: areas of high impact are reduced to areas of moderate impact (i.e. 50% mortality).

5.5.2.2.2. Potential Disturbance to Marine Mammals and Reptiles due to Noise Pollution

Although dredging is not as noisy as other major anthropogenic sources of underwater noise such as pile driving (impact hammer), seismic surveys, sonar surveys etc., it is louder than most shipping and drilling activities and therefore is generally considered a medium impact activity (135). Whilst some dredgers to be used on site are quitter, e.g., backhoe dredger, the noise levels resulting from the overall dredging activities are considered to overlap with the hearing ranges of all three megafauna groups, as well as vocalisation ranges of dugongs and dolphins.

Based on underwater noise measurements, Mean RMS (i.e, Sound Pressure Levels (SPL) root mean squared (RMS) in dB) ranged from 108.9 dB to 141.2 dB at Route 1. The maximum and minimum RMS ranged from 88.5 to 153.4 dB. Ambient background noise ranged from 99.6 dB to 120.1 dB RMS. Considering that invertebrate clicks and mammal vocalisations have been effectively isolated provides an indication of soundscape of mainly natural origin. Some recordings of anthropogenic noise, e.g. vessel passage, have been noted above the ambient levels (i.e., max RMS of 133.3 dB and a peak of 154.3 dB).

Marine fauna exposed to loud and / or sustained anthropogenic noise sources may exhibit changes in behaviour, experience temporary hearing loss (TTS) or even permanent hearing loss (PTS). Changes in behaviour can result from the masking of marine fauna communications, echolocation and passive listening abilities (listening for predator or prey), as well as general disturbance or stress which may displace fauna from essential habitat areas. Figure 5-185 details the hearing ranges of groups of marine megafauna in comparison with anthropogenic sources of underwater noise (including dredging).



Note: The values shown on the x-axis are sound wave frequency values in Hertz (cycles per second).

Figure 5-185: Comparison of hearing range of marine megafauna with sources of anthropogenic noise

Based on past studies on marine mammal behaviour, it is possible to infer points in space and time when behavioural and physical impacts may occur (136) (137). Table 5-78 details the noise level thresholds for continuous noise for a number of marine mammal groups.

The criteria used to assess behavioural responses to noise stimulus is sound pressure level, whereas TTS and PTS should be compared to Sound Exposure Level (SEL). SEL includes the effect of the exposure duration and thus takes into account the total exposure energy to determine potential risks to animal hearing (136).

Table 5-78: Noise level thresholds for marine mammals

Functional Hearing Group	Behavioural Response Sound Pressure Level (dB re µ a)	TTS Sound Exposure Level (d re µ a .s)	PTS Sound Exposure Level (dB re µ a .s)
Low-frequency Cetaceans	120	178	198
Mid-frequency Cetaceans	120	178	198
Dugongs	120	183	197
Turtles	175	178	198

Noise in marine environments spreads much more efficiently than in air environments. It is important to note that sound attenuation in submarine environments is dependent on multiple factors, such as depth, sea state, frequency of the noise etc.

As an example, a study carried out on the propagation of CSD dredger noise was carried out in Queensland, Australia as part of an EIA for dredging activities (138). Two CSD dredgers (with differing sound pressure levels marked as lower and higher) and their corresponding booster pumps were measured at various distances in order to determine the approximate noise attenuation over distance. The average results over the survey period are detailed in Table 5-79.

Table 5-79: Sub-marine noise attenuation over distance of CSDs

Distance from Source (m)	Sound Pressure Level (dB re 1 micropascal (µPa))			
	Dredger (lower)	Dredger (upper)	Dredger (average)	Booster Pumps
1	180	187	184	181
50	146	153	150	147
100	140	147	144	141
200	134	141	138	135
500	126	133	130	127
1,000	120	127	124	121
2,000	114	121	118	115
4,000	108	115	112	109

A comparison with the behavioural noise thresholds in Table 5-78 with sound pressure levels likely to be generated by Trailer Suction Hopper Dredger and Backhoe dredger at various distances with reference to Table 5-79 suggest that dugongs and cetaceans may start to show behavioural responses at up to 2,200 m, while for turtles it would be less than 5 m. These distances assume no attenuation of sound due to changes in depth or the presence of sandbars or reefs that may block the sound (138).

It is important to note that sound attenuation in subsea environments is dependent on multiple factors, such as depth, sea state, frequency of the noise etc. However, in the absence of any site-specific data, and given the similarities in the equipment, the results of this historic analysis have been utilised for the purposes of the impact assessment.

In order for any marine animal to experience a SEL that would cause PTS, the exposure would have to occur at a distance of less than 5 m for an extended period of time (i.e., minutes rather than seconds). This scenario is considered unlikely to occur.

In order for an animal to be exposed to a SEL that could potentially cause TTS, the animal would have to be exposed for an extended period of time. The approximate distances and exposure durations at which TTS could occur due to dredging noise are summarised in Table 5-80.

Table 5-80: SEL thresholds with potential to cause temporary hearing loss in marine mammals during CSD operations

Distance (m)	Exposure Duration in order to reach TTS SEL
1	1 second
50	10 minutes
100	1 Hour
200	3 Hours

Based on the above thresholds for behavioural changes, it is anticipated that behavioural changes to marine mammals are anticipated to occur within an area of over 15 km^2, whereas the potential for PTS (worst case should the animals be present for up to three hours) would extend over an area of over 125,000 m^2. It is however worth noting that the animals are unlikely to remain within the impact area for extended periods of time and behavioural responses will include avoidance; the animals being displaced from the area of impact to simply move elsewhere, therefore, the duration of impact is unlikely to exceed one hour. It is noted that during the conduct of underwater noise surveys, marine mammal noises were recorded reinforcing the visual survey of species presence.

The impact effect to marine fauna due to dredger produced noise is considered to be of *low* due to the relatively large spread of the area impacted. However, the impact is not anticipated to be 'significant' due to the relatively short time frame of the impact – a matter of a few weeks at each individual location after which the impact will be reversed. This will result in an impact of **moderate negative** significance. Note, this impact assessment is considered to be highly conservative.

5.5.2.2.3. Potential Impact to Marine Mammals and Reptiles due to Marine Vessel Collision

Increases in marine vessel traffic due to construction works will increase the risk of accidental collisions with marine mammals and reptiles. There is a risk of impact to all marine mammals and reptiles, however, impact risk is considered to be higher for different species. For example, collision with slow moving whales is considered to be of higher risk as ship strikes with these species are well documented (139). The Bryde's Whale is known to be present in the UAE waters, however, in low numbers and the species has not been documented within the area of interest. Collision with fast moving cetaceans such as dolphins are considered to be of lower risk as they have the agility and speed to move away from ships if they present a threat. Agile dolphins are also known to actively approach ships out of curiosity and play within the bow waves. Marine strikes with dugongs are less common, and it has been suggested, based on research into Caribbean manatees, that Sirenians have the mental capacity to avoid vessels which may pose a threat (140). However, due to dugong's slow moving nature, impact risk cannot be entirely discounted, particularly if caught within the navigation channel at low tide with no means of retreat. Note that the baseline study has documented the high population density of turtles at MMBR. Such high density is considered to pose a higher risk than other areas outside of the MMBR.

Vessel speed has been implicated as a key factor in the occurrence and severity of vessel strikes with large species. Several independent studies indicate that vessel speeds of 10-14 knots increase by one-half or greater the probability that a whale will survive a collision with a ship (141).

The worst-case impact effect of a marine vessel with a marine mammal or reptile would be death of the affected individual. Species of turtles in particular are considered of *high* conservation value. However, considering that the probability of this occurring is anticipated to be very unlikely, the overall severity of the impact is considered to be *low.* This is anticipated to result in an impact of **moderate negative** significance.

5.5.2.2.4. Spill of Hazardous Materials to the Marine Environment

Re-fuelling and machine maintenance will require the storage and usage of hazardous materials such as lubricants, fuel and descaling products. Quantities of hazardous materials are currently unknown; however, it is envisioned that quantities will be relatively small. Usage of hazardous materials and possible spills resulting from the mishandling or incorrect usage procedure may result in contamination of the surrounding marine environment. Although seagrass habitat exists in the vicinity of the construction activities, the likelihood of spillage occurring is deemed unlikely and the severity resulting from a spillage can be considered to be *low*. This results in a **moderate negative** impact significance.

5.5.2.3. Operational Phase Impacts

Potential impacts to the marine environment resulting from the operational activities associated with the Project include the following:

- Introduction of new artificial benthic substrate as a result of concrete mattresses / cable rock protection deployment;
- Permanent changes to the localised hydrodynamics (flow, retention) including alteration to natural erosion or accretion processes; and,
- Potential impacts from electromagnetic field emissions.

No other impacts to marine ecology are anticipated during the operation phase of the project. Whilst unplanned activity such as repairs of the subsea cable may be expected, the activities are highly likely to be non-intrusive to result in substantial interaction with the marine ecology of the affected areas such that these are not assessed further in this report.

5.5.2.3.1. Introduction of New Artificial Benthic Substrate as a result of Rock Protection and Concrete Mattresses Deployment

The availability of new concrete and rock substrate installed along significant sections of both cable routes will provide colonisation space for opportunistic marine organisms. Although it is not certain how many of these concrete units will be installed, the computed length of the rock protection is estimated to be of 339 kilometres (R1- 64 kms and R2 – 275 kms.). The structure hard surface could be colonised by fouling species and corals. The spaces and crevices in between concrete blocks may be used by several fish species as hiding and refuge areas.

Some of these fish species are of commercial importance such as the Orange Spotted Grouper. Studies have shown that introduction of structures on the seabed such as artificial reef increases the biodiversity on the given location. Concrete mattresses or cable rock protection will have the same function as the ecological principles of Artificial Reef (AR) deployment. The impact is assessed to be **positive** and will aid in the habitat improvement of the otherwise low habitat value of unconsolidated bottom and enhance the function hardbottom ecosystems.

5.5.2.3.2. Impact on Marine Ecology due to Changes in the Localised Hydrodynamic Flow of the Channel

The increase in depth and width as a result of the planned floatation / dredged channels within the areas of Route 1 which require extensive dredging for floatation / dredged channels which has therefore increased the construction footprint. This could result in changes in flow or deposition rates of suspended sediments across the wider area. Scouring of channels could remove seagrass habitat, removing important nursery habitat for fish species. However, the channels created will allow the re-establishment of previously lost marine habitat as well as developing new habitat such as dredge wall flora and fauna assemblages and could increase the overall marine diversity footprint size within the reef. The alternate seabed profile and flow rates will allow subtidal habitat to be created.

However, and as explained in **Section 5.2.2** the channel is orientated perpendicular to the shoreline as in the case of Shuweihat fringing reef and the MMBR channel, ebb and flood currents will significantly interrupt sediment dynamics in the area. This process is anticipated to be slow, and therefore is not anticipated to alter habitat distribution in the short term. However, the facilitation of natural sediment dynamics will change the natural habitat progression of the area by increasing the supply of sediment in both the flood and ebb direction due to the channel acting as a sediment channel. he facilitation of sediment transport is considered to be very likely to occur, and the impact is anticipated to be of low severity, resulting in an impact of **moderate negative** significance.

5.5.2.3.3. Potential impacts from Electromagnetic Field Emissions

There is a growing concern over the potential ecological impacts of electromagnetic fields (EMF), which are generated by current flow passing through power cables (142). Electric fields are known to increase in strength with the increases in voltage and may reach up to 1000 µV/m for an electric cable but are generally effectively confined inside cables by armouring (*in* (142)). Factors that may impact upon the EMF emitted include the type of cable (power, fiber optic etc.), power and type of current (whether DC or AC), and if buried or not (although burying does not entirely eliminate EMF emissions). Recent advances in cabling industry have developed DC cables (mainly bipolar) are able to eliminate the magnetic fields when laid out in pairs with antiparallel DC currents.

Many marine species, in particular rays and sharks, fishes, mammals, turtles, molluscs, and crustaceans which abound in the area, are known to be sensitive to EMF and a number of species even utilize the Earth’s magnetic fields for orientation and migration. There is a potential for such organisms to be adversely impacted by EMF including effects on predator-prey interactions, avoidance/attraction and other behavioural effects, navigational capabilities, and physiological and developmental effects (142) (143).

Assessment however of such impacts remains largely difficult and complicated due to the general lack of body of knowledge or evidence of population-scale impacts among potentially impacted species. Data remain scarce for studies to inform on these impacts except for minor or non-significant impacts observed in a few studies. Furthermore, substantial gaps on the knowledge exist on the interaction of species and dynamic cables owing to the difficulty in evaluating impacts around these deployments. In rare instances where studies have been indeed undertaken, conclusions were such that subsea DC cables are unlikely to cause adverse impacts on marine species (143). For example, the results of the review of information have shown that the potential effects of altered magnetic or induced electric fields appears quite low or non-existent and that the marine organisms responses to exposure to the magnetic fields are temporary and spatially limited.

Based on the above, it is considered that the impact area (extent of EMF emissions) is very small (up to a few meters) compared to the wider area where the subsea cables will traverse. The probability then of resident marine species encountering areas of significant altered magnetic fields associated with the buried cables installed as part of this Project is very low. With the general lack of information in which to infer the assessment and the very low potential for interaction with marine species, such impact is not deemed of particular concern.

5.5.2.4. Cumulative Impacts

5.5.2.4.1. Construction Phase

No Type 1 cumulative impacts have been identified.

Considering that majority of the surrounding areas with ongoing and planned construction are mainly limited to the landing site of the cable routes, no Type 2 cumulative impacts are anticipated on the marine ecology of the areas.

5.5.2.4.2. Operational Phase

No Type 1 cumulative impacts have been identified.

It is acknowledged that there may be potential for cumulative effects on the hydrodynamics of the general area considering the works being completed particularly within the Zakum Field and areas surrounding Das Island, mainly associated with the oil field operations. It is of particular note on the potential for cumulative effects from heat dissipation and electromagnetic field where a number of subsea cables may be present within the general areas in close proximity of the Project alignment. However, it is considered that no areas of conservation importance will be substantially impacted by the cumulative footprint and given the nature of this Project resulting in mainly temporary cumulative impacts, except for the impacts on the approved disposal sites. Overall, the cumulative effects on marine ecology are assessed as being of **minor negative** significance.

5.5.3. Mitigation Measures

5.5.3.1. Potential Mitigation Measures

Table 5-81: Potential marine ecology impacts and mitigation measures

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
Construction Phase								
1	Direct loss of seagrass due to dredging activities along the route alignment with the North Disposal Area	General activities associated with trenching and backfilling associated with the cable installation.	Critical habitats, e.g., seagrasses within Route 1, Route 2 and North Disposal Area	Moderate Negative	– Avoid use of the South Disposal Area – Optimise the channel design and the construction methodology to reduce amount of required dredging – A dredging Management Plan (DMP) to be developed as part of the CESMP – Allow natural seagrass seeding to occur post construction – Undertake monitoring post construction – Extended monitoring of seagrass around the dredge area to document recolonisation process – Monitoring of turbidity by continuous monitoring buoys and multiparameter probe outside of silt curtains and at sensitive locations with dredging to cease if threshold values are exceeded	– Federal Law 23 and 24 of 1999	-	No
2	Direct loss of seagrass due the disposal of excess materials in the South Disposal Area	Disposal of excess material	Critical habitats, e.g., seagrasses within Route 1 South Disposal Area	Major Negative	– Optimise the disposal area design and the construction methodology to reduce impact – A dredging Management Plan (DMP) to be developed as part of the CESMP – Allow natural seagrass seeding to occur post construction – Undertake monitoring post construction – Extended monitoring of seagrass around the dredge area to document recolonisation process – Monitoring of turbidity by continuous monitoring buoys and multiparameter probe outside of silt curtains and at sensitive locations with dredging to cease if threshold values are exceeded	– Federal Law 23 and 24 of 1999	-	No
3	Direct loss of corals due to dredging activities.	General activities associated with trenching and backfilling associated with the cable installation.	Critical habitats, e.g., fringing reef within the nearshore section of Route 2	Moderate Negative	– Optimise the channel design and the construction methodology to reduce amount of required dredging – A dredging Management Plan (DMP) to be developed as part of the CESMP – In cable laying at coral reef areas where no trenching is planned, allow evasion from dense coral population – Undertake monitoring post construction – Monitoring of turbidity outside of silt curtains and at sensitive locations with dredging to cease if threshold values are exceeded – Consider compensation mitigation through establishment of artificial reefs – Coral relocation activities within the general site area but away from the dredging influence	– Federal Law 23 and 24 of 1999	-	No
4	Direct loss of medium-valued habitats due to dredging activities.	General activities associated with trenching and backfilling associated with the cable installation.	Critical habitats (e.g., coral reefs) in offshore areas within Route 1 and Route 2 and environmentally sensitive habitat (e.g., macroalgae) – All areas	Moderate Negative	– Optimise the channel design and the construction methodology to reduce amount of required dredging – A dredging Management Plan (DMP) to be developed as part of the CESMP – In cable laying at coral reef areas where no trenching is planned, allow evasion from dense coral population – Undertake monitoring post construction – Consider compensation mitigation through establishment of artificial reefs – Coral relocation activities within the general site area but away from the dredging influence – Monitoring of turbidity by continuous monitoring buoys and multiparameter probe outside of silt curtains and at sensitive locations with dredging to cease if threshold values are exceeded	– Federal Law 23 and 24 of 1999	-	No

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
5	Direct loss of low-valued habitats due to dredging activities.	General activities associated with trenching and backfilling associated with the cable installation.	All other habitats, e.g., unconsolidated bottom and man-made or non-natural habitats and associated benthic infauna and other communities and species	Negligible	– Optimise the channel design and the construction methodology to reduce amount of required dredging – A dredging Management Plan (DMP) to be developed as part of the CESMP – Undertake monitoring post construction – Monitoring of turbidity by continuous monitoring buoys and multiparameter probe outside of silt curtains and at sensitive locations with dredging to cease if threshold values are exceeded	– Federal Law 23 and 24 of 1999	-	No
6	Indirect loss of localised marine habitat, e.g., seagrasses within Route 1, and individual organisms	General activities associated with trenching and backfilling associated with the cable installation	Critical habitats, e.g., seagrasses within Route 1	Moderate negative	– Optimise the channel design and the construction methodology to reduce amount of required dredging – A dredging Management Plan (DMP) to be developed as part of the CESMP – Allow natural seeding to occur post construction – Installation of Type IV silt curtain between source of plume and critical habitat receptors. Silt curtains should be deployed to protect sensitive receptor in the area – Monitoring of turbidity by continuous monitoring buoys and multiparameter probe outside of silt curtains and at sensitive locations with dredging to cease if threshold values are exceeded – Undertake monitoring post construction – Extended monitoring of seagrass around the trench area to document recolonisation process	– Federal Law 23 and 24 of 1999	-	Yes
7	Indirect loss of localised marine habitat e.g., seagrasses within Route 2, and individual organisms	General activities associated with trenching and backfilling associated with the cable installation	Critical habitats, e.g., seagrasses within Route 2	Minor Negative	– Optimise the channel design and the construction methodology to reduce amount of required dredging – A dredging Management Plan (DMP) to be developed as part of the CESMP – Spoil disposal onshore – Allow natural seeding to occur post construction – Installation of Type IV silt curtain between source of plume and critical habitat receptors. Silt curtains should be deployed to protect sensitive receptor in the area – Monitoring of turbidity by continuous monitoring buoys and multiparameter probe outside of silt curtains and at sensitive locations with dredging to cease if threshold values are exceeded – Undertake monitoring post construction – Extended monitoring of seagrass around the trench area to document recolonisation process	– Federal Law 23 and 24 of 1999	-	Yes
8	Indirect loss of localised marine habitat, e.g., coral reefs, and individual organisms	General activities associated with trenching and backfilling associated with the cable installation	Critical habitats, e.g., coral reefs	Moderate Negative	– Optimise the channel design and the construction methodology to reduce amount of required dredging – A dredging Management Plan (DMP) to be developed as part of the CESMP – Spoil disposal onshore – Allow natural seeding to occur post construction – Installation of Type IV silt curtain between source of plume and critical habitat receptors. Silt curtains should be deployed to protect sensitive receptor in the area – Monitoring of turbidity by continuous monitoring buoys and multiparameter probe outside of silt curtains and at sensitive locations with dredging to cease if threshold values are exceeded – Undertake monitoring post construction	– Federal Law 23 and 24 of 1999	-	Yes

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
9	Displacement of marine fauna due to noise pollution	Generation of noise associated with trenching and backfilling associated with the cable installation	Cable route alignments	Moderate negative	– Optimise the channel design and the construction methodology to reduce amount of required dredging – Excess dredge spoil disposal onshore – A dredging Management Plan (DMP) to be developed as part of the CESMP – Slow start up – Strict adherence to mitigations relating to a dedicated on board Marine Mammal and Reptile Observer (MMRO) and application of JNCC protocols during encounters with marine mammals and turtles – Limitation and reduction of construction, where feasible, of the following period: ▪ Dugong birthing / calving periods of pre-winter and post winter (October to November and March to April) ▪ Heightened spawning season of important fish species (March to July (as per Marine Environment Research Centre of MoCCAE)) ▪ Turtle nesting season (April to June)	– Federal Law 23 and 24 of 1999	-	Yes
10	Death or injury of marine mammals and reptiles.	Incidental collision of marine mammals and reptiles due to general activities associated trenching and backfilling associated with the cable installation	Cable route alignments	Moderate negative	– Reduce marine vessel trip frequency – Reduce marine vessel speed within sensitive area – Limit marine vessel operation to dedicated navigation corridors, when possible – Strict adherence to mitigations relating to a dedicated on board Marine Mammal and Reptile Observer (MMRO) and application of JNCC protocols during encounters with marine mammals and turtles – Limitation and reduction of construction, where feasible, of the following period: ▪ Dugong birthing / calving periods of pre-winter and post winter (October to November and March to April) ▪ Heightened spawning season of important fish species (March to July (as per Marine Environment Research Centre of MoCCAE)) ▪ Turtle nesting season (April to June)	– Federal Law 23 and 24 of 1999	-	Yes
11	Contamination of the surrounding marine environment	Spill of hazardous material to the marine environment due to marine-based activities associated with trenching and cable laying	Cable route alignments	Moderate negative	– Use non-polluting materials wherever possible (eg. biodegradable oils etc.) – Correct material refilling and usage techniques – Spill response kits permanently on site – Store hazardous materials at designated sites on board the vessels – Refuelling, oil change and greasing to be done under strict supervision of project engineers and specialists to avoid spills and contamination of marine water – Containerising and labelling waste – Appropriate spill kits and spill clean-up material on marine vessels and chemical, fuel and waste storage areas – Repairs to vessels only on designated mooring and port areas – Spill kits to be kept in the vicinity of fuelling and maintenance areas	– Federal Law 23 and 24 of 1999	-	Yes
Operation Phase								
12	Provision of artificial substrate (rock protection and concrete mattresses)	Rock protection and concrete mattresses	Cable route alignments except in the nearshore areas	Major positive	– N/A	– N/A	-	N/A

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
13	Impact on marine ecology due to changes in the localised hydrodynamic flow of the channel.	Trenching and backfilling	Trenched and backfilled areas	Moderate negative	– Reduction of dredge footprint and depth – Design of channel to work with predominant flow patterns – Habitat compensation and improvement	– Federal Law 23 and 24 of 1999	-	Yes
14	Potential impacts from Electromagnetic Field Emissions	Cable operation	In close proximity to cable	Unknown	– N/A	– N/A	-	N/A

5.5.3.2. Selected Mitigation Measures

One potential mitigation measure mentioned above was not selected and the reasoning is provided below:

- Spoil disposal onshore: as presented in **Section 6.3.3** and in **Appendix 6.8**: onshore disposal is not a technically feasible option. This would require even more dredging channels to be created for the material to be transported back onshore and a bigger area to be disturbed by vessel movements. This would significantly increase marine impacts associated with the Project.

For this reason, the mitigation measures presented in the below sub-sections have been selected.

5.5.3.2.1. Construction Phase

The mitigation listed above are viable measures to be implemented and incorporated in the EMP that will be developed for the Project. These environmental mitigation measures aim to preserve the integrity of the marine habitat that might be impacted by the Project. The marine ecology considerations are hinged on spatial factors e.g., seagrass meadow, fish home ranges and areas where sessile organisms inhabit. Since the factor is spatial in nature and can be accounted for in terms of area vis a vis flora and fauna present. The final approved and selected mitigation will require a cooperative consensus between appointed Contractor/s and client with oversight approval from EAD and authorities. However, at the current stage of the Project development, the proponent commits to the mitigation measures included herein. The EPC Contractor shall adopt and implement the following mitigation measures:

Local Direct Loss of Benthic Marine Habitats

A detailed process of optimisation has been undertaken as part of the development of this ESIA. Nevertheless, it is recommended that the following is undertaken:

- Avoid the use of the South Disposal Area (wherever possible) as this will significantly reduce the direct loss of seagrass;
- Further optimisation of the dredged channel design and the construction methodology is undertaken to reduce the amount of required dredging wherever possible; and
- A dredging Management Plan (DMP) will be required to be developed as part of the CESMP.

Given the limited opportunities to avoid impacts, it will therefore be necessary to implement a compensation programme. The Project Company will appoint a qualified marine biologist to develop a Biodiversity Action Plan (BAP), which will be developed to achieve a net biodiversity gain. The BAP will include the following as a minimum:

- Proposed methods to relocate healthy corals from the dredged corridors to adjacent areas suitable to act as receptor sites;
- Proposed methods to reinstate the dredged corridor to enable the recolonisation of seagrass beds;
- Allow natural seagrass seeding to occur post construction;
- Proposed methods for extended monitoring of the natural re-establishment of seagrass beds, with potential trigger values for further targeted interventions if re-establishment is less successful than anticipated;
- Additional actions to provide a net biodiversity gain, such as the placement of reef forming structures within the Project site;
- Additional actions to provide a net biodiversity gain, where appropriate;
- A long-term management plan; and

- A long-term biodiversity monitoring and evaluation program.

Indirect Loss of Localised Marine Habitat and Individual Organisms

Sedimentation Controls

- A dredging Management Plan (DMP) shall be developed as part of the CESMP;
- Prior to construction, the Marine Works Contractor will be required to obtain additional permits for undertaking marine construction works;
- No activities shall take place outside of the pre-defined construction corridor;
- The type of equipment should be selected carefully to minimise the impact on the surrounding environment;
- The Marine Works Contractor's working practices should incorporate the following measures:
  - Prior to the start of any works in the marine environment, the Marine Works Contractor should install silt screens to minimise the dispersion of marine sediments (see further details below);
  - Best available techniques to reduce sedimentation and minimise water turbidity should be employed (based on a technical and environmental evaluation);
  - Consideration of natural variations within the coastal environment, including tidal and other sea level patterns, and the possibility of synchronising the activity with these changes to minimise environmental impacts;
  - Monitoring of turbidity by continuous monitoring buoys and multiparameter probe outside of silt curtains and at sensitive locations with dredging to cease if threshold values are exceeded.

Based on the assessment results, areas of potentially high risk for increased sedimentation will occur around the trenching and backfilling areas, particularly within the floatation / dredged channel areas. As such, it is considered necessary for silt curtains to be installed in these areas. Refer to Figure 5-186 and Figure 5-187 for the recommended silt curtain installation configuration for Route 1 and Route 2, respectively. The silt curtain arrangement has been selected based on the magnitude of dredging works and proximity to sensitive habitats, particularly within protected area. It will be the responsibility of the EPC to determine from a logistical and financial perspective whether the silt curtain will be fixed along the proposed arrangement (approximately 2 x 2.5 km for route 1, and 2 x 5 km for route 2), or whether silt curtains of a set length will be moved in conjunction with the movement of the trenching/dredging activities. Whether a fixed or mobile option is selected will likely be a compromise between raw material expense and logistics for a fixed option and utility and manpower requirements of a mobile option. Should a mobile option be selected, the minimum length of the silt curtains on either side of the trenching/dredging equipment will be 1km (i.e. two parallel lengths of 1km length each side of the dredger). The final locations, and logistics of deployment will be selected by the contractor and detailed within the CESMP.

Areas of Potential Work Restrictions / Limitations

The most sensitive areas within Route 1 and Route 2 are the nearshore areas as detailed in Figure 5-188 and Figure 5-189, respectively, in which the works will commence and where the Dugong and turtles are most frequently observed.

Marine Restrictions / Limitations (Dugong, Turtle and Fish Reproduction Period)

With a strict adherence to mitigation relating to a dedicated on board Marine Mammal and Reptile Observer (MMRO) and application of JNCC protocols during encounters with marine mammals and turtles, no working restriction periods will be required.

For Route 2, no working restriction periods are considered to be required.

For Route 1 where the route is located within the MMBR boundary and transition zone as well as works associated with the floatation / dredged channel, it is recommended that the EPC construction programme consider limiting and reducing, where feasible, works during the following periods:

- Dugong birthing / calving periods of pre-winter and post winter (October to November and March to April); and
- Heightened spawning season of important fish species (March to July (as per Marine Environment Research Centre of MoCCAE)).

Beach Restrictions / Limitations (Turtle Nesting)

During the terrestrial ecology survey, it was identified that the beach at Mirfa and Shuweihat are generally unsuitable for turtle nesting; however, this cannot be confirmed without detailed studies and this remains as a potential risk. As per the EPC schedule, it is understood that onshore works will not occur before the end of June 2023, therefore two options are proposed:

- **Option 1:** Construction work does not occur at the landfall areas during the turtle nesting season (April to June);
- **Option 2:** A hatching and nesting survey is undertaken during the turtle nesting season (April to June 2023) to confirm the absence of turtle nesting in the landfall areas. If turtles are found, mitigation and monitoring measures will be included in the hatching and nesting survey results. The results of the surveys and recommendations shall be shared with EAD to confirm approved mitigation and monitoring measures.

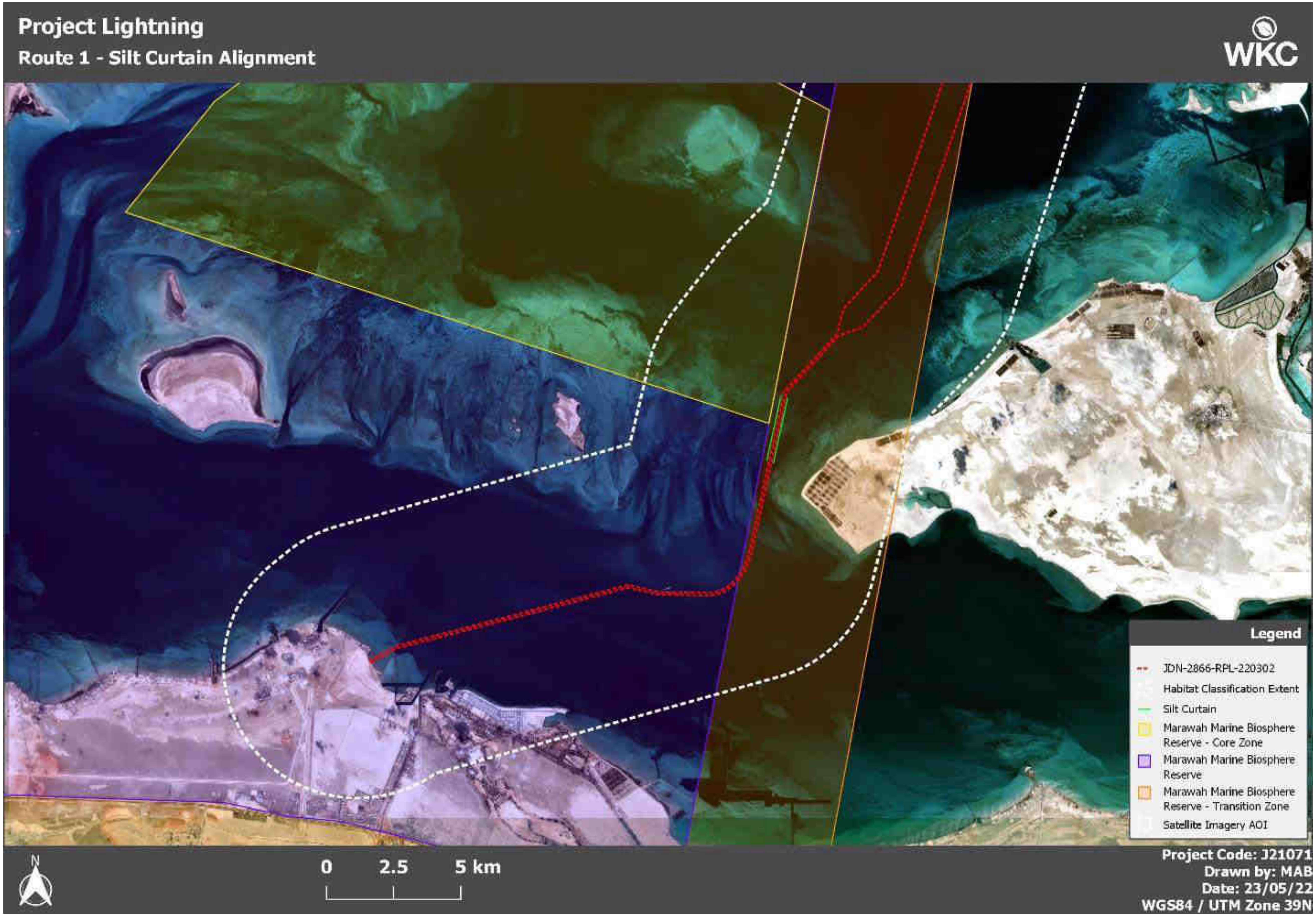


Figure 5-186: Proposed locations for silt curtain installation along Route 1 (final locations to be confirmed in the CESMP)

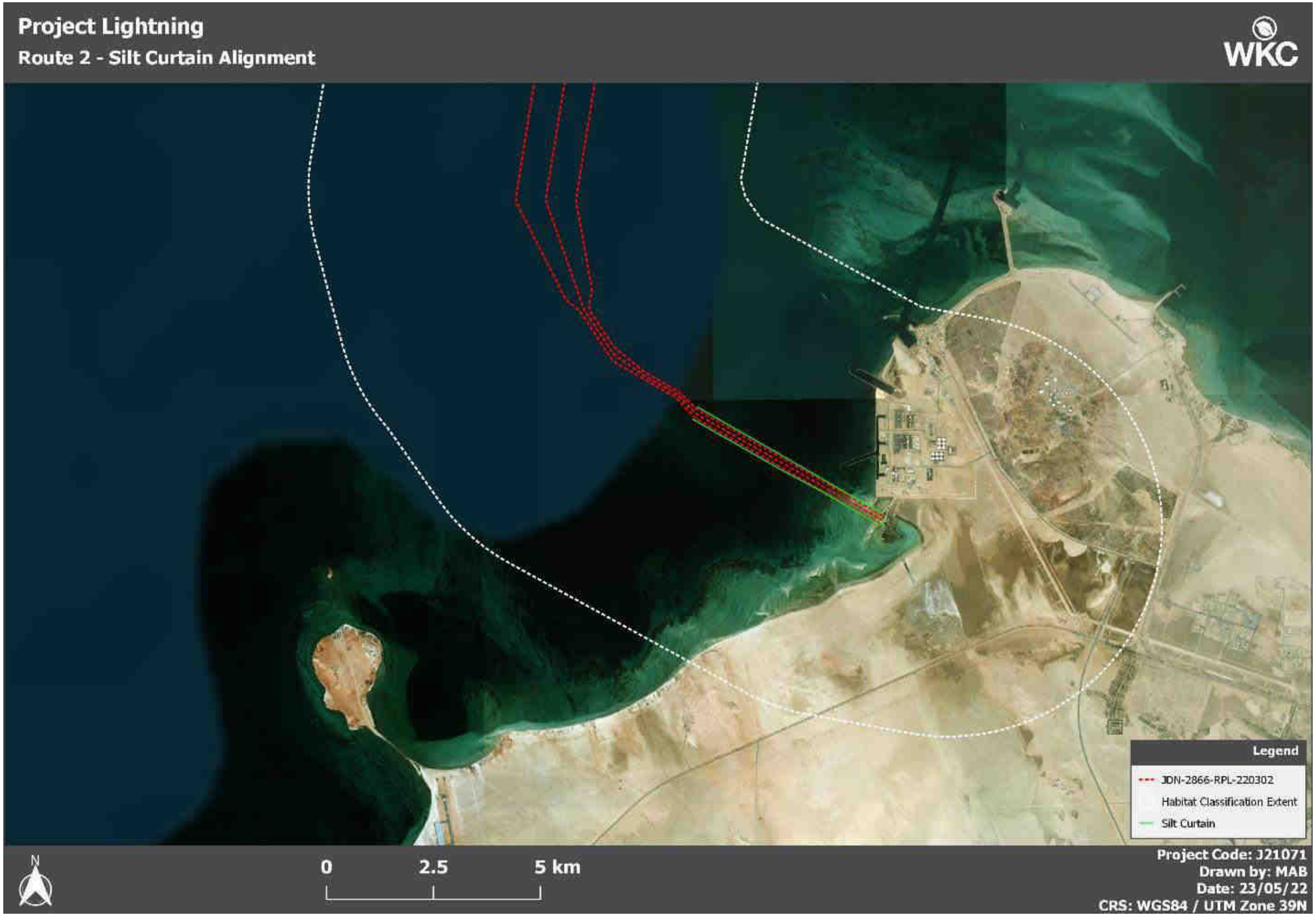


Figure 5-187: Proposed locations for silt curtain installation along Route 2 (final locations to be confirmed in the CESMP)

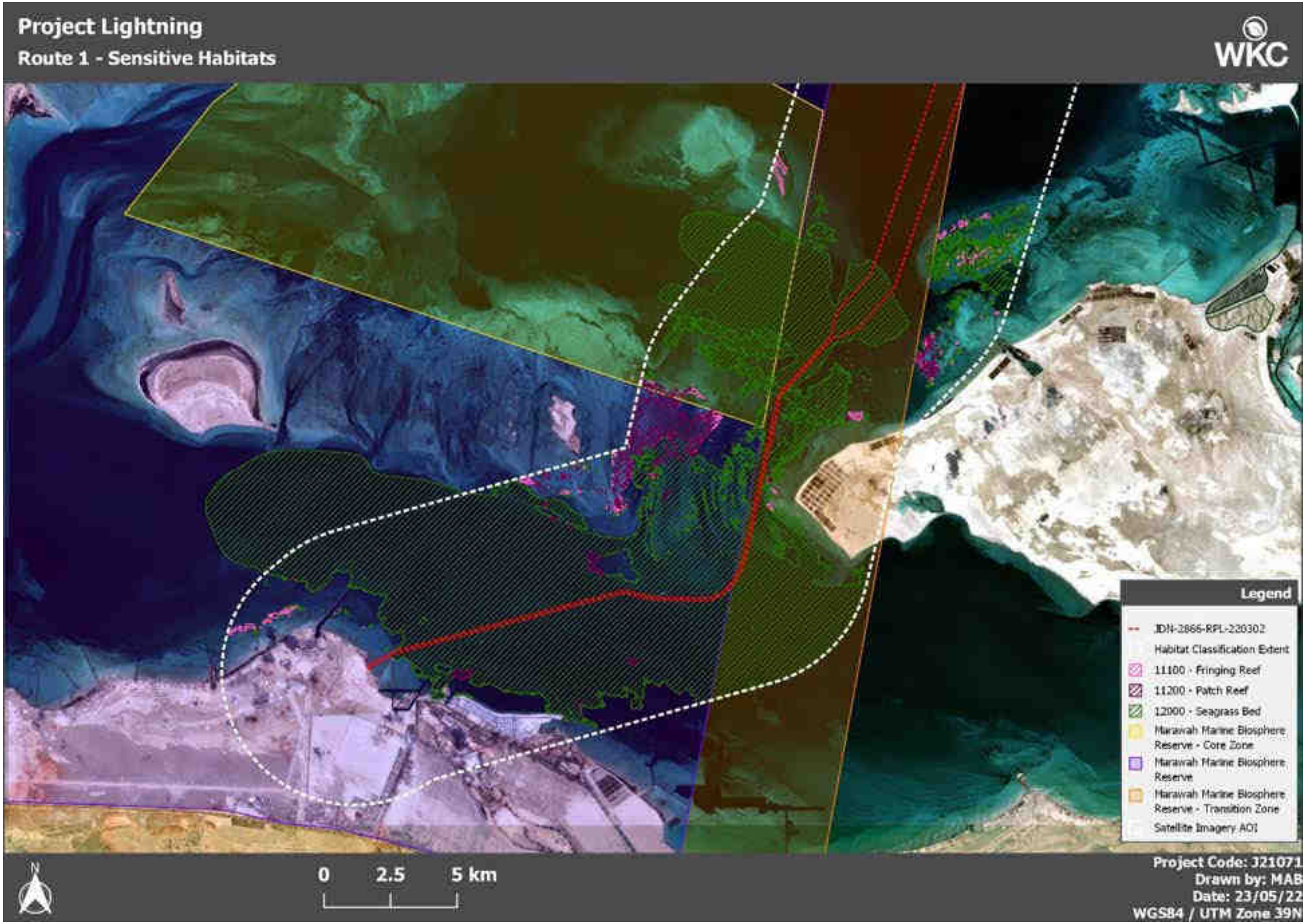


Figure 5-188: Sensitive areas within Route 1 requiring work restrictions

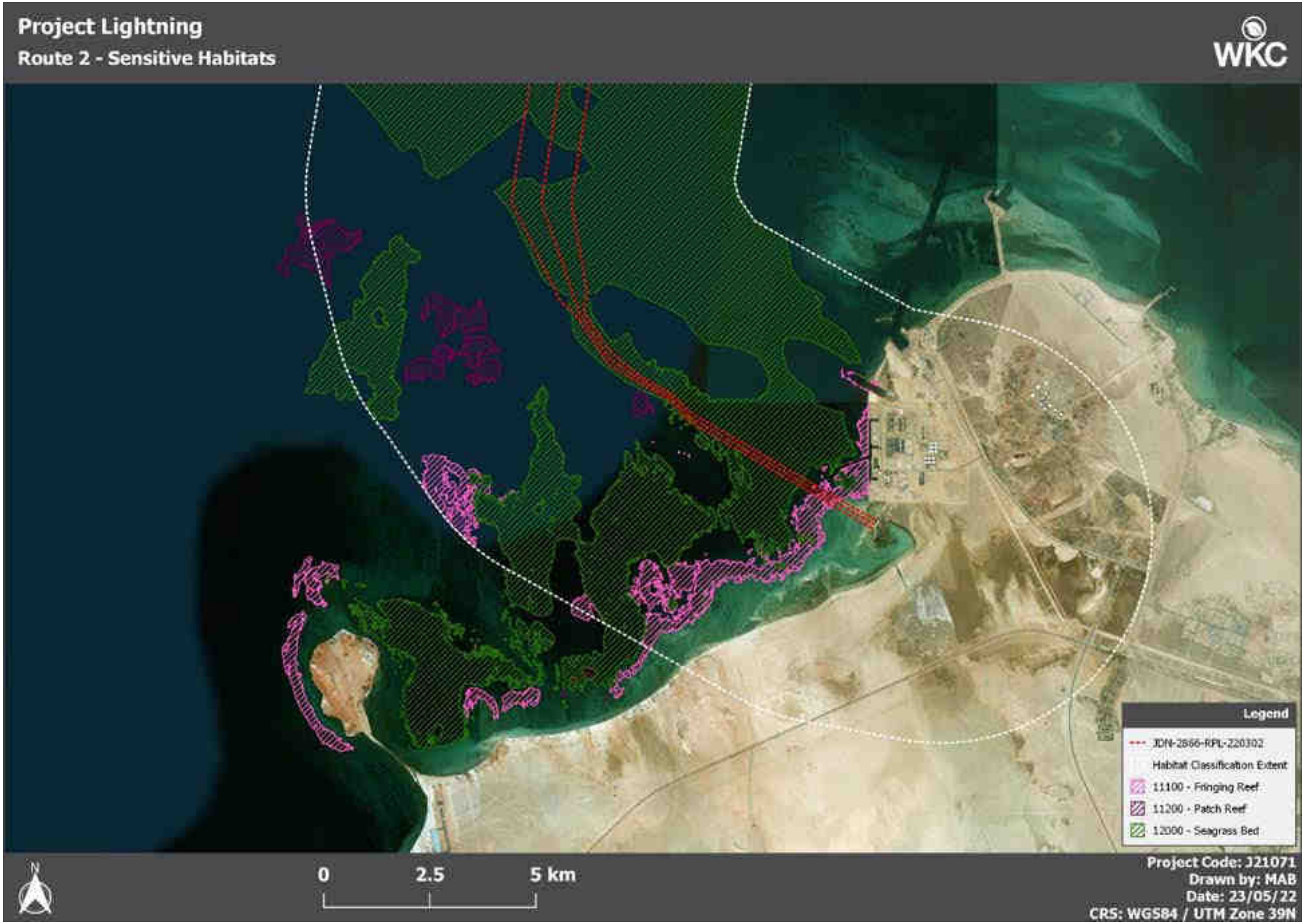


Figure 5-189: Sensitive areas within Route 2 requiring work restrictions

Potential Disturbance to Marine Mammals and Reptiles due to Noise Pollution

In order to limit impacts associated with marine noise and vibration, the following will be implemented:

- Slow start up of construction activities;
- Selection of equipment and vessels with lower noise and vibration emission where feasible and available;
- Limit marine vessel operations to dedicated navigation corridors;
- Reduce marine vessel trip frequency;
- Reduce marine vessel speed within sensitive areas;
- Deployment of MMRO personnel on marine vessels;
- Strict application of JNCC protocols during encounters with marine mammals and turtles; and
- If the marine construction team identify marine mammals or retiles during noise and vibration generating activities, works should be temporarily suspended until the animal has moved away.

Potential Impact to Marine Mammals and Reptiles due to Marine Vessel Collision

To reduce the potential impact of collision with marine fauna, members of the marine construction team should be familiar in the spotting of marine fauna. In the event that marine mammals or reptiles are spotted within 150m of operations, then works should temporarily cease until the area is clear. Additional mitigation measures should include:

- Slow start up of construction activities;
- Reduce marine vessel trip frequency;
- Reduce marine vessel speed within sensitive areas;
- Deployment of MMRO personnel on marine vessels;
- Strict application of JNCC protocols during encounters with marine mammals and turtles;
- When possible, limit marine vessel trips to daylight hours; and
- If the marine construction team identify marine mammals or retiles, works should be temporarily suspended until the animal has moved away.

Spill of Hazardous Materials to the Marine Environment

Introduction of contaminants from accidental oil, fuel or chemical spills and inappropriate waste disposal would be mitigated through best practices and procedures including the following (note that additional measures are also provided within **Section 5.5: Marine Ecology**, which should be read in conjunction with this section)::

- Use non-pollution materials wherever possible (e.g. biodegradable oils etc.);
- Store hazardous materials at designated containers and appropriate areas on the vessel;
- Refuelling, oil change and greasing to be done with strict supervision from project engineers and specialist top avoid spills and water contaminations;
- Provide appropriate (110% volume) secondary containment system at chemical and fuel storage areas;
- Containerising and labelling waste;
- Spill Response Plan;
- Appropriate spill kits and spill clean-up material on on-site at all time including on marine vessels and always in the vicinity of chemical, fuel, waste storage areas, maintenance areas, fuelling areas etc.;

- Correct material refilling and usage techniques;
- Repairs to vessels only on designated mooring and port areas;
- Wastewater collected in sump to be treated as liquid waste and disposed of appropriately;
- Marine vessels to be washed off-site within appropriate port facilities;
- Strictly no bilge water discharge policy for all vessels assigned to the Project;
- Environmental management induction shall be conducted to all personnel engaged in the Project with particular emphasis on pollution prevention; and
- Vessel and all its equipment shall undergo inspection to be conducted prior to mobilisation for work at Project site.

5.5.3.2.2. Operational Phase

It shall be noted that proper and adequate measures to mitigate environmental impacts at areas with the flotation channel will have to be proportionate to the activity. Marine ecology monitoring is important to provide information to formulate environmental policies that are in line with the Project objectives. Part of the mitigation on marine ecosystems does not only dwell in the preservation and enhancement of the associated marine habitats, but also aids in directly improving the quality of the marine environment include:

- Enhancement of conditions within the dredge / floatation channel footprint;
- Design of channel to work with predominant flow patterns; and
- Habitat compensation and habitat improvement strategies.

5.5.3.3. Mitigation Measures to Address Cumulative Impacts

The mitigation measures listed above will be included in an EMP developed by the contractor, to reduce the probability of impacts beyond the assessed development area. The construction Contractor will be obliged to fulfil all directives outlined within the contractor EMP and it is thus expected that any cumulative impact to marine ecology will be negligible.

5.5.3.4. Residual Impacts

The significance of impacts after implementation of mitigation measures are outlined in Table 5-82.

Table 5-82: Marine ecology residual impacts

Description of the Impacts	Impact Significance Prior to Mitigation Measures	Residual Impact Significance
Construction Phase		
Direct loss of seagrass due to dredging activities along the route alignment with the North Disposal Area	Moderate negative	Minor negative
Direct loss of seagrass due the disposal of excess materials in the South Disposal Area	Major negative	Moderate negative
Direct loss of corals due to dredging activities	Moderate negative	Minor negative
Direct loss of medium-valued habitats due to dredging activities	Moderate negative	Minor negative
Direct loss of low-valued habitats due to dredging activities	Negligible	Negligible
Indirect loss of localised marine habitat, e.g., seagrasses within Route 1, and individual organisms	Moderate negative	Minor negative
Indirect loss of localised marine habitat e.g., seagrasses within Route 2, and individual organisms	Minor negative	Negligible
Indirect loss of localised marine habitat, e.g., coral reefs, and individual organisms	Moderate negative	Minor negative
Displacement of marine fauna due to noise pollution	Moderate negative	Minor negative
Death or injury of marine mammals and reptiles.	Moderate negative	Minor negative
Contamination of the surrounding marine environment	Moderate negative	Minor negative
Operation Phase		
Provision of artificial substrate (rock protection and concrete mattresses)	Major positive	Major positive
Impact on marine ecology due to changes in the localised hydrodynamic flow of the channel.	Moderate negative	Minor negative
Potential impacts from Electromagnetic Field Emissions	Unknown	

5.5.4. Monitoring Program

5.5.4.1. Monitoring Program for Compliance with Selected Mitigation Measures

5.5.4.1.1. Construction Phase

The monitoring program to be implemented during construction to assess the effectiveness of the measures employed to mitigate the impacts on marine ecology as a result of the Project is provided in Table 5-83.

Table 5-83: Monitoring program for marine ecology impacts during construction

Impact	Phase	Monitoring Activity and Location	Frequency	Responsible Party
Habitat	Construction	– DDV / ROV inspection of seagrass and coral habitat near trenching activities to ensure siltation is contained. Total of eight locations (four on each side of the trench) at 50m,100m, 150m and 300m from the dredger centerline – Deployment of continuous monitoring buoy at strategic locations along critical habitat areas (refer to Table 5-32 in **Section 5.2**)	Weekly	Contractor
Fish	Construction	– Census (DDV / ROV) conducted to ascertain species composition	Weekly	Contractor
Marine Mammal and Reptiles	Construction	– MMRO personnel on board during construction phase	Daily	Contractor

5.5.4.1.2. Operational Phase

The monitoring program to be implemented during operation to assess the effectiveness of the measures employed to mitigate the impacts on marine ecology as a result of the Project is provided in Table 5-84.

Table 5-84: Monitoring program for marine ecology impacts during operation

Impact	Phase	Monitoring Activity and Location	Frequency	Responsible Party
Habitat	Operation	– Video inspection of impacted areas to assess habitat succession rates (15 locations along Route 1 and 5 along Route 2 dredging area)	Twice per year for three years	Operator
Fish	Operation	– Census (DDV / ROV) conducted to ascertain species composition (15 locations along Route 1 and 5 along Route 2 dredging area)	Yearly	Operator
Marine Mammal and Reptiles	Operation	– MMRO survey to ascertain species and population composition.	Twice a year for three years	Operator

5.5.4.2. Monitoring Program for Cumulative Impacts

It is anticipated that the monitoring programme listed above will be sufficient to monitor cumulative impacts in conjunction with existing baseline data.

5.5.4.3. Monitoring Program for Residual Impacts

No significant residual impacts were identified for the implementation of the Project. Therefore, no additional monitoring is required or proposed.

5.6. Terrestrial Ecology

Mott MacDonald (MM), on behalf of the Abu Dhabi National Oil Company (ADNOC), commissioned Nautica Environmental Associates LLC (Nautica), an Abu Dhabi based environmental consultancy, to conduct environmental surveys at three landfall locations for the ADNOC Lightning Project, namely Mirfa, Shuweihat and Das Island. The survey methodologies and results relating to terrestrial and intertidal ecology are presented in the below subsections for each location.

5.6.1. Description of the Environment

5.6.1.1. Baseline Methodology

5.6.1.1.1. Mirfa – Existing Nautica Surveys (85)

Field surveys were conducted by Nautica over six days, between the 4th and 31st May 2021. Surveys were conducted using a combination of walkover and vehicle drive throughs of the site location, in addition to deploying camera traps. Camera traps were deployed for a minimum of one overnight period (≥12 hours). The location of the camera traps is presented in Figure 5-190 below. Camera traps were deployed at locations considered potentially suitable for mammal and/or reptile activity, such as near burrows or in areas of particularly dense vegetation and/or visible track activity (85).

Binoculars were also used to help find and identify bird species within the area and where possible, high-definition pictures were taken. This was undertaken throughout the days of 20th to the 22nd of May and on the morning of 24th of May 2021 (85).

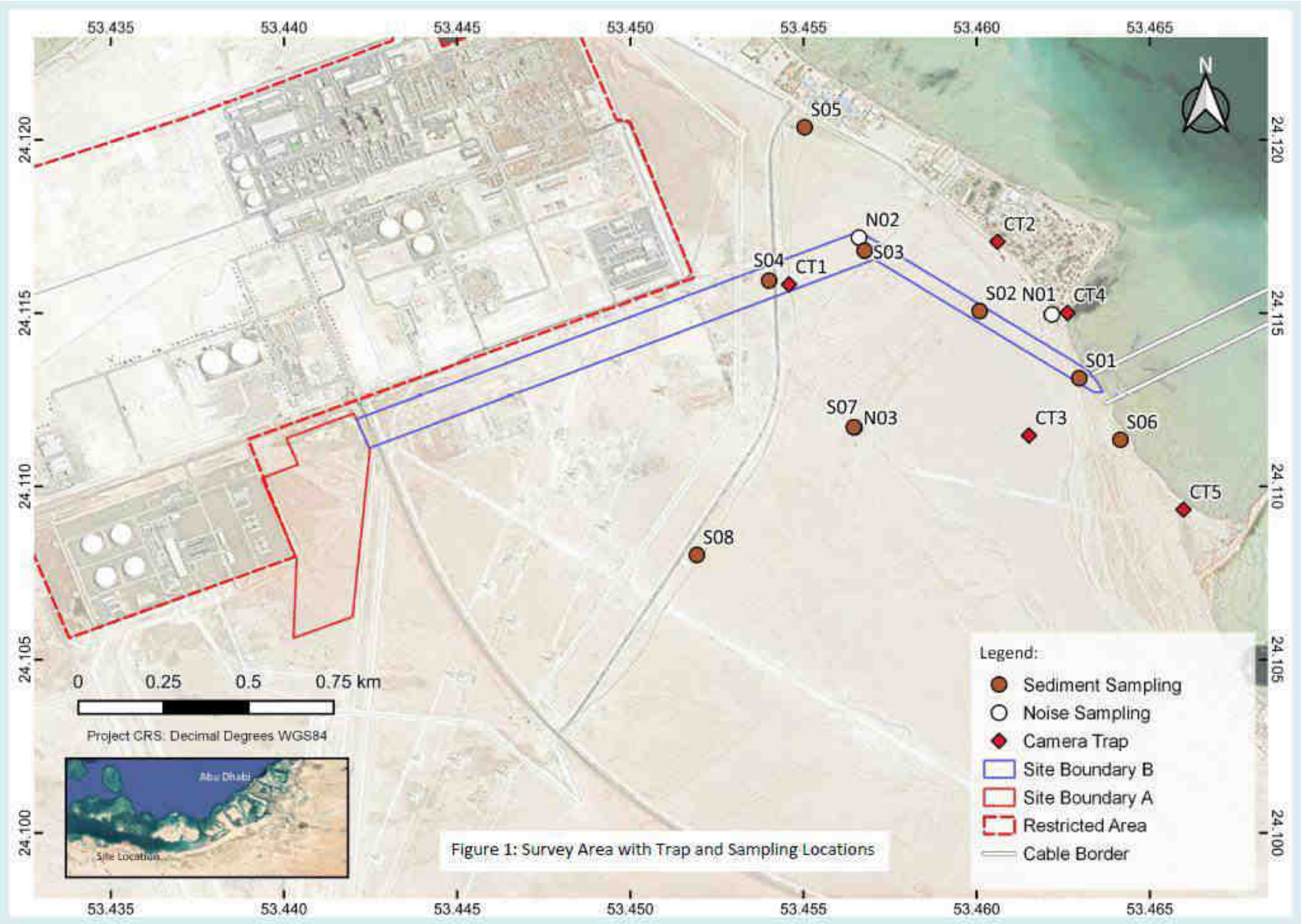


Figure 5-190: Location of the deployed camera traps – Nautica Survey (85)

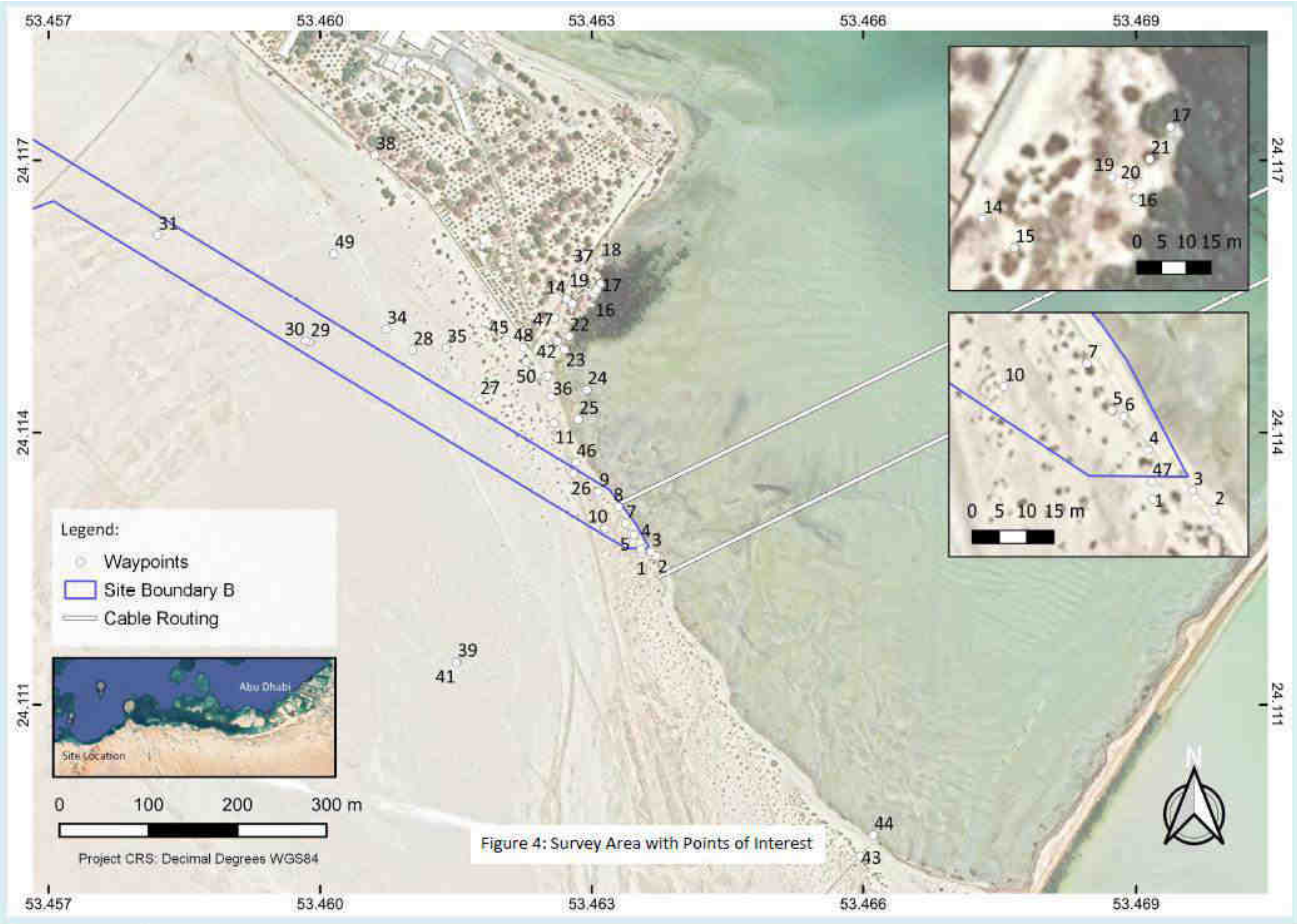


Figure 5-191: Mirfa Survey area with points of interest – Nautica Survey (85)

5.6.1.1.2. Shuweihat – Existing Nautica Surveys (84)

Field surveys were conducted by Nautica over three days, between the 22nd and 24th May 2021. Surveys were conducted using a combination of walkover and vehicle drive through of the site location and deploying camera traps. Field activities involved day-time drive-over and walkabouts in selected areas, with one overnight trapping effort involving deployment of Browning camera traps at selected locations.

Browning camera traps were deployed at locations considered potentially suitable for mammal and/or reptile activity, such as near burrows or in areas of particularly dense vegetation and/or visible track activity.

Binoculars were also used to help find and identify bird species within the area and where possible, high-definition pictures were taken and have been used in this report were deemed appropriate.

Locations of recorded points of interest are presented in Figure 5-192 below.

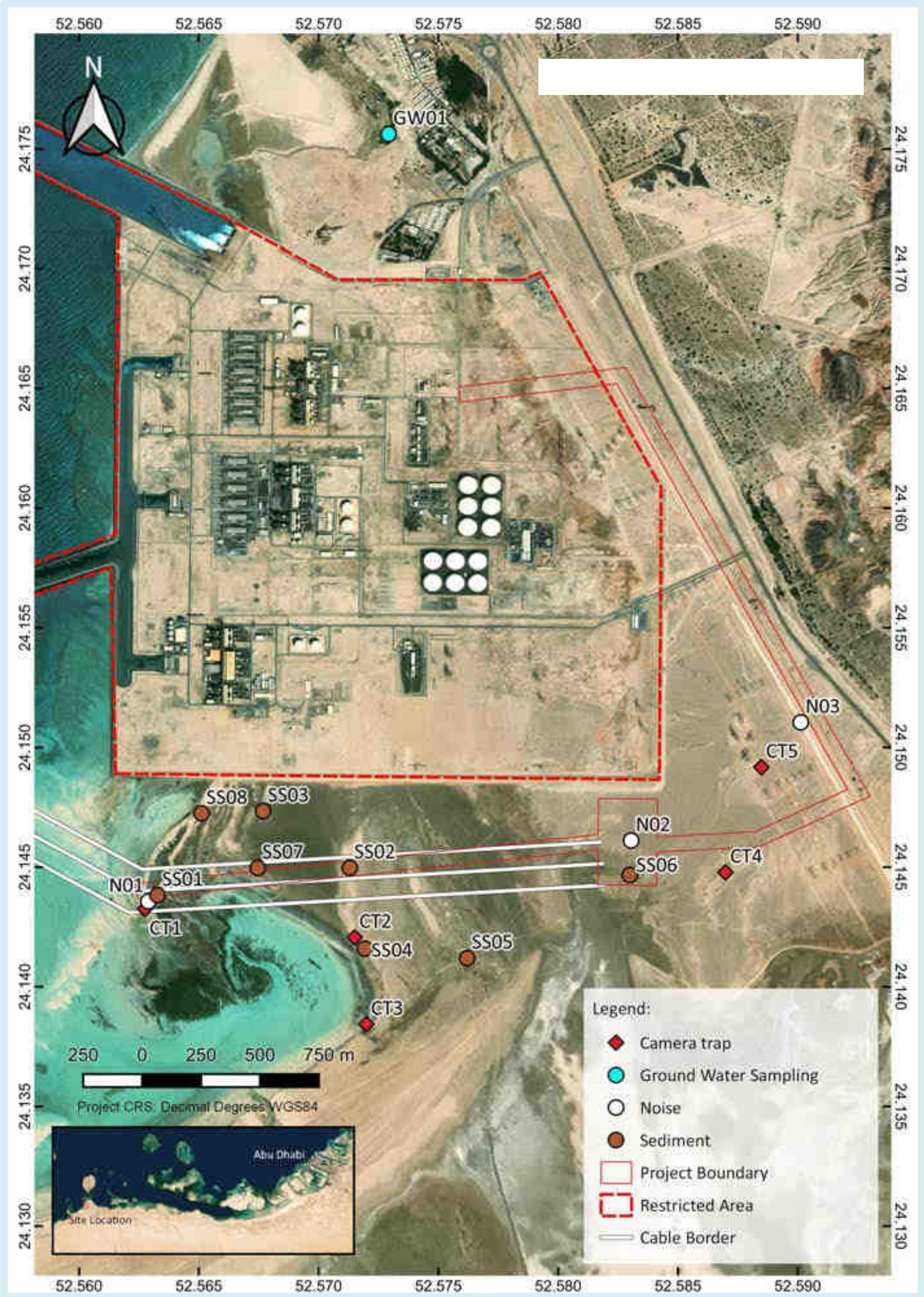


Figure 5-192: Locations of camera traps at Shuweihat (Nautica Survey)

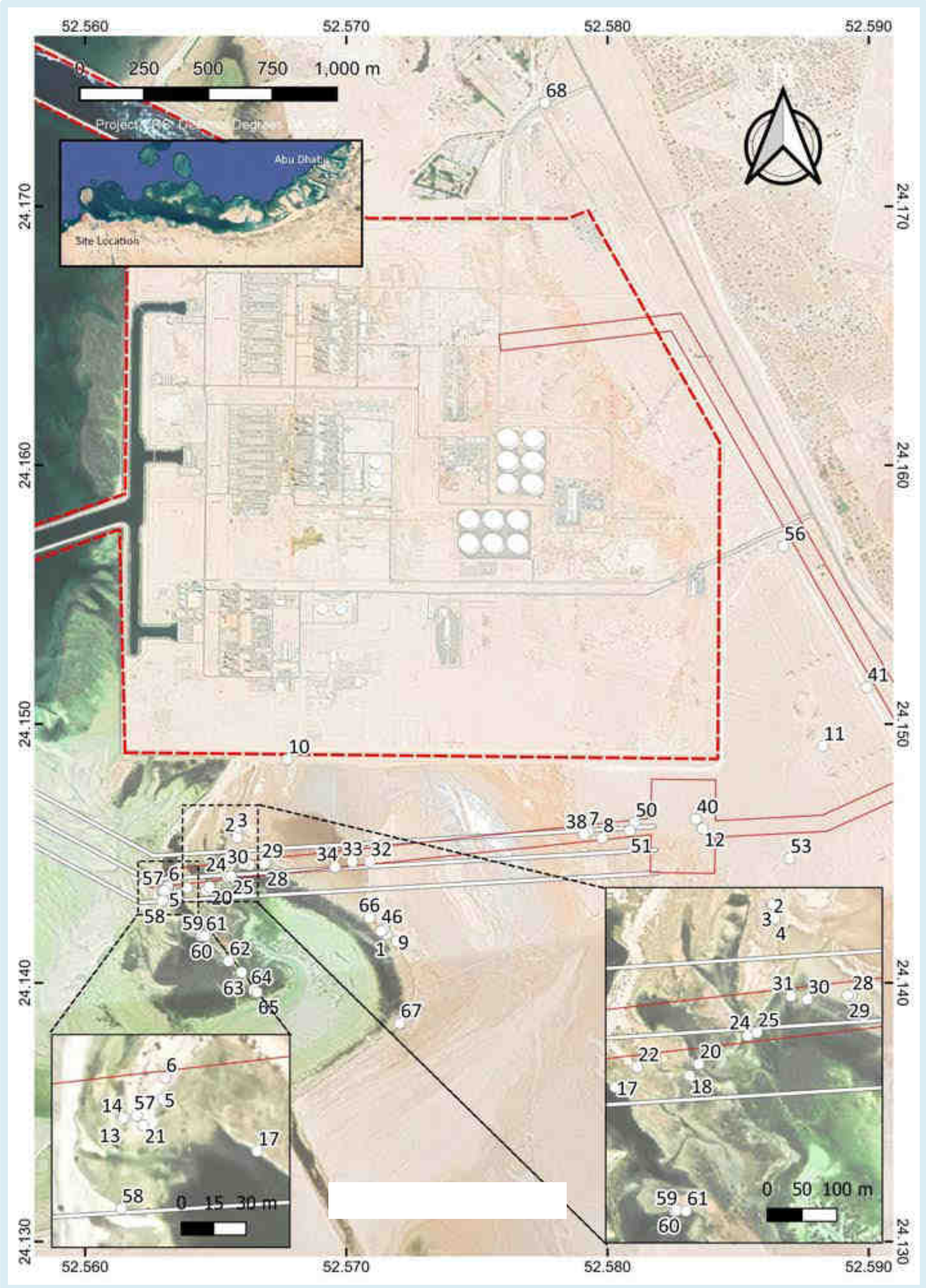


Figure 5-193: Points of interest at Shuweihat (Nautica Survey)

5.6.1.1.3. Das Island – Existing Nautica Surveys (42)

Field surveys were conducted by Nautica over four days, between the 3rd and 6th August 2021. Surveys were conducted using a combination of walkover and vehicle drive through of the site location and deploying camera traps. The location of the camera traps is provided in Figure 5-194. Binoculars were also used to help find and identify bird species within the area. Figure 5-195 presents the recorded points of interest.

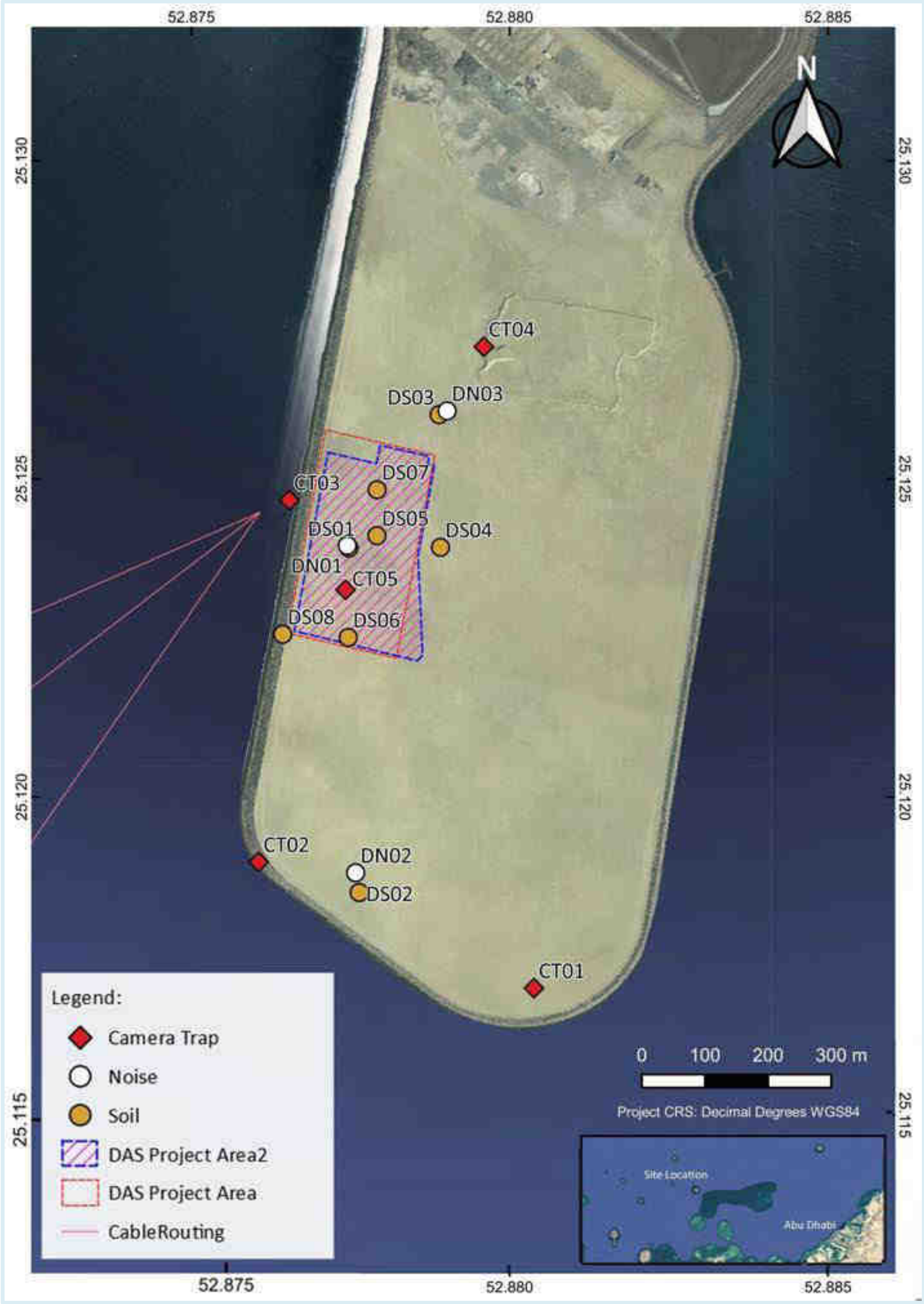


Figure 5-194: Location of camera traps deployed on Das Island

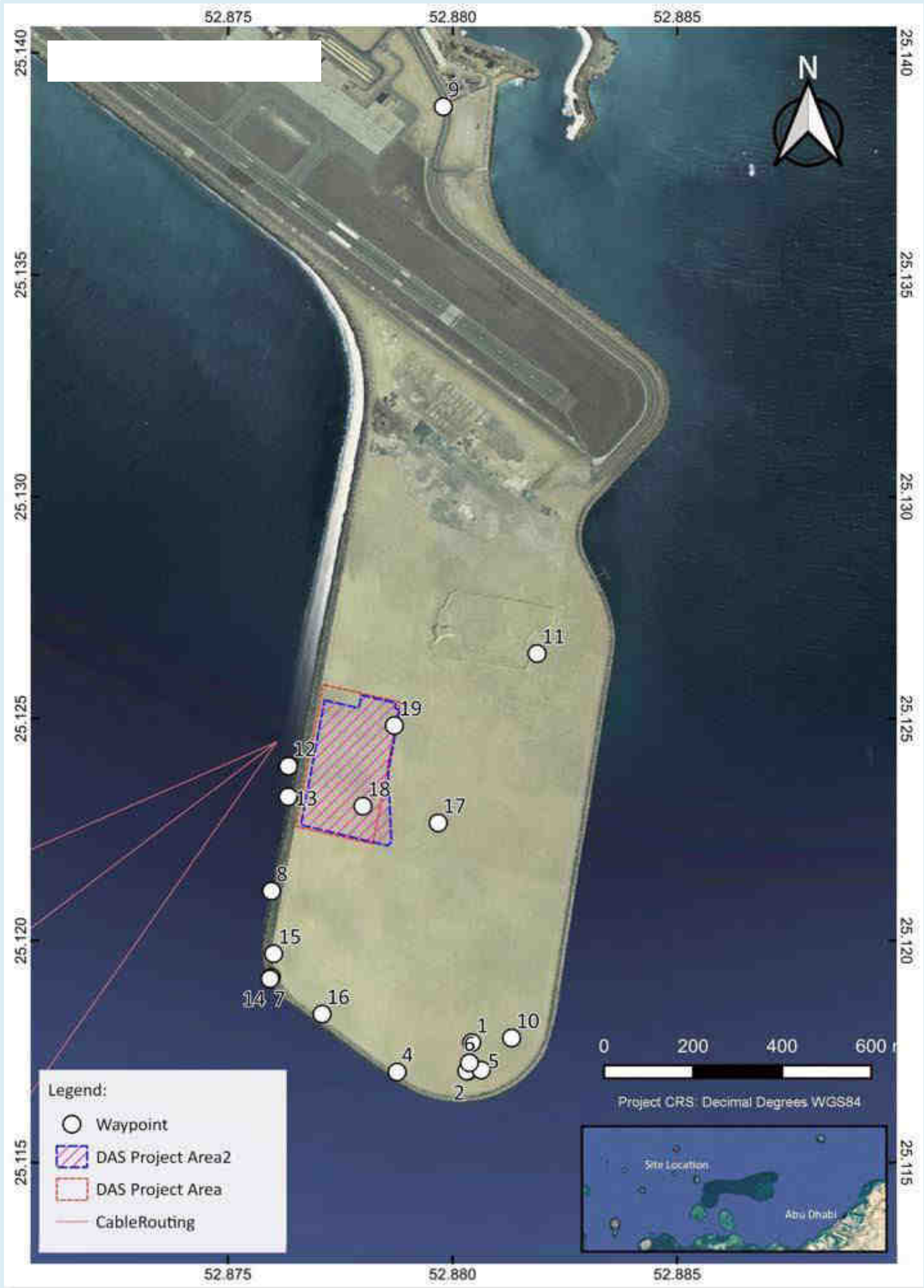


Figure 5-195: Points of interest recorded during the Das Island survey

5.6.1.1.4. Shuweihat and Mirfa – New Anthesis Surveys

January 2022

Winter season mangrove and avifauna surveys were conducted by Anthesis concurrently on the 18th and 19th of January 2022 to verify the information previously collected by Nautica.

Avifauna surveys were conducted by means of vantage point counts. Vantage points were selected adjacent to the proposed landfall/tie in locations of the alignments at both Shuweihat and Mirfa. Eight vantage points were selected within the vicinity of the Shuweihat tie in location and six vantage points were selected within the vicinity of the Mirfa tie in location. The locations of the vantage points are given in Figure 5-196 and Figure 5-197 below.

As a first approximation, mangrove forests were delineated using satellite imagery. Mangrove study sites were then selected within these delineated areas, as illustrated in Figure 5-198 to Figure 5-199 below. The study sites were investigated during the field surveys, and the following mangrove attributes were noted:

- Density;
- Condition (health);
- Approximate age;
- Height; and
- Recruitment.

April 2022

Avifauna surveys were conducted by Anthesis concurrently on the 27th and 28th April 2022 to verify the information previously collected by Nautica.

Avifauna surveys were conducted by means of vantage point counts. Vantage points were selected adjacent to the proposed landfall/tie in locations of the alignments at both Shuweihat and Mirfa. Eight vantage points were selected within the vicinity of the Shuweihat tie in location and five vantage points were selected within the vicinity of the Mirfa tie in location. The locations of the vantage points remain the same as the surveys completed in January 2022 (refer to Figure 5-196 and Figure 5-197).

Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:13705
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 10/05/22

Figure 5-196: Shuweihat vantage point sites

Figure 5-197: Mirfa vantage point sites

Figure 5-198: **Shuweihat mangrove study sites**

Figure 5-199: Mirfa mangrove study sites

5.6.1.2. Baseline Conditions

5.6.1.2.1. Mirfa – Existing Nautica Surveys (85)

The results of the terrestrial and intertidal ecology surveys undertaken by Nautica over a period of six days between the 4th and 6th May 2021 are summarised in the below subsections.

Habitats

The proposed cable route will initially make landfall over an area of intertidal mudflats exposed at low tide. Upon reaching the coastline, the proposed route passes diagonally over a strip of coastal sand sheets and low dunes that at the point of planned dissection are approximately 150 metres wide. From this point on, the route will traverse exclusively over approximately 2.6km of the habitat: coastal plains on well-drained sandy ground, until the onshore processing plant is reached.

The Project study area (within 500m of the Project footprint) encompasses a total of nine terrestrial habitats. Of these, the following anthropogenic habitats were identified:

- Oil Industry (EAD Habitat Code (HC) 9210);
- Low Density Urban (EAD HC 9120);
- Date Plantations (EAD HC 8100); and
- Pipelines Infrastructure (EAD HC 9500).

Natural habitats identified within the Project study area include:

- Mudflats and Sand Exposed at Low Tide (EAD HC 1010);
- Coastal Sand Sheets and Low Dunes (EAD HC 2020);
- Coastal Sabkha (EAD HC 3100);
- Mangroves (EAD HC 1040); and
- Coastal Plains on Well-drained Sandy Ground (EAD HC 2011).

The distribution of these habitats is illustrated in Figure 5-200. A description and percentage cover of the four habitats directly situated within the proposed route are presented in Table 5-85 below.

Table 5-85: Description and percentage cover of the habitats situated within the proposed route (85)

H/T	Description	Threat Status	Area (km^2)	Percentage
1010	Mudflats and sand exposed at low tide	Critical Habitat	0.00637273	1.8%
2011	Coastal plains on well- drained sandy ground	Not Sensitive or Critical	0.33734763	95.09%
2020	Coastal sand sheets and low dunes	Environmentally Sensitive Habitat	0.01069161	3.01%
3100	Coastal sabkha, including sabkha matti	Not Sensitive or Critical	0.00034359	0.1%

Table Notes:

H/T = Habitat Type.

A summary of the recorded habitat types, flora and fauna identified during the surveys is presented in the below subsections.

Mangroves

The mangroves in the study area appeared to be in good health with healthy leaves and branches and no apparent diseases or dead trees were observed. Fish fry and the Mottled Crab, *Metopograpsus messor*, a grapsid crab that inhabits mangroves, were found in abundance between the mangrove pneumatophores. Covering a relatively small area (119,000m^2), the mangroves present in the survey area were absent from the EAD habitat map (85).

Coastal Sabkha

P. arabicus was found in close proximity to an area of coastal sabkha during the survey. The only other species proven to frequent the sabkha habitat in the site of study was Arabian Red Fox, *Vulpes vulpes arabica*, identified here by their tracks. Being highly mobile, home ranges of up to 50km are common. Though unlikely to find food in such barren expanses, foxes will instead traverse areas of sabkha into favourable habitats where food is more plentiful (85).

Mudflats and Sand Exposed at Low Tide

The mudflats in the study area extend from the shoreline for 800 metres and cover an area of approximately 0.59km^2. According to the EAD Habitat Map this habitat type at the project location covers approximately an area of within the greater survey area, and 1.8% of the proposed Project footprint. This is an important habitat for wading birds feeding on benthic invertebrates during low tides (85).

Flora

With the exception of the *Conocarpus lancifolius* trees planted alongside the private villa perimeter wall at the east of the site boundary, just seven naturally occurring species of vascular plant were recorded across each habitat in the survey area, as summarised below and presented in Table 5-86:

- Salsola imbricata;
- Halopeplis perfoliata;
- Heliotropium kotschyi;
- Suaeda vermiculata;
- *Avicennia marina* (Grey Mangrove);
- Tetraena qatarensis; and
- Tetraena simplex.

Mammals and Reptiles

An extensive diurnal walkover was conducted to search for the presence of mammals and reptiles within the site boundary. Five camera traps were also set overnight to record any nocturnal specimens. The traps were set at locations deemed to be support the highest density of fauna based on the frequency of ecological indicators such as tracks, burrows, and scats (85).

Vulpes vulpes arabica, *Felis catus* and *Gerbillus cheesmani*, were the only mammals recorded in the survey; their presence initially indicated by frequent tracks, later proven through camera trap footage. An occupied burrow belonging to the latter was also located.

Lizard tracks were seen in several locations, normally where the density of vegetation was a higher such as along the low dunes landward of the beach. Gecko prints were clearly visible here although it would be very difficult to identify the gecko to species level using the tracks alone, due to the size of the prints and the almost identical prints of several geckos associated with such locations in the UAE.

Additional prints made by a small lizard were seen in the same location. These tracks were identified as being made by a member of the Phrynosomatidae family that are commonly referred to as the Fringe-toed Lizards. Tracks made by these lizards show a tail drag mark and, as their common name suggests, fringed toes of varying lengths. Based on the location and proximity to the coast, it is most likely that a Schmidt’s Fringe-toed Lizard, *Acanthodactlyus schmidti*, made the tracks, but this cannot be verified by tracks alone.

A single Arabian Toad-headed Agama, *Phrynocephalus arabicus*, was the sole reptilian species sighted and thus identified to species level throughout the entire survey period, showing the site supports a low diversity of reptiles. The agama was seen within a habitat transitional zone between sabkha and coastal plains where vegetation is sporadic, and some is dead/dormant.

P. arabicus is a small agamid, highly specialised for life on soft, aeolian sand and is one of the most common lizards in the UAE, found wherever there are sand sheets, dunes or sandy plains. They are most often seen during the heat of midday, as was the case during the survey (85).

A summary of the mammal and reptile species recoded is presented in Table 5-87.

Birds

In total, 13 species of birds, totaling 73 individuals were recorded during the site visits. Counts of all the birds seen on the three days are given in Table 5-88, in addition to the scientific names for all taxa, as well as IUCN status.

Arthropods

Arthropods were assessed in the area during day-time walkover investigations. Anthropogenic debris was also moved to look for insects hiding beneath. All Arthropod species recorded during the survey are listed in Table 5-89. Any arthropod species observed were recorded, photographed and where possible were identified to species level.

Insects were found to be uncommon across the site at the time of survey. In fact, only four species were recorded throughout the duration of the survey. Namely, these were the Asian Dwarf Honeybee, *Apis florea*, Desert Locust, *Schistocera gregaria*, Desert Runner Ant, *Cataglyphis bicolor* and Darkling Beetle, Pimelia (85).

Table 5-86: Plant species recorded during the Mirfa surveys (85)

Family name	Scientific Name	Status During Survey	Status in UAE	IUCN Status
Amaranthaceae	*Halopeplis perfoliata*	The dominant plant species in the coastal dune habitat, occurring in high densities	Common saltmarsh plant	Not Evaluated (NE)
Amaranthaceae	*Salsola imbricata*	Occasionally noted	Common halophyte	NE
Amaranthaceae	*Suaeda vermiculata*	Occasionally noted	Common halophyte	NE
Avicenniaceae	*Avicennia marina*	A dense and mature stand present on the shoreline	Locally common	NE
Boraginaceae	*Heliotropium kotschyi*	Rare in the survey area. Only a single specimen found	Common on the coastline of the UAE	NE
Zygophyllaceae	*Tetraena qatarensis*	Most abundant flora within the overall site	Common to AD coast & N. Emirates	NE
Zygophyllaceae	*Tetraena simplex*	Occasionally noted	Common	NE

Table 5-87: Mammal and reptile species recorded during the Mirfa surveys (85)

Common Name	Scientific Name	Status During Survey	Status in UAE	IUCN Status
Arabian Red fox	*Vulpes vulpes*	Common. Numerous tracks were found, and an individual was captured several times on camera trap	Common and widespread	Least Concern (LC)
Feral Dog	*Canis lupus familiaris*	Tracks were observed, but no actual sightings	Common with human habitation	LC
Feral Cat	*Felis catus*	Caught on camera trap at a few locations	Common with human habitation	LC
Cheesman's Gerbil	*Gerbillus cheesemani*	A burrow belonging to the species was located. A specimen was later captured on camera trap	Common	LC
Arabian Toad-headed Agama	*Phyrocephalus arabicus*	One sighted within an area of coastal sabkha	Common	LC
Gecko	*Buopus* sp.	Tracks seen on a couple of occasions	Common and widespread	LC
Fringe-toed Lizard	*Acanthodactylus* sp.	Tracks seen on a couple of occasions	Common and widespread	LC

Table 5-88: Bird species recorded during the Mirfa surveys (85)

Common Name	Scientific Name	Count	Status On-site	Status in UAE	IUCN Status
Grey Francolin	*Francolinus pondicerianus*	3	Tracks frequently noted. Heard calling from within private villa grounds. A covey of 3 later observed	Common resident breeder	LC
Western Reef Heron	*Egretta gularis*	4	Four seen on the intertidal mudflats	Common resident breeder	LC
Osprey	*Pandion haliaetus*	1	Flew overhead on a single occasion over the mangrove area	Moderately common resident breeder	LC
Red-wattled Lapwing	*Vanellus vanellus*	1	One adult found incubating a nest of 4 eggs	Common resident breeder	LC
Kentish Plover	*Charadrius alexandrinus*	16	Seen foraging along beach and on intertidal flats	Common resident breeder	LC
Lesser Sand Plover	*Charadrius mongolus*	6	Seen foraging along beach and on intertidal flats	Migrant/visitor primarily in winter	LC
Eurasian Curlew	*Numenius arquata*	3	Three seen foraging on intertidal flats	Migrant/visitor primarily in winter	Near Threatened (NT)
Common Greenshank	*Tringa nebularia*	1	One seen on the beach at high tide	Migrant/visitor primarily in winter	LC
Eurasian Collared Dove	*Streptopelia decaocto*	6	Commonly seen within trees in and adjacent to the private villas	Very common resident breeder	LC
Laughing Dove	*Spilopelia senegalensis*	8	Commonly seen within trees in and adjacent to the private villas	Very common resident breeder	LC
Greater Hoopoe Lark	*Alaemon alaudipes*	1	One seen running between dwarf shrubs inland of the coastal dunes	Very common resident breeder	LC
White-eared Bulbul	*Pycnonotus leucotis*	8	Commonly seen within the mangroves and trees adjacent to the private villas	Very common resident breeder	LC
House Sparrow	*Passer domesticus*	15	Commonly seen within the mangroves and trees adjacent to the private villas	Very common resident breeder	LC

Table 5-89: Arthropod species recorded during the Mirfa surveys (85)

Common-Name	Scientific Name	Status On-site	Status in UAE	IUCN Status
Desert Locust	*Schistocerca gregaria*	Seen on one occasion	Common to Abu Dhabi Emirate	NE
Asian Dwarf Honeybee	*Apis florea*	>50 pollinating mangrove flowers	Common to Abu Dhabi Emirate	NE
Desert Runner Ant	*Cataglyphis niger*	Ant colonies made by this species seen within the vegetated coastal dune strip	Common to Abu Dhabi Emirate	NE
Darkling Beetle	*Pimelia* sp.	Tracks seen and photographed on coastal dune habitat	Common to Abu Dhabi Emirate	NE

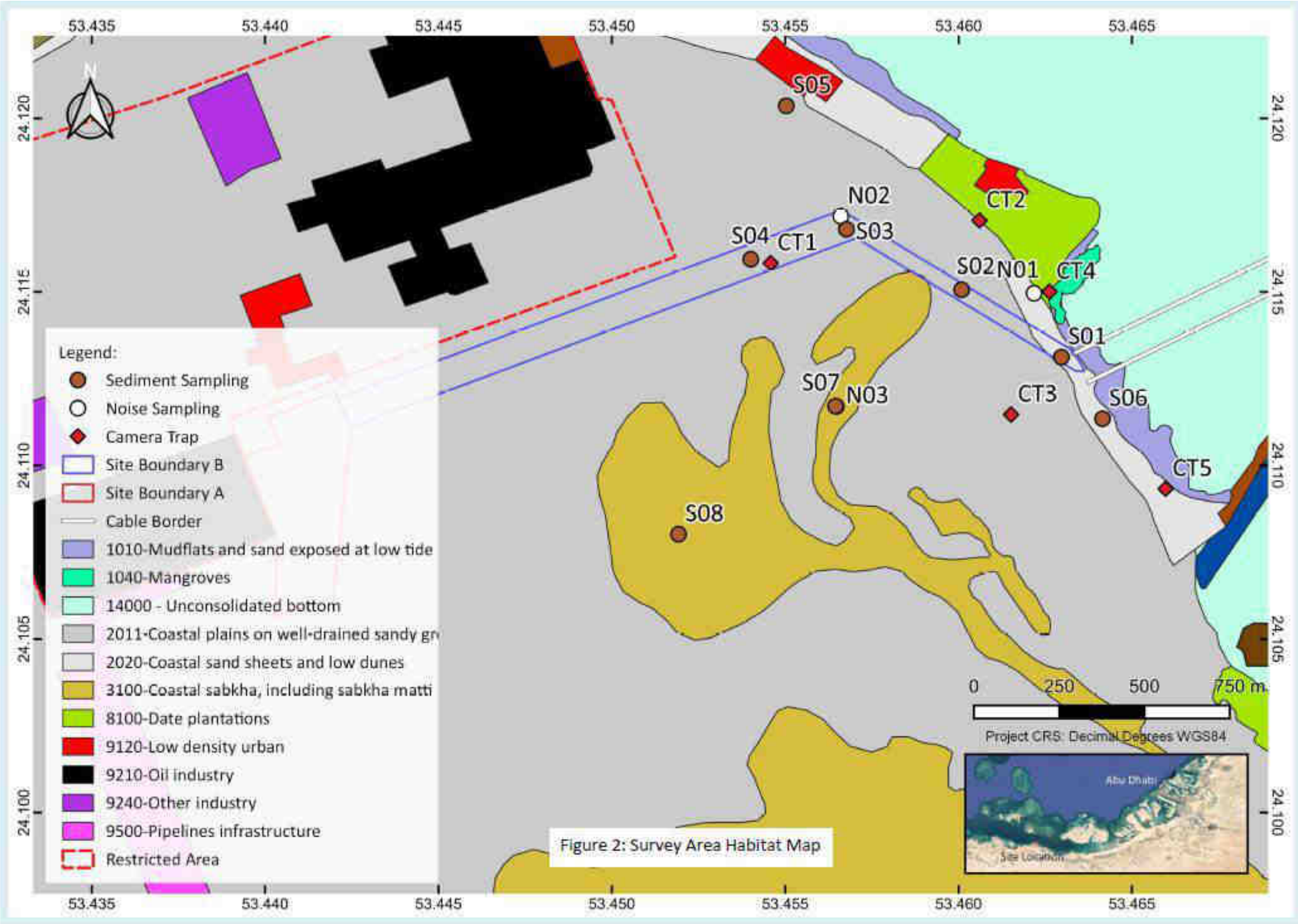


Figure 5-200: EAD habitat map at Mirfa (Nautica Survey) (85)

5.6.1.2.2. Shuweihat – Existing Nautica Surveys (84)

The results of the terrestrial and intertidal ecology surveys undertaken by Nautica over a period of six days between the 4th and 6th May 2021 are summarised in the below subsections.

Habitats

The proposed Project footprint at the onshore tie-in locations will traverse across a number of coastal habitats. Starting from the coast the cable will make landfall over an extensive area of intertidal mudflats before travelling over supratidal zones where mangrove forest, saltmarsh and cyanobacterial mats occur. The proposed route will then pass over a thin storm beach ridge which marks the high tide line and the end of the intertidal habitats. Beyond the intertidal zones, after traversing over coastal plains and sabkha, the route eventually reaches higher, rocky plains upon which the power complex's western limits and entrance sits.

The Project study area (within 500m of the Project footprint) encompasses a total of 13 terrestrial habitats. Of these, a number are considered to be important terrestrial, intertidal and subtidal habitats worthy of mitigation and preservation. The following non-natural habitats were identified:

- Other industry (EAD Habitat Code (EAD HC) 9240);
- Low Density Urban (EAD HC 9120);
- Paved Roads (EAD HC 9400); and
- Disturbed Ground (EAD HC 9600).

The remaining habitats are natural and comprise:

- Intertidal Mudflats and Sand Exposed at Low Tide (EAD HC 1010);
- Coastal plains on well-drained Rocky or Gravelly Terrain (EAD HC 2021);
- Coastal Plains on well-drained Sandy Ground (EAD HC 2011);
- Mangroves (EAD HC 1040);
- Storm Beach Ridges (EAD HC 1050);
- Saltmarsh (EAD HC 1030);
- Coastal Sabkha, including sabkha matti (EAD HC 3100);
- Coastal Sand Sheets and Low Dunes (EAD HC 2020); and
- Sheltered Tidal Flats with Cyanobacterial Mats (EAD HC 1020).

A description and percentage cover of the eight habitats directly situated within the Project footprint are presented in Table 5-90 below. Of these habitats, mudflats and sand exposed at low tide, saltmarsh and mangroves are considered by EAD to be Critical Habitats.

The distribution of these habitats is illustrated in Figure 5-201 below.

Table 5-90: Description and percentage cover of the habitats situated within the proposed route (84)

H/T	Description	Threat Status (EAD)	Area (km^2)	% Cover (PF)
1010	Mudflats and sand exposed at low tide	Critical Habitat	0.19920396	21.19
1030	Saltmarsh	Critical Habitat	0.03771049	4.01
1040	Mangroves	Critical Habitat	0.00403992	0.43
2011	Coastal plains on well-drained sandy ground	Not Sensitive or Critical	0.13806982	14.69
2012	Coastal plains on well-drained rocky or gravelly terrain	Not Sensitive or Critical	0.28663813	30.50
2020	Coastal sand sheets and low dunes	Environmentally Sensitive Habitat	0.01168455	1.24
3100	Coastal sabkha, including sabkha matti	Environmentally Sensitive Habitat	0.26082332	27.75
9400	Paved roads	Not Sensitive or Critical	0.00172188	0.18
Table Key: H/T = Habitat Type (EAD Classification, 2013) PF = Cable/Project Footprint % = Percentage Km^2 = Square Kilometres				

Mangroves

The mangroves in the study area appeared to be in good health with healthy leaves and branches and no apparent diseases or dead trees were observed. Fish fry and the Mottled Crab, *Metopograpsus messor*, a grapsid crab that inhabits mangroves, were found in abundance between the mangrove pneumatophores.

In areas where surface water remained the longest between tidal cycles, macroalgal species, dominated by *Chaetomorpha sp*. was recorded covering pneumatophores. The mangrove stands were largely devoid of any anthropogenic debris. However, a couple of discarded fishing nets were recorded entangled with the pneumatophores (84).

Saltmarsh

Within the saltmarsh habitat of the study area, *Arthrocnemum macrostachyum* is the dominant component of low-level saltmarsh that tolerates frequent inundation on the coast of the survey area. Striking feature of halophytic vegetation is that the individual stands tend to be species-poor or even monospecific where one species occupies large patches. This was found to be the case in the survey area where *A. macrostachyum* was predominant and often occurred in large swathes as the sole saltmarsh plant species representative of the habitat.

Organisms found in saltmarsh habitats include crabs; gastropods; and polychaetes. Saltmarsh is considered a “Blue Carbon” habitat type because it is a coastal and marine habitat that is able to sequester and store carbon (84).

Coastal Sabkha

The sabkha plains at the overall survey location cover approximately 27% of the onshore Project footprint.

Storm Beach Ridges

A storm beach ridge was identified within the Project area, characterised by sandy vegetated areas with knolls rising from the ground, situated running parallel to the shoreline. The storm beach ridge consists of shelly sand blown inland from the intertidal zone during storms. Halophytic vegetation was noted throughout the ridge area.

Mudflats and Sand Exposed at Low Tide

According to the EAD Habitat Map, this habitat type at the project location covers an area of approximately 0.86km^2 within the Project study area, and comprises 21.19% of the onshore Project footprint. This coastal wetland area is considered to be a Critical Habitat and is an important habitat for wading birds feeding on benthic invertebrates during low tides (84).

Sheltered Tidal Flats with cyanobacterial Mats

This habitat covered a relatively minor area (0.088km^2) at the onshore Project footprint. However, this habitat was absent from EAD's habitat map (84) although the survey efforts undertaken by Nautica indicate that the strip of intertidal flats to the west of the sheltered embayment were covered almost entirely by cyanobacteria.

Flora

With the exception of planted species along the roadside at the easternmost perimeter of the site, thirteen naturally occurring species of vascular plant were recorded across each habitat in the survey area, as follows:

- Cornulaca aucheri;
- Salsola imbricata;
- Haloxylon salicornicum;
- Avicennia marina (Grey Mangrove);
- Anabasis setifera;
- Stipagrostis plumosa;
- Arthrocnemum macrostachyum (Glasswort);
- Halopeplis perfoliata;
- Heliotropium kotschyi;
- Suaeda vermiculata;
- Cistanche Tubulosa (Desert Hyacinth);
- Tetraena qatarensis; and
- Tetraena simplex.

The identified species and their status are also presented in Table 5-91 below (84).

Mammals and Reptiles

Arabian Red Fox (*Vulpes vulpes arabica*) and feral dog (*Canis familiaris*) were the only mammals recorded during the survey. Three reptile species were identified during the survey, these were: Hadramaut Sand Lizard (*Mesalina adramitana)*, White-spotted Lizard (*Acanthodactylus schmidti*) and Hooded Malpolon (*Malpolon moilensis*) All mammal and reptile species recorded during the survey are listed in Table 5-92 (84).

Birds

15 species of birds, totaling 109 individuals were recorded during the site visits. Counts of all the birds seen on the three days are given in Table 5-93, in addition to the scientific names for all taxa, as well as IUCN status (84).

Arthropods

Arthropods were assessed in the area during day-time walkover investigations. Anthropogenic debris was also moved to look for insects hiding beneath. A total of 11 arthropod species were recorded during the survey, as listed in Table 5-94. Any arthropod species observed were recorded, photographed and where possible were identified to species level (84).

Table 5-91: Plant species recorded at Shuweihat (Nautica Survey) (84)

Family name	Scientific Name	Status During Survey	Status in UAE	IUCN Status
Acanthaceae	*Avicennia marina*	Present at a high density within the sheltered embayment and fringes	Common and widespread on the coastline of the UAE	LC
Amaranthaceae	*Arthrocnemum macrostachyum*	Very common. Dominant saltmarsh plant in survey	Common and widespread on both coasts	NE
Amaranthaceae	*Anabasis setifera*	Fairly common on the coastal plains at the site	Common in coastal areas, also on offshore islands	NE
Amaranthaceae	*Cornulaca aucheri*	Widespread within the survey area	Common and widespread in Abu Dhabi Emirate	NE
Amaranthaceae	*Halopeplis perfoliata*	Common along storm beach ridge	Common along the Arabian Gulf coast	NE
Amaranthaceae	*Haloxylon salicornicum*	Most common at higher ground to the east of the site	Common and widespread, except at higher elevations in mountains	NE
Amaranthaceae	*Salsola imbricata*	Occasionally noted in the storm beach ridge habitat	Common and widespread on both coasts	NE
Amaranthaceae	*Suaeda vermiculata*	Infrequently noted in the storm beach ridge habitat	Common on the coastline and offshore islands	NE
Boraginaceae	*Heliotropium kotschyi*	Uncommonly noted on the coastal plains	Common and widespread in coastal areas	NE
Orobanchaceae	*Cistanche Tubulosa*	A couple of dead specimens encountered	Common along coast and inland saline sand plains	NE
Poaceae	*Stipagrostis plumosa*	Occasionally present on coastal plains of higher elevation and lower salinity	Common and widespread. Very common along roadsides	NE
Zygophyllaceae	*Tetraena qatarensis*	Most abundant species away from saltmarsh and mangroves	Common on the coast of Abu Dhabi and in northern Emirates	NE
Zygophyllaceae	*Tetraena simplex*	Frequently noted on coastal plains	Common and widespread along UAE coastline and on offshore islands	NE

Table 5-92: Mammal and reptile species recorded at Shuweihat (Nautica Survey) (84)

Common Name	Scientific Name	Status During Survey	Status in UAE	IUCN Status
Arabian Red fox	*Vulpes vulpes arabica*	Very Common. Numerous tracks were found, and at least two individuals were captured several times on camera trap.	Common and widespread	LC
Feral Dog	*Canis lupus familiaris*	Tracks were observed, but no actual sightings.	Common and widespread	LC
Hadramaut Sand Lizard	*Mesalina adramitana*	Found on a few occasions.	Poorly known species	LC
White-spotted Lizard	*Acanthodactylus schmidti*	Found on one occasion.	Common and widespread	LC
Hooded Malpolon	*Malpolon moilensis*	Seen on a single occasion crossing a road to the north of the power plant.	Fairly common within gravelly habitats	LC

Table 5-93: Bird species recorded at Shuweihat (Nautica Survey) (84)

Common Name	Scientific Name	Count(s)	Status On-site	Status in UAE	IUCN Status
Western Reef Heron	*Egretta gularis*	9	9 seen in total, within the mangroves and on the intertidal mudflats	Common resident breeder	LC
Grey Heron	*Ardea cinera*	12	Commonly present on the intertidal mudflats. Also seen in-flight over the mangroves	Visitor, mostly winter	LC
Striated Heron	*Butorides striata*	1	One flushed from mangroves at the edge of a tidal creek	Common resident breeder	LC
Kentish Plover	*Charadrius alexandrinus*	14	Primarily seen foraging on intertidal mudflats. 3 nests containing eggs also found	Common resident breeder	LC
Lesser Sand Plover	*Charadrius mongolus*	5	Foraging on intertidal mudflats at low tide	Migrant/visitor primarily in winter	LC
Eurasian Curlew	*Numenius arquata*	3	Three seen foraging on intertidal mudflats at low tide	Migrant/visitor primarily in winter	NT
Common Redshank	*Tringa totanus*	1	One present within mangrove fringes	Migrant/visitor primarily in winter	LC
Bar-tailed Godwit	*Limosa lapponica*	3	A flock of 3 seen foraging on intertidal mudflats at low tide	Migrant/visitor primarily in winter	NT
Eurasian Collared Dove	*Streptopelia decaocto*	8	Heard and seen on the electricity pylons to the east of the site	Very common resident breeder	LC
Greater Hoopoe Lark	*Alaemon alaudipes*	2	A pair seen on 3 consecutive days at the storm beach ridge	Common resident breeder	LC
Graceful Prinia	*Prinia gracilis*	2	Both seen within the saltmarsh habitat	Common resident breeder	LC
Blue-cheeked Bee Eater	*Merops persicus*	4	Heard on the electricity pylons at the site. Later observed in-flight over mangroves	Migrant/migrant breeder	LC
Clamorous Reed Warbler	*Acrocephalus stentoreus*	1	One heard singing from within mangroves	Moderately common resident breeder	LC
White-eared Bulbul	*Pycnonotus leucotis*	20	Commonly seen within the mangroves	Very common resident breeder	LC
House Sparrow	*Passer domesticus*	24	Commonly seen within the mangroves	Very common resident breeder	LC

Table 5-94: Arthropod species recorded at Shuweihat (Nautica Survey) (84)

Common Name	Scientific Name	Status On-site	Status in UAE	IUCN Status
Globe Skimmer	*Pantala flavescens*	Observed on a few occasions, perched on mangroves	Common to Abu Dhabi Emirate	NE
Carmine Darter	*Crocothemis erythraea*	One seen perched on a mangrove pneumatophore	Common to Abu Dhabi Emirate	NE
Blue-spotted Arab Butterfly	*Colotis phisadia*	Approximately 10 seen pollinating mangrove flowers	Very common to Abu Dhabi Emirate	NE
Small Salmon Arab Butterfly	*Colotis amata*	Approximately 5 seen pollinating mangrove flowers	Common to Abu Dhabi Emirate	NE
Regal Blowfly	*Chrysomya marginalis*	One seen on a mangrove leaf	Common to Abu Dhabi Emirate	NE
Oriental Wasp	*Campsomeriella thoracica*	One seen pollinating a mangrove flower	Common to Abu Dhabi Emirate	NE
Asian Dwarf Honeybee	*Apis florea*	>100 pollinating mangrove flowers	Common to Abu Dhabi Emirate	NE
Streaky-wing Antlion	*Lopezus fedtschenkoi*	One seen on a *Halopeplis perfoliata* shrub	Moderately common to Abu Dhabi Emirate	NE
Arabian Darkling Beetle	*Pimelia arabica*	Seen on one occasion burying itself in sand	Common to Abu Dhabi Emirate	NE
Sulphurous Jewel Beetle	*Julodis euphratica castelnau*	Observed on one occasion flying	Common to Abu Dhabi Emirate	NE
Tiger Beetle	*Cicindelidae sp.*	One seen on the intertidal mudflats	Uncommon to Abu Dhabi Emirate	NE

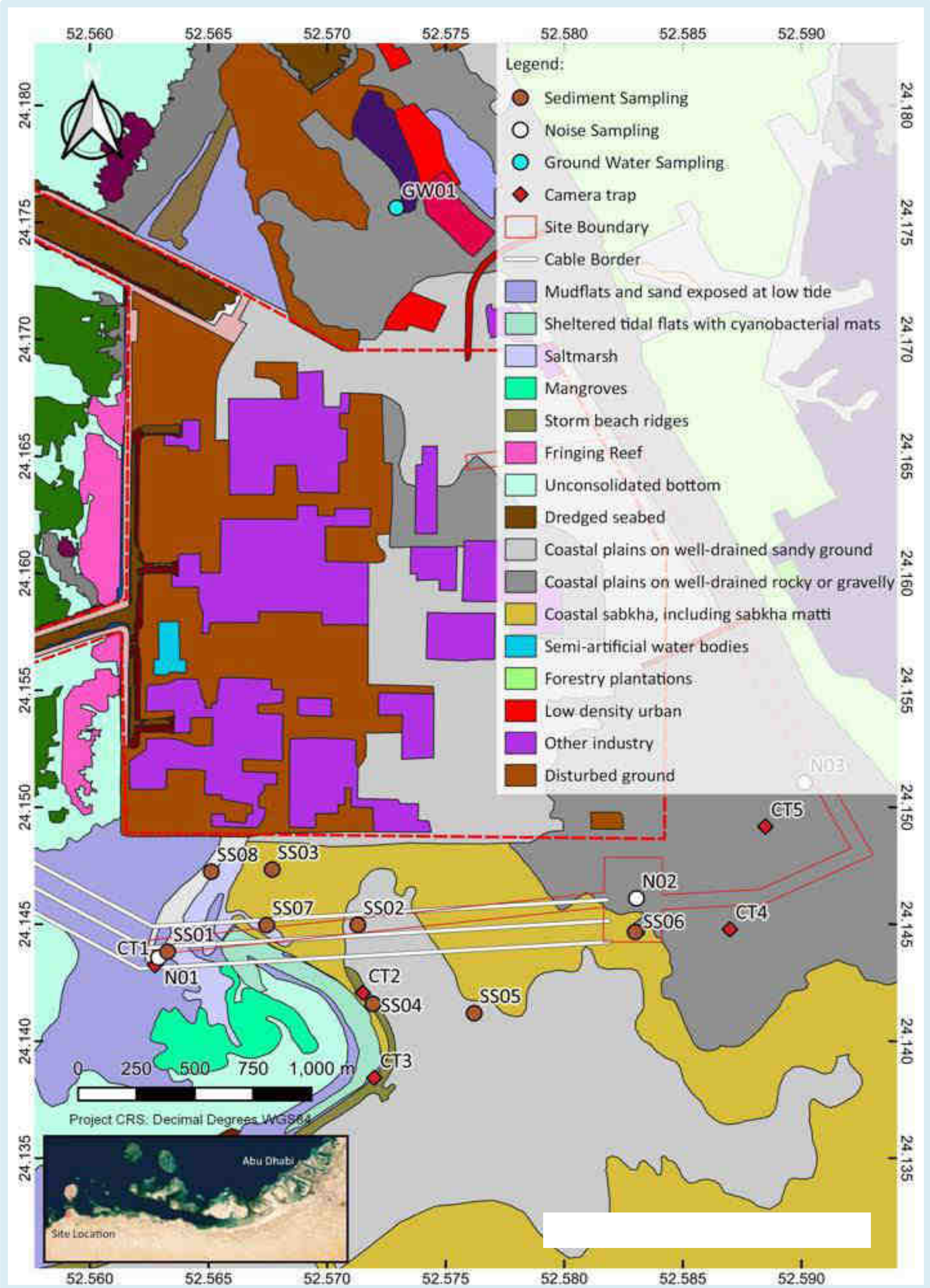


Figure 5-201: EAD habitat map at Shuweihat (Nautica Survey) (84)

5.6.1.2.3. Das Island – Nautica Surveys (41)

Field surveys were conducted by Nautica over four days, between the 3rd and 6th August 2021. The results are summarised in the below subsections.

Habitats

The Project footprint will be directly situated within just two unnatural habitats. The threat status, area and description of both habitats identified within the cable landfall location footprint, are presented in Table 5-95 below.

Table 5-95: Habitat description and percentage cover within Das Island (41)

H/T	Description	Threat Status (EAD)	Area (ha)	% Cover (PF)
15100	Rock Armouring	Not Sensitive or Critical	0.10	98.6
9600	Disturbed Ground	Not Sensitive or Critical	7.04	1.4
Table Key: H/T = Habitat Type (EAD Classification, 2013) PF = Cable/Project Footprint % = Percentage Km2 = Square Kilometres				

The distribution of these habitats is illustrated in Figure 5-202 below.

Disturbed Ground/Reclaimed Land

With the exception of the thin strip of rock armouring, the site is exclusively situated within the island extension that has been reclaimed in preparation for the residential development, which will eventually house staff accommodation facilities, related amenity buildings and external and infrastructure works. As this land is disturbed and unnatural, it is classified as Disturbed Ground (EAD Habitat Code 9600). This habitat constitutes 98.6% of the total terrestrial habitat cover within the proposed Project footprint (41).

Although the site is classified as disturbed ground, this is a rather broad categorisation that typically refers to longstanding natural habitats that have been subject to excavation and levelling/grading in preparation for development. In contrast, in the case of the survey site, the land consists of reclaimed ground that is just a few years old. Natural forces have been left to prevail for the last four to five years since the reclamation works were completed, which has allowed some halophytic vegetation to colonise the site. If left in a natural state for enough time, the site will become something reminiscent of the habitat: coastal plain on well-drained sandy ground, which the site's current state bears much resemblance to. *Salsola imbricata* is the dominant shrub within the disturbed ground habitat and is abundant at the survey site, particularly at the southern end.

Rock Armouring/Artificial Breakwater

Upon reaching land, the proposed cable landfall route will traverse over a rock armouring revetment that is classified through EAD's habitat classification system as Rock Armouring/Artificial Reef (EAD habitat code 15100). This man-made habitat consists of large limestone boulders that are moved into place by heavy machinery. The boulders are designed in such a way that their complex shapes dissipate wave energy, and their sheer mass absorbs wave energy, thereby protecting land from coastal erosion (41).

Flora

With the exception of the two planted Date Palms, *Phoenix dactylifera*, and *Bougainvillea* to the south of the reclaimed island extension, two other naturally occurring vascular plant species were recorded across the entire survey area. Namely, these were *Salsola imbricata* and *Sporobolus spicata.* Their status is presented Table 5-96 below (41).

Mammals and Reptiles

A stray cat, *Felis catus*, was the only mammal noted at the survey site. Another mammal introduced to the island: three Indian Palm squirrels, *Funambulus palmarum*, were sighted in Zayed Park Garden in the residential part of the island. Though an interesting discovery, the squirrels are 2.4 km away from the new island extension and will not inhabit the tree-less survey site but could move there following the development when some trees are likely to be planted (41). A summary is provided in Table 5-97.

No reptiles were recorded during the survey despite a concerted effort to search for any sign of them. Their absence in the study area was unsurprising as the island's isolation prevents colonisation by small fauna of low mobility. Further, the species- poor survey site would currently not sustain a population of lizards, primarily due to the low abundancy of arthropods (41).

Birds

Nine species of birds, totaling 137 individuals, were recorded during the site visits. Counts of all the birds are given in Table 5-98 in addition to the scientific names for all taxa, as well as IUCN status (41).

The main ornithological importance of Das Island is as a resting area for migratory birds, particularly passerines, and as a roosting and foraging area for terns and gulls.

Avian activity at the site was found to be concentrated along the rock armouring habitat. Birds can perch comfortably on the boulders, and the elevated structures proximate to the coast, act as a vantage point to scan for fish in the shallows below. When the wind blows perpendicular to the revetment slope, up-drafts are formed, creating a steady stream of lift that allows birds to slope-soar with minimal effort while scanning the sea surface for prey.

Table 5-96: Plant species recorded during the Das Island survey (41)

Family name	Scientific Name	Status During Survey	Status in UAE	IUCN Status
Chenopodiaceae	*Salsola imbricata*	Present at a high density within the sheltered embayment and fringes	Common and widespread on the coastline of the UAE	LC
Poaceae	*Sporobolus spicata*	Very common. Dominant saltmarsh plant in survey	Common and widespread on both coasts	NE

Table 5-97: Mammal and reptile species recorded during the Das Island survey (41)

Common Name	Scientific Name	Status During Survey	Status in UAE	IUCN Status
Stray Cat	*Felis catus*	Very Common. Numerous tracks were found, and at least two individuals were captured several times on camera trap.	Common and widespread	LC
Indian Palm Squirrel	*Funambulus palmarum*	Three seen in a date palm tree in Zayed Garden	Introduced	LC

Table 5-98: Bird species recorded during the Das Island surveys (41)

Common Name	Scientific Name	Count(s)	Status On-site	Status in UAE	IUCN Status
Socotra Cormorant	*Phalacrocorax nigrogularis*	6	Resting on the rock armouring and in- flight over the site	Visitor, mostly winter	Vulnerable (VU)
Grey Heron	*Ardea cinera*	1	One sighted in-flight to the south of the runway	Visitor, mostly winter	LC
Osprey	*Pandion haliaetus*	2	Two fishing along the rock armoring breakwater	Resident breeder	LC
Kentish Plover	*Charadrius alexandrinus*	1	One seen perched on a low rock armoring boulder close to the waters edge	Common resident breeder	LC
Sooty Gull	*Ichthyaetus hemprichii*	8	Seen in-flight chasing White-cheeked Terns and resting on the rock armouring	Resident breeder	LC
White-cheeked Tern	*Sterna repressa*	45	Flocks of adults and juveniles resting on the island in the mornings and evenings and fishing in the shallows during the day	Common resident breeder	LC
Rock Dove/Feral Pigeon	*Columba livia*	70	A large flock sighted at the survey site early one morning	Very common resident breeder	LC
Isabelline Wheatear	*Oenanthe isabellina*	1	The only migrant seen at the survey site foraging on the ground	Common passage migrant and winter visitor	LC
House Crow	*Corvus splendens*	3	Three captured on camera trap	Very common at coastal sites	LC

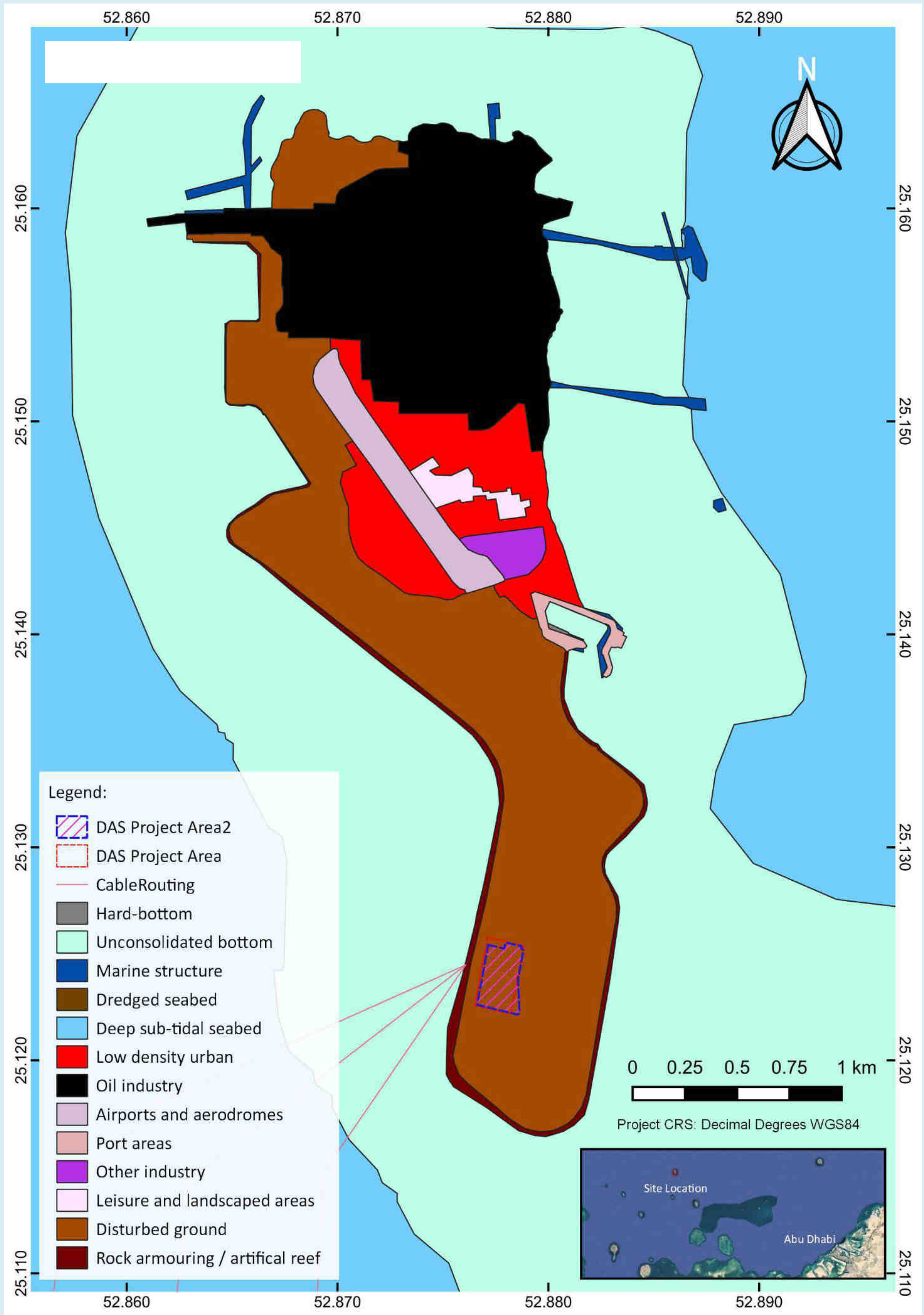


Figure 5-202: Habitat map – Das Island

5.6.1.2.4. Shuweihat and Mirfa – New Anthesis Surveys

January 2022

Avifauna

During the winter surveys undertaken in January 2022 a total of 1361 individuals belonging to 39 species were recorded. At Shuweihat, 1051 individuals belonging to 23 species were recorded while at Mirfa, 310 individuals belonging to 30 species were recorded. The birds recorded at each of the vantage points for both Shuweihat and Mirfa are presented in Table 5-99 and Table 5-100 below.

Of the species recorded, one is currently listed as vulnerable (VU) on the IUCN List of threatened species while four are listed on the recently published Abu Dhabi Red List of Species. Three of these species were recorded at the Shuweihat site while two were recorded at the Mirfa site. These species are given in Table 5-99 and Table 5-100 below.

Table 5-99: Avifauna recorded by Anthesis at Shuweihat (W1-W8)

Species	Common Name	ADRLS Status	IUCN Status	VP W1	VP W2	VP W3	VP W4	VP W5	VP W6	VP W7	VP W8	Total Shuweihat	Total species
Charadrius alexandrinus	Kentish Plover									12		**12**	**1**
Limosa lapponica	Bar-tailed Godwit						1			2		**3**	**1**
Calidris ferruginea	Curlew Sandpiper									4		**4**	**1**
Calidris minuta	Little Stint									3		**3**	**1**
Actitis hypoleucos	Common Sandpiper									8		**8**	**1**
Chroicocephalus genei	Slender-billed Gull			100	500	30	22			89		**741**	**1**
Ardea cinerea	Grey Heron					1	1	2	2	2	1	**9**	**1**
Egretta gularis	Western Reef-Heron			1	3		1			6	8	**19**	**1**
Pandion haliaetus	Osprey	EN								1	1	**2**	**1**
Phoenicopterus roseus	Greater Flamingo						2	2	20		128	**152**	**1**
Streptopelia decaocto	Eurasian Collared-Dove										2	**2**	**1**
Himantopus himantopus	Black-winged Stilt										2	**2**	**1**
Dromas ardeola	Crab Plover	VU									2	**2**	**1**
Galerida cristata	Crested Lark										3	**3**	**1**
Motacilla alba	White Wagtail										1	**1**	**1**
Spilopelia senegalensis	Laughing Dove											**0**	
Pluvialis squatarola	Grey Plover											**0**	
Charadrius hiaticula	Common Ringed Plover											**0**	
Numenius phaeopus	Eurasian Whimbrel						1					**1**	**1**
Numenius arquata	Eurasian Curlew			1			1					**2**	**1**
Calidris alba	Sanderling											**0**	
Xenus cinereus	Terek Sandpiper											**0**	
Ardeola ralloides	Squacco Heron											**0**	
Prinia lepida	Delicate Prinia											**0**	
Pycnonotus leucotis	White-eared Bulbul					70						**70**	**1**
Acridotheres tristis	Common Myna											**0**	

Species	Common Name	ADRLS Status	IUCN Status	VP W1	VP W2	VP W3	VP W4	VP W5	VP W6	VP W7	VP W8	Total Shuweihat	Total species
Oenanthe deserti	Desert Wheatear											**0**	
Vanellus indicus	Red-wattled Lapwing											**0**	
Calidris pugnax	Ruff											**0**	
Tringa nebularia	Common Greenshank											**0**	
Circus aeruginosus	Western Marsh Harrier	VU										**0**	
Coracias benghalensis	Indian Roller											**0**	
Phalacrocorax nigrogularis	Socotra Cormorant	EN	VU	1				1	1			**3**	**1**
Phalacrocorax carbo	Great Cormorant						3					**3**	**1**
Hydroprogne caspia	Caspian Tern						5					**5**	**1**
Haematopus longirostris	Oystercatcher						3					**3**	**1**
Lanius excubitor	Great Grey Shrike						1					**1**	**1**
Calidris alpina	Dunlin											**0**	
Passer domesticus	House Sparrow											**0**	
											Total:	**1,051**	**23**

Table 5-100: Avifauna recorded by Anthesis at Mirfa (E1 – E5)

Species	Common Name	ADRLS Status	VP E1	VP E2	VP E3	VP E4	VP E5	Total Mirfa	Total Species
Charadrius alexandrinus	Kentish Plover		28	33	1	17	13	**92**	**1**
Limosa lapponica	Bar-tailed Godwit		5	3				**8**	**1**
Calidris ferruginea	Curlew Sandpiper		3	2	1	2		**8**	**1**
Calidris minuta	Little Stint							**0**	
Actitis hypoleucos	Common Sandpiper			4				**4**	**1**
Chroicocephalus genei	Slender-billed Gull		17	6			4	**27**	**1**
Ardea cinerea	Grey Heron		2					**2**	**1**
Egretta gularis	Western Reef-Heron		10	2	1			**13**	**1**
Pandion haliaetus	Osprey	EN						**0**	
Phoenicopterus roseus	Greater Flamingo							**0**	
Streptopelia decaocto	Eurasian Collared-Dove						2	**2**	**1**
Himantopus himantopus	Black-winged Stilt			2				**2**	**1**
Dromas ardeola	Crab Plover	VU	1					**1**	**1**
Galerida cristata	Crested Lark			3				**3**	**1**
Motacilla alba	White Wagtail							**0**	
Spilopelia senegalensis	Laughing Dove		8	5	1			**14**	**1**
Pluvialis squatarola	Grey Plover		1	2				**3**	**1**
Charadrius hiaticula	Common Ringed Plover		2					**2**	**1**
Numenius phaeopus	Eurasian Whimbrel		2	2				**4**	**1**
Numenius arquata	Eurasian Curlew		6	6				**12**	**1**
Calidris alba	Sanderling		1					**1**	**1**
Xenus cinereus	Terek Sandpiper		2					**2**	**1**
Ardeola ralloides	Squacco Heron		1					**1**	**1**
Prinia lepida	Delicate Prinia		2					**2**	**1**
Pycnonotus leucotis	White-eared Bulbul		18	64	10			**92**	**1**
Acridotheres tristis	Common Myna		4					**4**	**1**

Species	Common Name	ADRLS Status	VP E1	VP E2	VP E3	VP E4	VP E5	Total Mirfa	Total Species
Oenanthe deserti	Desert Wheatear		1					**1**	**1**
Vanellus indicus	Red-wattled Lapwing			1				**1**	**1**
Calidris pugnax	Ruff			1				**1**	**1**
Tringa nebularia	Common Greenshank			1				**1**	**1**
Circus aeruginosus	Western Marsh Harrier	VU	1	1	1			**3**	**1**
Coracias benghalensis	Indian Roller			1				**1**	**1**
Phalacrocorax nigrogularis	Socotra Cormorant	EN						**0**	
Phalacrocorax carbo	Great Cormorant							**0**	
Hydroprogne caspia	Caspian Tern							**0**	
Haematopus longirostris	Oystercatcher							**0**	
Lanius excubitor	Great Grey Shrike							**0**	
Calidris alpina	Dunlin					1		**1**	**1**
Passer domesticus	House Sparrow				2			**2**	**1**
							Total:	**310**	**30**

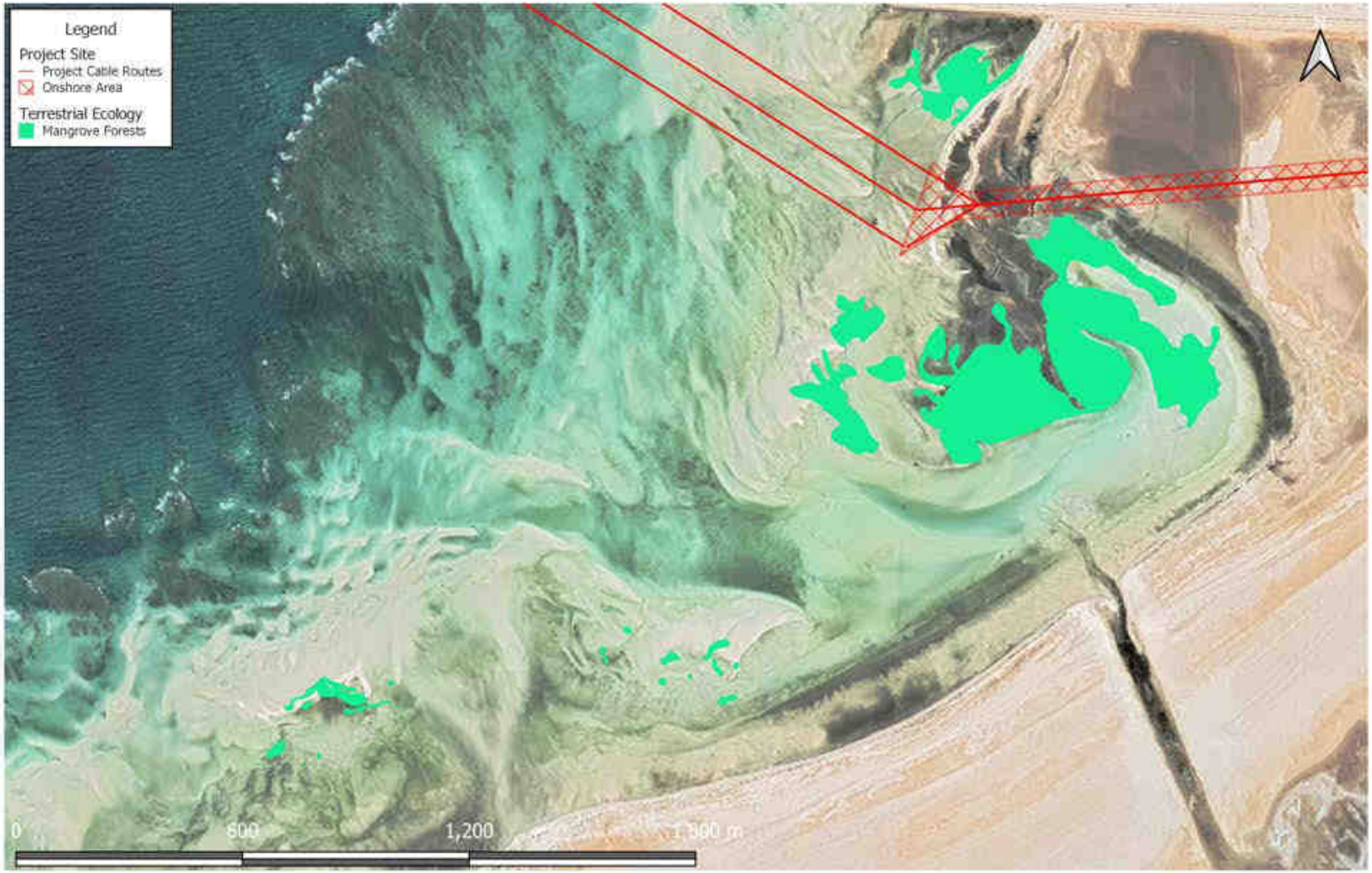
Mangroves

Shuweihat

Figure 5-203 shows the extent of the mangroves within the Shuweihat (western) study area. The mangroves in this area range in height between 0.5m to circa 4m in the older growth forest areas. Mangrove health is generally good. There is some natural dieback within the mangrove community but nothing that would appear unnatural. Density varies between as low as 175 trees/ha within parts of the newly colonised areas to circa 525 trees/ha within parts of the old growth forest area.

Flushing of the mangroves appears normal with no deaths from hypersalinity due to a lack of flushing identified and no hyper-recruitment caused by a lack of the removal of propagules due to reduced tidal flushing.

Figure 5-204 below shows the old and new growth mangrove forests areas. Forest areas visible on satellite imagery prior to 2000 (20+ years old) were delineated as old growth forests while subsequent forests areas were delineated as new growth forests. The ground truthing of the mangroves confirmed the relative ages of the trees within these areas.



Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:12431
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 10/05/22

Anthesis

Figure 5-203: Extent of mangroves at the Shuweihat study area

Figure 5-204: Extent of old and new growth mangroves within the Shuweihat study area

Mirfa

Figure 5-205 shows the extent of the mangroves within the Mirfa (eastern) study area. The mangroves in this area range in height between 0.5m to circa 5m in the older growth forest areas. Mangrove health is generally good. There is some natural dieback within the mangrove community but nothing that would appear unnatural. Density varies between as low as 175 trees/ha within parts of the newly colonised areas to over 1000 trees/ha within parts of the old growth forest area.

Figure 5-206 below shows the old and new growth mangrove forests areas. Forest areas visible on satellite imagery prior to 2000 (20+ years old) were delineated as old growth forests while subsequent forests areas were delineated as new growth forests. The ground truthing of the mangroves confirmed the relative ages of the trees within these areas.

In the new growth areas, tidal flushing appears to be normal with no deaths from hypersalinity due to a lack of flushing and no hyper-recruitment caused by a lack of the removal of propagules due to reduced tidal flushing.

In the old growth mangroves, the creation of breakwaters and the impediment of tidal action has resulted in some health issues in the mangroves which include:

- Hypersalinity due to reduced flushing;
- Dieback due to hypersalinity and eutrophication; and
- Hyper-recruitment and lack of self -thinning of mangrove forest.

These issues are particularly evident in the old growth forest areas as shown in Figure 5-207 and Figure 5-208.

Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:12431
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 10/05/22

Anthesis

Figure 5-205: Extent of mangroves at the Mirfa study area

Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:12431
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 10/05/22

Anthesis

Figure 5-206: Extent of old and new growth mangroves within the Mirfa study area

Figure 5-207: Hyper-recruitment in old growth mangroves in Route 1 (approximately 1.6km from the Project site)

Figure 5-208: Dieback and eutrophication in the central area of old growth mangrove in Route 1 (approximately 175m from the Project site)

Discussions and Conclusions

Avifauna

Avifauna species richness was moderate at both Shuweihat and Mirfa with a total of 39 species of birds being recorded at the combined sites. The Mirfa site showed higher species richness with 30 species as opposed to the 23 species recorded at the Shuweihat site. This is likely due to the increase in terrestrial species at Mirfa due to the forest plantations situated within close proximity to the site.

Abundance was far higher in the Shuweihat study area. Although more vantage point counts were conducted in the Shuweihat study area, this alone does not account for the far higher avifauna abundance (1051 individuals as opposed to 310 individuals in Mirfa). A number of factors have influence on the larger avian numbers recorded in Shuweihat, namely:

- Larger flocks of birds such as slender billed bulls and flamingos;
- Larger areas of intertidal foraging areas; and
- Reduced human disturbance.

Several bird species listed on the IUCN Red List were recorded within the Project study areas which will require best practices to be followed to minimise any possible impacts on these species, including pre-construction avifauna and nesting surveys. However due to the mobility of avifauna as a taxon, it is considered that impacts due to construction activities can be reduced to low significance.

Mangroves

Mangroves are a critical habitat according to the Abu Dhabi Emirate Habitat Classification and Protection Guideline (144). Mangroves are likely to be directly impacted at the Shuweihat landfall construction area as a section of mangroves will need to be removed during construction. This impact will require a number of actions to be taken including the development of a mangrove restoration/offsetting plan and a Mangrove Planting and Management Plan (MPMP) for the construction phase, in addition to the development and implementation of a monitoring plan. All management and mitigation plans will require prior approval from EAD.

Although the Project footprint will not directly encroach upon the mangroves within the Mirfa landfall area, these mangroves may fall within the area of influence of the construction works and therefore indirect impacts may arise. The poor health of some of these mangroves may result in individuals in these mangrove forests being more susceptible to disturbance and thus a management and monitoring plan, previously approved by EAD, would be advised. Full details on the recommended mitigation, management and monitoring requirements are provided in **Section 5.6.3** and **Section 5.6.4**.

April 2022

Avifauna

During the surveys undertaken in April 2022 a total of 346 individuals belonging to 18 species were recorded. At Shuweihat, 168 individuals belonging to 16 species were recorded while at Mirfa, 178 individuals belonging to 10 species were recorded. The birds recorded at each of the vantage points for both Shuweihat and Mirfa are presented in Table 5-101 below.

Of the species recorded, one is currently listed as vulnerable (VU) on the IUCN List of threatened species while four are listed on the recently published Abu Dhabi Red List of Species. Three of these species were recorded at the Shuweihat site while two were recorded at the Mirfa site. These species are given in Table 5-102 below.

Table 5-101: Avifauna recorded by Anthesis at Shuweihat (W1-W8)

Species	Common Name	ADRLS Status	IUCN Status	VP W1	VP W2	VP W3	VP W4	VP W5	VP W6	VP W7	VP W8	Total Shuweihat	Total species
Charadrius alexandrinus	Kentish Plover				1				8			**9**	**1**
Limosa lapponica	Bar-tailed Godwit									4		**4**	**1**
Chroicocephalus genei	Slender-billed Gull								20			**20**	**1**
Egretta gularis	Western Reef-Heron			1	1							**2**	**1**
Pandion haliaetus	Osprey	EN			1							**1**	**1**
Phoenicopterus roseus	Greater Flamingo					1						**1**	**1**
Galerida cristata	Crested Lark						1					**1**	**1**
Spilopelia senegalensis	Laughing Dove					1		14				**15**	**1**
Numenius arquata	Eurasian Curlew			3			3	3				**9**	**1**
Calidris alba	Sanderling			5	3							**8**	**1**
Pycnonotus leucotis	White-eared Bulbul				2	3						**5**	**1**
Coracias benghalensis	Indian Roller					1						**1**	**1**
Hydroprogne caspia	Caspian Tern									7	3	**10**	**1**
Calidris alpina	Dunlin						1					**1**	**1**
Pluvialis fulva	Pacific Golden-Plover		LC		1							**1**	**1**
Charadrius mongolus	Lesser Sand-Plover		LC				80					**80**	**1**
											Total:	**168**	**16**

Table 5-102: Avifauna recorded by Anthesis at Mirfa (E1 – E5)

Species	Common Name	ADRLS Status	VP E1	VP E2	VP E3	VP E4	VP E5	Total Mirfa	Total Species
Charadrius alexandrinus	Kentish Plover		11		15	4	3	**33**	**1**
Chroicocephalus genei	Slender-billed Gull			23		8		**31**	**1**
Egretta gularis	Western Reef-Heron		3	1	2		1	**7**	**1**
Streptopelia decaocto	Eurasian Collared-Dove						10	**10**	**1**
Himantopus himantopus	Black-winged Stilt		3					**3**	**1**
Galerida cristata	Crested Lark			9	12			**21**	**1**
Spilopelia senegalensis	Laughing Dove			4		13		**17**	**1**
Pycnonotus leucotis	White-eared Bulbul			42	2		2	**46**	**1**
Circus aeruginosus	Western Marsh Harrier	VU				1		**1**	**1**
Hydroprogne caspia	Caspian Tern		5					**5**	**1**
Passer domesticus	House Sparrow					2	2	**4**	**1**
							Total	**178**	**10**

5.6.2. Environmental Impact Prediction and Evaluation

5.6.2.1. Approach to the Ecological impact assessment (EcIA)

5.6.2.1.1. Introduction

In defining Ecological Impact Assessment, Treweek (145) states that:

he ecological impact assessment (EcIA) is firmly rooted in ecological science, drawing on traditional techniques of survey, monitoring, functional analysis and predictive modelling. In addition, however, EcIA requires evaluation of the implications of any predicted outcomes. It is this aspect of evaluation which distinguishes EcIA from the pure science of ecology and which has created demand for new approaches to the ways in which ecological information is handled... Ecological outcomes must therefore be translated into a common language or scale for comparison with other findings, whether these are of a social, economic or political nature. In short, EcIA should provide a scientifically defensible rationale for decision ma ing and for environmental management

The purpose of an EcIA is to provide reliable information about, and interpretation of, the ecological implications of any project or policy, from inception to operation and, where appropriate, decommissioning. An ecological assessment is an integral part of the preparation of an Assessment of Environmental Effects (AEE) supporting a permitting application for a development.

Ideally, an ecologist should be involved in the early project discussions with the proponent and his/her advisors about whether ecological issues are likely to be such that an EcIA will be needed, and, if so, at what level or scale. In its simplest form, an assessment may determine at the scoping stage that potential and actual effects will be minor or negligible so that further investigations are unnecessary. Authorities need to receive a good quality EcIA in order to decide on whether to approve, either fully or with limited notification, where there are effects on ecological components.

Notification is undertaken when the effects of the proposed activity are considered to be more than minor – a rigorous assessment of effects is needed to guide consent staff on this, even if the proposal is small in scale. Although EcIA is commonly used for large developments or major activities, it might equally apply to any occasion where change must be assessed; for example, monitoring and management of protected areas, monitoring of biodiversity across whole landscapes, assessing the potential impacts of proposed developments, or Strategic Environmental Assessment (SEA). EcIA should be integrated with the stages of project or policy development and complement or link to work in other disciplines being carried out in undertaking an EIA.

5.6.2.1.2. Approach for the Development of an EcIA

Having described or characterised the ‘existing environment’, the next step is to assess the value or values of that environment, in order to ultimately assess the scale of predicted impacts. By definition, evaluation of ecological features (sites, species, ecosystems, processes etc.) is an expression of human values. Individuals vary greatly in the value they place on any aspect of the environment. The term ‘value’ is used synonymously with ‘importance’ in this document. Areas of indigenous vegetation or habitat can also have recreational, cultural, landscape or spiritual values. Just as an ecologist may rely on the knowledge and information provided by another professional to assist in evaluation, ecological information may feed into these other types of value. This document will, however, address only ecological value.

The term ‘significance’ has a particular meaning when discussing impact assessments and should be reserved for use in that context. Usually significant /not significant is a binary condition – there are no degrees of significance. But the ecological value or importance of an area is a continuum ranging from (for example) none to very high. In general, an area of very high or high ecological value is likely to reach the threshold to be considered ‘significant’.

In this section, a method is proposed for assigning value for terrestrial sites that uses criteria that are consistent with those commonly used for significance assessment, but that allows for a ranking of ecological value, rather than simply assessing an area as 'significant' or 'not significant'.

Matrix Approach

Ecological features can be considered at a range of spatial and organisation scales (e.g. species, ecosystems, vegetation communities or habitats). A range of methods have been applied to assign value at these various scales, ranging from descriptive narratives, to highly structured formal evaluations such as threatened species lists for individual species, and the Abu Dhabi Emirate Habitat Classification and Protection Guideline (144)

Here, we propose a framework using a matrix to integrate these various levels of ecological evaluation and provide the overall assessments of ecological value that are required for impact assessment. The framework is based on guidelines developed by the Institute of Ecology and Environmental Management (146). The IEEM approach entails three main steps:

- Ecological values are ranked on a scale of Low, Moderate, High, or Very High (in order to obtain a central medium, we used Negligible, Low, Moderate, High, or Very High);
- The magnitude of effects on these values is ranked on a similar scale; and
- The overall importance (or 'significance') of effect is determined by a combination of value and the magnitude of the effect.

This matrix framework does not replace the need for rational interpretation of ecological data based on a sound understanding of environmental principles. An impact assessment always requires professional ecological judgement to explain the judgement and simple cases may not require a matrix approach. Placing ecological interpretation within a standard framework should lead to more consistent and transparent assessments of effects.

Sites to be Assessed

Ecological evaluation typically comprises assessment of:

- Sites that have previously been recognised as having ecological value and assigned a value. Many projects will potentially affect sites that have already some assigned value and level of formal protection based partly or entirely on their ecological values (e.g. National Parks; conservation areas and reserves; significant areas of indigenous vegetation or significant habitats of indigenous fauna). They may also potentially affect sites that, although not formally protected, have been identified as having value in other ecological publications, e.g. recommended areas for protection (RAPs). The fact that these sites have some existing formal status or level of recognition warrants consideration, and may require re-evaluation, as part of project investigations. Where the ecologist's evaluation differs from a previous evaluation, the reasons for this need to be explained; and
- Sites identified in the course of investigations of the specific project to be of ecological value (but not previously recognised as having value), Assessments of ecological value of these sites will be based on the review of existing data and additional investigations.

Levels of Ecological Organization

For any given site, it is conventional to assign value at some or all of the following levels of ecological organisation:

- Species (or in some cases sub-species or taxonomically indeterminate taxa);

- Assemblages or communities of plants and/or animals, especially when considering vegetation and soils (‘vegetation types’);
- Habitats. Habitats in the UAE are determined by vegetation and abiotic components and can be seen as synonymous with ecotopes; and
- Species specific habitats. Some habitats may contain little or no vegetation. Vegetation of low value, in itself, may provide habitat for high value fauna.
- Genetic and molecular levels of ecological organisation are not usually considered by EcIA.

Questions of Spatial Scale

Questions relating to spatial scale often arise, especially when dealing with impacts that may be spread over large spatial scales, sometimes in a fragmented manner: what sized units of vegetation or habitat should be considered? At what spatial scale should they be evaluated e.g. local, regional, national, or international? How should local authority boundaries be addressed in relation to Ecological District boundaries?

There are no consistent or generally accepted, definitions of ‘local’ or ‘regional’. Assessments often vary between using the local authority boundaries (where generally, District = local, Region = regional) and Ecological Region and District boundaries as the spaces within which value is assessed. The latter system is most appropriate in ecological terms. However, there may be circumstances where due to overlaps or distances between Ecological District/Region and local authority boundaries, an ecological feature that is common throughout an Ecological District is rare in a particular local authority area, or vice versa. It is important that the EcIA identify the local and regional study areas, where applicable.

Decisions about which ecological features, and at what level of organisation and spatial scale to evaluate them, are influenced by the assessment of effects and mitigation requirements. The values and effects on individual species should not be overlooked or amalgamated or averaged; but where there are likely to be effects of a similar level of significance, requiring similar mitigation actions, these can be addressed together at the community or assemblage level. For example, an area or site (such as a wetland) is likely to contain a variety of habitats, vegetation types, and plant and animal communities and assemblages having different values. These should be treated separately or grouped according to value, likely seriousness of effects, and mitigation opportunities for components.

5.6.2.1.3. Assigning Value

Assigning Value to Sites or Areas

When assigning value to sites or areas it is important that representativeness of the site or area, rarity/distinctiveness of the site or area, diversity and patterns within the site or area and the ecological context of the site or area are considered. Factors to be considered when assigning ecological value to a site or area, as well as the topics contributing to those factors, are given in Table 5-103.

Table 5-103: Factors to be considered when assigning ecological value to a site or area

Factor	Topics for which criteria are needed
Representativeness	– Extent to which area is typical or characteristic size
Rarity/distinctiveness	– Amount of habitat or vegetation remaining – Supporting nationally or locally threatened, at risk or uncommon species – Regional or national distribution limits – Endemism – Distinctive ecological features – Natural rarity
Diversity and pattern	– Level of natural diversity – Biodiversity reflecting underlying diversity
Ecological context	– Contribution to network, buffer, linkage, pathways – Role in ecosystem functioning – Important fauna habitat – Contribution to ecosystem services

Assigning Value at the Species Level

In order to assign value to individual species the most consistent method to use would be the global and/or national threat classification or protected status, as given in Table 5-104. The values assigned to these classifications are given in Table 5-105. Other methods such as keystone status within the study area or local importance can be used in cases where these attributes are demonstrable.

Table 5-104: Threat classification for species

Threat Classification	Threat Classification Authority
Globally threatened	International Union for Conservation of Nature (IUCN)
Critically endangered (CR)	
Endangered (EN)	
Vulnerable (VU)	
Nationally threatened	National Threatened Species Lists
Critically endangered (CR)	
Endangered (EN)	
Vulnerable (VU)	
Nationally protected	Ministerial Decree No. 224 of 2015 On the Protection of Wild Plants Species
Protected by decree	Federal Decree-Law No. 9 of 1983 (All bird species and eggs, Spiny tailed Lizard)

Table 5-105: Values given according to the classifications of species

Determining factors	Value
Globally or nationally threatened species	*Very High*
Nationally protected	*High*
Species listed as any other category of "At Risk" or demonstrable local importance or keystone species.	*Moderate-high*
Common indigenous species	*Low to Moderate*
Domestic or feral species	*Negligible*

Assigning Value at the Terrestrial Vegetation, Habitat or Ecosystem Level

In the UAE the term "habitats" are used to describe the vegetation communities or ecotopes occurring within the UAE. This is, in itself, slightly problematic as habitats are usually related to a specific species that resides within that habitat type and is not generally used to describe a vegetation community or ecotope occurring throughout a region.

However, as this is the nationally accepted term used to describe ecotopes or vegetation communities, this nomenclature is used pervasively in EcIA documents, until a more internationally accepted term is used to replace it. In *Abu Dhabi Emirate Habitat Classification and Protection Guideline,* Al Dhaheri et al (144) assign sensitivity to the habitat types occurring within the UAE. Three sensitivity types are defined within the guidelines (144), and are as follows:

- Critical habitats, which are described as "an ecosystem type of high biodiversity value" due to:
  - Habitat of significant importance to endemic species, rare species, locally threatened species or globally critically endangered, endangered species or vulnerable species;
  - Areas that are necessary for key stages of the life cycle of native species;
  - Habitat supporting globally significant concentrations of migratory species and/or congregatory species; and/or
  - Highly threatened and/or unique ecosystem, as per an assessment process based and adapted from the IUCN Red List of Ecosystems Criteria (Bland et.al, 2016). National Priority 2: To protect indigenous vegetation associated with sand dunes and wetlands; ecosystem types that have become uncommon due to human activity.
- Environmentally sensitive habitats, which are defined as "an ecosystem type that:
  - Any further loss of its natural habitat or deterioration of condition in these habitat types could result in it becoming critical; and / or
  - The ecosystem types are likely to have lost some of their structure, and functioning, and will be further compromised if they continue to lose natural habitat or deteriorate in condition.
- Natural habitats;
  - These can be described as natural habitats with negligible to moderate levels of degradation;
  - Because these categories do not consider local conditions or the presence or absence of species of conservation importance, these factors need to be assessed on a case by case basis; and
  - Habitats may not be listed in Al Dhaheri et al (144), but may be of higher value, due to it hosting species of conservation importance.

- Severely degraded habitats:
  - These are habitats that are severely degraded due to human activities;
  - Usually fall within the 8000-habitat type;
  - May still be important due to ecosystem functions such as breeding bird habitat; and
  - Could still be rehabilitated or restored to a functional natural habitat with an excessive amount of intervention.
- Transformed habitats:
  - These are areas that have been completely transformed by human intervention;
  - Usually fall within the 9000-habitat type;
  - Are unimportant for ecosystem services; and
  - Could usually not be rehabilitated.

Assigning Value to Ecosystem Services

In the simplest definition, ecosystem services are ‘benefits that people obtain from ecosystems. The Millennium Ecosystem Assessment (147) highlighted the importance of these services, while The Economics of Ecosystems and Biodiversity initiative (TEEB) is one of many organisations working to quantify and develop accounting methods for them.

Ecosystem services link closely with the “life-supporting capacity of ecosystems”. The science and policy around ecosystem services is not well developed. Nevertheless, an ecologist carrying out an EcIA needs to recognise and describe them. If it appears that ecosystem services may be impacted by a proposal, then more detailed assessment should be carried out. Due to the lack of guidelines on the values assigned to ecosystem services these values are usually left to the discretion of the ecologist conducting the study.

The four types of ecosystem service are:

- Support (or habitat) services; e.g. habitats for plants and animals on which other services are based; genetic diversity;
- Regulating services; e.g. pollination, bio-control, erosion and flood control;
- Cultural services; e.g. for recreation and tourism; culturally or spiritually important ecosystems and habitats;
- Provisioning services; e.g. habitats for food species; drinking and irrigation water; bio-prospecting; and
- Research areas.

5.6.2.1.4. Assessing Impacts

Describing Activities

The ecologist must identify and describe the specific effects potentially caused by activities (either singly or in combination). To do this the ecologist must have a good understanding of the proposal and be clear about:

- what activities will be undertaken;
- where they will be carried out;
- how they will be carried out;
- when (including duration and when the activities may cease); and
- by whom they will be carried out.

This includes both construction and operational activities for which consent (or other planning permit, concession etc.) is required. The regulatory body may also require information about, and assessment of, effects of decommissioning.

Activities may be temporary or permanent/on-going; and the effects they may cause may be:

- temporary (especially, but not always during construction), e.g. access roading to pylon sites;
- permanent (especially those associated with the operation of something that has been constructed), e.g. stormwater management system, road;
- direct, e.g. removal of vegetation;
- indirect, e.g. landform shaping affecting waterways; and
- off-site, e.g. at a workers' accommodation site.

Sometimes, 'mitigation' activities that reduce the adverse effects at the site may be considered to be part of the project. This may be a matter of legal requirement or best practice (e.g. stormwater treatment to maintain water quality) or project design (e.g. enhancement of a waterway through a residential subdivision.) These project components can be included in the initial assessment of effects or treated as separate mitigation actions incorporated at the redesign stage. Either approach is acceptable as long as the components are clearly defined.

Construction Activities likely to Impact on Ecological Features

These will vary in detail according to the purpose of the construction activity (e.g. road, building, jetty, wind farm) but there are general types of activity that have effects on ecological values:

- Excavation and earthworks, including waterway diversion;
- Abstraction and drawdown of water;
- Import of soil and other fill materials;
- Use of machinery and vehicles on site – compaction, noise, hazardous chemicals, dust;
- Increase in human activity associated with construction – noise, pests, litter, facilities and services;
- Vegetation clearance in construction corridors and access areas; and
- Construction of stormwater management structures.

Operational Activities likely to Affect Ecological Values

These too will be specific to the proposal being assessed, but generally effects on ecological values will be associated with:

- Use of noisy equipment/machinery/vehicles;
- Discharging to water or land;
- Taking water from the surface or groundwater;
- Presence of structures (e.g. turbines, dams, bridges, culverts);
- Introduction or increased presence of humans (e.g. workers, tourists, recreational visitors); and
- Management associated with environmental enhancement (e.g. indigenous planting, pest control, legal protection).

Decommissioning Activities likely to Affect Ecological Values

Because decommissioning is likely to occur in the distant future, it will not be possible to describe in detail activities and effects. Many decommissioning activities will be those associated with construction (deconstruction). Other effects may arise through the removal of environmental enhancement management or cessation of activities that were having adverse effects.

5.6.2.1.5. Describing the Effects on Ecological Features

Parameters

When describing or characterising the potential effects on ecological features from activities at any stage, the following aspects must be considered:

Direct or indirect. As well as direct effects on ecological features and processes found or occurring within the zone of influence, are there potential indirect effects caused by changes brought by the project. For example, weed or pest incursions into adjacent lands facilitated by establishing worker camps for the project.

Positive or beneficial as well as **adverse** effects should be assessed.

Spatial scale or **extent**. Over what area will the impact act? What area of habitat or vegetation type could be affected? This should be expressed in terms such as study area, corridor, project footprint, or zone of influence which were established at the start of the assessment process. Distance of the effect from the activity causing it is not a measure of the level of ecological effect.

Temporal scale. Will the effect be temporary or permanent; continuous or occasional? At the start of the assessment process, timescales should have been established and defined; ideally these should tie in with project stages, but this is not always possible. The timescales should make sense in ecological terms (e.g. relating to periods such as life cycles or vegetation regeneration times.

Duration. This is the time for which the effect will last and should be measured in ecological timescale rather than human (e.g. fish life cycles). An activity may be short in duration but the effect on a population or community may be long term

Reversibility. Are the potential effects reversible – either totally or partially? This can apply to both positive and adverse effects. An irreversible (permanent) effect is one from which recovery is not possible within a reasonable timescale; a reversible one (temporary) is an effect for which natural recovery may be possible or for which there is a commitment for mitigation action at the site (e.g. rehabilitation of ground cover).

Timing. How will the timing of undertaking activities and occurrence of their effects relate to plant or animal cycles and patterns? At what time of year will they occur and how does this relate to events such as breeding or migration?

Risk and uncertainty. The EcIA process is itself uncertain, since long term outcomes cannot be proved. In the UAE there are gaps in knowledge about biodiversity (distributions, occurrences, trends etc.) and ecological processes and relationships. Many of these are fundamental to evaluation and assessments of effects on ecological values. It is not reasonable or, indeed, possible for a project proponent to fill in many of these gaps (for example, population trends or regional species distributions). The ecologist must take a reasoned approach to uncertainty around both the availability of data and the delivery of forecast outcomes, and the risk this poses to biodiversity (and possibly to the project). Expert opinion must be used to make assessments, evaluations and predictions where there is insufficient information. The way in which such analysis has been done should be documented.

Confidence in predictions. Given the data available on all aspects of the project and of the ecological features studied, the ecologist should give an indication of the confidence in the predicted effects, that is, the likelihood of them occurring in the way predicted. Some things will be certain, e.g. vegetation clearance will reduce the population of some species by a proportion that can be measured or estimated; other effects less certain, e.g. the potential effects of a wind turbine on a migratory bird species is more difficult to predict. Modelling tools can assist in predicting effects and the level of effects (e.g. stormwater run-off models that predict the amount of sediment likely to reach a waterway). However, the limitations of any model must be recognised, and predictions used with appropriate levels of caution. When using model (or any other) information provided by a third party, the ecologist must ensure s/he has a good understanding of that model and its limitations.

Potential Effects on Ecological Features

When characterising effects, the ecologist should refer to a wide range of aspects of ecological structure and function. Broadly these include:

- Physical resources/environment;
- Stochastic processes;
- Ecological processes;
- Human influences on ecological patterns and processes;
- Historical context;
- Ecological relationships; and
- Ecosystem properties.

These features may be affected directly or indirectly or cumulatively through any activities causing disruption, such as:

- Fragmentation or isolation e.g. by removal of vegetation;
- Loss/ mortality;
- impact with structures;
- Food chain effects;
- Disturbance e.g. through increased human access, construction vehicles, noise;
- Barriers e.g. through damming, roading;
- Removal, reduction of physical resource e.g. by abstraction of water, removal of vegetation; and
- Change in physical resource e.g. through change to flow regime/patterns, run-off.

5.6.2.1.6. Evaluation of the Level of Effect of Impacts

Matrices are tools to assist in clarifying the evaluation of the level of effects, although in reality effects occur along a continuum. Matrices must always be accompanied by discussion and interpretation of the information they summarise, and the limitations and uncertainty associated with their use. The matrices proposed here are based on Regini (148; 149), used in developing the IEEM Guidelines. The approach proposed is that the level of an effect is determined by a combination of the magnitude of the effect and the value of the receptor (affected ecological feature). Magnitude is determined by a combination of scale (temporal and spatial) of effect and degree of change that will be caused in or to the ecological component.

5.6.2.1.7. Criteria for Describing Significance of Effect

A detailed description of the methodology used to describe the significance of the effect of an impact is given in **Section 5.6.2.2**. However, a basic understanding of the assigning of value to ecological components is outlined here. Assigning value to species

As discussed earlier, there is no nationally agreed method for assigning 'value' to species in a way that can be used in impact assessments in the UAE. A very simple system based on national threat classification lists with additional placing for 'locally rare' species was described in Table 5-103, and is shown again in Table 5-106.

Table 5-106: Assigning value to species for assessment purposes

Determining factors	Value
Globally or nationally threatened species	*Very High*
Nationally protected	*High*
Species listed as any other category of "At Risk" or demonstrable local importance or keystone species.	*Moderate-high*
Common indigenous species	*Low to Moderate*
Domestic or feral species	*Negligible*

5.6.2.1.8. Assigning Value to Vegetation Types or Habitats

In the absence of a national system for valuation, a proposed method is shown in Table 5-107, which is aligned with the habitat sensitivities as outlined by Al Dhaheri, et al.in the *Abu Dhabi Emirate Habitat Classification and Protection Guideline* (144).

Table 5-107: Assigning value to vegetation or habitat for assessment purposes

Ecosystems	Assigned value	Comment
Critical habitats	Very high	-
Environmentally sensitive habitats	High	-
Natural habitats	Moderate (unless hosting species of conservation importance)	Must be assessed on a case by case basis
Severely degraded habitats	Low	Must be assessed on a case by case basis
Transformed habitats	Negligible	-

Once determined significance or level of effect can be used as a guide to the extent and nature of ecological response required (including the need for biodiversity offsetting). For example:

- Critical effects are "red flag" effects that cannot be avoided or mitigated and are usually considered an obstacle to further progress;
- Very high are unmitigable effects and biodiversity offsetting should be considered where these adverse effects cannot be avoided;

- High represent a high level of effect on ecological or conservation values and warrant avoidance and/or extremely high intensity mitigation and remediation actions;
- Moderate represents a level of effect that requires careful assessment and analysis of the individual case. Such an effect could be mitigated through avoidance, design, or extensive appropriate mitigation actions;
- Low effects Are usually effects that although can be of moderate concern, are easily mitigated;
- Very low effects are usually minimized by normal design, construction and operational care; and
- Negligible effects can generally be considered as 'not more than minor' effects and should not normally be of concern.

5.6.2.1.9. Cumulative Impacts

"Cumulative effects are changes to the environment that are caused by an action in combination with other past, present and future human actions" (150). There are many definitions, but this simple one encompasses the fundamental aim of assessing cumulative effects.

In 2003 a UNEP Working Group noted:

"*However, there is often little understanding among regulatory authorities and developers of the concept of cumulative effects. This is also true in part for environmental impact assessment practitioners*" (UNEP, 2003).

An assessment of cumulative effects of a proposal should:

- Assess effects over a larger (e.g. 'regional') area that may cross jurisdictional boundaries; this includes effects due to natural perturbations affecting environmental components as well as other human actions;
- Assess effects occurring over a longer period than the specific project (both past and future);
- Consider effects on valued ecological features or attributes due to interactions with other actions, and not just the effects of the single action under review;
- Include other past, existing and future (i.e. reasonably foreseeable) actions beyond the specific project in question; and
- Evaluate the level of cumulative effects in consideration of other than just local, direct effects.

Cumulative effects are not necessarily very different from direct or indirect effects examined in an EcIA; in fact, they may be the same; e.g. where the EcIA considers the various components of a project footprint together such as a quarry and its access road. Cumulative effects assessment ensures that assessment is considered at an Ecological Region or District scale where appropriate.

The assessment must determine:

- how large an area around the action should be assessed;
- how long in time, and
- how to practically assess the often-complex interactions among the actions.

5.6.2.1.10. Impact Management and Mitigation

Avoidance

The avoidance of impact on biodiversity or ecological values is the most effective element of managing adverse effects. It can be spatial (e.g. through locating the proposal or a component of the proposal somewhere else to avoid sensitive habitat or vegetation); or temporal (e.g. avoiding an activity during bird migration or roosting periods which will reduce impacts on bird populations and recruitment).

For avoidance to be successful, ecological impacts need to be considered during the early stages of a project so that modification of design and operations can be taken into consideration. However, avoidance through project redesign can occur at any stage of the project. Avoidance can gain particular impetus when the practicalities or costs of mitigation and ecological enhancement (offsetting or compensation) become apparent. Although the avoidance of ecological impacts is considered early in some sectors of industry, there can be some reluctance to implement it if other alternative impact management approaches are available.

Legal protection status may require that specific areas are avoided. At a local level, in most cases protection or regulation follows the recognition of significant ecological or natural areas (SEAs or SNAs), generally identified and mapped in regulatory documentation or via published and unpublished records. For some activities based on natural resources, avoidance may not be possible since their location is dependent on the location of the resource (e.g. quarrying specific materials; development). In some cases, it may be possible to manage some impacts through timing of specific actions. In others there will be unavoidable adverse effects on biodiversity and ecosystems. Avoidance of impacts carries the greatest certainty of outcome for biodiversity within the proposed project footprint. Where risk and uncertainty form an important part of the impact management assessment process, avoidance should therefore be given the highest priority over other steps of the impact management ‘hierarchy’ for which outcomes are less certain and risk of failure more likely i.e. remedying, mitigating, offsetting or compensation.

Remediation / Rehabilitation / Restoration

These are remedying measures taken to improve degraded or removed ecosystems following exposure to impacts that cannot be completely avoided. Although the terms remediation, rehabilitation and restoration are often used interchangeably the meaning of each in practice is quite specific.

- Restoration attempts to return an area to the original ecosystem that occurred before impacts.
- Rehabilitation aims to restore basic ecological functions and/or ecosystem services (e.g. through planting vegetation alongside streams to carry out riparian functions; or enhancement planting within remnant forest).
- Remediation is the action of trying to improve the condition of an ecosystem, especially in reference to the reversal or stopping of damage to the environment. It encompasses actions taken to promote regeneration.

Remediation, rehabilitation and restoration are typically needed towards the end of a project’s lifecycle, but it may be possible to implement them either prior to commencement or during construction and operation of a development. Early initiation of these steps is recommended.

Mitigation: Minimization (Moderation, Reduction)

These are the measures taken to reduce the duration, intensity and/or extent of impacts that cannot be completely avoided. Effective minimisation can eliminate some negative impacts. Examples include implementing best practice guidelines for storm water management, earthworks and sediment management; air quality controls and treatment prior to discharge; designing infrastructure to reduce the likelihood of fatalities or injury to wildlife; reducing barriers to plant dispersal and animal movements; or building wildlife crossings on roads.

Mitigation: Translocation, Relocation, Rescue

Any transfer of plants or animals requires integrated and preparatory planning to ensure that the plant/ animals are in good condition prior to the move and that a suitable receiving environment is well-established prior to transfer. Transfer of indigenous species of animal usually requires a permit from the relevant authority. These elements must be considered early in the EcIA process as they can involve considerable time requirements for procedural processing and implementation.

Biodiversity Offsetting

As considered by the hierarchy, avoidance, remedy and the components of mitigation serve to reduce, as far as possible, the impacts that a development may have on the ecological character, community and function project of an area. Often these steps are sufficient to provide overall mitigation for the potential or actual impacts of a planned project. However, in some cases, even after best attempts have been carried out and effectively applied, there are residual adverse effects on biodiversity or ecological values that cannot be mitigated. To address these, additional steps may be required to deliver No Net Loss or a Net Positive Impact. Biodiversity offsets are measures taken to counterbalance any residual adverse impacts after implementation of the hierarchy. Biodiversity offsets are of two main types: 'restoration offsets' which aim to rehabilitate or restore degraded habitat, and 'averted loss offsets' which aim to reduce or stop biodiversity loss (e.g. future habitat degradation) in areas where this is predicted. Offsets are often complex and expensive, so attention to earlier steps in the hierarchy is usually preferable.

Compensation

This term is used when positive actions to protect and/ or enhance biodiversity values take place as a result of the project and positive outcomes for biodiversity are predicted and/or achieved, but 'no net loss of biodiversity' cannot be ensured. Environmental compensation may be carried out at the site of the adverse activity or nearby (151). In practice, compensation can be wide-ranging and may include: actions to protect and/or enhance biodiversity values at a site distant from the site of the adverse effects; biodiversity/ecological research or education initiatives; interpretation and access initiatives related to biodiversity and ecological features; and funding for existing or new community biodiversity projects.

Supporting Conservation Actions

These are additional measures taken by the proponent which have positive effects on biodiversity. However, they are difficult to quantify and often difficult to link to the effects of the proposal being assessed. These qualitative outcomes do not fit easily into the mitigation hierarchy but may provide crucial support to mitigation actions. For example, awareness activities may encourage changes in government policy that are necessary for implementation of novel mitigation; research on threatened species may be essential to designing effective minimisation measures; or capacity building might be necessary for local stakeholders to engage with biodiversity offset implementation.

Biodiversity Offsets

Biodiversity offsetting is defined as:

"Measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken. The goal of biodiversity offsets is to achieve no net loss and preferably a net gain of biodiversity on the ground"

Figure 5-209 illustrates the application of the hierarchy in this area as described by Business and Biodiversity Offsets Programme (152). Working from the left: at each of the first four stages a step is applied to the Predicted Impacts of a proposal: avoidance; minimisation; finally, restoration (or remediation). At this point there remain unmitigated residual impacts so there is a net loss of biodiversity. By developing an offset, the net loss is turned into a net gain; and this is increased with the further additional (supporting) conservation actions.

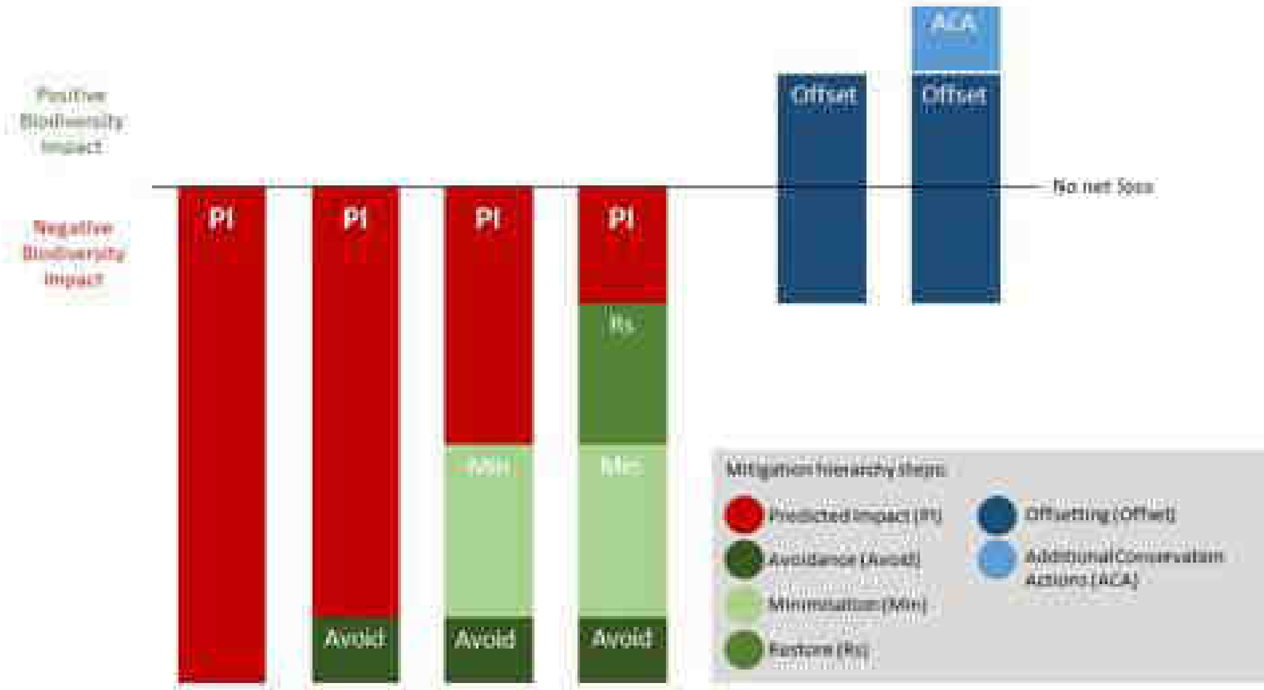


Figure 5-209: Impact management for net biodiversity gain

As illustrated in Figure 5-209, it is important to note that biodiversity offsetting should be used to assist develop a suite of impact management actions. By itself, and especially at an individual project level, biodiversity offsetting, even when planned and implemented effectively is still likely to result in net loss of ecological values from the project area and landscape Offsetting that is voluntarily applied by business, which includes all adverse effects at a site and seeks to provide a net positive impact outcome, is more likely to result in overall positive benefits to biodiversity. In locations where there is no regulatory requirement to do otherwise, offsetting considers only significant adverse effects (not activities for which their effects are deemed insignificant) and many projects avoid regulatory constraints on development impacts if activities are within permitted thresholds. Therefore, even the best no-net-loss impact management may contribute to local or regional decline of biodiversity.

A number of issues have arisen including in relation to offsetting:

- Offsetability / limits to offsetting – how to determine whether a biodiversity feature is so valued that it cannot be offset;
- Measuring and accounting for biodiversity loss and gain – how to measure net values and calculate future values at an offset site, determine equivalence of exchange between biodiversity types, and apply accounting frameworks to provide risk-adjusted exchanges over time;
- Offset site – how to locate similar sites and achieve measurable biodiversity; and
- Certainty – how to be sure that offset management work is ecologically and financially feasible, and provides guarantees of permanence of conservation gains into the future. Good process, scientific accuracy,

transparency, consultation and documentation are essential in considering offsets as part of the impact management package.

Internationally, ten principles for biodiversity offsetting were developed by the Advisory Committee of the Business Biodiversity Offsets Programme. These provide a comprehensive foundation when offsetting is considered in jurisdictions where established environmental laws are absent or ineffective. The ten principles establish a framework for designing and implementing biodiversity offsets and verifying their success and are listed as follows:

- **Principle 1.** Adherence to the mitigation hierarchy: A biodiversity offset is a commitment to compensate for significant residual adverse impacts on biodiversity identified after appropriate avoidance, minimization and on-site rehabilitation measures have been taken according to the mitigation hierarchy;
- **Principle 2.** Limits to what can be offset: There are situations where residual impacts cannot be fully compensated for by a biodiversity offset because of the irreplaceability or vulnerability of the biodiversity affected;
- **Principle 3.** Landscape context: A biodiversity offset should be designed and implemented in a landscape context to achieve the expected measurable conservation outcomes taking into account available information on the full range of biological, social and cultural values of biodiversity and supporting an ecosystem approach;
- **Principle 4.** No net loss: A biodiversity offset should be designed and implemented to achieve in situ, measurable conservation outcomes that can reasonably be expected to result in no net loss and preferably a net gain of biodiversity;
- **Principle 5**. Additional conservation outcomes: A biodiversity offset should achieve conservation outcomes above and beyond results that would have occurred if the offset had not taken place. Offset design and implementation should avoid displacing activities harmful to biodiversity to other locations;
- **Principle 6**. Stakeholder participation: In areas affected by the development project and by the biodiversity offset, the effective participation of stakeholders should be ensured in decision-making about biodiversity offsets, including their evaluation, selection, design, implementation, and monitoring;
- **Principle 7**. Equity: A biodiversity offset should be designed and implemented in an equitable manner, which means the sharing among stakeholders of the rights and responsibilities, risks and rewards associated with a development project and offset in a fair and balanced way, respecting legal and customary arrangements. Special consideration should be given to respecting both internationally and nationally recognised rights of indigenous peoples and local communities;
- **Principle 8**. Long term outcomes: The design and implementation of a biodiversity offset should be based on an adaptive management approach, incorporating monitoring and evaluation, with the objective of securing outcomes that last at least as long as the development project's impacts and preferably in perpetuity;
- **Principle 9**. Transparency: The design and implementation of a biodiversity offset, and communication of its results to the public, should be undertaken in a transparent and timely manner; and
- **Principle 10**. Scientific information, and, where applicable, traditional knowledge, shall be utilised when designing.

How Much Mitigation to Apply

One of the key questions around ecological impact management is "how much mitigation is needed?" This relates to the amount of ecological work to ensure no net loss and the nature of work needed to meet regulatory requirements. It is closely associated with the cost of doing such work to the proponent, so must be discussed openly between proponent and ecologist/ consultant.

The ecologist should propose the amount of compensatory ecological enhancement that they consider necessary to address the damage or loss through adverse effects and meet relevant regulatory requirements. They should be prepared to put a cost on implementation of this work (including long term management needed) and to discuss this with the proponent/client. They should also be prepared to discuss this with consenting authority staff (reporting officers).

The assessment of biodiversity value affected, and the scale of adverse effects guides what action is needed and where. As a guide, the amount of enhancement effort and activity needed is guided by:

- National standards or policy;
- Regional/District policy;
- Significance of ecological values adversely impacted;
- Level of ecological effects;
- Feasibility of implementation;
- Costs and benefits and likelihood of success of impact management; and
- Proponent's ability and willingness to pay.

There is no published guidance on what area, habitat, vegetation, or number of plants or animals need to be protected, restored or otherwise managed to mitigate or adequately compensate for effects on a specific area or number subject to adverse effects. This remains something that is the subject of expert judgment and stakeholder consultation for each project and environment, taking into account the seven factors listed above.

Where there are multi-ecosystem type impacts, policy directives such as 'like for like' and 'no net loss' generally distinguish between the different types of impact management required. For example, quantification of impacts on a remnant forest are separate from impacts on a riparian margin or a wetland. It follows that any compensatory impact management (offset, conservation actions, compensation) needs to be clearly distinguished for each ecosystem type. In some cases, 'trading up', where impacted values are compensated for by improvements to values of higher conservation priority in a 'like-for-unlike' offsetting exchange, may be permitted, encouraged or even required as part of a formal offsetting assessment.

Double-dipping occurs where the management of impacts on one ecosystem type are counted again as management of impacts on a different ecosystem type. For example, the planting of 2 ha of stream margin as offset for the loss of a waterway cannot be again counted as 2 ha for the offset planting for the removal of an area of wetland habitat. An evaluation of the additional value generated by proposed management should thus form a key consideration of the offset's contribution towards managing adverse effects on specific ecological values. This ensures that management proposals are truly additional to work that would be undertaken anyway in the absence of the project, and to avoid double-dipping where multiple, overlapping advantages may accrue from single management actions and implementing the offset.

5.6.2.1.11. Monitoring

It is good practice to develop a monitoring programme to review impact assessment outcomes and measure the success (or otherwise) of the implementation of the agreed impact management. Monitoring can occur during the implementation of impact management, at the end, or for a period of time after the completion of impact management, or even a combination of all three. It will involve some measurements prior to the commencement of the development to form the baseline against which any anticipated changes or enhancements are measured; or indeed to confirm that there are no changes or impacts.

This presents a tension between good ecological management practice and statutory requirements in relation to the amount and nature of monitoring needed, which should be discussed between ecologist and client/employer.

Globally, there is a concern that a lack of monitoring is obscuring biodiversity losses. Monitoring outcomes of impact assessment and consent conditions around biodiversity is not widely carried out (151). Often authorities have limited resources for monitoring and enforcement, making it difficult to meet expectations for those processes.

Design of a monitoring programme that is ecologically rigorous and provides useful information for impact management is an important component of EcIA, but one that is often undervalued. A project proponent may be reluctant to pay for monitoring after a project is implemented, while a consenting authority may not have the staff resources to ensure post-consent monitoring is carried out.

Purpose of Monitoring

In the context of ecological impact assessment, the purpose of monitoring is to:

- Observe and measure (to the extent possible) the actual effects of the proposal assessed on ecological values and biodiversity, to determine the accuracy of predictions of potential effects.
- Observe and measure the progress and outcomes of impact management carried out in relation to ecological values and biodiversity affected by the proposal assessed, to provide feedback on implementation to the proponent and consenting authority.
- Enable better outcomes for ecological values and biodiversity, by informing future assessments, impact management and decision-making.

Types of Monitoring

Although monitoring is now regarded as an essential component of impact assessment, there is a variety of types of monitoring with specific meaning. Different types of monitoring aim to address different ecological questions and serve to meet different management or regulatory needs, including whether previously formulated standards (e.g. National Standards) are being met. As part of any ecological impact assessment some or all aims may be addressed at various times and localities during the investigation. Different types of monitoring include:

- Census: Typically refers to population counts which may be used in monitoring programmes.
- Survey: An exercise in which a set of standardized observations is taken from a site (or series of sites) within a short period of time to furnish qualitative or quantitative data. This form of 'monitoring' is typically carried out at the commencement of an assessment of environmental effects but may be repeated again, during or after development. Typically survey monitoring may form a baseline of the ecological condition of a location or localities for future consideration.
- Surveillance: A continued programme of surveys systematically undertaken to provide a series of observations over time. Observations may include reference or control sites.
- Ecological state of ecosystems: An assessment of the integrity of ecosystems or ecosystem health in relation to a specific impact. This form of monitoring may also be defined as state of environment monitoring but is different (see below). Similar attributes may be measured in each type of monitoring. Observations may include reference or control sites.

- State of the environment (SOE) monitoring: Monitoring undertaken to detect trends over a period of time and usually across a wide area, such as a local authority Region or District. Observations may include reference or control sites. State of the environment monitoring is generally not used to measure the success of specific impact management. However, it may provide information about trends in the wider environmental context against which proposal-related trends can be assessed. SOE monitoring is not discussed further in this document.

Each of the above types will have specific advantages dependent on the objective of the study and the overall question being asked. A clear understanding of the purpose of the monitoring is therefore necessary, along with an understanding of how the information will finally be used (see below).

Design of Monitoring Programmes

Objectives and Purpose of Monitoring

Several possible aims relevant to the assessment of the impacts are considered below:

- To detect every single breach of a particular consent condition.
- To determine whether there is a significant adverse effect on the ecosystem, habitat, community or species.
- To obtain early warning of environmental deterioration by monitoring to detect change in ecosystem, habitat, community or species or a combination of some or all.
- To determine whether ecosystem or habitat conditions or community or species populations are being maintained, improved, or are deteriorating as a result of the development.
- To determine compliance with a specific outcome value or standard.
- To determine the success or otherwise of anticipated mitigation or restoration outcomes

Each monitoring objective will require a different sampling programme design in order to obtain defensible results. Detection or monitoring of spatial biological pattern, natural spatial environmental pattern or natural temporal environmental change, are all confounding influences (or noise) as far as achieving the stated objective is concerned. Study designs therefore must facilitate the making of appropriate comparisons through the collection of relevant data, elimination of confounding effects and the selection of appropriate analyses.

A sampling strategy to meet the given objective must consider the number and locations of sampling sites, sampling methods, sampling frequency, sample replication, sample processing protocols and the need for qualitative, quantitative, semi-quantitative or relative abundance data.

Study Design and the Use of Statistics in Monitoring Programmes

Monitoring programmes invariably involve studying patterns of distribution and abundance of organisms in order to detect environmental changes, and to infer the causes of change by associating biological changes with corresponding changes in biotic or abiotic variables.

Considerations for Monitoring

Several elements need to be considered for any monitoring programme:

- Sample site selection;
- Sampling frequency;
- Sampling methods;
- Sample size and sample replication;

- Qualitative, semi-quantitative or quantitative data;
- Statistical testing and data analyses; and
- Use of remote sensing balanced by field observations.

Cost-effective ecological monitoring as part of EcIA should focus on matters that are key to the proposed impact management:

- Ecological value of the affected species, habitats, ecosystems, targeting valued ecological features;
- Predicted effects of proposal and expected frequency/duration of effects, targeting the effects on valued ecological features;
- Lifecycles and movements of species affected, to ensure the monitoring programme reflects temporal and spatial patterns;
- Predicted outcomes of impact management and timing of their expected occurrence, setting realistic target dates and goals at different stages of impact management;
- Existing monitoring programmes in place relating to the site or affected ecological feature, to avoid duplication but allowing for synergies;
- Requirements for feeding results back into adaptive management programme or consent authority; and
- National, regional or local conservation goals, strategies or policies, to identify gaps in data that might be filled through EcIA monitoring.

5.6.2.2. Environmental Impact Evaluation

5.6.2.2.1. Considerations and Approach

Considerations

In order to objectively assess the impact of the development on the terrestrial ecosystems, within the area of influence of the project, several issues and factors were considered during the development of this EcIA that pertain to the nature of the systems in the study area. These are outlined as follows:

- The impact on terrestrial ecology is expected to be minimal compared to the marine ecology impact as only a very small fraction of the Project footprint actually impacts on terrestrial or intertidal areas;
- Much of the terrestrial study area is characterised by coastal sabkha and disturbed ground, both these habitats are considered low sensitivity areas with regards to biodiversity as few, if any, species inhabit these habitats;
- Coastal sabkha is an important storage of blue carbon, containing a carbon storage of approximately 80 tons/ha (153). Although not assessed as part of the ecological impact assessment the carbon cost of this project, due to disturbance of blue carbon storage is estimated to be approximately 5040 tons of carbon (the equivalent of the lifetime sequestration of 16800 mangrove trees);
- The habitat types within the 9000 class of habitats according to Brown and Boer (55) can be considered as transformed areas and are of negligible ecological importance and are therefore excluded in this EcIA and will be addressed in other sections;
- The impact assessment will be limited to the following habitats and associated flora and fauna:

- 1010 - Mudflats and Sand Exposed at low tide;
- 1030 – Saltmarsh;
- 1040 – Mangroves; and
- 2011 - Coastal Plains on well drained Sandy Gravel.

Assessment methods

The impacts of this projects were determined per vegetation community (habitat type) identified in the study area. This was done in order to give a more realistic indication of the impact of the project on habitats that occur within the region of the study area.

In order to do this the following approach was used:

- Determination of habitat sensitivity;
- Determination of spatial scale of impact on the habitat;
- Determination of duration of the impact; and
- Determination of reversibility of the impact.

Determination of Habitat Sensitivity

In order to determine the habitat sensitivity of a vegetation community (habitat type), the following factors were considered:

- Proximity to formally protected area
- Ecological integrity
- Conservation importance
- Probability of occurrence of SoC
- Level of Degradation

Rehabilitation Index

Each of these factors were determined using the indices outlined in Table 5-108.

Table 5-108: Habitat sensitivity indices

Factor	Factor value	Factor Index
Proximity to formally protected area (Prox)	<5km	5
	5-20km	4
	20-40km	3
	40-60km	2
	60-100km	1
	>100km	0
Ecological integrity (EI)	High	5
	Moderate	3
	Low	1
Conservation importance (CI)	High	5

Factor	Factor value	Factor Index
	Moderate	3
	Low	1
Probability of occurrence of SoC (SoC)	Recorded	5
	High	4
	Moderate	3
	Low	2
	Very Low	1
	Negligible	0
Ecoregion Status (WWF) (ES)	Critical/endangered	5
	Vulnerable	3
	Relatively stable/relatively intact	1
Level of Degradation (LD)	No degradation	1
	Low	2
	Moderate	3
	High	4
	Transformed	5
Rehabilitation Index (RI)	Low	5
	Moderate	3
	High	1

The sensitivity index (SI) for each of the vegetation communities was calculated using the formula:

$$SI = \frac{\left(\frac{Prox + CI + ES}{LD}\right) + EI + SoC + RI}{3}$$

Where:

SI = Sensitivity Index

$Prox$ = Proximity to formally protected area

CI = Conservation importance

ES = WWF Ecoregion status

LD = Level of Degradation

EI = Ecological integrity

SoC= Probability of occurrence of Species of Conservation importance

RI = Rehabilitation index

Using this formula, a sensitivity index (SI) of between 0.4 and 10 for each of the vegetation communities was determined. The sensitivity index gives an indication of the sensitivity of the vegetation as shown in Table 5-109.

Table 5-109: Sensitivity determined by Sensitivity Index (SI)

Sensitivity (SI)	Sensitivity
0,4 – 2.0	Negligible
2.1 – 4.0	Low
4.1 – 6.0	Moderate
6.1 – 8.0	High
8.1 – 10.0	Very High

Determination of Impact Magnitude

In order to determine the magnitude of the impact the geographic extent, duration and frequency are used. The descriptions of each of these factors as well as the ratings of each of these factors are given in Table 5-110.

Table 5-110: Factors and ratings of impacts

Impact	Rating	Description of rating	Score
Intensity of Impact	Negligible	Environmental changes are within the existing limits of natural variations.	1
	Low	Environmental changes exceed the existing limits of natural variations. Natural environment is completely self-recoverable.	2
	Moderate	Environmental changes exceed the existing limits of natural variations and result in damage to the separate environmental components. Limited remediation required for recovery.	3
	High	Environmental changes result in significant disturbance to environmental components and ecosystems. Major rehabilitation required for recovery.	4
	Very High	Environmental changes result in significant disturbance to environmental components and ecosystems. Recovery not possible	5
Spatial scale	Negligible	Affecting <1% of the habitat	1
	Low	Affecting between 1 and 10% of the habitat	2
	Moderate	Affecting more than 10% but not exceeding 25% of the habitat	3

Impact	Rating	Description of rating	Score
	High	Affecting more than 25% but not exceeding 50% of the habitat	4
	Very High	Affecting more than 50% of the habitat	5
Temporal Scale	Transient	Observed for hours to days	1
	Short term	Observed for a period not exceeding one season or up to 6 months	2
	Medium term	Observed for a period not exceeding two seasons or up to 1 year	3
	Long term	Observed for a period not exceeding 5 years	4
	Permanent	Impact observed for more than 5 years	5
Probability of occurrence	Unlikely	Unlikely	1
	Probable	Probable	2
	Definite	Definite	3
Frequency of occurrence	Negligible	Single event	1
	Low	Stochastic	2
	Moderate	Intermittent	3
	High	Regular	4
	Very High	Continuous	5

The impact factor scores are used to determine the magnitude (Mag) of the impact by using the equation:

$$Mag = 2\left[\frac{(I + S + T + P + F)}{5}\right]$$

Where:

Mag = Magnitude of Impact

I = Intensity of Impact

S = Spatial scale

T = Temporal scale

P = Probability of occurrence

F = Frequency

This will give a magnitude of between 2 and 10.

The magnitude determined by the above equation and the significance of the magnitude is given in Table 5-111.

Table 5-111: Magnitude scores and significance of magnitude

Magnitude	Significance
2.0 - 3.6	Negligible
3.7 - 5.2	Low
5.3 - 6.8	Moderate
6.9 - 8.4	High
8.5 - 10.0	Very High

Determination of Significance Level

The magnitude is used in conjunction with the sensitivity of the receptor (receiving habitat), in order to determine the significance of the impact on that vegetation community (Table 8.7. This allows us not only to determine the magnitude of the impact on an arbitrary level, but also the significance of the effects of the impact on the receptors, of that impact.

The significance of Effects (SOE) on a habitat are given by multiplying the magnitude of the impact by the sensitivity of the receiving vegetation community in the equation:

$$SOE = \sqrt[2]{Mag \times SI}$$

Where:

SOE = Significance of the effect

Mag = Magnitude of the impact

SI = Sensitivity Index of the receptor

This will give a score of between 1.4 and 10 and the ecological significance of the effects of the impact scores are given in Table 5-112 as well as how these are related to the Environmental Impact Assessment significance of effects.

Table 5-112: Significance of the effects scores

SOE Score	Ecological Significance Level	Implications	ESIA Significance Level
1.4 – 2.6	Negligible	Negligible effects can generally be considered as ‘not more than minor’ effects and should not normally be of concern.	Negligible
2.7 – 3.9	Marginal negative	Very low effects are usually minimized by normal design, construction and operational care	Minor negative

SOE Score	Ecological Significance Level	Implications	ESIA Significance Level
4.0 – 5.1	Minor negative	Low effects Are usually effects that although can be of moderate concern, are easily mitigated.	
5.2 – 6.3	Moderate negative	Moderate represents a level of effect that requires careful assessment and analysis of the individual case. Such an effect could be mitigated through avoidance, design, or extensive appropriate mitigation actions.	Moderate negative
6.4 – 7.6	Significant negative	High represent a high level of effect on ecological or conservation values and warrant avoidance and/or extremely high intensity mitigation and remediation actions.	Major negative
7.7 – 8.8	Major negative	Very high are unmitigable effects and biodiversity offsetting should be considered where these adverse effects cannot be avoided.	
8.9 – 10.0	Critical	Critical effects are “red flag” effects that cannot be avoided or mitigated and are often considered an obstacle to further progress.	

5.6.2.3. Sensitive Receptors

5.6.2.3.1. Habitat Sensitivity

A total of 15 habitats were recorded within the landfall areas and onshore areas of the project alignments. These habitats are:

- 15100 - Rock Armouring/Artificial Reef (on Das Island only)
- 1010 - Mudflats and Sand Exposed At Low Tide
- 1030 - Saltmarsh
- 1040 – Mangroves
- 1050 - Storm Beach Ridges
- 1070 - Beach Rock and Gravelly Beaches
- 2011 - Coastal Plains on Well-Drained Sandy Ground
- 2012 - Coastal Plains on Well-Drained Rocky or Gravelly Terrain
- 2030 - Coastal Cliffs, Headlands, Rocky Slopes and Wadis In Coastal Situations
- 3100 - Coastal Sabkha, Including Sabkha Matti
- 8400 - Forestry Plantations

- 9120 - Low Density Urban
- 9240 - Other Industry
- 9400 - Paved Roads
- 9600 - Disturbed Ground

As an initial exclusion of habitats and due to the fact that they can be considered transformed habitats with little or no ecological importance, all the 9000 category habitats as well as 15100 – Rock Armouring were excluded from the habitat sensitivity assessment. The habitats excluded under the initial exclusion were:

- 9120 - Low Density Urban
- 9240 - Other Industry
- 9400 - Paved Roads
- 9600 - Disturbed Ground
- 15100 - Rock Armouring/Artificial Reef

Furthermore, habitats that were unlikely to host any species of concern or habitats on which impacts are likely to be negligible due to distance from the impact unlikely to impact upon the ecology of the habitat. These habitats include:

- 1070 - Beach Rock and Gravelly Beaches
- 2030 - Coastal Cliffs, Headlands, Rocky Slopes and Wadis in Coastal Situations
- 8400 - Forestry Plantations

Habitat sensitivity was calculated for all natural or semi-natural habitats that are likely to fall within the area of influence of the development. Furthermore, habitats that fell within the area of influence but are unlikely to be impacted upon were omitted from the habitat sensitivity assessment. The habitats that were assessed are as follows:

- 1010 - Mudflats and Sand Exposed at Low Tide
- 1030 - Saltmarsh
- 1040 – Mangroves
- 1050 - Storm Beach Ridges
- 2011 - Coastal Plains on Well-Drained Sandy Ground
- 2012 - Coastal Plains on Well-Drained Rocky or Gravelly Terrain
- 2030 - Coastal Cliffs, Headlands, Rocky Slopes and Wadis in Coastal Situations
- 3100 - Coastal Sabkha, Including Sabkha Matti

Habitat sensitivity ranged from low in areas such as the Coastal Sabkha, to very high for the Mangroves. The sensitivity indices and rationale for the determination of the sensitivity indices is given in Table 5-113.

Table 5-113: Habitat sensitivity scores for the habitats assessed

Habitat sensitivity	1010 - Mudflats and Sand Exposed at low tide		1030 - Saltmarsh		1040 - Mangroves		1050 - Storm Beach Ridges		1070 - Beach Rock And Gravelly Beaches		2011 - Coastal Plains On Well-Drained Sandy Ground		2012 - Coastal Plains On Well-Drained Rocky or Gravelly Terrain		3100 - Coastal Sabkha, Including Sabkha Matti	
	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale
Proximity to formally protected area (Prox)	2	The study area and all associated habitat fall between 40km and 60km of the closest protected area. Any ecological synergies with this protected area are highly unlikely.	2	The study area and all associated habitat fall between 40km and 60km of the closest protected area. Any ecological synergies with this protected area are highly unlikely.	2	The study area and all associated habitat fall between 40km and 60km of the closest protected area. Any ecological synergies with this protected area are highly unlikely.	2	The study area and all associated habitat fall between 40km and 60km of the closest protected area. Any ecological synergies with this protected area are highly unlikely.	2	The study area and all associated habitat fall between 40km and 60km of the closest protected area. Any ecological synergies with this protected area are highly unlikely.	2	The study area and all associated habitat fall between 40km and 60km of the closest protected area. Any ecological synergies with this protected area are highly unlikely.	2	The study area and all associated habitat fall between 40km and 60km of the closest protected area. Any ecological synergies with this protected area are highly unlikely.	2	The study area and all associated habitat fall between 40km and 60km of the closest protected area. Any ecological synergies with this protected area are highly unlikely.
Ecological integrity (EI)	5	The mudflats within the study areas have remained relatively undisturbed. These mudflats serve as a habitat for a number of species of waders and shorebirds	5	Although a natural habitat this habitat has been impacted upon by the creation of an island around it thereby irreversibly changing the nature of a coastal habitat to a landlocked one.	5	The mangroves within the study area are remnants of mangroves of the original island. These mangroves have multiplied over the last number of years and although impacted, are showing a moderate to high level of ecological integrity	3	This habitat has been significantly impacted by pollution, and to some extent by offroad vehicles and is therefore considered moderately impacted	5	This habitat has been impacted by pollution, but is therefore considered having a low level of impact and high ecological integrity	3	This habitat has been significantly impacted by overgrazing, offroad vehicles and construction and is therefore considered moderately impacted	1	This habitat has been significantly impacted by offroad vehicles and construction and is therefore considered severely impacted	3	This habitat has been significantly impacted by overgrazing, offroad vehicles and construction and is therefore considered moderately impacted
Conservation importance (CI)	5	This habitat is listed as a critical habitat by the EAD and therefore is considered of high conservation importance	5	This habitat is listed as a critical habitat by the EAD and therefore is considered of high conservation importance	5	This habitat is listed as a critical habitat by the EAD and therefore is considered of high conservation importance	4	This habitat is considered an ecologically sensitive habitat by the EAD and therefore regardless of degradation is considered moderate to high conservation importance	3	This habitat is considered an ecologically sensitive habitat by the EAD and therefore regardless of degradation is considered moderate to high conservation importance	2	This habitat is considered as of moderate to low conservation importance	2	This habitat is considered as of moderate to low conservation importance	4	This habitat is considered an ecologically sensitive habitat by the EAD and therefore regardless of degradation is considered moderate to high conservation importance
Probability of occurrence of SoC (SoC)	5	Several IUCN and UAE red data listed bird species utilise this habitat, recorded species include: Crab plover, Eurasian Curlew, Bar-tailed Godwit, and Socotra cormorant, These areas can also be considered as important to avifauna species by virtue of the number of shorebirds that utilise these areas	4	Several IUCN and UAE red data listed bird species utilise this habitat, recorded species include: Eurasian Curlew, Bar-tailed Godwit, Osprey and Crab plover. These areas can also be considered as important to avifauna species by virtue of the number of shorebirds that utilise these areas	5	Several IUCN and UAE red data listed bird species utilise this habitat, recorded species include: Bar tailed Godwit, Western marsh-harrier, Crab plover and Socotra cormorant	3	Probability of species of concern utilising this habitat is moderate due to its proximity to areas where SoCs were recorded, although no SoCs were recorded utilising this habitat	3	Probability of species of concern utilising this habitat is moderate due to its proximity to areas where SoCs were recorded, although no SoCs were recorded utilising this habitat	1	Probability of species of concern utilising this habitat is low and no SoCs were recorded utilising this habitat	1	Probability of species of concern utilising this habitat is low and no SoCs were recorded utilising this habitat	0	Probability of species of concern utilising this habitat is negligible, and no SoCs were recorded utilising this habitat

Habitat sensitivity	1010 - Mudflats and Sand Exposed at low tide		1030 - Saltmarsh		1040 - Mangroves		1050 - Storm Beach Ridges		1070 - Beach Rock And Gravelly Beaches		2011 - Coastal Plains On Well-Drained Sandy Ground		2012 - Coastal Plains On Well-Drained Rocky or Gravelly Terrain		3100 - Coastal Sabkha, Including Sabkha Matti	
	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale	Score	Rationale
Ecoregion Status (WWF) (ES)	5	The Gulf of Oman desert and semi-desert is regarded as Critical by the WWF and this habitat forms part of the original islands	5	The Gulf of Oman desert and semi-desert is regarded as Critical by the WWF and this habitat forms part of the original islands	5	The Gulf of Oman desert and semi-desert is regarded as Critical by the WWF and this habitat forms part of the original islands	5	The Gulf of Oman desert and semi-desert is regarded as Critical by the WWF and this habitat forms part of the original islands	5	The Gulf of Oman desert and semi-desert is regarded as Critical by the WWF and this habitat forms part of the original islands	5	The Gulf of Oman desert and semi-desert is regarded as Critical by the WWF and this habitat forms part of the original islands	5	The Gulf of Oman desert and semi-desert is regarded as Critical by the WWF and this habitat forms part of the original islands	5	The Gulf of Oman desert and semi-desert is regarded as Critical by the WWF and this habitat forms part of the original islands
Level of Degradation (LD)	1	This habitat is considered undisturbed little or no signs of degradation noted within this habitat type	1	This habitat is considered undisturbed little or no signs of degradation noted within this habitat type	1	This habitat is considered undisturbed little or no signs of degradation noted within this habitat type	3	This habitat exhibits a high level of degradation	1	This habitat exhibits a low level of degradation	4	This habitat exhibits a high level of degradation	4	This habitat exhibits a high level of degradation	3	This habitat exhibits a moderate level of degradation
Rehabilitation Index (RI)	2	Structural rehabilitation of this habitat will not be challenging, however the ecological patterns and processes would take many years or decades to recuperate, and soil carbon storage lost will be irreplaceable.	3	Structural rehabilitation, and even replanting, of this habitat will not be challenging, however the ecological patterns and processes would take many years or decades to recuperate, and soil carbon storage lost will be irreplaceable	3	Structural rehabilitation, and even replanting, of this habitat will not be challenging, however the ecological patterns and processes would take many years or decades to recuperate, and soil carbon storage lost will be irreplaceable	3	Habitats in arid areas are generally difficult to rehabilitate due to the low level of rainfall and often arid soils	5	This habitat would be impossible to rehabilitate due to its rocky substrate	3	Habitats in arid areas are generally difficult to rehabilitate due to the low level of rainfall and often arid soils	3	Habitats in arid areas are generally difficult to rehabilitate due to the low level of rainfall and often arid soils	3	Habitats in arid areas are generally difficult to rehabilitate due to the low level of rainfall and often arid soils
Sensitivity Index (SI)	**8.0**		**8.0**		**8.3**		**4.2**		**7.7**		**3.1**		**2.4**		**3.2**	
Sensitivity level	High		High		Very High		Moderate		High		Low		Low		Low	

5.6.2.4. Construction Phase Impacts

Note that due to the artificial nature of Das Island and the fact that no natural habitats were recorded there, the habitats on Das island were assessed to undergo no significant effects from the proposed development.

5.6.2.4.1. Impact 1: Vegetation Clearing / Trenching and Disturbance to Breeding Birds

During the construction phase, the intertidal and terrestrial habitats along the route of the linear infrastructure will be cleared in order to facilitate the construction process. Based on the design drawings provided by the client, this construction impact will affect the following natural habitats:

- 1010 - Mudflats and Sand Exposed at low tide (critical habitat);
- 1030 – Saltmarsh (critical habitat);
- 1040 – Mangroves (critical habitat);
- 1050 - Storm Beach Ridges (Environmentally sensitive habitat);
- 2011 - Coastal Plains on Well-Drained Sandy Ground;
- 2012 - Coastal Plains on Well-Drained Rocky or Gravelly Terrain; and
- 3100 - Coastal Sabkha, Including Sabkha Matti (Environmentally sensitive habitat).

The loss of critical and environmentally sensitive habitats is given in Table 5-114, below

Table 5-114: Loss of critical and environmentally sensitive habitats

Habitat loss	Shuweihat (ha)	Mirfa (ha)
Critical habitats		
1010 – Mudflats and Sand Exposed at Low Tide	8.23	2.2
1030 – Saltmarsh	1.2	-
1040 – Mangroves	0.2	-
Environmentally sensitive habitats		
1050 – Storm Beach Ridges	1.3	1.2
3100 – Coastal Sabkha	20.7	3.4

Due to the fact that the design has changed since the surveys were conducted the exact number of mangrove trees that will be lost is not determined, however the number is estimated at approximately 30 trees at Shuweihat and no loss of trees at Mirfa.

This impact assessment assumes complete loss of vegetation along the entire footprint as given in the design drawings.

- The effects of vegetation clearing, and complete loss of these habitats are:
- Loss of flora species through destruction of species;
- Loss of fauna species through displacement due to loss of habitat;

- Loss of fauna species through mortality; and
- Loss of fauna and flora of conservation importance.
- The effects of this impact at the two landfall sites are assessed as follows:
- Vegetation clearing impact on species and ecological patterns and processes in the 1040 –Mangrove habitat is expected to be **major negative** at the Shuweihat landfall area as a limited amount of mangroves are likely to be removed. At the Mirfa landfall, this impact is likely to be to be **negligible**, as the proposed route does not traverse this habitat at Mirfa;
- The effects of this impact are likely to **major negative** on the 1010 - Mudflats and Sand Exposed at low tide habitats at both the Shuweihat and Mirfa;
- The effects of vegetation clearing and trenching are likely to be **major negative** on the 1030 – Saltmarsh habitat at the Shuweihat landfall area. As this habitat does not exist in the Mirfa area there will be no impact;
- The effects of vegetation clearing and trenching on the 1050 - Storm Beach Ridges habitat at Shuweihat are likely to be **minor negative** due to the fact that small areas of this habitat will be lost. This habitat does not occur at the Mirfa site;
- At Mirfa the 1070 - Beach Rock and Gravelly Beaches habitat will be unaffected by this impact and therefore the effects of this impact on this habitat were assessed as **negligible**;
- Due to the already disturbed nature of the 3100 - Coastal Sabkha, including Sabkha Matti at both sites as well as the fact that these areas host little or no fauna or flora, the ecological impact on this habitat at both the Shuweihat and Mirfa sites is considered **minor negative**. There is however the release of blue carbon stored in this habitat to be considered and this will be considered in **Section 5.11: Climate Change**;
- The effects of this impact on the 2011 - Coastal Plains on Well-Drained Sandy Ground at the Mirfa landfall was assessed as **minor negative** due to the fact that this habitat already shows significant levels of disturbance and a very small percentage of this habitat is likely to be affected based on the existing project design. This habitat does not occur within the project footprint at the Shuweihat site; and
- 2012 - Coastal Plains on Well-Drained Rocky or Gravelly Terrain habitat exists at the Shuweihat site, but is already severely degraded due to construction impacts in the area for this reason the effects of this impact on this habitat is assessed as **minor negative.**

5.6.2.4.2. Impact 2: Vibration and Noise Disturbance

Due to the fact that the entire island is likely to be cleared of any natural habitats with exception of the Zeugen area before the landscaping and construction are underway, there will be very little natural fauna and flora to be impacted upon by the vibration and noise caused by further construction.

The effects of the vibration and noise caused by the development area therefore likely to result in:

- The displacement of any remaining fauna in the remaining habitats adjacent to the project footprint including likely displacement of fauna on the mud flats, saltmarsh and in the mangroves; and
- Interference in avifauna behaviour such as breeding of any avifauna that have not been displaced.
- The effects of this impact at the two landfall sites are assessed as follows:

- The effect of noise and vibration on the 1040 – Mangrove habitat is expected to be **major negative** at the Shuweihat landfall and the Mirfa landfall as these areas are frequented by large numbers of bird species that are likely to be temporarily or permanently displaced;
- The effect of noise and vibration are likely to **major negative** on the 1010 - Mudflats and Sand Exposed at low tide habitats at both the Shuweihat and Mirfa due to the displacement of large numbers and increased species richness of shorebirds that utilize this habitat;
- The effect of noise and vibration are likely to be **major negative** on the 1030 – Saltmarsh habitat at the Shuweihat landfall area, due to the displacement of large numbers and increased species richness of shorebirds that utilize this habitat. As this habitat does not exist in the Mirfa area there will be no impact in that area;
- The effect of noise and vibration on the 1050 - Storm Beach Ridges habitat at Shuweihat are likely to be **minor negative** due to the fact that few species were found to utilise this habitat;
- At Mirfa the 1070 - Beach Rock and Gravelly Beaches habitat will be unaffected by this impact due to the distance from the impact and therefore the effects of this impact on this habitat were assessed as **negligible**.
- Due to the already disturbed nature and the very low species diversity of the 3100 - Coastal Sabkha, Including Sabkha Matti at both sites as well as the fact that these areas host little or no fauna or flora, the ecological impact on this habitat at both these sites is considered **negligible**;
- The effects of this impact on the 2011 - Coastal Plains on Well-Drained Sandy Ground at the Mirfa landfall was assessed as **negligible** due to the fact that this habitat already shows significant levels of disturbance and few if any species likely to be affected by this impact were recorded;
- 2012 - Coastal Plains on Well-Drained Rocky or Gravelly Terrain habitat exists at the Shuweihat site, but is already severely degraded due to construction impacts in the area for this reason the effects of this impact on this habitat is assessed as **negligible**; and
- In addition, the effect of light pollution upon local bird populations has also been considered at both Mirfa and Shuweihat, particularly due to the expected construction activities taking place 24/7. However, due to the presence of the existing industrial areas adjacent to both onshore Project sites, it is considered that light spill is already affecting the area and local bird populations are likely to be acclimated to the existing nighttime artificial light conditions. This in combination with the fact that light spill from the Project construction is likely to be minimal and unlikely to significantly increase the existing light spill, the impact is assessed as **negligible**.

5.6.2.4.3. Impact 3: Chemical Pollution

From an ecological perspective, any chemical pollution that may occur during the habitat clearing or construction phase of the project may cause harm to or loss of fauna and flora species and contamination of resources utilised by any species remaining in the area.

The impact at the two landfall sites are assessed as follows:

- Due to the high species diversity and the semi-aquatic nature of the habitat, making a chemical spill difficult to contain, effects of chemical pollution on the 1040 –Mangrove habitat is expected to be **major negative** at the Shuweihat landfall and the Mirfa landfall;
- Due to the high species diversity and the semi-aquatic nature of the habitat, making a chemical spill difficult to contain, effects of chemical pollution on the 1010 - Mudflats and Sand Exposed at low tide habitat is expected to be **major negative** on the at both the Shuweihat and Mirfa sites;
- Due to the high species diversity and the semi-aquatic nature of the habitat, making a chemical spill difficult to contain, effects of chemical pollution on the 1030 – Saltmarsh habitat at the Shuweihat landfall area are likely to be **major negative** as this habitat does not exist in the Mirfa area there will be no impact in that area;
- Due to the sandy nature of the habitat making a chemical spill easier to contain than in other habitats, the effects of this impact on the 1050 - Storm Beach Ridges habitat at Shuweihat are likely to be **minor negative**.
- At Mirfa the 1070 - Beach Rock and Gravelly Beaches habitat will be unaffected by this impact due to the distance from the impact and therefore the effects of this impact on this habitat were assessed as **negligible**;
- Due to the sandy nature of the habitat making a chemical spill easier to contain than in other habitats, and low species diversity of the habitat, the effects of this impact on the 3100 - Coastal Sabkha, Including Sabkha Matti at both sites is considered **minor negative**;
- Due to the sandy nature of the habitat making a chemical spill easier to contain than in other habitats, and low species diversity of the habitat, the effects of this impact on the 2011 - Coastal Plains on Well-Drained Sandy Ground at the Mirfa landfall was assessed as **minor negative**; and
- Due to the sandy nature of the habitat making a chemical spill easier to contain than in other habitats, and low species diversity of the habitat, the effects of this impact on the 2012 - Coastal Plains on Well-Drained Rocky or Gravelly Terrain habitat at the Shuweihat site, effects of this impact on this habitat is assessed as **minor negative**.

5.6.2.4.4. Impact 4: Dust Deposition

Flora species in the habitats adjacent to the development footprint may experience a reduction in growth and fecundity due to dust deposition. A secondary effect of the reduction in growth and fecundity would be the loss of fauna species due to reduction in habitat quality of any remaining habitats.

- Due to the high species diversity and the significant flora in this habitat, the effects of dust deposition on the 1040 –Mangrove habitat is expected to be **major negative** at the Shuweihat landfall and the Mirfa landfall;

- Due to the lack of photosynthetic flora and the fact that this habitat is frequently flushed, the effect of dust deposition on the 1010 - Mudflats and Sand Exposed at low tide habitat is expected to be **negligible** on the at both the Shuweihat and Mirfa sites;
- Due to the high species diversity and the significant flora in this habitat, the effects of dust deposition on the 1030 – Saltmarsh habitat at the Shuweihat landfall area are likely to be **major negative**;
- Due to the fact that this habitat does host some flora species, even though diversity and abundance are low, the effects of this impact on the 1050 - Storm Beach Ridges habitat at Shuweihat are likely to be **moderate negative**;
- Due to the lack of photosynthetic flora and the fact that this habitat is frequently flushed, the effect of dust deposition on the Mirfa 1070 - Beach Rock and Gravelly Beaches habitat was assessed as **negligible**;
- Due to the lack of photosynthetic flora and the fact that this habitat is frequently flushed, the effect of dust deposition on the 3100 - Coastal Sabkha, Including Sabkha Matti at both sites is considered **negligible**;
- Due to the fact that this habitat does host some flora species, even though diversity and abundance are low, and the fact that this area shows significant levels of disturbance, the effects of this impact on the 2011 - Coastal Plains on Well-Drained Sandy Ground at the Mirfa landfall was assessed as **minor negative**; and
- Due to the fact that this habitat does host some flora species, even though diversity and abundance are low, and the fact that this area shows significant levels of disturbance, the effects of this impact on the 2012 - Coastal Plains on Well-Drained Rocky or Gravelly Terrain habitat at the Shuweihat site, effects of this impact on this habitat is assessed as **minor negative**.

5.6.2.4.5. Impact 5: Impediment to Local Migrations

Due to the fact that linear infrastructure is going to be laid perpendicular to the coastline it is likely that species that traverse the coastline, parallel to the coastline itself, are likely to be impeded by the infrastructure. Factors that reduce the effects of this impact are the fact that few terrestrial fauna species were recorded and that the infrastructure will be buried and therefore the impact is likely to be transient.

- Due to the high species diversity in this habitat, the effects of this impact on the 1040 –Mangrove habitat is expected to be **moderate negative** at the Shuweihat landfall and as the infrastructure does not traverse this habitat at the Mirfa landfall, there will be no effect of this impact at the Mirfa site;
- Due to the high species diversity in this habitat, the effects of this impact on the 1040 –Mangrove habitat is expected to be **moderate negative** on the 1010 - Mudflats and Sand Exposed at low tide habitat at both the Shuweihat and Mirfa sites;
- Due to the high species diversity, the effects of this impact on the 1030 – Saltmarsh habitat at the Shuweihat landfall area are likely to be **moderate negative**;
- Some fauna species almost certainly utilize the 1050 - Storm Beach Ridges habitat at Shuweihat in order to travel parallel to the beach and therefore the effects of this impact on this habitat is likely to be at least **minor negative**;
- Due to the fact that the infrastructure does not cross this habitat, the effect of this impact on the Mirfa 1070 - Beach Rock And Gravelly Beaches habitat was assessed as **negligible**;

- As the infrastructure does not completely bisect this habitat, and the habitat hosts no resident fauna species, the effect of this impact on the 3100 - Coastal Sabkha, Including Sabkha Matti at both sites is considered **negligible**;
- The infrastructure traverses only a minor section of this of the 2011 - Coastal Plains on Well-Drained Sandy Ground at the Mirfa landfall, and this habitat already shows significant disturbance. For these reasons the effect of this impact was assessed as **negligible** for this habitat; and
- The infrastructure traverses only a minor section of this of the 2012 - Coastal Plains on Well-Drained Rocky or Gravelly Terrain habitat at the Shuweihat site, and this habitat is already severely impacted, effects of this impact on this habitat is assessed as **negligible.**

The impacts described here are summarised in Table 5-115 below.

5.6.2.4.6. Impact 6: Increase Sediment Load on Mangrove Habitats

As shown in the results of the modelling studies in **Section 5.2**, significant total suspended sediment will be impacting the intertidal zones where a number of mangroves are located. Nevertheless, due to the fact that tidal regime is not going to be impeded by the Project, this increase of sediment load should have very limited short-term impact and therefore this impact has been considered as ‘no change’.

Table 5-115: Summary of construction phase impacts

Habitat	1010 - Mudflats and Sand Exposed at low tide				1030 - Saltmarsh				1040 - Mangroves				1050 - Storm Beach Ridges			
Impact	HS	MoI	SOE	Significance	HS	MoI	SOE	Significance	HS	MoI	SOE	Significance	HS	MoI	SOE	Significance
Vegetation clearing/Trenching	8.0	7.2	7.6	Major negative	8.0	7.2	7.6	Major negative	8.3	7.2	7.7	Major negative	2.4	8.0	4.4	Minor negative
Vibration and noise disturbance	8.0	7.0	7.5	Major negative	8.0	7.0	7.5	Major negative	8.3	7.0	7.6	Major negative	2.4	8.0	4.4	Minor negative
Chemical pollution	8.0	6.0	6.9	Major negative	8.0	6.0	6.9	Major negative	8.3	6.0	7.1	Major negative	2.4	7.0	4.1	Minor negative
Dust deposition	8.0	6.0	6.9	Negligible	8.0	6.5	7.2	Major negative	8.3	6.0	7.1	Major negative	2.4	6.5	4.0	Moderate negative
Impediment to local migrations	8.0	4.0	5.7	Moderate negative	8.0	4.0	5.7	Moderate negative	8.3	4.0	5.8	Moderate negative	2.4	5.0	3.5	Minor negative

Habitat	1070 - Beach Rock and Gravelly Beaches				2011 - Coastal Plains on Well-Drained Sandy Ground				2012 - Coastal Plains on Well-Drained Rocky or Gravelly Terrain				3100 - Coastal Sabkha, Including Sabkha Matti			
Impact	HS	MoI	SOE	Significance	HS	MoI	SOE	Significance	HS	MoI	SOE	Significance	HS	MoI	SOE	Significance
Vegetation clearing/Trenching	3.2	2.0	2.5	Negligible	3.1	8.0	5.0	Minor negative	2.4	7.6	4.3	Minor negative	3.2	7.6	4.9	Minor negative
Vibration and noise disturbance	3.2	4.0	3.6	Negligible	3.1	4.5	3.7	Negligible	2.4	4.5	3.3	Negligible	3.2	4.5	3.8	Negligible
Chemical pollution	3.2	2.0	2.5	Minor negative	3.1	6.0	4.3	Minor negative	2.4	6.0	3.8	Minor negative	3.2	6.0	4.4	Minor negative
Dust deposition	3.2	2.5	2.8	Negligible	3.1	6.0	4.3	Minor negative	2.4	6.0	3.8	Minor negative	3.2	5.5	4.2	Negligible
Impediment to local migrations	3.2	2.0	2.5	Negligible	3.1	4.0	3.5	Negligible	2.4	4.0	3.1	Negligible	3.2	3.5	3.4	Negligible

Note: HS: Habitat sensitivity
MoI: Magnitude of impact
SOE: Significance of impact

5.6.2.5. Operational Phase Impacts

Due to the fact that all infrastructure will be buried during the construction phase and that little or no above ground infrastructure will remain on site it is expected that operational phase impacts, if any, will be **negligible**.

5.6.2.6. Cumulative Impacts

5.6.2.6.1. Construction Phase

Type 1 cumulative impacts are expected upon sensitive receptors including avifauna and sensitive habitats within the Project footprint and within the local area. Such receptors are likely to experience the combined impacts of a deterioration in air quality from vehicular emissions and/or dust generation, in conjunction with potentially elevated noise levels, potential contamination events and general disturbance levels.

Type 2 impacts upon terrestrial and intertidal ecology and associated receptors are likely to occur during construction. For example, the likely overlap of construction periods with the nearby Project Wave, at Mirfa and Mugharraq Port at Shuweihat which cumulatively may increase the impacts on sensitive habitats disturbed or lost, increase general noise levels within the area in addition to dust and gaseous emissions within the local airshed.

5.6.2.6.2. Operation Phase

Given that no impacts are predicted in terms of terrestrial ecology during the operational phase, it is not considered that any cumulative impacts will occur either, during operation.

5.6.3. Mitigation Measures

5.6.3.1. Potential Mitigation Measures

Potential mitigation measures during the construction and operation phases are presented in Table 5-116 below.

Table 5-116: Terrestrial ecology impacts and potential mitigation measures

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
CONSTRUCTION PHASE								
1	Loss of vegetation	Site clearance activities	Project site	Negligible to Major negative	– Avoidance through no-go – Avoidance through selection of a different route. – Tunnelling under the habitat through oblique drilling – Pre-construction surveys should be undertaken in order to remove any less-mobile species from the area before vegetation clearing begins and make sure that no species of conservation importance are present – A qualified environmental officer should be on site at all times in order to oversee ground-clearing operations – Avoidance of vegetation clearing during the peak breeding season (April to July) unless a pre-construction survey is undertaken just before the clearance work. If any active nests are present, these cannot be disturbed and these areas must be protected, with a 300m stand-off until such time as the nest is no longer active. Once surveys by a qualified ecologist have confirmed that the nests are no longer active, these trees can also be cleared (subject to the necessary Authority permits being in place) and these areas will be considered to be clear for the remainder of the construction phase and no further restrictions would apply – Mudflats and saltmarshes should be restored after the cables have been laid and covered, a restoration plan should be compiled prior to construction detailing how this will be achieved – The loss of mangroves will need to be mitigated by the planting of mangroves in a suitable area. It is suggested that a mangrove introduction and colonization programme be developed, and not arbitrary introduction of mangroves in an area	Not applicable	Not applicable	Yes
2	Vibration and noise disturbance	Noise generating construction machinery and plant	Project site and surrounding areas	Negligible to Moderate negative	– Avoidance through no-go – Where possible noise should be limited and any severely excessive noise should be mitigated	Not applicable	Not applicable	Yes
3	Chemical pollution	Accidental leaks and spills of hazardous materials and chemicals	Project site	Negligible to Major negative	– Avoidance through no-go – Use of manual labour only with no heavy machinery thus eliminating the need for fuel and lubricants on site – A best practice spill response plan be followed during the construction phase of the project – Spill kits should be available in all areas on site	Not applicable	Not applicable	Yes
4	Dust deposition	Dust generating activities e.g. excavation and trenching	Project site and surrounding areas	Negligible to Moderate negative	– Avoidance through no-go – Dust suppression measures should be implemented in areas where construction is likely to produce dust.	Not applicable	Not applicable	Yes
5	Impediment to local migrations	Installation of linear infrastructure perpendicular to the coastline	Project site and surrounding areas	Negligible to Moderate negative	– Avoidance through no-go – Tunnelling under the habitat through oblique drilling – The trenching, laying of cables and filling should be conducted in sections in order to reduce the impediment of terrestrial species – System / structures to ensure no animal trapped in the open trenches	Not applicable	Not applicable	Yes

5.6.3.2. Selected Mitigation Measures

Some potential mitigation measures detailed above were not selected and the reasoning is provided below:

- A no-go option for the Project was deemed un-feasible by the developer, it should be taken into consideration that this Project will significantly reduce carbon emissions from offshore power generation;
- A number of routes were investigated prior to the selection of the current route, however damage to marine ecosystems would have resulted in more severe impacts than the current route and therefore this onshore route remain the best solution;
- Tunnelling under the habitats was considered however, this solution was determined to not be a feasible for a number reasons including the potential for operational issues to occur such as heat dissipation, in addition to maintenance and repair problems for the cables. Further details can be found in **Chapter 6** in regard to Horizontal Directional Drilling (HDD) limitations;
- The use of manual labour for the trenching would be very time consuming and working in a trench running through semiaquatic habitats would place the people working in the trench in significant danger of collapsing sides; and
- The mitigation measure of trenching, laying of cables and filling that should be conducted in sections in order to reduce the impediment of terrestrial species was deemed not feasible as the cables will be laid together.

For this reason, the mitigation measures presented in the below sub-sections have been selected.

5.6.3.2.1. Construction Phase

Impact 1: Vegetation Clearing / Trenching and Disturbance to Breeding Birds

It must be ensured that bird breeding areas are not cleared during the breeding season (generally considered to be April to early July although birds can breed outside of this season).

It is important to note that bird breeding habitat can be cleared outside of the bird breeding season (subject to the necessary Authority permits being in place to remove these trees), ensuring that these areas are then free from breeding birds for the rest of the construction phase. This presents two possible options as follows:

- **Option 1 (Preferred Option): Construction works to commence outside bird breeding season (August to March):**
  - Vegetation located within the coastal zones identified in Figure 5-210 and Figure 5-211 below should be removed (subject to the necessary Authority permits being in place) and these areas will be considered to be cleared for the remainder of the construction phase and no further consideration with respect to breeding birds is required;
  - A qualified environmental officer should be on site at all times in order to oversee ground-clearing operations;

- **Option 2: Construction works commence during bird breeding season (April to July):**
  - Pre-construction surveys should be undertaken in the coastal zones identified in Figure 5-210 and Figure 5-211 below in order to remove any less-mobile species from the area before vegetation clearing begins and make sure that no species of conservation importance are present and to ensure no bird breeding is occurring in the area;

- Areas of vegetation where active nests are not present can be cleared immediately after the surveys (subject to the necessary Authority permits being in place) and these areas are now considered to be clear for the remainder of the construction phase and no further restrictions would apply;
- If any active nests are present, these cannot be disturbed and these areas must be protected, with a 300m stand-off until such time as the nest is no longer active. Once surveys by a qualified ecologist have confirmed that the nests are no longer active, these trees can also be cleared (subject to the necessary Authority permits being in place) and these areas will be considered to be clear for the remainder of the construction phase and no further restrictions would apply.
- A qualified environmental officer should be on site at all times in order to oversee ground-clearing operations;

In addition to the above, the following mitigation are recommended:

- Mudflats and saltmarshes should be restored after the cables have been laid and covered, a restoration plan should be compiled prior to construction detailing how this will be achieved; and
- The loss of mangroves will need to be mitigated by the planting of mangroves in a suitable area. It is suggested that a mangrove introduction and colonisation programme be developed, and not arbitrary introduction of mangroves in an area. A mangrove planting and management plan will be required to be submitted to EAD for approval prior replanting mangroves for the area adjacent to Shuweihat in accordance with EAD requirements. This will include specific details of:
  - Area of mangrove loss and estimated number of individuals;
  - Proposed compensation site;
  - Proposed method of compensation – presumed at this stage to be planting of mangrove seedlings at a ratio of 2:1 for the number of mangrove individuals lost;
  - Methodology for site preparation and planting;
  - Requirements for management and replacement during establishment phase; and
  - Long-term management and monitoring requirements.

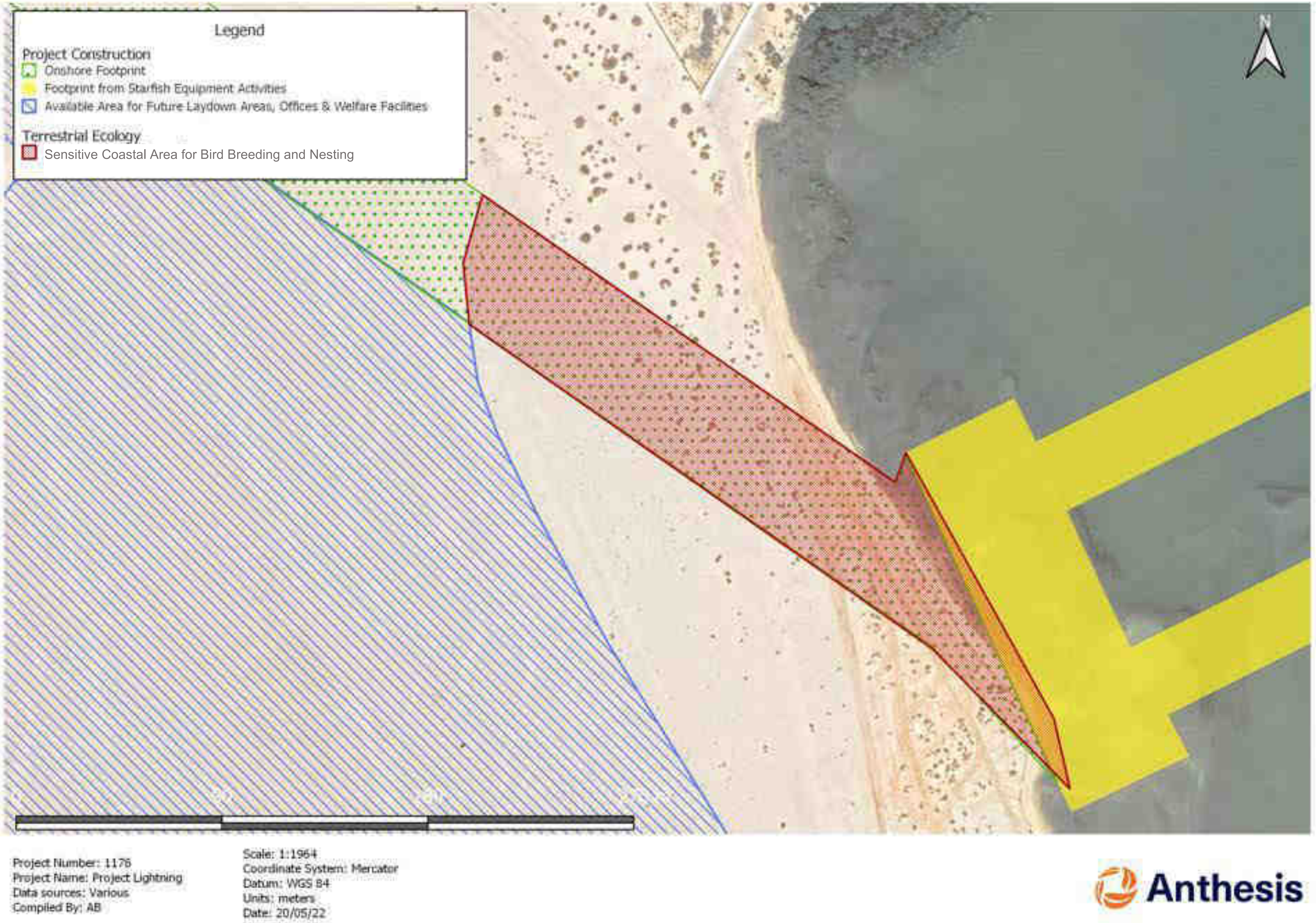
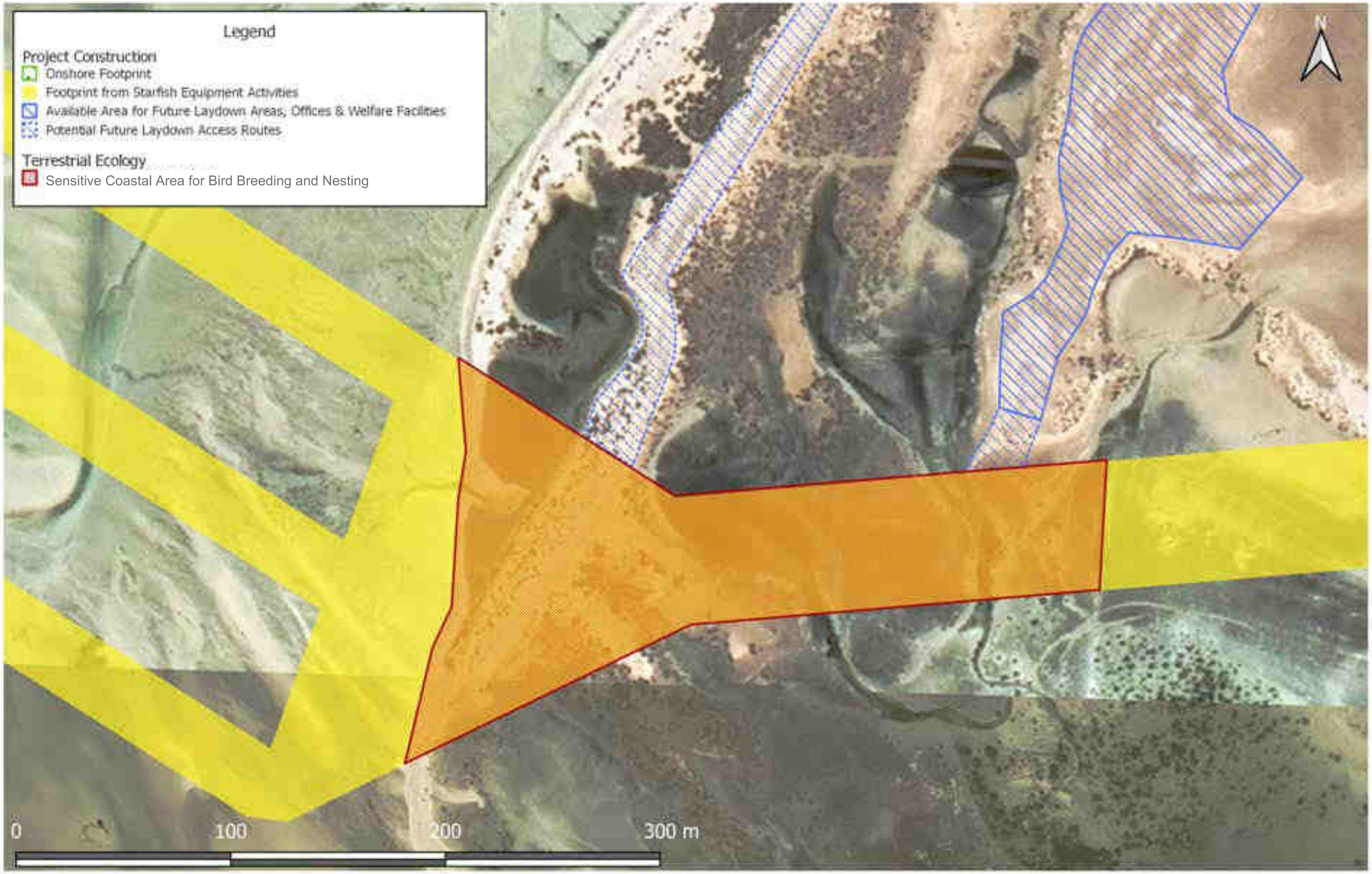


Figure 5-210: Identified coastal zones where vegetation clearance can impact bird breeding and birds nests in Mirfa Area (Route 1)



Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:2187
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 20/05/22

Anthesis

Figure 5-211: Identified coastal zones where vegetation clearance can impact bird breeding and birds nests in Shuweihat Area (Route 2)

Impact 2: Vibration and Noise Disturbance

Where possible noise should be limited and any severely excessive noise should be mitigated (see **Section 5.7: Noise**).

Impact 3: Chemical Pollution

Any chemicals stored on site need to be correctly stored and bunded. A best practice spill response plan be followed during the construction phase of the project, members of staff should be trained to correctly deal with possible chemical spills and spill kits should be available in all areas on site.

Impact 4: Dust Deposition

Dust suppression measures should be implemented to avoid increased levels of dust deposition on plants adjacent, resulting in decreased growth and fecundity (see **Section 5.1: Air Quality**).

Impact 5: Impediment to Local Migrations

The following measures shall be applied:

- Temporary concrete slabs / wooden board covered with sands to be laid across the trenches every 50-100 metres to provide natural land bridges for fauna species;
- Where trenches cannot be temporarily covered, escape structures shall be provided to ensure animals do not become trapped in the trenches; and
- HSE officer to investigate every morning the open trenches to ensure no animals are trapped, injured and/or dead. If trapped, the HSE officer or an experienced ecologist shall remove the trapped animal.

5.6.3.2.2. Operational phase

Due to the fact that all the infrastructure should be buried during the construction phase, provided the mitigation measures for the construction phase are implemented, there should be no impacts that require mitigation during the operational phase of the project.

5.6.3.3. Mitigation Measures to Address Cumulative Impacts

Based on the IUCN Policy on cumulative assessments and international consensus on the scope of cumulative ecological impact assessments, an assessment of cumulative effects of a Project should, only "consider effects on valued ecological feature or attributes" also called Valued Ecosystem Components or VECs. As no residual impacts are envisaged for this project, it follows that this project will not contribute to any future cumulative impacts.

5.6.3.4. Residual Impacts

As shown in Table 5-117 below, after the implementation of the selected mitigation measures the significant residual impacts are:

- loss of mangrove habitat; and
- disturbance of mudflat habitats and associated bird populations.

These impacts are to be compensated through the replanting of mangroves in suitable areas (on or offsite) and the restoration of the mudflats and saltmarshes that may be impacted.

Table 5-117: Terrestrial ecology residual impacts

Impact	Significance Before Mitigation	Significance After mitigation
Construction Phase		
Vegetation clearing	Minor negative to Major negative	Minor negative
Vibration and noise disturbance	Negligible to Moderate negative	Negligible
Chemical pollution	Negligible to Major negative	Negligible
Dust deposition	Negligible to Moderate negative	Negligible
Impediment to local migrations	Negligible to Moderate Negative	Negligible
Operation Phase		
No terrestrial or intertidal impacts are envisaged for the operational phase		

5.6.4. Monitoring Program

5.6.4.1. Monitoring Program for Compliance with Selected Mitigation Measures

5.6.4.1.1. Construction phase

During the construction phase a qualified environmental officer should be on site at all times to monitor and record impacts. An environmental incident log will be kept in order to keep a record of these impacts.

5.6.4.1.2. Operational phase

The compensation for the residual loss of habitats and associated species are as follows:

- Repropagation of mangrove trees lost due to the development; and
- Restoration of the mudflats and saltmarshes that may be impacted

The repropagation plan as well as the restoration plan should include monitoring of the repropagation and restoration measures in order to determine the effectiveness of these compensation measures. Success of these compensation measures should be conducted as follows:

A monitoring plan for each of these habitats needs to be developed in order to determine the success of these compensation measures. These monitoring programs should include:

- Fixed point photography of each of these habitats in order to show succession of these habitats; and
- Biannual fauna and flora surveys of these habitats in order to determine the colonization of these habitats by fauna and flora species.

It is likely that at least some management of these compensation measures will be required in order to achieve a successional state that can qualify as compensation for the habitat lost. A management plan with measurable goals (based on the successional state and species diversity of the lost habitats) needs to be developed and implemented for each of the habitats compensated. The monitoring of these habitats should form part of a monitoring – management feedback loop in order to achieve successful compensation.

5.6.4.2. Monitoring Program for Cumulative Impacts

As no cumulative impacts are envisaged due to the nature of the project. No monitoring is likely to be required.

5.6.4.3. Monitoring Program for Residual Impacts

Other than the monitoring proposed for the monitoring of the compensation for lost habitats, no further monitoring of residual impacts is proposed.

5.7. Noise

5.7.1. Description of the Environment

This section of the ESIA details the assessment which has been undertaken with regards to noise levels associated with the construction and operation of the Project. The results of baseline surveys undertaken by Nautica in 2021 have been summarized and used to provide an assessment and comparison against applicable standards in order to identify the potential significance of impacts.

Underwater noise monitoring has been undertaken by WKC, the results of which, and an accompanying assessment of potential impacts upon marine life as a result of the marine works, are presented within **Section 5.5**.

5.7.1.1. Baseline Methodology

Project site specific baseline noise surveys were undertaken by Nautica on behalf of Mott MacDonald in May 2021 at three separate Project locations, as follows:

- Mirfa;
- Shuweihat; and
- Das Island.

No noise monitoring was undertaken at Al Ghallan Island.

At each of the above locations, baseline noise measures were undertaken at three locations including both weekday and weekend measurement periods. Measurements were conducted for 15 minutes at each location, during both daytime and nighttime periods (total of 4 measurements per site). The following parameters were measured:

- L_{Aeq};
- L_{AMax};
- L_{A10};
- L_{A50}; and
- L_{A90}.

The noise measurement locations are illustrated in Figure 5-212 to Figure 5-214 below. Coordinates for each of the monitoring locations are provided below in Table 5-118.

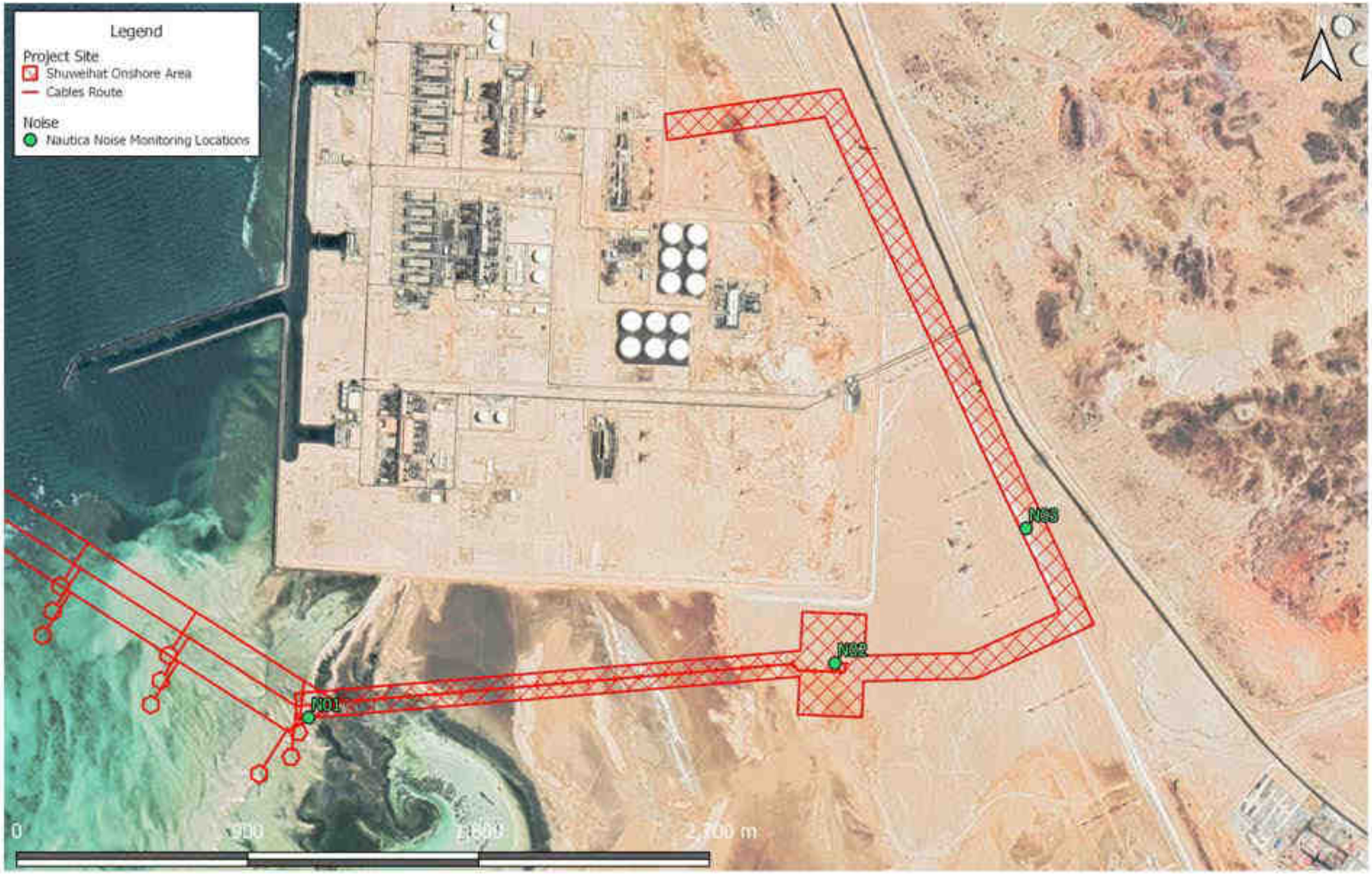
Table 5-118: Noise monitoring location coordinates

Noise monitoring location	Latitude (N)	Longitude (E)
Mirfa		
N01	24.114964	53.46217196
N02	24.11718101	53.45660102
N03	24.11170201	53.456468
Shuweihat		
N01	24.14356397	52.56288604
N02	24.14610227	52.58304192
N03	24.15104399	52.59012404
Das Island		
N01	25.12395	52.87745
N02	25.11881	52.87758
N03	25.12607	52.87901

The monitoring was undertaken using a bench and field calibrated Rio NL-52 integrating Class 1 (IEC 61672-2002) sound meter level. Measurement locations were selected to minimize reflective phenomena or any weather conditions which may be distortive, in accordance with ISO1996-1:2016. Parameters recorded include maximum and average noise levels in addition to identification of specific sound events. Measurements recorded are summarised below:

- 15 minutes at each location (day/night/weekday/weekend);
- Total 1-hour measurement per site; and
- Total 3-hours at each location e.g. Mirfa, Shuweihat and Das Island.

Figure 5-212: **Noise monitoring locations at Mirfa (Nautica Survey)**



Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:18295
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 22/04/22

Anthesis

Figure 5-213: Noise monitoring locations at Shuweihat (Nautica Survey)

Figure 5-214: **Noise monitoring locations at Das Island (Nautica Survey)**

5.7.1.2. Baseline Conditions

Noise measurements recorded at Mirfa, Shuweihat and Das Island by Nautica are provided below in Table 5-119 to Table 5-127.

In terms of comparisons of noise levels against relevant EAD and IFC criteria, the Project areas have been defined as follows, in terms of land use classifications:

- Mirfa: 'residential with light traffic';
- Shuweihat: '*Heavy industry*'; and
- Das Island: 'Heavy Industry'.

The results of the noise surveys identified two minor exceedances (of less than 2db) of the UAE residential ambient noise limits at two monitoring locations at Mirfa (highlighted in red in Table 5-120 and Table 5-121). The source of the exceedances was not able to be identified since the monitoring locations were isolated with no obvious noise sources. It is possible that off-road vehicle movements within the vicinity caused these exceedances.

However, the overall ambient noise baseline data is considered to be representative of the local area at Mirfa, which is subject to anthropogenic sources of noise relating to recreational activities only.

No exceedances were noted at Shuweihat or Das Island, which were classified by Nautica as industrial areas and therefore subject to less stringent ambient noise limits.

No exceedances of IFC noise limits were recorded at any of the monitoring locations.

Anthesis propose that the noise monitoring undertaken at Mirfa and Shuweihat is sufficient in identifying the noise baseline and consider that impacts will be limited to during the construction phase. Therefore, no significant changes to the noise baseline within the landfall or offshore island tie-in locations are expected during operation and noise sensitive receptors are therefore not likely to be significantly impacted. Noise monitoring at Al Ghallan Island landfall area is not considered necessary due to the temporary nature of construction on an industrial offshore island.

Table 5-119: Noise measurements recorded at Mirfa – N01

Measurement	Unit	N01			
		Week Day	Week Night	Weekend Day	Weekend Night
L_{Aeq}	dBA	48.9	34.3	40.4	36.2
L_{max}	dBA	66.2	49.2	53.3	52
L_{10}	dBA	52.8	35.9	43.3	37.1
L_{50}	dBA	47.9	33.8	39.4	36
L_{90}	dBA	43	33	36	35
Environmental Conditions					
Average windspeed	m/s	1.95	1.23	3.51	0.76
Max windspeed	m/s	4.47	2.17	5.11	2.31

Measurement	Unit	N01			
		Week Day	Week Night	Weekend Day	Weekend Night
Average temp	˚C	35.6	25.2	37.4	32.3
Average humidity	%	64.8	91.5	40.8	75.3

Table 5-120: Noise measurements recorded at Mirfa – N02

Measurement	Unit	N02			
		Week Day	Week Night	Weekend Day	Weekend Night
L_{Aeq}	dBA	36.6	41.6	36.7	31.7
L_{max}	dBA	46.4	49.9	47.8	53.6
L_{10}	dBA	37.9	42.4	39.4	32.6
L_{50}	dBA	36.4	41.5	36.0	30.3
L_{90}	dBA	35.5	40.9	33.9	29.5
Environmental Conditions					
Average windspeed	m/s	2.56	1.43	4.03	1.72
Max windspeed	m/s	3.11	1.78	5.31	2.89
Average temp	˚C	28.4	24.2	37.7	31.5
Average humidity	%	85.2	92.4	47.1	80.5

Table 5-121: Noise measurements recorded at Mirfa – N03

Measurement	Unit	N03			
		Week Day	Week Night	Weekend Day	Weekend Night
L_{Aeq}	dBA	51.5	39.8	35.2	35.9
L_{max}	dBA	66.2	58.8	52.3	54.7
L_{10}	dBA	55.0	43.8	37.0	37.0
L_{50}	dBA	50.6	37.8	34.7	35.7
L_{90}	dBA	44.0	35.7	33.2	34.1

Measurement	Unit	N03			
		Week Day	Week Night	Weekend Day	Weekend Night
Environmental Conditions					
Average windspeed	m/s	2.24	1.90	3.87	0.56
Max windspeed	m/s	3.39	2.50	5.11	0.92
Average temp	˚C	30.9	24.4	35.8	29.8
Average humidity	%	75.7	93.4	53.8	85.8

Table 5-122: Noise measurements recorded at Shuweihat – N01

Measurement	Unit	N01			
		Week Day	Week Night	Weekend Day	Weekend Night
L_{Aeq}	dBA	44.2	45.5	38.2	42.1
L_{max}	dBA	56.4	54.2	49.9	49.3
L_{10}	dBA	45	47.6	39.2	43.5
L_{50}	dBA	44.1	44.9	38	41.8
L_{90}	dBA	43.3	43.2	37.1	40.8
Environmental Conditions					
Average windspeed	m/s	3.61	1.89	1.98	1.34
Max windspeed	m/s	4.56	3.42	3.94	2.67
Average temp	˚C	37.4	33.1	40.3	31.6
Average humidity	%	35	42.1	17.1	68.2

Table 5-123: Noise measurements recorded at Shuweihat – N02

Measurement	Unit	N02			
		Week Day	Week Night	Weekend Day	Weekend Night
L_{Aeq}	dBA	37.9	44.4	39.0	40.5
L_{max}	dBA	61.2	49.8	50.6	52.3
L_{10}	dBA	39.5	45.4	41.3	41.5
L_{50}	dBA	37.2	44.4	38.4	40.4
L_{90}	dBA	35.6	43.4	36.5	39.4
Environmental Conditions					
Average windspeed	m/s	3.64	3.92	4.82	2.37
Max windspeed	m/s	4.69	5.58	5.81	3.81
Average temp	°C	37.5	34.6	41.9	33.3
Average humidity	%	34.6	37	14.1	57.4

Table 5-124: Noise measurements recorded at Shuweihat – N03

Measurement	Unit	N03			
		Week Day	Week Night	Weekend Day	Weekend Night
L_{Aeq}	dBA	41.8	51.4	45.4	47.7
L_{max}	dBA	50.2	62.8	57.2	59.2
L_{10}	dBA	44.0	54.3	48.3	51.0
L_{50}	dBA	41.4	50.5	44.2	46.9
L_{90}	dBA	39.7	48.1	41.6	42.1
Environmental Conditions					
Average windspeed	m/s	2.79	4.59	4.57	1.59
Max windspeed	m/s	4.14	7.08	6.44	3.08
Average temp	°C	39.1	34.1	42.0	33.8
Average humidity	%	29.1	44.6	15.8	51.2

Table 5-125: Noise measurements recorded at Das Island – N01

Measurement	Unit	N01			
		Week Day	Week Night	Weekend Day	Weekend Night
L_{Aeq}	dBA	31.4	39.9	30.9	37.2
L_{max}	dBA	47.8	50.7	45.1	48.7
L_{10}	dBA	33.4	41.3	32	38.3
L_{50}	dBA	30.8	39.7	30.7	37
L_{90}	dBA	29.4	38.5	29.9	36.1
Environmental Conditions					
Average windspeed	m/s	2.99	1.20	1.63	1.25
Max windspeed	m/s	3.67	1.78	2.42	1.86
Average temp	°C	37.7	34.7	34.6	34.6
Average humidity	%	60.8	75.3	77.2	69.2

Table 5-126: Noise measurements recorded at Das Island – N02

Measurement	Unit	N02			
		Week Day	Week Night	Weekend Day	Weekend Night
L_{Aeq}	dBA	36.2	42.6	32	35.1
L_{max}	dBA	48.5	62.2	49.2	47.5
L_{10}	dBA	38.1	44.4	33.7	36.0
L_{50}	dBA	35.8	42.2	31.5	35.0
L_{90}	dBA	34.2	40.5	30.5	34.3
Environmental Conditions					
Average windspeed	m/s	2.33	0.12	1.66	0.72
Max windspeed	m/s	3.00	0.56	3.11	0.94
Average temp	°C	37.8	33.5	36.0	34.2
Average humidity	%	62.0	77.3	68.1	69.7

Table 5-127: Noise measurements recorded at Das Island – N03

Measurement	Unit	N03			
		Week Day	Week Night	Weekend Day	Weekend Night
L_{Aeq}	dBA	37.2	44.2	33.7	39.1
L_{max}	dBA	47.9	53.6	50.3	52.9
L_{10}	dBA	39.0	46.2	35.1	40.5
L_{50}	dBA	36.8	43.7	33.2	38.9
L_{90}	dBA	35.3	42.6	32.0	37.7
Environmental Conditions					
Average windspeed	m/s	2.35	1.33	1.57	0.02
Max windspeed	m/s	2.94	2.44	2.19	0.47
Average temp	°C	36.7	34.1	37.1	32.7
Average humidity	%	65.7	75.5	63.4	76.2

5.7.2. Environmental Impact Prediction and Evaluation

5.7.2.1. Sensitive Receptors

The noise sensitive receptor locations are displayed in Table 5-128 below.

Table 5-128: Noise sensitive receptors

Sensitive Receptor	Receptor Class Value	Justification
Operational staff at adjacent facilities including Al Mirfa and Al Shuweihat Power and Water Complex, and facilities on Das Island and Al Ghallan Island.	*Low*	Existing operational staff at adjacent industrial facilities are considered to be working in an already degraded environment and sensitivity to temporary noise impacts are therefore reduced.
Construction workers associated with the Project	*Medium-High*	Construction workers will be subject to the greatest noise impacts due to their proximity to noise generating activities.
Residential properties at Al Mirfa	*Medium-High*	Nearby residential properties will be sensitive to noise emissions

5.7.2.2. Construction Phase Impacts

5.7.2.2.1. Overview

Noise emissions will occur during construction works, with the most significant noise levels expected during excavations, concrete pouring, metal work activities (cutting, grinding and bending) and through the use of machinery and plant.

Typical construction activities which will result in noise generation include the operation of heavy machinery, trucks, excavators, shovels, the operation of marine vessels involved in the nearshore dredging activities and the movement of construction plant and vehicles. As the construction contractor(s) has not yet been appointed, the specific items of plant and equipment as well as resulting noise emissions cannot be determined. However, this will have a temporary impact on the surrounding environment. It is understood that construction activities will take place 24 hours a day, 7 days a week. This therefore will result in potential impacts associated with the required lighting for overnight construction activities. An assessment of potential impacts of lighting upon bird species is provided within **Section 5.6.2**.

Impacts have been assessed based on distance from the Project site, as follows:

All Routes – Existing Operational Workers

Shuweihat, Das Island and Al Ghallan Islands are classified as areas of '*heavy industry'.* Although the noise environment within Mirfa is classified as '*residential ith light traffic'*, adjacent industrial facilities can be considered as potentially noisy environments and as such operational workers at adjacent facilities are considered to be of *low* sensitivity since the receptors are at their place of work, with existing noise generating sources. Construction noise is considered to represent an impact magnitude of *low* severity upon receptors, therefore resulting in an overall impact of **negligible** significance.

All Routes – Construction Workers

Construction workers within the Project sites at Mirfa, Shuweihat, Das Island and Al Ghallan Island will be subject to the greatest impact since they are located at the point source of noise, will be operating noise generating machinery and may potentially be exposed to high noise levels for extended durations throughout the working day. The impact of construction related noise is considered to represent an impact magnitude of *medium* severity upon receptors of *high* sensitivity, therefore resulting in an impact of **major negative** significance, in the absence of mitigation measures.

Route 1 – Mirfa

Residential receptors within 500m (with the nearest receptor being located 90m from the Project site boundary near Mirfa) are likely to experience noise disturbance from marine works being undertaken in the nearshore areas such as dredging in addition to construction activities onshore, including trenching for the onshore cable laying, earthworks, laydown areas activities, truck movements etc. The onshore cable trenching activities and installation of adjacent gravel road which will traverse closest to the residential receptors (90m) are expected to last for a duration of approximately 4 weeks. Other construction activities associated with converter stations are located >500m from the nearest residential receptors and therefore are unlikely to result in significant disturbance.

Construction noise is therefore considered to represent an impact magnitude of *low* severity upon receptors of *high* sensitivity, therefore resulting in an overall impact of **moderate negative** significance prior to the implementation of mitigation measures.

Sensitive receptors located more than 500m from the Project site at Mirfa are considered to be of *low-medium* sensitivity with construction noise representing an impact significance of *low* severity, therefore resulting in an impact of **negligible** significance.

Route 2 – Shuweihat

Operational workers in adjacent facilities and construction workers associated with the Project are the only sensitive receptors present <500m from the Project site at Shuweihat, as discussed above.

Sensitive receptors located more than 500m from the Project site at Shuweihat are considered to be of *low* sensitivity with construction noise representing an impact significance of *low* severity, therefore resulting in an impact of **negligible** significance.

Impacts upon terrestrial and intertidal ecology

Noise impacts upon terrestrial and intertidal ecology are presented in **Section 5.6: Terrestrial Ecology**.

Underwater noise impacts

Underwater noise impacts are presented within **Section 5.5: Marine Ecology**.

5.7.2.3. Operational Phase Impacts

As stated within the approved Project Lightning Scoping Document (27th September 2021), no significant impacts are anticipated during operation as there will be no significant noise emissions. Therefore, a detailed assessment was proposed to be scoped out of the ESIA.

The potential impacts are described below.

5.7.2.3.1. Noise Emissions from Converter Stations and Associated Equipment

Noise emissions are only likely to arise from the plant equipment located at Mirfa, Shuweihat, Al Ghallan Island and Das Island, with no noise emissions expected from the cables buried onshore and offshore. Operational noise impacts may be experienced by operational workers within the onshore Project sites including converter station buildings. The expected noise level associated with the operation of all Project components will be 60dB and therefore will be within allowable UAE and IFC noise limits. Impact magnitude is therefore expected to be *low* upon receptors of *low* sensitivity, therefore resulting in an overall impact of **negligible** significance, in the absence of mitigation measures.

No significant operational impacts are expected upon noise sensitive receptors. Noise sensitive receptors located < 500m of the Project site boundary, including residential receptors at Mirfa, plus operational workers at all Project sites in adjacent industrial facilities are unlikely to notice any perceptible increase in noise levels during operation. In addition, noise emitting equipment within the Project sites will be housed within appropriately designed structures ensuring attenuation of noise emissions. Operational noise emissions are therefore considered to represent an impact magnitude of *no change* upon receptors of *high* sensitivity (residential properties <500m distant) therefore resulting in an impact of **negligible** significance.

No impacts are expected upon noise sensitive receptors > 500m from the Project site boundaries at Mirfa, Shuweihat, Al Ghallan Island or Das Island.

5.7.2.3.2. Noise Emissions from Operational Vehicles

Noise will be generated from the movement of vehicles associated with operational staff and maintenance requirements accessing Mirfa and Shuweihat Project sites. However, the local road network is relatively quiet, and several alternative routes are available to avoid traffic passing through Ruwais and Mirfa.

No detailed information has been provided on volumes or frequencies of operational traffic. However, the operational worker numbers are low, with a total of seven employees proposed to work per day across three shifts. Traffic movements are therefore limited to three return journeys from the workers accommodation daily, in addition to operational maintenance activities which are scheduled monthly, quarterly, bi-annually and annually. It is therefore considered that traffic trips generated in the area as a result of the operational phase of the Project would represent an impact magnitude of *slight* severity on a receptor of *medium* sensitivity which would result in an impact of **negligible** significance in the absence of mitigation measures.

5.7.2.4. Cumulative Impacts

5.7.2.4.1. Construction Phase

Type 1 cumulative impacts are expected upon noise sensitive receptors including the residential properties nearest to the construction corridor for the cables. Such properties are likely to experience the combined impacts of a deterioration in air quality from vehicular emissions and/or dust generation, in conjunction with potentially elevated noise levels and a reduction in visual amenity.

Type 2 impacts are possible given the likely concurrent construction of Project Wave at Mirfa and Mugharraq Port in Shuweihat, which together with noise emissions from the Project construction activities may cumulatively result in exceedances of allowable noise levels at sensitive receptors. This is considered to be unlikely at Mirfa since Project Wave is located 2km from the Project site, but increased traffic movements may contribute to the noise environment. At Shuweihat, sensitive receptors may experience a more significant noise level since the accommodation camps to the north of the Project site are situated immediately adjacent to Mugharraq Port site boundary.

5.7.2.4.2. Operational Phase

Although there may be a marginal increase in noise levels within the Project area as a result of the operation of the Project, it is considered that the operational noise levels will be minimal and will not significantly contribute to the wider noise environment. Therefore, no Type 1 or Type 2 cumulative noise impacts are expected.

5.7.3. Mitigation Measures

5.7.3.1. Potential Mitigation Measures

A range of mitigation measures will be required to offset the noise impacts associated with the Project. The potential mitigation measures are set out within Table 5-129 below.

Table 5-129: Noise impacts and potential mitigation measures

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
CONSTRUCTION PHASE								
1	Existing operational workers	Noisy construction activities e.g. trenching and earthworks	Adjacent industrial facilities Al Mirfa and Al Shuweihat Power and Water Complex, and facilities on Das Island and Al Ghallan Island.	Negligible	– Orientating noisy equipment such as generators away from noise sensitive receptors; and – Carry out loading and unloading away from noise sensitive areas	Noise emissions limits set out within Cabinet Decree No 12 of 2006 for the protection of air quality IFC EHS General Guidelines	**UAE** Within 'Industrial Areas (Heavy industries): Daytime: 60 – 70 dB Night-time: 50 – 60 dB **IFC** 70 L_{Aeq} dB(A) at an industrial receptor for daytime and night-time periods; or A maximum 3dB(A) increase in background levels at the nearest receptor location off-site.	Yes
2	Health impacts upon construction workers within the Project site	Noise generating construction activities such as excavations and operating heavy machinery	All Project sites	Major negative	– Construction workers should be issued with appropriate PPE; – Limit time periods spent by construction workers operating noisy equipment; and – Site inductions to cover the importance of noise control and available noise reduction measures should be undertaken	Noise emissions limits set out within Cabinet Decree No 12 of 2006 for the protection of air quality IFC EHS General Guidelines	**UAE** Within 'Industrial Areas (Heavy industries): Daytime: 60 – 70 dB Night-time: 50 – 60 dB **IFC** 70 L_{Aeq} dB(A) at an industrial receptor for daytime and night-time periods; or A maximum 3dB(A) increase in background levels at the nearest receptor location off-site.	Yes
3	Disturbance to residential receptors	Noise generating construction activities including nearshore dredging and cable laying activities	Residential properties <500m from the Mirfa Project site boundary,	Moderate negative	– Orientating noisy equipment such as generators away from noise sensitive receptors; and – Carry out loading and unloading away from noise sensitive areas.	Noise emissions limits set out within Cabinet Decree No 12 of 2006 for the protection of air quality IFC EHS General Guidelines	**UAE** Within 'Industrial Areas (Heavy industries): Daytime: 60 – 70 dB Night-time: 50 – 60 dB **IFC** 70 L_{Aeq} dB(A) at an industrial receptor for daytime and night-time periods; or A maximum 3dB(A) increase in background levels at the nearest receptor location off-site.	Yes

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
OPERATION PHASE								
4	Noise emissions from operation	Noise generating machinery	Within the Project sites at Mirfa, Shuweihat, Al Ghallan Island and Das Island	Negligible	– Provision of appropriate PPE; and – It is considered that the Project design will house all noise generating equipment within appropriate housing to ensure attenuation of noise levels.	Noise emissions limits set out within Cabinet Decree No 12 of 2006 for the protection of air quality IFC EHS General Guidelines	**UAE** Within 'Industrial Areas (Heavy industries): Daytime: 60 – 70 dB Night-time: 50 – 60 dB **IFC** 70 L_{Aeq} dB(A) at an industrial receptor for daytime and night-time periods; or A maximum 3dB(A) increase in background levels at the nearest receptor location off-site.	Yes
5	Noise emissions from operational vehicles	Movement of operational vehicles	<500m from the Project site boundaries	Negligible	– No mitigation required.	Noise emissions limits set out within Cabinet Decree No 12 of 2006 for the protection of air quality IFC EHS General Guidelines	**UAE** Within 'Industrial Areas (Heavy industries): Daytime: 60 – 70 dB Night-time: 50 – 60 dB **IFC** 70 L_{Aeq} dB(A) at an industrial receptor for daytime and night-time periods; or A maximum 3dB(A) increase in background levels at the nearest receptor location off-site.	Not applicable

5.7.3.2. Selected Mitigation Measures

5.7.3.2.1. Construction Phase

Noise from construction activities can be controlled through Health, Safety and Environmental (HSE) Management Plans, such as a Construction Environmental and Social Management Plan (CESMP). The following mitigation measures are proposed for construction activities at onshore and offshore Project locations:

- Site inductions to cover the importance of noise control and available noise reduction measures should be undertaken;
- The EPC Contractor shall develop a project construction noise control plan, which shall be approved and implemented prior to commencement of any construction activity;
- Noise monitoring will be carried out at residential communities and hospitals / clinics as shown in Figure 4-49 to Figure 4-52 within **Section 4.2.4.3** when construction activities likely to give rise to significant noise impacts (e.g. earthworks and certain road works) are on-going. If exceedances are recorded above the UAE limits for 'Residential Areas with Light Traffic' (Table 3-11), night-time working will be carefully controlled to ensure that construction activities likely to give rise to significant noise impacts (e.g. earthworks and certain road works) are not undertaken;
- Noise monitoring should be undertaken at sensitive receptor locations during critical periods of construction in order to identify non-compliance and the need for additional noise controls where necessary;
- Implementation of noise controls such as portable screening would be employed if monitoring indicates the need or in response to concerns;
- Orientating noisy equipment such as generators away from noise sensitive receptors;
- Carry out loading and unloading away from noise sensitive areas;
- Construction contractors should be required to use equipment that is in good working order and that meets current best practice noise emission levels. This should be achieved by making it a component of contractual agreements with the construction contracts;
- As far as reasonably practicable, sources of significant noise should be enclosed. The extent to which this can be done depends on the nature of the machines to be enclosed and their ventilations requirements;
- Minimise reversing of equipment to prevent nuisance caused by reversing alarms;
- Driver practices when approaching and leaving the site should minimise noise emissions created through activities such as unnecessary acceleration and breaking squeal;
- Construction site speed limits shall be established and enforced during the construction period;
- Electrically-powered equipment instead of pneumatic or internal combustion powered equipment shall be used, where feasible;
- Construction site and haul-road speed limits shall be established and enforced during the construction period;
- The use of noise-producing signals, including horns, whistles, alarms, and bells shall be for safety warning purposes only;

- Community grievance mechanism and active information dissemination regarding the construction schedule and noisy activities; and
- The on-site construction supervisor shall have the responsibility and authority to receive and resolve noise complaints. A clear appeal process shall be established prior to construction commencement that will allow for resolution of noise problems that cannot be immediately solved by the site supervisor.

5.7.3.2.2. Operational Phase

Impacts during the operational phase are expected to be minimal. However, the following mitigation measures are proposed to ensure the minimisation of any potential impacts upon noise sensitive receptors both within and beyond the boundaries of the Project sites:

- Plant operations should always be carried out using equipment that is in good working order and that meets current best practice noise emission levels;
- Noise monitoring should be undertaken during the initial commissioning and early operational stages of the Project in order to determine the operational noise emission levels and to aid the selection of additional noise controls where necessary. Additional noise controls such as portable screening would be employed if monitoring indicates the need or in response to concerns. Ongoing monitoring may be required in future if sensitive receptors are developed / established close to the facility; and
- Developing a mechanism to record and respond to complaints.

Additionally, there are a number of noise mitigation measures largely relating to the incorporation of acoustic attenuation within building design, as follows:

- Selecting equipment with lower sound power levels;
- Installing acoustic enclosures for equipment casing radiating noise;
- Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m^2 in order to minimise the transmission of sound through the barrier. Barriers should be located as close to the source or to the receptor location to be effective; and
- Developing a Project noise control plan during the EPC phase.

5.7.3.3. Mitigation Measures to Address Cumulative Impacts

With regard to Type 1 cumulative impacts, it is anticipated that the mitigation measures provided in the preceding sections will serve to address cumulative impacts from multiple impact types (e.g. air quality and noise) upon a particular sensitive receptor, whereby all parties will be obligated to adhere to the EAD permitting process and implement specific measures to ensure that both construction controls (e.g. through the development of a CESMP by the EPC Contractor).

Type 2 impacts, although not predicted to occur, would be adequately mitigated by the selected mitigation measures provided in the preceding sections.

Mitigation measures are not considered necessary for cumulative impacts during operation.

5.7.3.4. Residual Impacts

As presented in Table 5-130 below, no significant residual impacts are anticipated for the Project should the mitigation measures be successfully implemented for both construction and operation phases of the Project.

Table 5-130: Noise residual impacts

Description of the Impacts	Impact Significance Prior to Mitigation Measures	Residual Impact Significance
Construction Phase		
Existing operational workers at Al Mirfa and Al Shuweihat Power and Water Complex, adjacent facilities on Al Ghallan and Das Island	Negligible	Negligible
Health impacts upon construction workers within all Project site areas	Major negative	Minor negative
Disturbance to residential receptors < 500m from Mirfa Project site boundary	Moderate negative	Minor negative
Operation Phase		
Noise emissions from operation	Negligible	Negligible
Noise emissions from operational vehicles	Negligible	Negligible

5.7.4. Monitoring Program

5.7.4.1. Monitoring Program for Compliance with Selected Mitigation Measures

5.7.4.1.1. Construction Phase

Baseline noise measurements should be undertaken at the nearest receptor location off site (boundary of the property located 90m from Project site boundary at Mirfa) to understand the existing noise environment.

Noise monitoring should then be carried out at this receptor and other nearest residential sensitive receptors during critical periods of construction in order to identify non-compliance with UAE and IFC allowable noise limits and identify the need for additional noise control measures.

5.7.4.1.2. Operation Phase

As no significant operational impacts are expected, not monitoring requirements are considered necessary.

5.7.4.2. Monitoring Program for Cumulative Impacts

No additional monitoring, other than that described above is considered necessary for cumulative impacts.

5.7.4.3. Monitoring Program for Residual Impacts

No additional monitoring, other than that described above is considered necessary for residual impacts.

5.8. Traffic and Transportation

5.8.1. Description of the Environment

5.8.1.1. Route 1 – Mirfa

The town of Mirfa is accessed from the main E11 Highway – Sheikh Khalifa Bin Zayed Al Nahyan International Road via an interchange to Ah Shaheed Ahmed Khamis Al Hammadi Street. Al Mirfa Power and Water Complex is accessed via the local road network and is approached from Al Khor Street.

5.8.1.2. Route 2 – Shuweihat

The Project site is located within a remote coastal area in the Eastern Region of Abu Dhabi, adjacent to the town of Ruwais. The E11 Highway – Sheikh Khalifa Bin Zayed Al Nahyan International Road traverses parallel to the coast and diverts into Al Rubban Street, the main access road to Ruwais. From the local road network within Ruwais, the Project site is accessed via Qarn Mgharraq Street.

5.8.2. Environmental Impact Prediction and Evaluation

5.8.2.1. Sensitive Receptors

The anticipated sensitive receptors in relation to traffic and transportation are set out below in Table 5-131.

Table 5-131: Traffic and transportation sensitive receptors

Sensitive Receptor	Value	Justification
Local road network within the vicinity of the Project sites	*Low*	The local road network is small in scale and due to the limited development within the vicinity, it is not expected that the road network is heavily utilised.
Residents, commercial and any other land use relying on the local road network	*Medium*	Although a limited number of residential properties at Mirfa share the same access road to the Project area, sensitive receptors (i.e. road users) are otherwise not reliant upon the local road network which will be utilised for construction.

5.8.2.2. Construction Phase Impacts

Traffic anticipated to be generated by the Project during the construction phase will likely involve the following movements:

- Delivery of construction materials, including 2.6 million tons of rock from an existing UAE quarry. The quarry location and proposed delivery routes from the quarry to the loading port is currently unknown and will need to be specified within the CESMP, although note that it is assumed that rock will be sourced from an existing operational quarry and thereore additional assessments or approvals are not required;
- Construction equipment and plant, including excavators, earthmovers, dump trucks and piling rigs;
- Workers arriving and departing from the Project construction sites and travelling to the construction accommodation camps on a daily basis; and
- The transportation of any waste materials requiring removal to local waste infrastructure.

The increase in traffic will largely be mainly from Heavy Goods Vehicles (HGVs) used for material transport and buses for construction workers. Considering both the construction of onshore elements such as the converter buildings and other components in addition to the laying of cables along both corridors, it can be expected that a significant amount of construction materials and cables/associated equipment will need to be delivered to the Project sites. The increase in traffic will mainly be in relation to Heavy Goods Vehicles (HGVs) used for material transport and buses for construction workers. The local road networks serve a relatively low level of traffic since the surrounding areas at Mirfa and Shuweihat are not densely populated and the Project sites at both locations are located away from the central areas of Mirfa and Ruwais suggesting that construction traffic will not require routing through the built-up areas.

No impacts are predicted on Das Island or Al Ghallan Island. The following impacts are predicted at Mirfa and Shuweihat:

Route 1 – Mirfa

A number of sensitive receptors are located within close proximity of the Project site area at Mirfa, with numerous residential receptors located to the east of the Project site along the shoreline. As a result, it is considered that these receptors are likely to experience a certain level of disturbance upon the local road network in terms of delays and congestion. This is particularly likely due to the fact that the residential receptors will be sharing the main access road to the vicinity of the Project site area.

The impact of an increase in construction related traffic upon residential and commercial receptors within the vicinity of the Project site and wider area of Mirfa town will likely represent an impact magnitude of *low* severity upon receptors of *medium* sensitivity, therefore resulting in an overall impact of **minor negative** significance, on a temporary basis.

Route 2 – Shuweihat

The Project area at Shuweihat contains very few sensitive receptors in terms of traffic impacts. Receptors in this area would be limited to the operational traffic associated with the Al Shuweihat Power and Water Complex, in addition to the accommodation camps to the north and ADNOC jetty and facilities to the north. Ruwais city is located 5km to the south-east of the Project area and is therefore unlikely to be significantly impacted since alternative routes are available to avoid the direct routing of construction traffic through the city area. Therefore, construction traffic is considered to represent an impact magnitude of *low* severity upon receptors of *low* sensitivity, therefore resulting in an impact of **negligible** significance.

5.8.2.3. Operational Phase Impacts

During the operational phase, impacts relating to the local traffic network are expected to be associated with maintenance vehicle movements and the transportation of operational personnel only.

No detailed information has been provided on volumes or frequencies of operational traffic. However, the operational worker numbers are low, with a total of seven employees proposed to work per day across three shifts. Traffic movements are therefore limited to three return journeys from the workers accommodation daily, in addition to operational maintenance activities which are scheduled monthly, quarterly, bi-annually and annually.

It is therefore considered that operational vehicles accessing the Project site areas are insignificant in terms of impacts upon other road users and the local traffic network, as are the number of operational personnel expected to be employed by the Project. Detailed assessment of operational impacts relating to traffic have therefore been scoped out of this ESIA and are not considered further.

5.8.2.4. Cumulative Impacts

5.8.2.4.1. Construction Phase

Type 1 impacts are possible during construction, since disturbances due to an increase in traffic and the movement of heavy machinery and vehicles may occur for users of the local road network in addition to residential properties close to roads, in combination with additional air and noise impacts resulting from gaseous and noise emissions from such traffic movements.

It is considered possible that Type 2 impacts may also arise as a result of the addition of traffic from the Project to the existing traffic levels associated with adjacent industrial areas such as the Al Mirfa and Al Shuweihat Power and Water Complexes, as well as construction traffic generated by Project Wave at Mirfa and Mugharraq Port at Shuweihat which are likely to be under construction concurrently with the Project.

5.8.2.4.2. Operation Phase

Type 1 impacts during operation are possible for the same reasons albeit likely at a lower level since operational traffic associated with the Project is likely to be minimal.

It is considered possible that Type 2 impacts may arise as a result of the addition of traffic from the Project to the existing traffic levels associated with adjacent industrial areas such as the Al Mirfa and Al Shuweihat Power and Water Complexes during operation. However, since operational traffic levels are expected to be low, it is not considered that the cumulative impacts will be significant.

5.8.3. Mitigation Measures

5.8.3.1. Potential Mitigation Measures

A range of mitigation measures will be required to offset the traffic impacts associated with the Project. The potential mitigation measures are set out within Table 5-132 below.

Table 5-132: Traffic and transportation impacts and potential mitigation measures

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
CONSTRUCTION PHASE								
1	Impact on local road network from an increase in construction traffic in Mirfa	Construction related traffic	Project site and surrounding road network	Minor negative	– Routes shall be planned to be as direct as possible; – Vehicle and truck movements on the local road network should avoid AM and PM Peak hours – Transport buses, construction vehicles and construction deliveries/collection to and from the Project Site should travel at different times	Not applicable	Not applicable	Yes
2	Impact on local road network from an increase in construction traffic at Shuweihat	Construction related traffic	Project site and surrounding road network	Negligible	– All construction drivers should be appropriately licensed and trained in road and traffic safety – Trip durations should be capped to prevent excessive driving times and driver exhaustion – Appropriate warning signs and flag operators should be used to warn the public of any adverse driving conditions as a result of construction traffic	Not applicable	Not applicable	Yes
OPERATION PHASE								
3	Disturbance to local road network due to operational vehicle movements	Operational vehicles	Project site and surrounding road network	Negligible	– Not applicable	Not applicable	Not applicable	Not applicable

5.8.3.2. Selected Mitigation Measures

5.8.3.2.1. Construction Phase

The main contractor will be required to provide a comprehensive Traffic Management Plan within the CESMP to control traffic impacts. Measures will include:

- Timing restrictions to limit night-time traffic movements;
- Careful routing to avoid Mirfa and Ruwais settlements where possible to minimise impacts on the most sensitive receptors e.g. by bypassing residential areas and schools;
- Routes shall be planned to be as direct as possible;
- Transport buses, construction vehicles and construction deliveries/collection to and from the Project Site should travel at different times;
- Slow moving vehicles carrying heavy equipment/loads shall be restricted to travel only during times with lowest traffic;
- Workers based in accommodation camps shall be transported by bus rather than cars;
- Where possible, construction traffic shall be scheduled in off-peak traffic times and on well-maintained routes;
- Appropriate traffic safety signage will be provided to warn the public of construction traffic where traffic merges with normal road traffic;
- Where appropriate, locally sourced materials shall be utilised within the construction phase to minimise driving distances, and workers shall be transported to Project site by bus to minimize external traffic;
- All construction drivers shall be appropriately licensed and trained in road and traffic safety;
- Trip durations shall be capped to prevent excessive driving times and driver exhaustion;
- Appropriate warning signs and flag operators shall be used to warn the public of any adverse driving conditions as a result of construction traffic; and
- Appropriate warning signs and flag operators should be used to warn the public of any adverse driving conditions as a result of construction traffic.
- Provision of temporary signage to ensure that construction vehicles adhere to the recommended routes and diversions.

5.8.3.2.2. Operation Phase

During the operational phase there will be very limited requirements for traffic movements associated with the Project. Operational traffic will be limited to transportation of the limited staff and any maintenance vehicles which may be required. Therefore, no specific mitigation measures are considered necessary.

5.8.3.3. Mitigation Measures to Address Cumulative Impacts

With regard to Type 1 cumulative impacts, it is anticipated that the mitigation measures provided in the preceding sections will serve to address cumulative impacts from multiple impact types (e.g. air quality and noise) upon a particular sensitive receptor, whereby all parties will be obligated to adhere to the EAD permitting process and implement specific measures to ensure that both construction controls (e.g. through the development of a CESMP by the EPC Contractor).

Type 2 impacts, although not predicted to occur, would be adequately mitigated by the selected mitigation measures provided in the preceding sections.

Mitigation measures are not considered necessary for cumulative impacts during operation.

5.8.3.4. Residual Impacts

As presented in Table 5-133 below, no significant residual impacts are anticipated for the Project should the mitigation measures be successfully implemented for both construction and operation phases of the Project.

Table 5-133: Traffic and Transportation residual impacts

Description of the Impacts	Impact Significance Prior to Mitigation Measures	Residual Impact Significance
Construction Phase		
Increase of traffic from construction traffic in Mirfa	Minor negative	Negligible
Increase of traffic from construction traffic in Shuweihat	Negligible	Negligible
Operation Phase		
Increase in traffic due to operational activities	Negligible	Negligible

5.8.4. Monitoring Program

5.8.4.1. Monitoring Program for Compliance with Selected Mitigation Measures

Monitoring requirements are proposed for air quality and noise which are detailed in **Section 5.1.4.1** and **Section 5.7.4.1**, respectively which will adequately monitor potential impacts associated with traffic and transportation.

5.8.4.2. Monitoring Program for Cumulative Impacts

No additional monitoring, other than that described above is considered necessary for cumulative impacts.

5.8.4.3. Monitoring Program for Residual Impacts

No additional monitoring, other than that described above is considered necessary for residual impacts.

5.9. Socio-Economic

5.9.1. Description of the Environment

This section of the ESIA details the assessment which has been undertaken with regards to potential socio-economic impacts associated with the construction and operation of the Project. The results of a desk-based study are provided and an assessment undertaken in order to identify the potential significance of impacts. Where appropriate, mitigation and control measures are then set out.

5.9.1.1. Baseline Methodology

Existing baseline conditions within Abu Dhabi Emirate and the Project site area have been determined through a combination of a desk-based socio-economic baseline studies, a site visit undertaken by Anthesis personnel to identify current socio-economic conditions and existing land uses within the Project site area including the presence of sensitive receptors. The desk-based socio-economic studies have excluded any community engagement.

The results of this baseline study and survey are presented below.

5.9.1.2. Baseline Study – Desk Based Results

In order to provide an overview of the current socio-economic conditions present within the Emirate of Abu Dhabi as a whole, a desk-based exercise was undertaken to provide a summary of the following components:

- Population statistics and demographics;
- Economic development overview;
- Education statistics;
- Tourism statistics; and
- Commercial and economic development.

The following sources have been reviewed in order to understand key socio-economic data such as statistical population data for Ruwais and the socio-economic profile of the wider Abu Dhabi Emirate:

- The World Factbook, CIA – UAE (154);
- Statistics Centre of Abu Dhabi (80);
- Statistical Yearbook – Population 2020 (80);
- Statistical Yearbook – Employment 2020 (80);
- Statistical Yearbook – Education 2020 (80); and
- Plan Abu Dhabi 2030 – Urban Structure Framework Plan (37).

5.9.1.2.1. Population Statistics

The Statistics Centre of Abu Dhabi (SCAD) provides the most up to date population data and estimates within the Statistical Yearbook of Abu Dhabi 2020 (80). The latest census information dates from 2016 and is provided within the Statistical Yearbook 2020. It is estimated that the total population of the Emirate of Abu Dhabi, including Abu Dhabi Island, Al Ain and Al Gharbia regions in 2016 was 2,908,173 persons, which represents an average annual growth rate of 5.6% since 2010 as detailed in Table 5-134. Within this general population estimate, the approximate gender mix was estimated in 2016 to be 1,857,618 males and 1,050,555 females. It was recorded that more than 63.9% of the population of Abu Dhabi Emirate are males, due to an influx of male migrant workers.

Table 5-134: Population estimates by region and gender – mid 2010 and mid 2016 (thousand persons) (80)

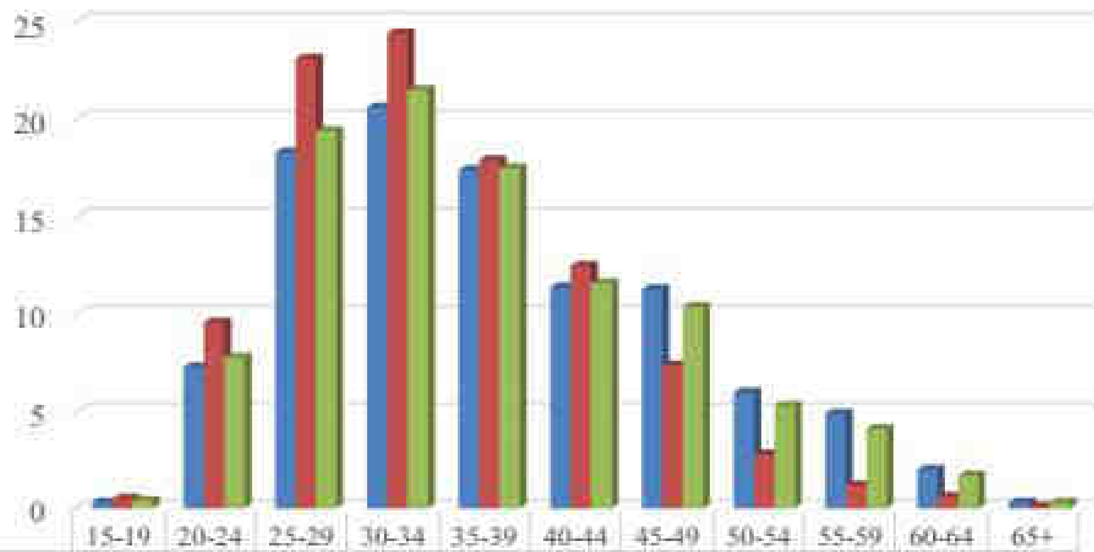
Region	Males	Females	Total
Abu Dhabi Emirate			
2010	1,461	633,7	2,095
2016	1,858	1,051	2,908
Abu Dhabi Region			
2010	871,5	394,6	1,266
2016	1,122	685,3	1,807
Al Ain Region			
2010	376,8	209,2	585,9
2016	451,8	315,2	766,9
Al Gharbia Region315,2			
2010	212,5	30,0	242,0
2016	283,9	50,1	334,0

The overall average population density within Abu Dhabi Emirate was estimated as being 48.9 persons per square kilometre in 2016 (80), which represents a rise from 35.2 persons per square kilometre in 2010. Within the wider Abu Dhabi region, Al Ain and Al Dhafra regions, population density estimated to be 164.2, 57.3 and 9.5 persons per square kilometre, respectively. Although it is clear that Al Dhafra has a significantly lower population density, it is reported to have the fastest population growth (80).

Of the total Abu Dhabi Emirate population, 19.0% are Emirati citizens, while the non-citizen population comprise 81.0% of the remaining total resident population. The population is expected to grow due to strong revenues from the oil sector and proposed housing developments as well as plans to establish new industrial areas (80).

One of the major drivers of employment growth within the Emirate of Abu Dhabi is the economic performance and associated demand for non-national workers. In 2015, an employment rate of 96.3% was recorded. Labour force estimates indicate that the largest proportion (63.8%) of the employed population was in Abu Dhabi Region. The distribution by status in employment revealed that the majority of employed persons in the Emirate of Abu Dhabi were paid employees (97.9%), while the remainder (1.6%) were own-account workers (80).

The private sector engaged the largest proportion (50.5%) of the employed population, while 12.2% worked for the government sector. As for employed citizens, 74.8% worked in the government sector and 5.5% in the private sector (80). The percentage distribution of employed population estimates by age and gender in 2016 illustrated below in Figure 5-215.



	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65+
Males (%)	0.3	7.3	18.3	20.6	17.4	11.4	11.3	6	4.9	2	0.3
Females (%)	0.5	9.6	23.1	24.4	17.9	12.5	7.4	2.8	1.2	0.6	0.1
Total (%)	0.4	7.8	19.4	21.5	17.5	11.6	10.4	5.3	4.1	1.7	0.3

Figure 5-215: Distribution of employed population estimates by age and gender in 2016 (80)

The percentage distribution of estimated employed population (15 years and over) by main occupations is illustrated in Figure 5-216. Indicators show that elementary occupation has the largest share of employees with 26.3% followed by service or sales workers at 16.4% (80).

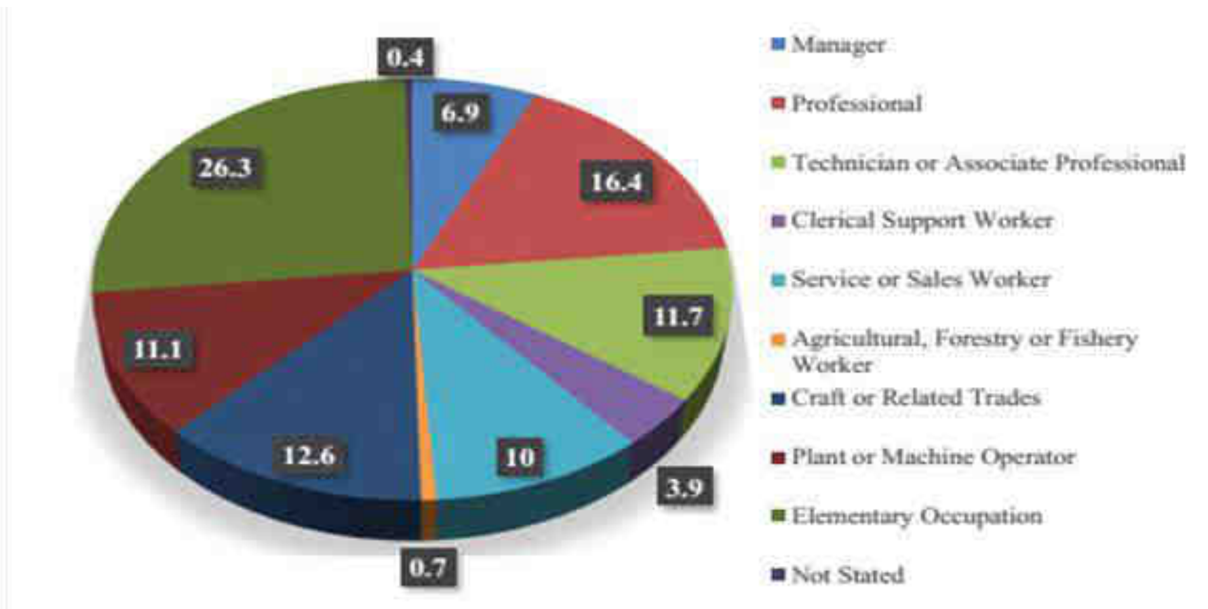


Figure 5-216: Distribution of employed population estimates based on occupation in 2016 (80)

5.9.1.2.2. Economy Overview

Overview

The UAE's economy has been shaped by the discovery of oil within the country's borders over 60 years ago. Since the time that oil was discovered until present day, the country has witnessed a dramatic growth period from an initially underdeveloped economy with a partially nomadic population and small desert settlements, to a now thriving modern and globally important multinational hub (154).

The economy of modern-day UAE is open with a high per capita income, and a demonstrable annual trade surplus. In order to facilitate economic diversification from the oil and gas sector, strategic plans have been formulated to promote the UAE as a global trade and tourism hub with a focus on industrialization and improved education and training opportunities, particularly for UAE nationals (154). Increases made in Government spending across the decades have facilitated job creation and significant infrastructure development. Foreign investment is significant and has grown substantially since the introduction of free trade zones throughout the country, which offers 100% foreign ownership and zero tax (154). In addition to the petrochemical (including the production of petrochemical products such as ammonia, urea fertilizers, polyethylene and polypropylene) and tourism industry, industries in the UAE include, but are not limited to; the import and export of commodities e.g. gold, jewellery etc., fishing, aluminium and cement production in addition to many other construction materials, commercial shipping activities including repairs etc., textiles and agriculture (154). A breakdown of sectoral contribution to GDP in 2019 is provided below in Table 5-135.

Table 5-135: Sectoral Distribution of GDP at constant prices for 2019 (155)

Sector	Percentage (%) of GDP
Mining and quarrying (including crude oil and natural gas)	29.8
Wholesale and retail trade and repair of motor vehicles and motorcycles	12.5
Manufacturing	8.4
Construction	8.3
Financial and insurance activities	8.0
Transportation and storage	5.7
Real estate activities	5.4
Public administration, defense and compulsory social security	5.2
Electricity, gas, water supply and waste management activities	2.9
Information and communication	2.9
Professional, scientific, and technical activities	2.6
Accommodation and food services activities	2.3
Administrative and support services activities	1.7
Human health and social work activities	1.3

Sector	Percentage (%) of GDP
Education	1.0
Other sectors	1.9

Of the seven Emirates within the UAE, Abu Dhabi contains the largest proven reserves of oil and gas. Key statistics relating to these activities in recent years is set out below in Table 5-136 which show an upwards trend across the range of indicators listed. However, it is reported that economic diversification has also been successful and that despite growing indicators within the oil and gas sector, the portion of GDP from oil and gas has been reduced to just under 30%. During 2019, contributions to the economic growth in the UAE in terms of outflow was driven by consumer and investment expenditure.

Table 5-136: Key statistics of oil and gas activity (80)

Indicators	2016	2017	2018	2019
Share in GDP at current prices (%)	30.9	33.2	40.8	39.8
Gross output (% of GDP at current prices)	33.4	38.6	44.2	39.8
Capital formation (% of GDP at current prices)	7.6	3.8	3.7	3.9
Compensation of employees (million AED)	14,330	14,327	15,263	15,520

Twice during the 21st century, the UAE has demonstrated resilience and capacity represented by its strong economy, first during 2008-2009 financial crisis and more recently throughout the Covid pandemic. This was achieved through the adoption of an integrated and flexible plan for recovering from these crises, driven largely by the Ministry of Economy, in partnership with other sectors of Federal and Local Government.

Covid-19 Impacts

Since 2020, the impact of Covid-19 was absorbed relatively well by the UAE's diverse economy, due to a number of factors. With an advanced broadband infrastructure with fast broadband speeds, the UAE adapted rapidly to working at home, online commerce and distance learning for schools (156). Other elements considered paramount in enabling the UAE to endure the pandemic include:

- Favourable credit rating;
- Sufficient foreign exchange reserves;
- Manageable debt levels; and
- Significant investment flows (156).

These points, in addition to the rapid deployment of the national vaccination programme and high uptake of the vaccine means that 100% of the population is now believed to have been either fully inoculated or at least received the first dose of the vaccine. This is likely to have significantly eased the burden on the health care system and ensure the uninterrupted delivery of services throughout the Emirate (156).

Although no specific data has yet been published in relation to growth within Abu Dhabi Emirate since the pandemic, as a result of the actions described above, the UAE economy is expected to have recovered significantly during 2021 and will continue to in the coming years.

5.9.1.2.3. Education Statistics

The educational system in the Emirate of Abu Dhabi includes three major divisions, namely general, technical, and higher education. The statistics summarised below covers the education progress of the Abu Dhabi, Al Ain and Al Dhafra region for the period 2018 - 2019 (80):

- The number of schools for the school year 2018 - 2019 was 499. Of these, 251 are government schools and 198 were private schools. 37.5% of all pupils were attending government schools, whilst 64.3% were enrolled in private education;
- Student percentages progressing to secondary schools were 95.7% for males and 94.9% for females;
- In 2018 – 2019 the average number of pupils per teacher was 13.3, with 23.2 pupils per classroom; and
- In total, in 2018-2019, 386,722 pupils were enrolled in all educational stages, a rise of 21.9% from 2010-11, displaying a steady educational growth in the Emirate of Abu Dhabi (80).

5.9.1.2.4. Tourism Statistics

Based on the information provided by the Department of Culture and Tourism, it is estimated that 5.1 million guests visited Abu Dhabi Emirate in 2019 (157) which shows a significant increase of 25% on the estimates from 2015 of 4.1 million tourists visits. Presently, there are 32,818 hotel rooms, including serviced hotel apartments with approximately 8000 under construction (157). The main sources of leisure guests originate from China, India, GCC, Germany, United Kingdom, Egypt and the United States (157).

5.9.1.2.5. Fisheries

Overview

The following is a summary from the environmentalatlas.ae website, maintained by the EAD (158).

Within the Emirate of Abu Dhabi, fishing grounds range from very shallow to deep waters and from rocky, sparsely vegetated areas to densely covered seagrass beds. Fishing methods are classified as a combination of boat type and gear type. Lansh (dhow) fishermen use gargoor traps, which are usually deployed in medium to deep waters. Tarad boats use a variety of fishing methods and generally fish in more shallow waters and use the following methods:

- Hadaq (hook and line):
- Al defara (encircling net);
- Nesabah (standing gill net);
- Al sakkar (barrier net); and
- Al hadhra (enclosure trap).

Of the above, three types of fishing activity appear to be most pertinent to the Project area as follows:

- Gargour fishing within deeper offshore areas of the Project site;
- Al defara, which is specifically designed for use in seagrass habitats, deployed by tarad boats; and
- Al Hadra, which is a permanent intertidal enclosure trap.

These are described further below.

Lansh Boats & Gargoor Fishing Method

Lanshes are traditionally built wooden dhows ranging from 12–22 metres in length that are equipped with inboard diesel engines. There are around 350 lansh boats active in Abu Dhabi Emirate that fish from their main home ports in Abu Dhabi (Free Port) and on Dalma Island.

The gargoor is a dome-shaped wire trap, which is usually baited with a mixture of bread and dried fish and sunk for a period of 5–20 days. In 2003, fisheries management regulations were imposed in Abu Dhabi Emirate that allowed licensing of gargoor only to fishermen on lansh boats, and a maximum of 125 gargoor per boat.

Two distinct fishing grounds are identified for lansh boats deploying gargoor fish traps. The fishing ground stretching west from Sir Abu Nu'air is exclusively visited by lansh boats from Free Port in Abu Dhabi. Because of the distance they need to travel, fishermen undertake 3–4 trips per month, with each trip lasting on average 3.5 days. They usually deploy the maximum number of 125 gargoors (garagir) each trip.

The fishing ground north of Dalma is frequented by the fleet based in Dalma. Due to the relatively short distance, these fishermen take up to 20 daily trips a month, using only 50 gargoors each trip. The areas which are fished using this method are shown in Figure 5-217. From this it can be seen that:

- Route 1 would impact less upon fishing grounds, although fisheries with low and medium visits would be impacted within the northern section and a very small area of fisheries with high visits at the very northern extent close to Al Ghallan Island; and
- Route 2 would have a greater impact upon fishery grounds, with the route crossing fisheries with medium and high visits close to Delma Island in the central section and fisheries with medium visits at the norther extent closer to Das Island.

Tarad Boasts & Al Defara Fishing Method

Tarads are open fibreglass dories measuring 6–8 metres in length which are usually equipped with 2 outboard engines. The duration of a fishing trip is usually 4–8 hours with an occasional maximum trip length of 2 days.

There are a total of 750 active tarad vessels in Abu Dhabi Emirate. Hadaq or hand line is a single line with 1–2 baited hooks, used by hand. There are no restrictions on the use of hadaq operated by commercial or recreational fishermen.

The fishing grounds used by tarads are close to their home ports because of limitations on the range these vessels can travel. Hadaq fishing (hook and line) is allowed for local fishermen living inside the Marawah Marine Biosphere Reserve. In contrast, no fishing is allowed in Al Yasat or Bul Syayeef Marine Protected Areas.

In and around Mirfa, approximately 90 tarads are active. Because Mirfa is located within the Marawah Marine Biosphere Reserve, the traditional system of bahoor fishing must be observed, restricting fishermen to operating traditional fishing gear including nesaab, al defara, al sakkar and al hadhra.

Al defara is an encircling gill net targeting small-sized pelagic and demersal species, such as Bluefin Trevally (jesh), Blackspot Snapper (naiser) and Bluespot Mullet (beyah arabia). The net is usually 2–4 metres high and 150 metres wide, with a weighted bottom line that sits on the seagrass bottom, without harming the benthic ecosystem.

The areas which are fished by Tarad boats are shown in Figure 5-218. From this it can be seen that:

- Route 1 avoids fisheries within the Marawah Marine Biosphere Reserve and only impacts upon fisheries with low and medium visits on one of the Zakum Cluster re-routing areas where it bisects a small part of the fishery;

- Route 2 would have a greater impact upon fishery grounds, with the route crossing fisheries with medium and high visits close to Delma Island in the central section.

Al Hadhra

Al hadhra is a permanent intertidal enclosure trap structure of a round corral (10–20 metres diameter) that has a single opening and is connected to a 30–50-metre-long fence set perpendicular to the coast. With the receding tide, fish move along the fence to deeper water and are guided into the corral, where they become trapped. Al hadhra are usually operated during the summer and targets species such as Milk Fish (aifah), Longtail Silver Biddy (badah) and Rabbitfish (safi).

The fishing community within Mirfa practice the historical intertidal hadrah fishing method within the shallow coastal areas using fixed stakes, or fence traps and nets which guide fish into the trap. It is understood that hadrah fishing activities are allowed only during April to September and licenses are issued by EAD to the hadrah fishermen. The duration of the licences is not known but is assumed to be for one period only (a license per year).

A review of satellite imagery identified the presence of three hadrah fishing traps within the Mirfa area, which are shown below in Figure 5-219. It was confirmed during nearshore marine surveys by WKC in March 2022 that one of these identified hadrah traps extends perpendicularly to the triangular breakwater structure at Mirfa, which is located directly within the footprint of the proposed cable route as illustrated below in Figure 5-220. This hadrah trap is illustrated below in Figure 5-221 and Figure 5-222 below.

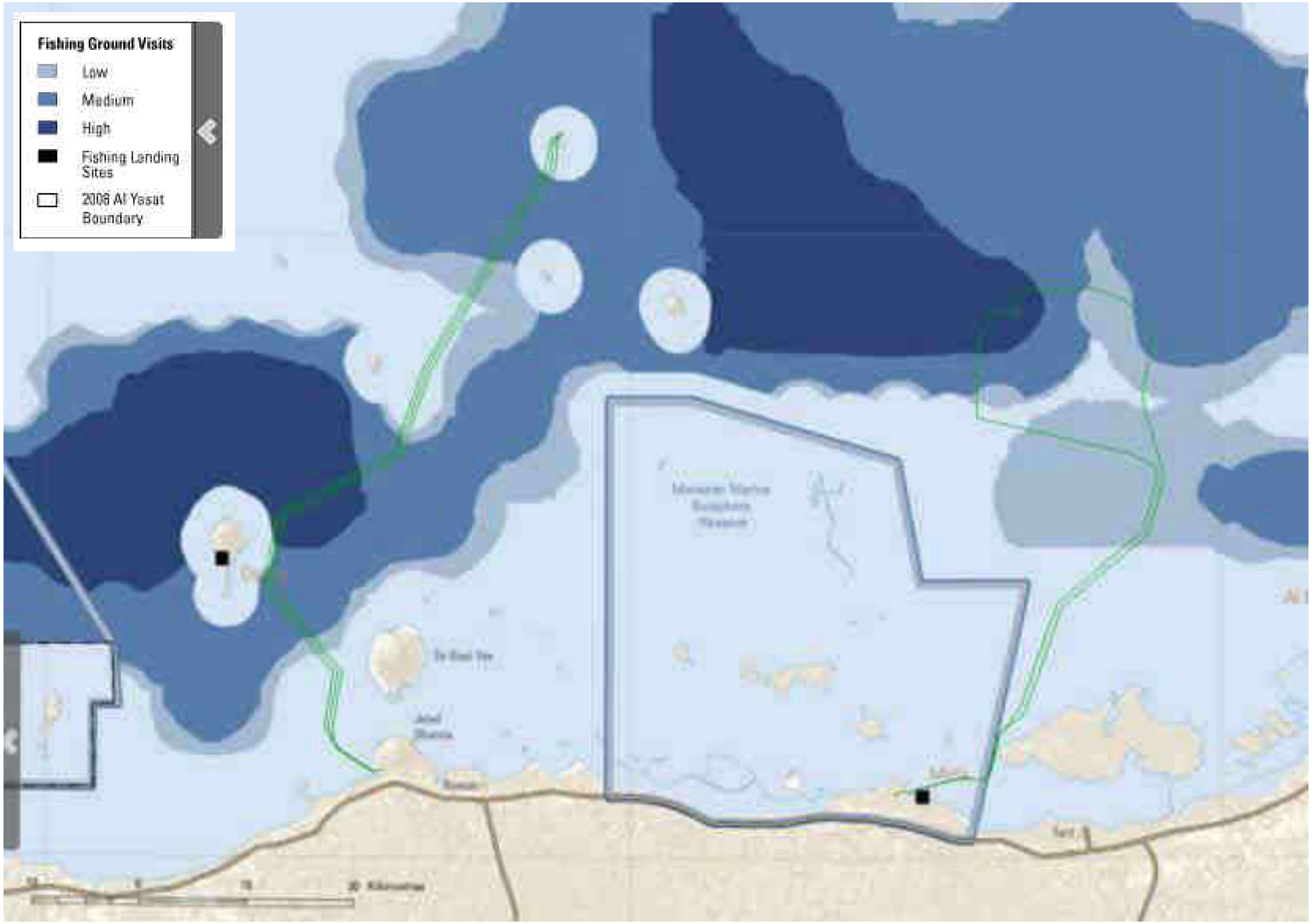


Figure 5-217: Commercial fishing areas lansh boats, gargoor fishing method

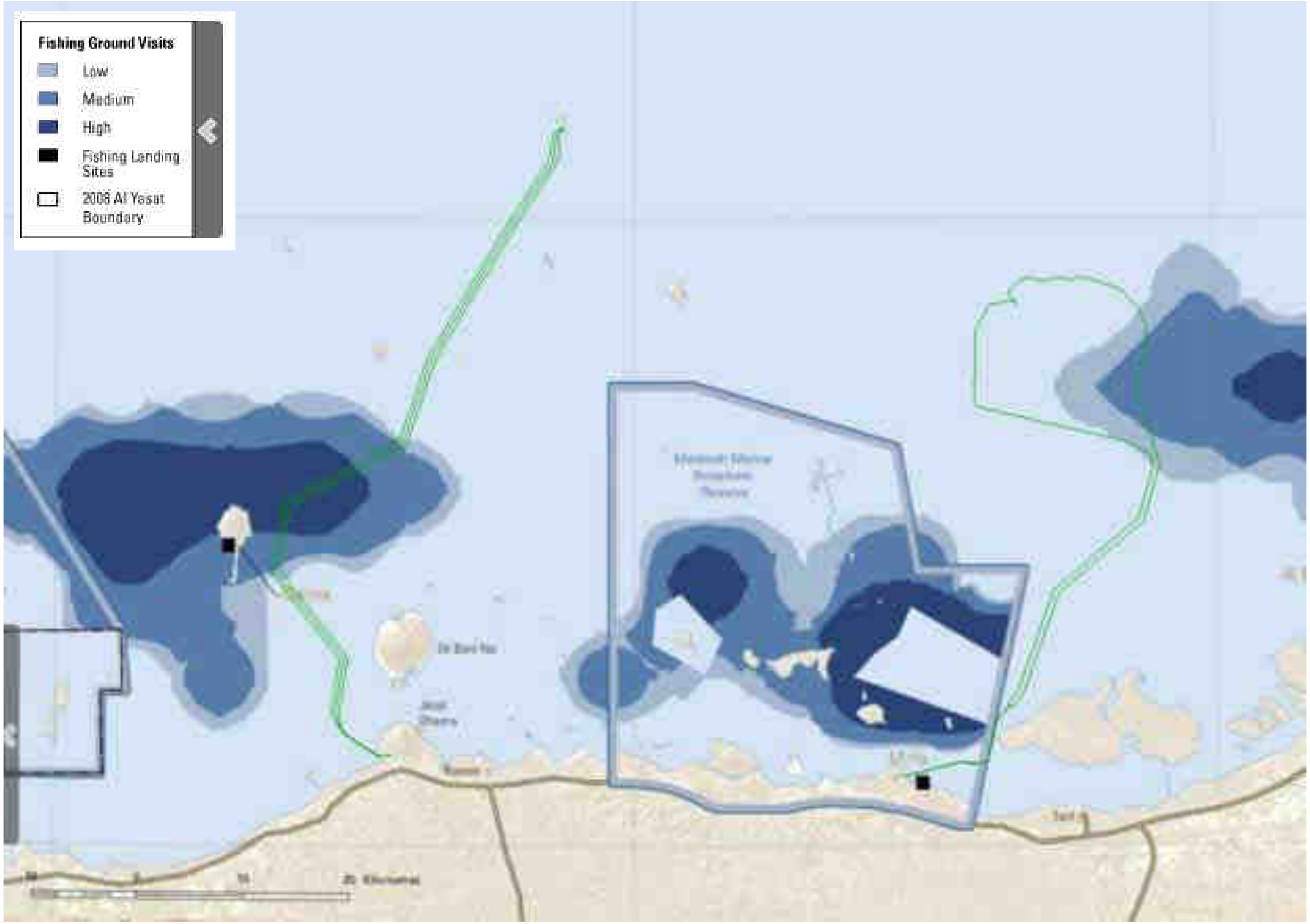
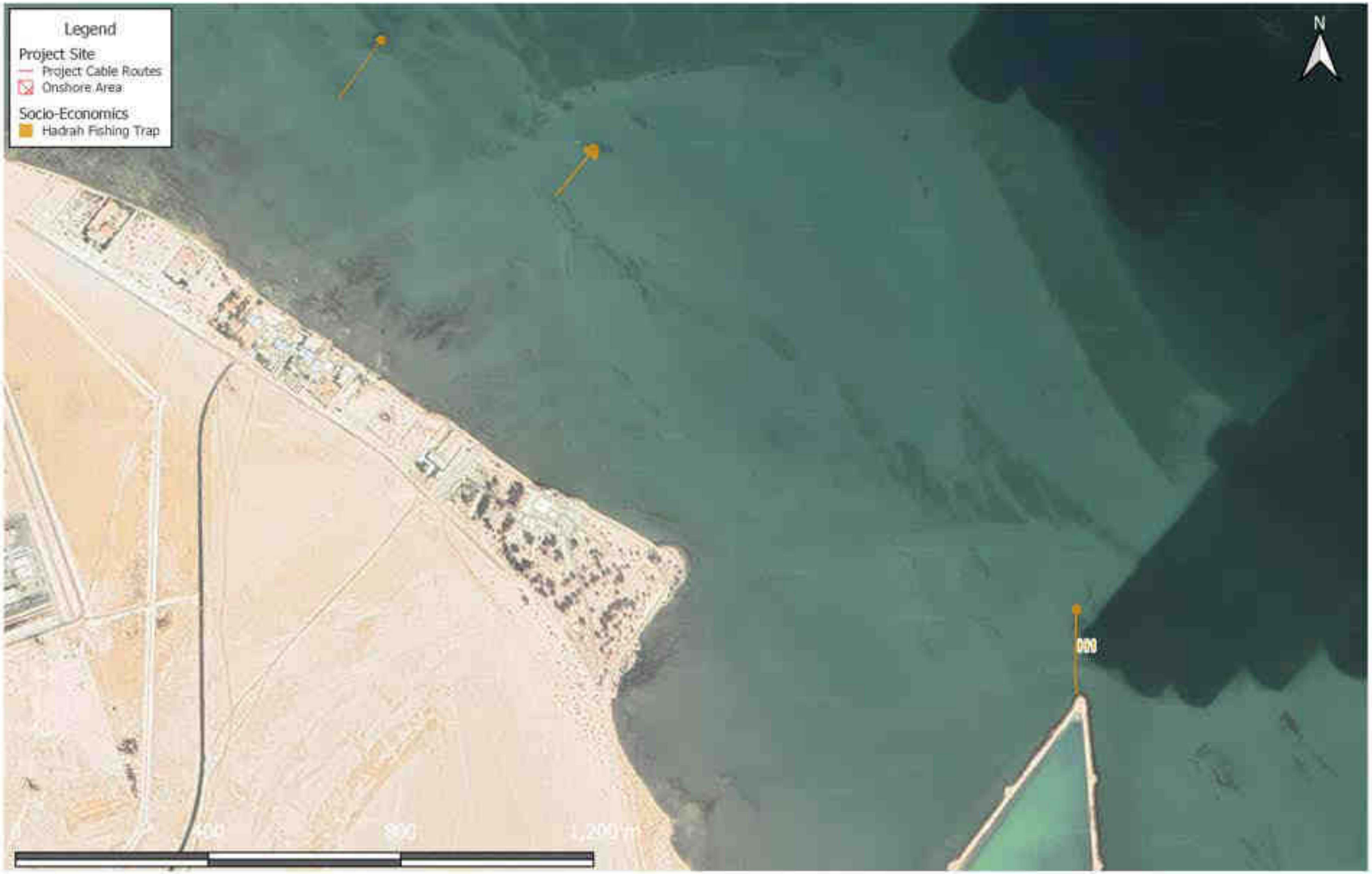


Figure 5-218: Commercial fishing areas tarad boats, hadaq fishing method



Project Number: 1176
Project Name: Project Lightning
Data sources: Various
Compiled By: AB

Scale: 1:9740
Coordinate System: Mercator
Datum: WGS 84
Units: meters
Date: 10/05/22

Anthesis

Figure 5-219: Location of hadrah fishing traps within the vicinity of Mirfa Project site

Figure 5-220: Zoom on the hadrah fishing traps located within the Project site footprint

Figure 5-221: Hadrah fishing trap with Mirfa in the background

Figure 5-222: View inside hadrah trap

Landing Sites

A total of seven landing sites are active in Abu Dhabi as follows:

- Ra's Sadr;
- Saadiyat;
- Free Port (Abu Dhabi);
- Al Bateen;
- Dalma Island;
- Mirfa; and
- Sila.

The total wholesale value of fish landed by lansh boats deploying garagir in Abu Dhabi Emirate was estimated at 33 million AED in 2008 (the latest year for which data are available from the EAD), as shown in Figure 5-223. Abu Dhabi Free Port was the principal landing site, making up 74% of the total wholesale value of fish landed by lansh boats.

The total wholesale value of fish landed by tarad fishermen using hadaq in Abu Dhabi Emirate was estimated at 24 million AED in 2008 (the latest year for which data are available from the EAD), as shown in Figure 5-224. Kingfish (kan'aad), hamour, Spangled Emperor (shaari) and Bluefin Trevally (jesh) were the most valued species, accounting for 30%, 23%, 21% and 21% of the total wholesale value, respectively. The Abu Dhabi Free Port was the single most important landing site (61%), followed by Al Sadr (19%) and Dalma (9%).

On average, 560 metric tonnes is landed in Mirfa annually, comprising mostly Bluespot Mullet (beyah arabia) and Bluefin Trevally (jesh). It is presumed that these fish are sold upon landing at the fish market within Mirfa.

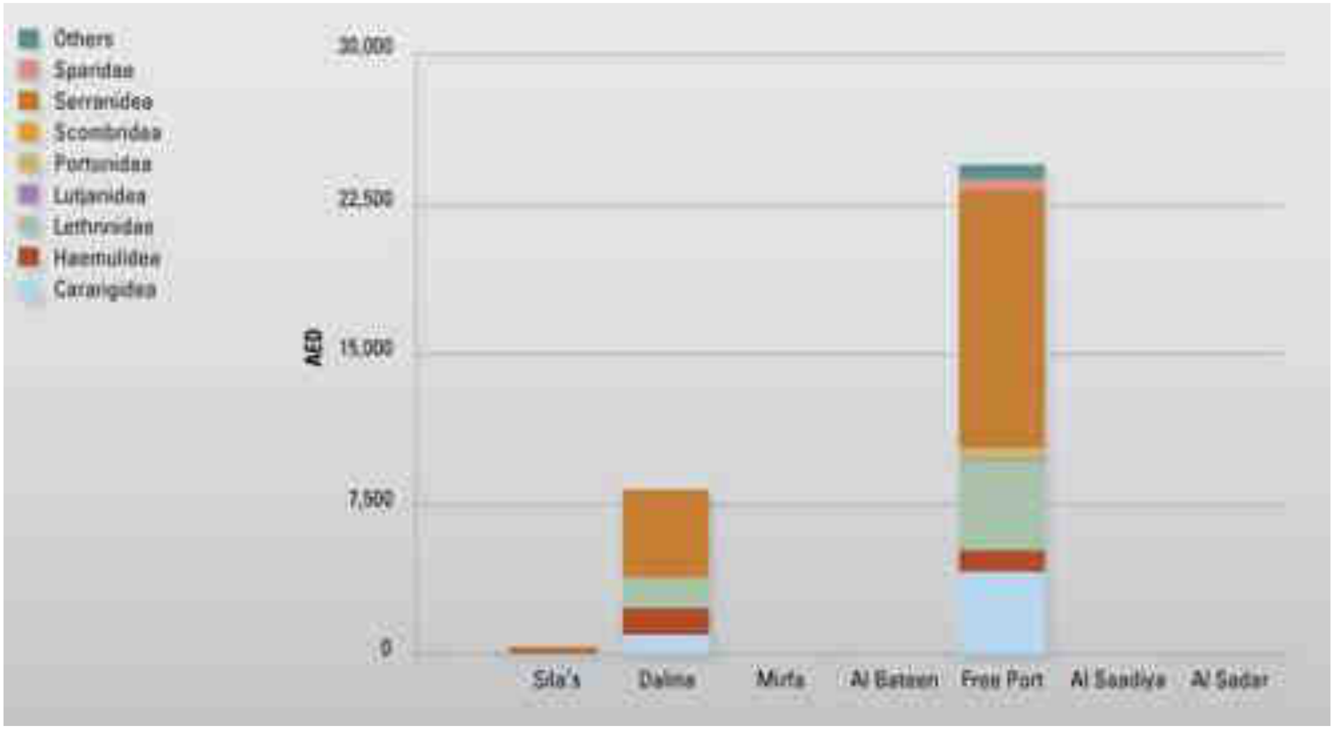


Figure 5-223: Wholesale value landing by lansh boats (158)

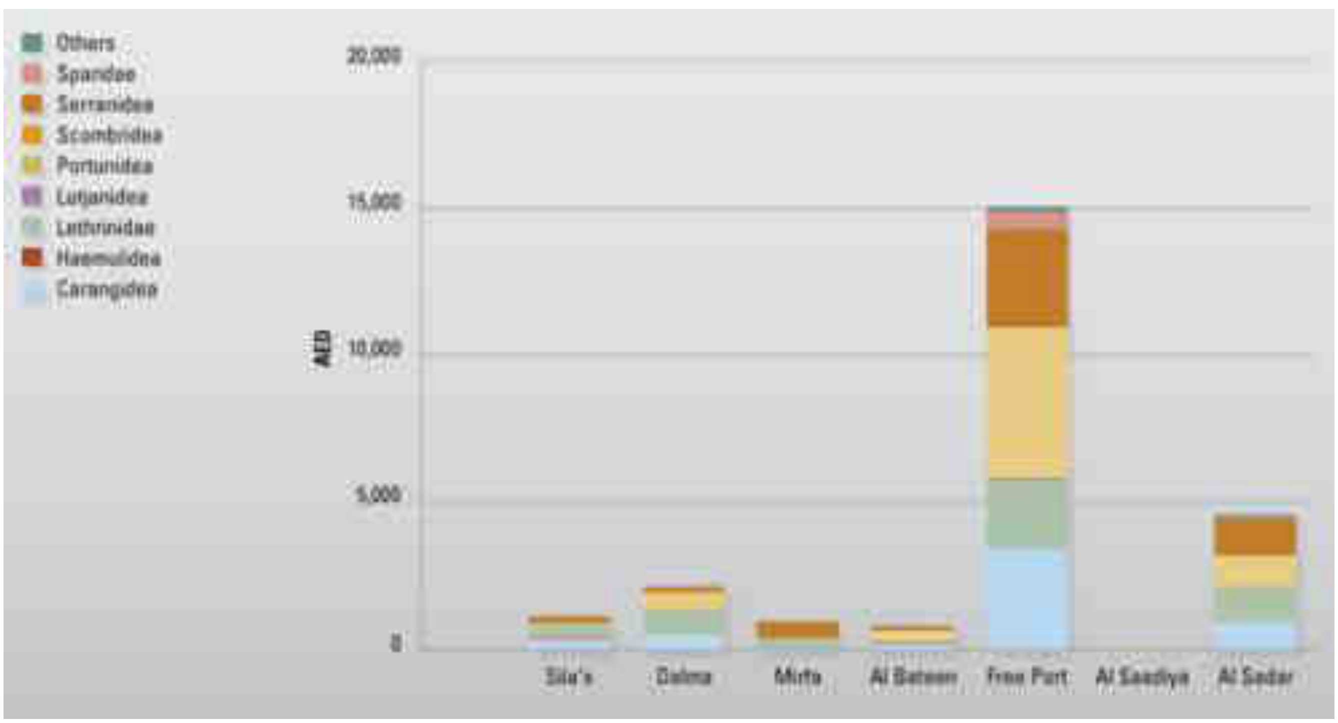


Figure 5-224: Wholesale value landing by tarad boats (158)

5.9.1.2.6. Marine Traffic

Figure 5-225 and Figure 5-226 below illustrate that the maritime environment within the vicinity of the Project routes can generally be described during 2020 and 2021 as being busy with significant vessel movements throughout the area. It can be seen that the greatest concentration of marine traffic is associated with the port areas in Abu Dhabi City, in addition to at Mirfa Port and Mugharraq Port and Ruwais.

Route 1 passes through areas of high marine traffic, particularly associated with the area surrounding Al Ghallan Island, where marine traffic density is high.

Route 2 passes through less densely travelled marine routes although it can be seen close to the nearshore areas in particular that the Project alignment alongside several major and busy traffic routes before crossing these routes at several points.

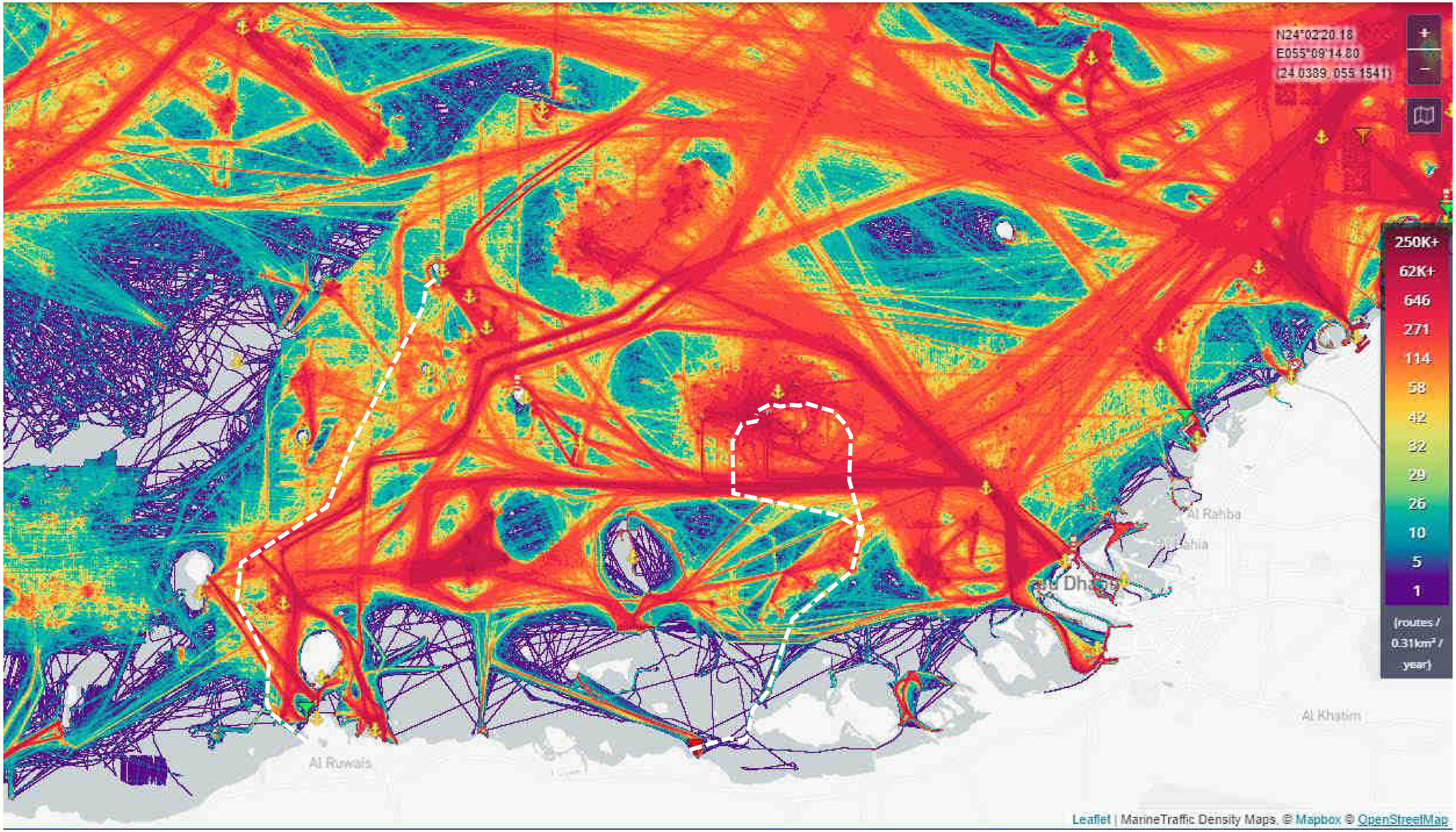


Figure 5-225: Marine traffic in 2020 in relation to the Project routes (44)

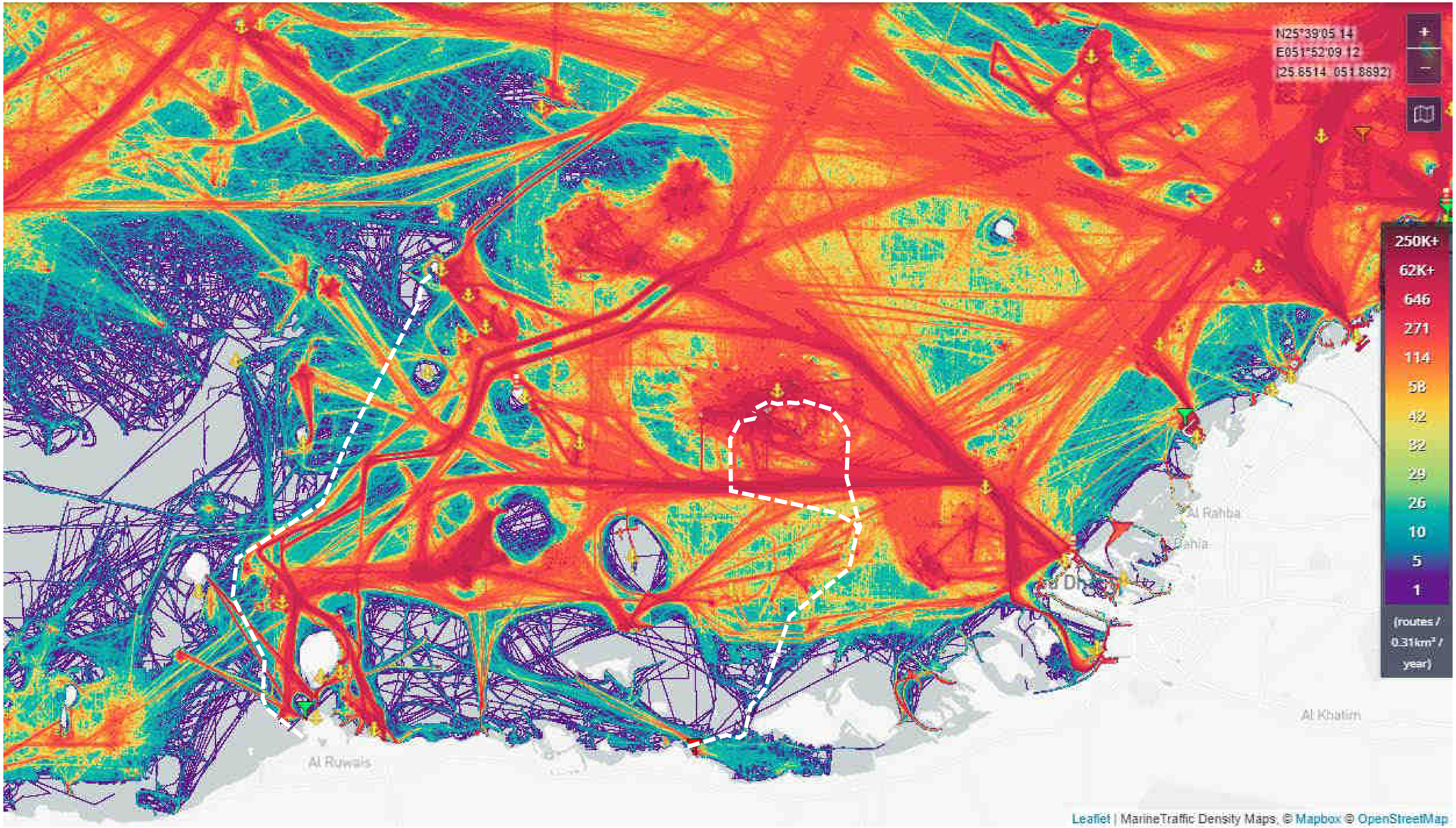


Figure 5-226: Marine traffic in 2021 in relation to the Project routes (44)

5.9.1.3. Anthesis Site Survey Findings

Walkover surveys were undertaken to provide area and site-specific information relating to the existing socio-economic conditions present within the Project sites, namely at the onshore tie-in locations at which each transmission line from Route 1 and Route 2 will connect to the HVDC converter stations, Al Mirfa Power and Water Complex, and Al Shuweihat Power Complex, respectively.

5.9.1.3.1. Route 1 – Mirfa to Al Ghallan Island

The Route 1 sub-sea transmission cable will originate at the Al Mirfa Power and Water Complex located approximately 110km south-west of Abu Dhabi city. The surrounding land uses within the onshore area is predominantly open desert areas, with residential housing located to the east and south-east of the plant and Mirfa Hotel and Mirfa Harbour to the east.

Al Ghallan Island, the terminating point for the Project alignment within Route 1 is a purpose built ADNOC offshore facility located approximately 84km north of Mirfa.

Mirfa can be described as a mixed-use coastal town, with an estimated population of approximately 29,000. A large proportion of Mirfa's population work as fishermen (further described in **Section 5.9.1.2.5** above) and the rest are predominantly employed by the various governmental agencies, including municipality plantations, industries and tourism.

5.9.1.3.2. Route 2 – Shuweihat to Das Island

The Das Cluster sub-sea transmission cable will originate at the Shuweihat substation within Al Shuweihat Power and Water Complex located approximately 190km to the south-west of Abu Dhabi city. The surrounding land uses adjacent to Al Shuweihat Power and Water Complex largely comprise of open desert, with the town of Al Ruwais situated approximately 10km to the east.

Ruwais has expanded considerably since the 1970s when it was formally a small fishing village. It is now a successful industrial and housing complex with an estimated population of 25,000.

The development of Ruwais has largely been driven by ADNOC as a major contributor to the national economy and represents a series of multimillion-dollar investments by the company. Ruwais has several major industries including an oil refinery, fertilizer plant, marine terminal and a sulphur handling terminal. The town has several schools, a hospital and shopping and entertainment facilities.

Das Island, the terminating point for the Project alignment within Route 2, is a naturally occurring island located approximately 110km north of Al Shuweihat Power and Water Complex and has been significantly altered and adapted over the past 60 years to facilitate oil and gas exploration, production and export activities to various countries including Japan and throughout Europe. Das Island contains an airport and is inhabited by over 6,000 personnel on a rotational basis, working in the oil and gas industry. It is understood that the island has been periodically inhabited for several centuries, owing to the presence of Islamic pottery and artefacts found prior to the development of the island for oil and gas purposes (159).

A range of socio-economic receptors are located within the Project area, which are summarised below in Table 5-137 below.

5.9.2. Environmental Impact Prediction and Evaluation

5.9.2.1. Sensitive Receptors

The identified list of socio-economic receptors is presented in Table 5-137 below.

Table 5-137: Socioeconomic sensitive receptors

Sensitive Receptor	Receptor Class Value	Justification
Local residents and visitors, particularly at Mirfa	*High*	Residential receptors will be highly sensitive to changes in the socio-economic conditions within the area
Local businesses and commercial sites	*Medium*	Existing commercial and business receptors are classed as receptors of medium value.
Local Hadrah fishermen	*High*	Trenching and cable laying activities will temporarily result in fish dispersal from the area due to noise and increased sedimentation and direct impact upon one identified hadrah trap
Lansh boat fishermen based in and around Abu Dhabi City (Route 1) and Dalma (Route 2), largely fishing in deeper offshore waters	*High*	Trenching and cable laying activities will temporarily result in fish dispersal from the area due to noise and increased sedimentation and direct impact upon fishing grounds
Tarad boat fishermen based in Mirfa and the surrounding areas, largely fishing in nearshore areas and within MMBR (Route 1)	*High*	Trenching and cable laying activities will temporarily result in fish dispersal from the area due to noise and increased sedimentation and direct impact upon fishing grounds
Future Dalma Island Sea Cage	*Medium*	The distance between the Project and proposed sea cage will reduce the severity of any impacts but fish may be sensitive to noise and any increased sedimentation.
Local maritime traffic	*Medium*	Marine vessels within the vicinity of the Project route may require route diversions or experience higher traffic levels.
Construction workers employed by the project	*High*	Construction workers are classed as receptors of high value since they will be exposed to the greatest magnitude of impacts.
Operational employees at adjacent industrial facilities	*Low*	Operational workers at the adjacent industrial facilities are considered to be of low sensitivity.

5.9.2.2. Construction Phase Impacts

5.9.2.2.1. Disruption to the Local Economy and Population

Construction activities have the potential to result in disruption to businesses, services and residential areas located within close proximity of the Project area. These impacts may include temporary traffic disruptions and congestion, a reduction in air quality resulting from dust and PM_{10} generation, noise impacts resulting from construction traffic and general loss of amenity.

At Mirfa, the nearest sensitive receptors include residential receptors located within close proximity (the closest being 150m east) of the Project site, in addition to commercial and residential receptors located at a greater distance of >2km e.g. within the town of Mirfa and accommodation camps to the south. Hadrah and conventional fishermen utilising the shallow intertidal areas also represent sensitive receptors in terms of offshore cable laying activities in the nearshore and offshore areas, respectively.

At Shuweihat, sensitive receptors within close proximity of the Project site are limited to the accommodation camps located approximately 2km north of the Project site, Sir Bani Yas Ferry and harbour area and the town of Ruwais located approximately 7km east of the Project area.

Socio-economic receptors associated with the offshore islands of Al Das Island and Al Ghallan Island where the HVDC cables will terminate are limited to the employees present on the offshore facilities, both in terms of construction workers for the Project and existing workers residing on the islands.

Due to the limited numbers of sensitive receptors within close proximity of the Project site, and the industrial nature of the area, it is expected that socio-economic impacts will be minimal. Nevertheless, these impacts have been assessed as follows:

Construction Dust Impacting on Sensitive Receptors

As identified within Section **5.1.2.2: Air Quality**, dust impacts upon sensitive receptors are expected to be of **negligible** to **minor negative** significance in relation to dust emissions prior to the implementation of mitigation measures.

Emissions from Construction Equipment and Vehicles

As identified within **Section 5.1.2.2: Air Quality**, emissions impacts upon sensitive receptors are expected to be of **negligible** to **minor negative** significance in relation to vehicle exhaust emissions prior to the implementation of mitigation measures.

Disturbance from Construction Noise

An assessment of construction traffic noise has been undertaken in **Section 5.7.2.2: Noise**. At this stage of the Project, no planning or calculations have been provided with regards to construction traffic quantities or frequencies.

As summarised within **Section 5.7: Noise**, noise impacts upon sensitive receptors are expected to be of **moderate negative** significance at the closest residential properties in Mirfa, in the absence of mitigation measures. Impacts upon other receptors were deemed to be **negligible** in significance.

Disturbance to Local Traffic Network

The Project is located in a generally remote area but is accessible via paved access roads to the Al Mirfa and Shuweihat Power and Water Complexes.

Existing traffic in the area is therefore considered to be minimal and largely associated with the settlements of Mirfa and Ruwais (near Shuweihat). However, due to the distance of several kilometres between these main residential areas and the Project sites, it is considered that construction traffic is likely to bypass these built-up areas and therefore impacts upon the local traffic network are likely to be minimal. However, at Mirfa, some disruption to local residents located on the coastline to the east of the Al Mirfa Power and Water Complex may experience some disruption to the local road network since the access road to these residential areas also provides access to the Al Mirfa Power and Water Plant. Therefore, in the absence of mitigation measures this is considered to represent an impact magnitude of *low* severity, upon receptors of *medium* sensitivity, therefore potentially resulting in an impact of **minor negative** significance.

During the construction phase, it is expected that there will be a perceptible impact on the existing traffic utilising the Sheikh Khalifa Bin Zayed Al Nahyan International Road (E11 Highway) caused by additional truck movements going to and from the Project sites at both Mirfa and Shuweihat Project sites. Despite the limited number of sensitive receptors in the area, the E11 Highway is a significant national highway providing access along the eastern Al Dhafra and coastal regions of the UAE and beyond to the border of Saudi Arabia. However, the increase in traffic will be temporary in nature and therefore, the impact magnitude upon the local traffic network as a result of the construction phase is expected to be of *low* severity upon receptors of *medium* sensitivity, thereby resulting in a **minor negative** impact prior to the integration of appropriate mitigation measures.

Disturbance to Lansh Fisherman

The fishing ground stretching west from Sir Abu Nu'air is exclusively visited by lansh boats from Free Port in Abu Dhabi. Because of the distance they need to travel, fishermen undertake 3–4 trips per month, with each trip lasting on average 3.5 days. They usually deploy the maximum number of 125 gargoors (garagir) each trip.

The fishing ground north of Dalma is frequented by the fleet based in Dalma. Due to the relatively short distance, these fishermen take up to 20 daily trips a month, using only 50 gargoors each trip. The areas which are fished using this method are shown in Figure 5-217. From this it can be seen that:

- Route 1 would impact less upon fishing grounds, although fisheries with low and medium visits would be impacted within the northern section and a very small area of fisheries with high visits at the very northern extent close to Al Ghallan Island; and
- Route 2 would have a greater impact upon fishery grounds, with the route crossing fisheries with medium and high visits close to Delma Island in the central section and fisheries with medium visits at the norther extent closer to Das Island.

Where construction activities are taking place, this will result in three types of disturbance as follows:

- Direct impacts from trenching and cable laying, including loss of benthic habitats such as seagrass;
- Impacts over a wider area associated with marine sediment releases and marine noise, which would be likely to disperse fish from the area; and
- A recovery period where benthic habitats have not yet re-established.

Section 5.2: Marine Water includes dredge plume modelling to predict the likely significance of impact. The trenching and backfilling involved within the construction programme for both Route 1 & 2 are sparsely spread both temporally (occurring over five months and eight months respectively) and spatially (consisting of a very narrow dredge cross section over a long overall length). Due to this sparsity in activities, the impacts are limited. For Route 2, exceedances of ambient water quality standards are expected to occur for over two weeks, whereas within for Route 1, exceedance is generally limited to less than one week. The actual impact upon fisheries is therefore predicted to be temporary at any one location. Furthermore, the actual area of impact within the wider context of the extensive fishing grounds makes it highly improbable that fishing boats would not be able to fish in alternative areas while construction activities are ongoing. Finally, the longer term impacts upon seagrass and other benthic habitats will be limited both spatially and temporally as a relatively quick reestablishment post-construction would be expected. Therefore, the impacts are predicted to be low severity upon an impact of high sensitivity. The significance of impact is therefore predicted to be **moderate negative** in the absence of mitigation measures.

Disturbance to Tarad boat fishermen

It is assumed that Tarad boat fishermen are based in and around Mirfa and the surrounding areas, largely fishing in nearshore areas and within MMBR. The same impacts as discussed in the previous section for Lansh boat fisherman are predicted, although in this case the extent of fishing grounds directly impacted is lower, particularly along Route 1. The areas which are fished by Tarad boats are shown in Figure 5-218. From this it can be seen that:

- Route 1 avoids fisheries within the Marawah Marine Biosphere Reserve and only impacts upon fisheries with low and medium visits on one of the Zakum Cluster re-routing areas where it bisects a small part of the fishery;
- Route 2 would have a greater impact upon fishery grounds, with the route crossing fisheries with medium and high visits close to Delma Island in the central section.

The impacts are predicted to be low severity (in the case of Route 2 where higher severity effects are likely to occur) upon an impact of high sensitivity. The significance of impact is therefore predicted to be **moderate negative** in the absence of mitigation measures.

Disturbance to Local Hadrah Fishing Activities

During construction, significant disturbance will occur within the nearshore areas associated with trenching, cable laying and backfilling, including noise, vibration and generation of sediment plumes which all are likely to result in the dispersal of fish from the shallow nearshore areas. A Hadrah fishing trap is located directly within the footprint of the proposed cable route in the vicinity of Mirfa shoreline and therefore this trap will require relocation. Any other hadrah traps within the vicinity are likely to experience significant disturbance due to marine dredging activities, the resultant sedimentation, noise and a general increased anthropogenic presence including the movement of marine vessels resulting in fewer catches, and local hadrah fishermen therefore may experience a loss of earnings as a consequence of reduced yields from the fish traps. The disturbance to hadrah fishermen will be temporary and therefore the impact magnitude is *low* in severity (due to the fact that only one hadrah trap is likely to be directly impacted), upon receptors of *high* sensitivity thereby resulting in an impact of **moderate negative** significance prior to the implementation of mitigation measures.

Disturbance to proposed EAD Dalma Sea Cage Aquaculture Project

The proposed EAD sea cage aquaculture Project is located off the east coast of Dalma Island, and at the closest point, cable Route 2 will pass within approximately 1.3km. The proposed location of the Dalma Island Sea Cage is illustrated in Figure 5-227. It is understood that the sea cage will cultivate finfish species, most likely Grouper. Therefore, whilst no direct impacts are expected upon the sea cage, it is possible that some underwater noise and potentially sediment plumes may reduce water quality or alter marine conditions such that impacts upon the fish stocks could occur, such as stunted fish growth, disease or death. This would subsequently result in a potentially lower harvest. However, given the separation distance, and the cable installation methodology to be used at this location (cable trenching where necessary and rock installation) it is considered that sediment release will be minimal and unlikely to significantly impact the sea cage at 1.3km distance. Therefore, it is considered that impact magnitude will be *low*, upon receptors of *low-medium* sensitivity, therefore resulting in an impact of **negligible** significance.

Figure 5-227: Proposed location for Dalma Sea Cage

Impacts upon Local Maritime Traffic

During cable laying activities within the marine environment, an increase in marine traffic resulting from construction vessels may represent the potential for disturbance to maritime traffic and the potential for vessel collisions. Online data published on www.marinetraffic.com provides live location maps of vessels, and identifies that the areas within the vicinity of Route 1 and Route 2 are both relatively busy (as illustrated in Figure 5-225 and Figure 5-226 in **Section 5.9.1.2.6**), with a variety of marine vessels present including, but not limited to:

- ADNOC vessels;
- Tugs and small craft;
- Sealiners;
- Cargo ships;
- Pleasure boats; and
- Fishing vessels.

Several ports are present within close proximity of both Route 1 and Route 2, as described in **Section 4.2.3.4**. Mirfa Port (approximately 1.2km south of Route 1), Mugharraq Port (approximately 1.7km from the Project site for Route 2) and Dalma Port on Dalma Island (approximately 5km east of Route 2) are the nearest ports, all of which are busy areas providing facilities for fishing activities, cargo and handling facilities, ADNOC refuelling, in addition to berthing for recreational vessels. The anchoring area for Mugharraq Port (illustrated in Figure 4-47) illustrates that Route 2 remains outside of the allocated area and therefore is not expected to impact upon the anchoring area.

During construction, a significant number of vessels will be active within the Project area as a result of the Project, including backhoe dredgers, cable laying barges, auxiliary floating equipment, guard vessels, accommodation barges, crew transfer vessels and survey catamaran. In total, 59 individual vessels will be used, although the timeframes for use vary significantly. It is expected that during trenching, dredging and backfilling, in addition to cable laying, an exclusion zone will be implemented around the vessels to prevent inadvertent collisions or delays, but the high number of vessels suggests a certain level of disturbance or delays may be possible whilst navigating or entering/leaving ports. A number of support vessels will also be active during the cable laying activities which will increase traffic within the vicinity of the cable routes, although due to the progressive nature of the cable laying activities, the location of the construction vessels will be constantly moving and will therefore not cause prolonged disturbance in the same areas. The vessels utilised for the Project will also require regular refuelling, which will also increase marine traffic movements within the area, potentially disrupting other seafarers journey times and/or routes, in addition to increasing waiting times for refuelling. It is considered that the impact magnitude of the disturbance to other marine traffic is of *medium* severity, upon receptors of *medium* sensitivity, therefore resulting in an impact of **minor negative** significance.

Infrastructure and Equipment Design and Safety

There are safety and security risks which are generated from the creation of a construction site and ongoing construction activities where there were none before. Construction activities and resulting excavations, vehicle and plant movements and the presence of partially constructed structures and fall hazards can provide a source of major risk. Furthermore, the storage of hazardous materials as well as explosive / flammable materials can increase the risk of onsite fires or explosions. In the event of serious accident, the resulting fire / explosions and/or release of hazardous materials can risk the health and safety of surrounding residents.

Firstly, the construction of the Project is not likely to represent physical risks to the local community, considering that the nearest residential property boundary is located 90m from the Project boundary (at Mirfa) and access through the security perimeter would be prevented.

Furthermore, the Project:

- Will not comprise any high-risk elements; and
- Will be designed and constructed in full accordance with best international practices, codes and standards.

The surrounding communities represent a receptor of *high* sensitivity although the potential impact severity would be considered as '*no change'* given that there would be no access to the Project site and there are no high-risk structures or components which could potentially impact the local community in the event of failure or accident. The impact is therefore considered to be **negligible**.

Hazardous Materials Management and Safety

The potential for exposure of the local community to hazardous materials within the Project site is highly unlikely as the community is limited to residents at nearby accommodation camps at Shuweihat and residential properties located several hundred metres from the Project site at Mirfa. These receptors will not have access through the security perimeter. Nevertheless, there is a potential risk of accidents associated with the transportation of hazardous materials to and from the Project sites. If accidents occur on the local road network, this could result in the release of hazardous materials. The materials used would comprise fuels and oils, and various paints, chemicals etc. which would typically be used within construction processes and as such, are not anticipated to represent a major hazard and any spillages or releases would be expected to be highly localised. The local community is considered to be of *low* sensitivity given the lack of receptors adjacent to the main highway. The impact magnitude is considered to be of *low* severity, on the basis that the types of hazardous materials and quantities being transported, would not represent a significant risk and would only affect the immediate area in the event of an accident or spillage. The impacts are therefore predicted to be of **negligible** significance in the absence of control measures.

5.9.2.2.2. Health and Safety

With respect to health and safety at work, construction sites are considered to be a relatively dangerous working environment and without proper health and safety controls there is a considerable risk of serious injury or fatalities. The potential exists for detrimental impacts upon the workers employed within the Project site for the duration of the construction phase as a result of a number of activities including, but not limited to:

- Risk of exposure to heat and dehydration;
- Fire events;
- Accidents involving heavy machinery; and
- Exposure to harmful products such as asbestos, solvents or chemicals.

The potential health and safety impacts upon construction workers are predicted to be of *medium* severity upon receptors of *high* sensitivity, therefore resulting in an overall impact of **major negative** significance prior to the implementation of mitigation measures.

Other working conditions such as reasonable working hours, wages and other benefits are considered to be good working practices and should be employed at all times. In addition, a large number of construction staff may be housed temporarily on or near the site. It must be ensured that the working conditions are of an acceptable standard. Housing must be adequately designed with adequate sanitary and safety facilities such as fire suppressants. Issues such as retrenchment policies must be clearly defined prior to work beginning.

In the absence of mitigation measures to ensure fair working conditions and appropriate accommodation, the potential impacts upon construction workers are considered to be of *medium* severity upon receptors of *medium-high* sensitivity, which subsequently represents the potential for an impact of **moderate negative** significance.

5.9.2.2.3. Enhancement of the Local Economy

Due to the influx of construction workers during the construction phase which will be approximately 3 years in duration, significant skilled and unskilled employment opportunities are represented by the development of the Project. This will also generate revenue for local surrounding businesses, thereby resulting in a positive impact upon the local economy. Estimates for construction worker numbers provided within Section 4.3.2.3 identify that the manpower requirements for the Project will result in the temporary introduction to Mirfa and Shuweihat of 1000's of workers cumulatively throughout the Project construction period.

The majority of the workforce during the construction phase will be expatriate migrant workers. This is also expected to generate local revenue. Additionally, construction materials can be purchased from local business or UAE suppliers generating further economic benefit. These impacts, whilst all considered to be short term in nature will likely be of **minor positive** significance.

5.9.2.2.4. Landscape and Visual Impacts

Landscape and visual impacts resulting from the construction phase are expected to be limited due to the already disturbed nature of the surrounding areas, presence of industrial facilities and infrastructure and limited sensitive receptors. The temporary construction traffic and hoarding or stockpiling of materials and associated machinery may result in a slight reduction in visual amenity within the surrounding areas at Mirfa near to Mifra Hotel and the residential properties both inland and in terms of vistas offshore whilst dredging and cable laying activities are underway. Given the relatively low landscape value within the area adjacent to the Project site as a result of the existing industrial complex, these impacts are expected to be of *low* severity upon receptors of *low-medium* sensitivity therefore resulting in temporary impacts of **negligible** significance.

5.9.2.3. Operational Phase Impacts

This Project is expected to result in both economic and sustainability benefits to Abu Dhabi Emirate in terms of oil and gas activities and capabilities through reducing energy demands and associated maintenance costs, in addition to reducing the existing carbon footprint associated with the electrical power requirements for offshore activities. These objectives strongly align with the demonstrable and ongoing efforts made towards climate change and carbon footprint reduction underway within the UAE

5.9.2.3.1. Disruption of the Local Economy and Population

Gaseous Emissions from O&M Vehicles

As the Project will receive all power requirements from the TRANSCO electrical grid connection, it is not anticipated that significant volumes of air emissions will occur. These are expected to be limited to emission from operational service vehicles etc. The potential impacts associated with operational emissions are therefore expected to be of **negligible** significance.

Operational Noise

A full assessment of noise impacts associated with the operational phase of the Project has been undertaken within **Section 5.7.2.3**, which identifies that Project related noise impacts at identified sensitive receptors will likely be below the Federal daytime, evening and night-time noise limits as well as the IFC daytime and night-time noise limits.

No detailed information has been provided on volumes or frequencies of operational traffic. However, the operational worker numbers are low, with a total of seven employees proposed to work per day across three shifts. Traffic movements are therefore limited to three return journeys from the workers accommodation daily, in addition to operational maintenance activities which are scheduled monthly, quarterly, bi-annually and annually. It is therefore considered that traffic trips generated in the area as a result of the operational phase of the Project are expected to be minimal and would be of **negligible** significance.

Impacts on Local Economy and Social Issues

Indirect opportunities for various support service providers including guards, cleaners and other site management will provide employment and a further source of income for these services resulting in a likely **minor positive** impact.

The employment of local workers on such a project of national importance with the requisite training which will be included within their contracts will improve their capabilities and skill. This will also result in improving their employability should they move on from the Project. This is deemed to be a **negligible** to **minor positive** impact.

Similar to the construction phase, a potentially positive economic impact will result from any local employment created by the operational phase of the Project. Whilst the likely nature of these impacts, and the effect of expatriate workers, is largely unchanged from the construction phase, they are likely to be amplified by the greater timescales involved in the operation of the site. However, the relatively small workforce likely to be required during the operational phase means that potential impacts are likely to be less significant. This is deemed to be a **negligible** to **minor positive** impact since the number of employment opportunities is likely to be limited.

Disruption to Traffic Levels

The Project sites at both Mirfa and Shuweihat are located in relatively remote areas with a limited road network. Existing traffic in the area is therefore considered to be minimal and not highly sensitive due to the low residential traffic in the surrounding area. Sensitive receptors at Mirfa can be considered as slightly more susceptible to changes in traffic volumes since the Project site is located near to a small number of residential properties and closer to the settlement of Mirfa Town.

During the operational phase, truck movements and O&M traffic are expected to be minimal in volume. No detailed information has been provided on volumes or frequencies of operational traffic. However, the operational worker numbers are low, with a total of seven employees proposed to work per day across three shifts. Traffic movements are therefore limited to three return journeys from the workers accommodation daily, in addition to operational maintenance activities which are scheduled monthly, quarterly, bi-annually and annually. As such, due to the low number of sensitive receptors in the area, the impact significance generated upon the local traffic as a result of the operational phase is expected to be **negligible**.

Infrastructure and Equipment Design and Safety

The Project will not comprise any high-risk elements and will be designed and constructed in full accordance with best international practices, codes and standards.

Although the nearby residential receptors at Mirfa would be considered as receptors of *high* sensitivity, the potential impact severity would be considered as *'no change'* given that there would be no access to the Project site. The impact is therefore considered to be **negligible**.

Hazardous Materials Management and Safety

The potential for exposure of the local community to hazardous materials within the Project site is highly unlikely as the local community cannot access through the security perimeter. The Project sites are also located a significant distance from the nearest sensitive receptors i.e. residential properties situated approximately 200m to the east of the Mirfa Project site. Finally, the materials being used do not represent a significant risk of widespread effects in the event of accidents.

Nevertheless, there is a potential risk of accidents associated with the transportation of hazardous materials to and from the Project sitea. If accidents occur on the local road network, this could result in the release of hazardous materials. The materials used would are not anticipated to represent a major hazard and any spillages or releases would be expected to be highly localised. The local community is considered to be is considered to be of *low* sensitivity given the lack of receptors adjacent to the access roads and main E11 Highway. The impact severity is potentially *low* to *medium*, on the basis that the types of hazardous materials and quantities being transported, would not represent a significant risk and would only affect the immediate area in the event of an accident or spillage. The impacts are therefore predicted to be of **minor negative** significance in the absence of control measures.

5.9.2.3.2. Health and Safety

Operational Worker Welfare

One of the key socio issues is ensuring that operational staff and contractors are protected from workplace incidents and illness through appropriate health and safety systems both during normal operation and other tasks such as maintenance and repair.

Appropriate safety systems such as fire protection, detection of electrical issues and emergency procedures will also be required. The potential health and safety impacts are considered to be of *medium* severity upon receptors of *high* sensitivity, therefore resulting in a potential impact of **major negative** significance in the absence of suitable control measures.

Landscape and Visual Impacts

Landscape and visual impacts resulting from the operation phase are expected to be **negligible** due to the already disturbed nature of the surrounding areas, presence of industrial facilities and infrastructure and limited sensitive receptors. The Project components will be constructed adjacent to the existing power and water complexes at Al Mirfa and Al Shuweihat and will therefore not result in any significant changes to the local landscape character.

5.9.2.4. Cumulative Impacts

5.9.2.4.1. Construction Phase

Type 1 cumulative impacts pertaining to combined effects relating to different environmental aspects associated with construction may occur at residential and commercial properties within proximity to the Mirfa Project site, particularly at residential properties located to the east and south-east of the Project site. The combined impacts of a deterioration in air quality from vehicular emissions and/or dust generation, in conjunction with potentially elevated noise levels for example and a reduction in visual amenity, may result in a more significantly degraded environment at the detriment of sensitive receptors nearby, albeit on a temporary basis.

Type 2 impacts are also likely given that Project Wave and Mugharraq Port at Shuweihat are likely to be constructed concurrently with the Project. Therefore, impacts associated with the simultaneous construction of these projects may include cumulative air quality and noise impacts on sensitive receptors within the vicinity e.g. accommodation camps to the north of the Project site at Shuweihat. At Mirfa, since the Project Wave site is located approximately 2km to the west, cumulative impacts resulting from concurrent projects are more likely to include disturbance from increased combined levels of construction traffic on the local road network. Construction vehicle and plant air and noise emissions will be temporary and unlikely to lead to a significant deterioration in the local environment.

5.9.2.4.2. Operation Phase

During the operation of the Project, it is not considered that any significant cumulative impacts will be experienced by socio-economic receptors, other than slight positive impacts arising from the general increased economic activity and a potential improvement in air quality at Mirfa and Shuweihat due to the decommissioning of the GTGs.

5.9.3. Mitigation Measures

5.9.3.1. Potential Mitigation Measures

A range of mitigation measures will be required to offset the socio-economic impacts associated with the Project. The potential mitigation measures are set out within Table 5-138 below.

Table 5-138: Socio-economic impacts and potential mitigation measures

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
CONSTRUCTION PHASE								
➢ **Disruption to the local economy and population**								
1	Health related impacts and disturbance to sensitive receptors	Construction related dust generation	Project site and surrounding area	Negligible to Minor negative	– Ensure wetting down and dust minimisation techniques are applied throughout the Project site areas – Limit excavation work during windy conditions – Ensure sheeting of stockpiles or loose materials	– ADNOC HSE Requirements	Not applicable	Yes
2	Health related impacts and disturbance to sensitive receptors	Emissions from construction equipment and vehicles	Project site and surrounding area	Negligible to Minor negative	– Ensure vehicles are regularly maintained – Reduce idling and unnecessary revving	– ADNOC HSE Requirements	Not applicable	Yes
3	Disturbance from construction noise	Noise generating construction machinery and activities	Residential properties to the east of Mirfa along the shoreline	Negligible to Moderate negative	– Limit working times to ensure no night-time disturbances – Regular monitoring to ensure no exceedances of allowed limits	– ADNOC HSE Requirements	Not applicable	Yes
4	Disturbance to residential receptors at Mirfa	Construction related traffic using the local traffic network	Local road network	Minor negative	– Introduce traffic controls and measures to minimise traffic movements during peak traffic hours – Combine deliveries where possible to ensure minimisation of traffic accessing the Project sites.	– ADNOC HSE Requirements	Not applicable	Yes
5	Disturbance to the wider regional transport network as a result of construction traffic	Construction related traffic using the regional traffic network	Regional road network	Minor negative	– Introduce traffic controls and measures to minimise traffic movements during peak traffic hours – Combine deliveries where possible to ensure minimisation of traffic accessing the Project sites	– ADNOC HSE Requirements	Not applicable	Yes
6	Disturbance to Lansh boat fishermen	Cable laying activities in the offshore areas including trenching	Marine environment in the deeper offshore areas	Moderate negative	– A maritime traffic management plan should be prepared and implemented by the EPC Contractor to ensure that disruption to local marine traffic is minimised – Ensure best practice construction methodology employed to minimise sediment plumes etc.	– ADNOC HSE Requirements – Federal Law 23 and 24 of 1999	EAD Recommended Ambient Marine Quality Standard	Yes
7	Disturbance to Tarad boat fishermen	Cable laying activities in the nearshore areas including trenching	Marine environment in the shallow nearshore areas	Moderate negative	– A maritime traffic management plan should be prepared and implemented by the EPC Contractor to ensure that disruption to local marine traffic is minimised – Ensure best practice construction methodology employed to minimise sediment plumes etc.	– ADNOC HSE Requirements – Federal Law 23 and 24 of 1999	EAD Recommended Ambient Marine Quality Standard	Yes

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
8	Disturbance to local hadrah fishing activities	Cable laying activities in the nearshore areas including trenching.	Marine environment in the shallow nearshore areas	Moderate negative	– The EPC shall consult with EAD prior the start of the Project construction and removal of the hadrah located within the Project footprint	– ADNOC HSE Requirements	Not applicable	Yes
9	Disturbance to proposed EAD Dalma Sea Cage Aquaculture Project	Cable laying activities near Dalma Island	Near Dalma Island on Route 2	Negligible	– Ensure best practice construction methodology employed to minimise sediment plumes etc.	– Not applicable	Not applicable	Yes
10	Impacts upon local maritime traffic	Movement of construction vessels associated with the cable laying activities	The marine environment within the Project area	Minor negative	– Provide adequate exclusion zones to provide warnings to vessels – Issue Notice to Mariners (NTM) to inform vessels within the vicinity of the works	– Not applicable	Not applicable	Yes
11	Infrastructure and equipment design and safety – implications for local community	Construction activities, use of hazardous materials and the introduction of a fire risk.	Local area	Negligible	– Ensure that all components are designed and constructed in full accordance with best International practices, codes and standards	– ADNOC HSE Requirements	Not applicable	Yes
12	Hazardous materials management and safety – exposure of local community	Accidental leakages or mishandling	Local area	Negligible	– Ensure that all hazardous materials transported to the Project site are packaged and appropriately managed to prevent accidents and/or spillages on the local road network	– ADNOC HSE Requirements	Not applicable	Yes
13	Health and safety impacts upon construction works	Working in hot conditions, exposure to harmful substances, work related accidents	Project site	Major negative	– Implement strict working hours outside of hottest hours of the day – Ensure adequate health and safety plan in place to prevent incidents and risks to personnel	– ADNOC HSE Requirements; – IFC Performance Standard 1; and – IFC Performance Standard 2;	Not applicable	Yes
14	Health and safety impacts resulting from unfair working conditions	Inadequate working conditions, accommodation or unfair wages	Project site	Moderate negative	– Ensure the proper implementation of a labour accommodation plan to ensure that bedding, safety provisions, cleanliness and well-being are ensured e.g. regular cleaning of bed sheets and regular inspections by EPC Contractor	– ADNOC HSE Requirements	Not applicable	Yes
15	Enhancement of the local economy	Increase in demand and spending at local businesses	Local area	Minor positive	– No mitigation measures required.	– ADNOC HSE Requirements	Not applicable	Yes
16	Landscape and visual impacts	Presence of construction machinery, stockpiles and general site activity	Local area	Negligible	– Installation of hoarding, reduction of stockpiling and removal of waste materials from site.	– ADNOC HSE Requirements	Not applicable	Yes
OPERATION PHASE								
➢ **Disruption to the local economy and population**								
17	Health impacts upon sensitive receptors	Gaseous emissions from O&M vehicles	Residential, commercial and business areas within proximity of the construction routes within the local road networks.	Negligible	– Route deliveries and operational vehicles to ensure the bypass of built-up areas e.g. Mirfa and Ruwais where possible	– ADNOC HSE Requirements	Not applicable	Yes

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
18	Noise impacts and disturbance upon sensitive receptors	Noise generating operational machinery	Project site	Negligible	– Ensure that noise generating equipment is housed in appropriate noise attenuation structures	– ADNOC HSE Requirements	Not applicable	Yes
19	Impacts upon local economy and social issues	Increase in spending at local businesses and services	Local area	Negligible to minor positive	– No mitigation measures required	– ADNOC HSE Requirements	Not applicable	Yes
20	Disruption to local traffic levels	Increase in vehicles due to maintenance and operation staff accessing the site	Local road network	Negligible	– Route deliveries and operational vehicles to ensure the bypass of built-up areas e.g. Mirfa and Ruwais where possible	– ADNOC HSE Requirements	Not applicable	Yes
21	Infrastructure and equipment design and safety – impacts on local community	Explosions, accidents, fires or other operational hazards	Local area	Negligible	– Ensure that all components are designed and constructed in full accordance with best International practices, codes and standards – Provide thorough training for all personnel responsible for the operation of any high-risk elements of the Project.	– ADNOC HSE Requirements; and – IFC Performance Standard 4;	Not applicable	Yes
22	Hazardous materials and management safety – impacts on local community	Accidents, spillages, fires etc. resulting from the use of hazardous materials	Project site and local road network	Minor negative	– Ensure appropriate storage of explosive or flammable materials; and – Provide thorough training for all personnel responsible for the handling of potentially explosive or flammable materials.	– ADNOC HSE Requirements	Not applicable	Yes
➢ **Health and Safety**								
23	Operational worker welfare	Inadequate working conditions, or unfair wages	Project site	Major negative	– Ensure that fair contracts are maintained to provide appropriate compensation packages, accommodation, complaints procedures and health care	– ADNOC HSE Requirements – IFC Performance Standard 1; – IFC Performance Standard 2; – IFC Performance Standard 4; and – Noise emissions limits within Cabinet Decree No. 12 of 2006; and – IFC EHS Guidelines for Noise	– UAE Limit: 60-70 dB during daytime and 50-60 dB during night-time; and – IFC Limit: 70dB (A) at an industrial receptor during daytime or night-time.	Yes
➢ **Landscape and Visual**								
24	Reduction in visual amenity and alteration to the landscape character	Alteration in landscape character as a result of new structures	Nearby receptors e.g. residential properties within the visual zone of influence	Negligible	– No mitigation required	– Not applicable.	Not applicable	Yes

5.9.3.2. Selected Mitigation Measures

5.9.3.2.1. ADNOC HSE Requirements

During all phases of the Project, all activities will be required to comply with ADNOC HSE Management Systems (HSEMS) processes and ADNOC HSE practices on Health, Safety and Environment. In the event that any potential impacts are not addressed by ADNOC HSEMS, all ADNOC HSEMS Guidelines and local HSE legislation shall be adhered to, in addition to UAE Labour Law (Federal Law No. 8 of 1980). This will be in addition to the requirements set out within IFC Performance Standard 1.

The Project EPC Contractors and operators during all phases of the Project shall produce and implement a Project HSE Strategy in compliance with ADNOC HSE practices on Health, Safety and Environment specifically created for each aspect of the Project.

The Project EPC Contractors and operators will implement ADNOC's HSE Management of Contractors procedure (ADNOC Doc. No. Z0000-PB-GEN-N-032-019). The following HSE objectives will be met at all stages of the Project:

- All personnel will conduct their activities in accordance ADNOC's HSE policy;
- HSE documentation produced by the EPC Contractor and operators must be in compliance with ADNOC Health, Safety and Environmental Management Systems (HSEMS);
- All personnel must participate in training in accordance with ADNOC's procedure 'HSE Management of Project Company'. H_2S training will be obtained from an OPITO approved training institute;
- Site induction training on site is mandatory for all personnel visiting the Project facilities; and
- HSE deliverables prepared by the Project company must comply with current ADNOC Health, Safety and Environmental Management Systems (HSEMS).

A full list of applicable standards, codes or practices, guidelines and procedures which must be considered are listed within **Appendix 7.2**). The following will also be relevant to the Project:

- ADNOC Offshore SIMOPS_A0-DR-P-GDL-001 Rev.01;
- HAZOP Review Procedures;
- Pre-Startup Safety Review;
- ADNOC Group Standardised HSE Welfare and Medical Req in Contracts;
- ADNOC Group Medical Fitness Guidelines;
- Pre-Employment Medical Checklist
- List of Accredited Facilities Providing Occupational Medicine;
- HSE Operations Manual - HSE Training; and
- ADNOC Accountability Framework.

5.9.3.2.2. EPC Contractor Specific Requirements

Specific HSE frameworks associated with the appointed Project Contractors (a Consortium between JDN and SCT) will also be applicable in conjunction with the requirements specified above by ADNOC, and IFC EHS Guidelines and performance standards.

JDN, responsible for all offshore and onshore trenching, backfilling and cable installation works, are committed to achieving high standards of occupational health, safety and welfare for all employees. This commitment is enacted through the Quality, Health, Safety Security and Environmental Management System of Jan De Nul Group, which is certified by the following:

- Lloyd's Register EMEA according to the ISO 9001:2015 Quality Standard;
- ISO 45001:2018 (Management system for H&S) SCC 2008/5.1 Standard (VCA - SHE Checklist for Contractors); and
- ISO 14001:2015 Environmental Standard.

The QHSSE Management System of JDN also complies with the requirements of the International Management code for the Safe Operation of Ships and for Pollution Prevention (ISM-code). All ships are ISM, ISPS and MLC (Maritime Labour Convention) certified.

The minimum requirements for specific project documents relating to QHSSE are as follows:

- Project QHSSE Implementation Plan;
- Inspection and Test Plan;
- Organisation Chart;
- Risk and impact register; and
- Emergency response charts.

5.9.3.2.3. Construction Phase

During the construction phase the key mitigation measure will relate to the adoption of best working practices to reduce nuisance through noise and dust generation in addition to traffic congestion impacts associated with the Project.

Appropriate control measures are set out below and will form the framework for the development of a site-wide CESMP to be developed and implemented by the EPC Contractor. Specifically, the CESMP will need to be prepared in accordance with all pertinent ADNOC Codes of Practice (COP), provided within the following:

- Volume 1 – ADM;
- Volume 2 – Environment;
- Volume 3 – Health;
- Volume 4 – Safety;
- Volume 5 – Risk Management; and
- Volume 6 - Integrity

Disruption to the Local Economy and Population

Air Quality Impacts

Section 5.1.3.2: Air Quality sets out a series of measures which will be implemented during the construction phase to ensure that the generation of dust and emissions is minimized as far as possible.

Noise Impacts

Section 5.7.3.2: Noise sets out a series of controls to reduce the noise impacts during construction which will reduce the impacts of noise during construction.

Impacts Upon Offshore and Nearshore Fishing Activities

A maritime traffic management plan should be prepared and implemented by the EPC Contractor to ensure that disruption to local marine traffic is minimised and the potential for collisions and/or disturbance is reduced. Mitigation measures may include, but not be limited to:

- Issuing a notice to mariners (NTM) prior to the commencement of construction activities to inform all vessels of the proposed works and locations;
- Provision of a VHF radio to all Project vessels;
- Establishment of a clear emergency response plan;
- Establish an exclusion zone of 500m and provide security vessels to patrol this zone;
- Establishment of a Communication Plan which should be shared with all local ports and appropriate authorities to enable liaison throughout construction and to provide a method for grievances to be received from authorities and local mariners;
- All construction vessels should follow the agreed designated routes and be made aware of all anchoring and/or restricted areas;
- Boat crew must be approximately licensed and trained; and
- Sailing routes will be as direct as possible to the construction areas.

In addition to the above, mitigation measures to minimise sediment plumes from construction activities are provided within **Section 5.5.3.2: Marine Ecology**, including the deployment of silt curtains, which will reduce impacts upon fishing activities in both nearshore and offshore areas.

Impacts Upon Hadrah Fishing Activities

The EPC will be required to consult with EAD prior the start of the Project construction and removal of the hadrah located within the Project footprint. As EAD issue licenses to fishermen, it is expected that EAD will not re-issue annual licence for the hadrah located within the Mirfa (Route 1) footprint. Following EAD consultation with the EPC, EAD will advise if compensation measures will be required. All EAD's requirements will be followed.

Impacts upon EAD Dalma Sea Cage

Application of mitigation set out within **Section 5.2** and **Section 5.5** will ensure that all marine water quality and ecology impacts are mitigated as far as possible.

Management of Construction Traffic

It is recommended that a Traffic Management Plan (TMP) is implemented as part of the CESMP. Traffic management measures are listed within **Section 5.8.3.2.1**

Management of Maritime Construction Traffic

A maritime traffic management plan should be prepared and implemented by the EPC Contractor to ensure that disruption to local marine traffic is minimised and the potential for collisions and/or disturbance is reduced. Mitigation measures may include, but not be limited to:

- Issuing a notice to mariners (NTM) prior to the commencement of construction activities to inform all vessels of the proposed works and locations;
- Provision of a VHF radio to all Project vessels;
- Establishment of a clear emergency response plan;

- Establish an exclusion zone of 500m and provide security vessels to patrol this zone;
- Establishment of a Communication Plan which should be shared with all local ports and appropriate authorities to enable liaison throughout construction and to provide a method for grievances to be received from authorities and local mariners;
- All construction vessels should follow the agreed designated routes and be made aware of all anchoring and/or restricted areas;
- Boat crew must be approximately licensed and trained; and
- Sailing routes will be as direct as possible to the construction areas.

Health and Safety

Health, Safety and Security Control Plan

In order to ensure that that community health and safety is maintained during construction works by the EPC Contractor, the following will be implemented:

- All facilities will be designed and constructed in full accordance with International practices, codes and standards;
- Traffic safety will be maintained as part of a Traffic Control Plan;
- Appropriate emergency preparedness and response procedures will be developed as part of an HSE Plan; and
- Security access to the Project site is maintained at all times using Abu Dhabi licensed companies and security guards.

Construction Worker Welfare

- The development of a Health and Safety and Environmental Policy, in line with the requirements set out within ADNOC CoPs and HSE documentation (listed in full in **Appendix 7.2**), will provide detailed health and safety guidelines for staff, personnel and sub-contractors, including non-discrimination, grievance mechanisms, employees rights, personal safety, site conduct, security, site safety zoning and emergency procedures;
- In accordance with Performance Standard 2, on-site medical facilities must be made available throughout the construction phase for the use of workers. Trained health and safety and first aid personnel must be identified to workers as part of their training schedule;
- Suitably qualified personnel must be chosen for potentially hazardous activities such as for the installation and testing of specialist electrical equipment;
- Appropriate action must be taken for outbreaks of illnesses amongst workers (e.g. but not limited to Covid-19), minimising the transmission as far as is possible;
- The Contractor must establish a Human Resources Policy in accordance with ADNOC guidelines and requirements which will be communicated to employees with information including, but not limited to, their rights under national labour and employment laws, salary, and other associated information, such as medical care and insurance. The Human Resources Policy will ensure an approach of non-discrimination is followed with equal opportunities for all. No child labour or forced labour will be used for the proposed facility;

- In accordance with Performance Standard 1 (Section 23), the establishment of a 'grievance mechanism' for workers will involve the identification of a local environmental coordinator, identified by the contractor within the management structure, to identify and log all concerns. This contact information will be provided via appropriate transparent measures and a placard left on the perimeter of the site with further details of contact arrangements. The resultant procedure to address these concerns will be made clear to the complainant and a set process followed, as identified within the CESMP, and within a suitably prompt period;
- Throughout the construction period, a long-term training programme should be implemented to ensure adequate training and qualification of all staff employed. The aim of this programme would be to ensure that personnel acquire and maintain the combination of knowledge and demonstrated skills as required to safely and adequately fulfil their responsibilities. The objective of the long-term training plan will be to ensure that the facility is operated safely and efficiently, while also guaranteeing the long-term economic success of the Project; and
- In accordance with Performance Standard 4, all components of, and infrastructure associated with, the Project will be constructed in accordance with industry standards.

Covid 19 Protocol

Additionally, as a result of the global spread of Covid-19, precautions will be in place to prevent and control the spread of possible outbreak of epidemic diseases. For the prevention epidemic disease outbreak in the Project site and camp, the following protection measures will be applied as a minimum:

- 1) Restriction of movement and travel between administrative regions;
    - Thorough sanitation management;
    - Equipped with hand sanitizers and periodic education;
    - Use of surgical masks and gloves onsite as additional PPE;
- 2) Check a body temperature at each gate and at the beginning of every working day for all staffs;
    - Periodic medical check by the site nurse and keeping the records of new worker/employees and any visitors;
    - Education of the campaign and enhanced site health monitoring; and

    3) Emergency plan on COVID -19 (Action plan on the Site outbreak, Readiness of Emergency Team (site nurse, Ambulance, HSE personnel) and isolated area).

Landscape and Visual Impacts

The following mitigation measures will be implemented by the EPC Contractor to minimise impacts relating to visual receptors and a reduction in landscape quality as a result of the construction activities and laydown areas required. A summary of these measures is as follows:

- Strategic installation of hoarding of an appropriate height within areas along the Project site within close proximity to residential areas and roads in order to shield the view of construction activities from the identified sensitive receptors;
- Establishment of a grievance mechanism for local and nearby residents;
- Ensure good housekeeping throughout the construction site and storage areas to minimise unsightly visual impacts; and
- Identify dedicated construction traffic routes, including use of appropriate signage to ensure that construction vehicles are routed away from residential areas where feasible.

Impacts on Surrounding Receptors

Construction activities undertaken for the Project may result in an impact to construction worker accommodation, depending upon its eventual location, which is yet to be determined. It is important that this will be managed in such a way as to minimise construction impacts.

Firstly, the worker accommodation should be appropriately sited to avoid noise impacts from the construction activities. Where this is not possible appropriate noise attenuation measures should be provided.

Secondly, any on-going issues will be managed through the CESMP which will be implemented and monitored by the EPC Contractor and any sub-contractors, to include an update of existing environment, health and safety (EHS) documentation. The CESMP will be required to incorporate all the mitigation measures identified throughout this ESIA. This will ensure that the effects of construction work upon any sensitive receptors is minimised.

Complaint Procedures

During the Project construction phase, the EPC Contractor(s) will be required to develop a comprehensive CESMP. This CESMP shall include a grievance mechanism to allow any complaints from the general public to be adequately and promptly addressed using a transparent reporting process. In addition, the grievance mechanism process should be properly communicated to all potential stakeholders i.e. all residents, businesses and other receptors present within and surrounding Mirfa and Shuweihat Project sites should be informed of the process.

The grievance mechanism will include the following:

- Clear contact numbers for key construction management staff who can be contacted in the case of complaints, which could be posted on signage near to the site access gates; and
- A clear grievance procedure which involves studying the basis of complaints, identifying corrective actions and communicating the response to the complainant.

Labour Accommodation Plan

At this stage the type and locations of construction workers accommodation camps is unknown. These will presumably be located within or close to the Project site and could comprise rented space from existing facilities (e.g. existing Contractors Camps) from third parties or the development of specific facilities by the EPC Contractor. If facilities are rented from an existing supplier or dedicated accommodation facilities are developed by the EPC Contractor, it will be ensured that the accommodation facilities meet the minimum requirements of UAE and ADNOC regulations and International Labour Organization (ILO), as follows:

- The camp accommodation facilities will comply with the requirements specified by the IFC Worker’s Accommodation: Processes and Standards;
- Undertake quarterly camp accommodation audits to ensure that the camp accommodation facilities comply;
- In providing worker accommodation, the objective should be to ensure “adequate and decent housing accommodation and a suitable living environment”;
- Development of an Accommodation Plan in line with the IFC Worker’s Accommodation: Processes and Standards;
- The housing and related community facilities should be of durable construction, taking into account local conditions;
- The location of workers’ housing should ensure that workers are not affected by air pollution, surface run-off or sewage or other wastes;

- The following standards shall apply:

  a. a separate bed for each worker;
  b. adequate headroom, providing full and free movement, of not less than 203 centimetres;
  c. the minimum inside dimensions of a sleeping space should be at least 198 centimetres by 80 centimetres;
  d. beds should not be arranged in tiers of more than two;
  e. bedding materials should be reasonably comfortable;
  f. bedding and bedframe materials should be designed to deter vermin;
  g. separate accommodation of the sexes;
  h. adequate natural light during the daytime and adequate artificial light;
  i. a reading lamp for each bed;
  j. adequate ventilation to ensure sufficient movement of air in all conditions of weather and climate;
  k. heating where appropriate;
  l. adequate supply of safe potable water;
  m. adequate sanitary facilities;
  n. adequate drainage;
  o. adequate furniture for each worker to secure his or her belongings, such as a ventilated clothes locker which can be locked by the occupant to ensure privacy;
  p. common dining rooms, canteens or mess rooms, located away from the sleeping areas;
  q. appropriately situated and furnished laundry facilities;
  r. reasonable access to telephone or other modes of communications, with any charges for the use of these services being reasonable in amount; and rest and recreation rooms and health facilities, where not otherwise available in the community;

- In workers' sleeping rooms the floor area should not be less than 7.5 square metres in rooms accommodating two persons; 11.5 square metres in rooms accommodating three persons; or 14.5 square metres in rooms accommodating four persons. If a room accommodates more than four persons, the floor area should be at least 3.6 square metres per person. Rooms should indicate the permitted number of occupants;
- As far as practicable, sleeping rooms should be arranged so that shifts are separated and that no workers working during the day share a room with workers on night shifts;
- Adequate sanitation facilities should be provided, including:
  - A minimum of one toilet, one wash basin and one tub or shower for every six persons;
  - Sanitary facilities provided should meet minimum standards of health and hygiene. They should also provide reasonable standards of comfort, including hot and cold fresh running water;
  - There should be separate sanitary facilities provided for men and for women;
  - Sanitary facilities should have ventilation to the open air, independently of any other part of the accommodation;
  - Soap and hygienic paper should be adequately stocked;
- As far as possible, floors walls, ceilings and equipment should be constructed to minimize health risks;
- The accommodations should be kept free of rats, mice, insects and vermin;

- In areas where mosquitoes are prevalent, workers should be provided netting;
- Measures should be taken to prevent the spread of diseases;
- Separate facilities should be provided for sick workers to prevent the spread of transmissible diseases among the occupants;
- Fire safety measures should be taken, including installing and maintaining fire equipment (alarms, extinguishers, etc.);
- Workers should be trained in fire procedures;
- Bedding should not contain flammable materials;
- Radiators and other heating apparatus should be placed so as to avoid risk of fire and shielded where necessary to prevent discomfort to occupants;
- Safety exits should be clearly marked;
- Adequate means of escape should be provided and properly maintained;
- Provisions should be made for workers' physical safety and well-being, and protection of their belongings. Measures should be reasonable and not unduly restrict workers' freedom of movement;
- Workers should be allowed visits for social relations or business;
- Premises will be inspected regularly by the EPC Contractor to ensure that the accommodation is clean, decently habitable and maintained in a good state of repair. The results of each such inspection should be recorded and be available for review; and
- Upon termination of employment, the worker should be entitled to a reasonable period of time to vacate the premises.

5.9.3.2.4. Operation Phase

Of key importance will be the integration of all relevant ADNOC Codes of Practice (CoP), ADNOC HSE Management Systems (HSEMS) processes and ADNOC HSE practices on Health, Safety and Environment. This extensive set of documentation will require to be implemented by the ADNOC HSE Manager for each of the Project sites.

To provide the employees with a safe and risk-free environment, it is recommended that a site specific HSE plan is developed and implemented within the wider Project sites OEMP. This framework, in line with Performance Standard 2 and will incorporate the requirements set out by ADNOC CoP documents, will address measures for accident prevention, identification, mitigation and management of hazards (including physical, chemical, and radiological hazards), training of workers and reporting of accidents and incidents.

Air Quality Impacts

5.1.3.2: Air Quality sets out a series of measures which will be implemented during the operations phase to ensure that the generation of dust and emissions is minimised as far as possible.

Noise Impacts

5.1.3.2: Noise sets out a series of controls to reduce the noise impacts during operation which will reduce the (very limited) impacts of noise during operation.

Impacts upon Local Businesses

As the impacts are considered to be **positive** there is no requirement for any mitigation measures to be implemented.

Impacts upon local road network

As the number of operational vehicles expected to be required is minimal, no specific mitigation measures are considered necessary other than routing any operational vehicles away from the residential and commercial areas of Mirfa and Ruwais town centres.

5.9.3.2.5. Health and Safety

Health, Safety and Security Control Plan

- All facilities will be designed and constructed in full accordance with International practices, codes and standards;
- Traffic safety will be maintained as part of a Traffic Control Plan;
- Appropriate emergency preparedness and response procedures have been developed as part of a HSE Plan; and
- Security access to the Project site is maintained at all times using Abu Dhabi licensed companies and security guards.

Operational Worker Welfare

- To provide the employees with a safe and risk-free environment, it is recommended that a comprehensive EHS plan is developed and implemented. This framework, in line with Performance Standard 2, will address measures for accident prevention, identification, mitigation and management of hazards (including physical, chemical, and radiological hazards), training of workers and reporting of accidents and incidents;
- Occupational noise standards need to be maintained as part of the Health and Safety of the employees at the facility. It is therefore important that noise levels in working areas are limited to less than 85 dB(A) at 1m from any noise generating equipment. It is further recommended that a full occupational noise survey is undertaken in the interests of the health and safety of the site employees;
- In accordance with Performance Standard 2, the Project operate a human resource policy in line with ADNOC and IFC requirements outlining the management approach towards working conditions, entitlement to wages and any benefits and terms of employment. This policy must be disseminated and accessible for all employees, clearly defining the employees' legal rights and the management's statement on child labour, forced labour and on non-discrimination and equal opportunities. This policy will also provide the mechanism through which employees can express and register their concerns and the system through which these grievances will be addressed.
- Expatriate staff must be provided with an induction course (as part of their training), which will highlight local customs, cultures and living conditions in the UAE. The objective of this course will be to familiarise the expatriate staff with knowledge of their host country and provide an understanding and respect for other

cultures. The aim will be to reduce, prevent and mitigate against social and cultural tensions and potential hostility between workers and the residents of surrounding communities;

- The provision of facilities for workers, such as kitchen facilities, dining areas, washrooms, and a mosque, will minimise the placing of undue pressure on existing local services; • Where feasible, staff will be of local origin where suitably qualified applicants are available. This will ensure a degree of balance between the use of expatriate workers and locally employed personnel during the operational phase, and limit the impact on the local economy;
- In common with Performance Standard 4, all components of and infrastructure associated with the Project will be operated in accordance with industry best practice by qualified staff; and
- In line with IFC Performance Standard 1, it is also recommended that a grievance mechanism is established for any local residents (not currently understood to be present but in case of the arrival of future residents) and the workers, giving them a platform to raise any concerns.

5.9.3.3. Mitigation Measures to Address Cumulative Impacts

With regard to Type 1 cumulative impacts, it is anticipated that the mitigation measures provided in the preceding sections will serve to address cumulative impacts from multiple impact types (e.g. air quality and noise) upon a particular sensitive receptor, whereby all parties will be obligated to adhere to the EAD permitting process and implement specific measures to ensure that both construction controls (e.g. through the development of a CESMP by the EPC Contractor).

Mitigation measures are not considered necessary for cumulative impacts during operation.

5.9.3.4. Residual Impacts

The predicted residual impacts following the implementation of mitigation measures as part of the construction and operation phase are identified in Table 5-139 below.

Table 5-139: Socio economic residual impacts

Description of the Impacts	Impact Significance Prior to Mitigation Measures	Residual Impact Significance
Construction Phase		
➢ **Disruption to the local economy and population**		
Construction dust impacting on sensitive receptors	Negligible to Minor negative	Negligible
Emissions from construction equipment and vehicles	Negligible to Minor negative	Negligible
Disturbance from construction noise	Negligible to Moderate negative	Negligible

Description of the Impacts	Impact Significance Prior to Mitigation Measures	Residual Impact Significance
Disturbance to residential receptors at Mirfa due to impacts upon local traffic network	Minor negative	Negligible
Disturbance to the wider regional transport network as a result of construction traffic	Minor negative	Negligible
Disturbance to Lansh boat fishermen	Moderate negative	Minor negative
Disturbance to Tarad boat fishermen	Moderate negative	Minor negative
Disturbance to local hadrah fishing activities	Moderate negative	Minor negative
Disturbance to proposed EAD Dalma Sea Cage Aquaculture Project	Negligible	Negligible
Impacts upon local maritime traffic	Minor negative	Negligible
Infrastructure and equipment design and safety	Negligible	Negligible
Hazardous materials management and safety	Negligible	Negligible
Health and safety impacts upon construction works	Major negative	Minor negative
Health and safety impacts resulting from unfair working conditions	Moderate negative	Negligible
Enhancement of the local economy	Minor positive	Minor positive
Landscape and visual impacts	Negligible	Negligible
Operation Phase		
➢ **Disruption to the local economy and population**		
Gaseous emissions from O&M vehicles	Negligible	Negligible
Operational noise impacts upon sensitive receptors	Negligible	Negligible
Impacts on local economy and social issues	Negligible to minor positive	Negligible to minor positive
Disruption to traffic levels	Negligible	Negligible
Infrastructure and equipment design and safety	Negligible	Negligible
Hazardous Materials Management and Safety	Minor negative	Negligible
➢ **Health and Safety**		

Description of the Impacts	Impact Significance Prior to Mitigation Measures	Residual Impact Significance
Operational worker welfare	Major negative	Negligible
➢ **Landscape and Visual**		
Landscape and Visual	Negligible	Negligible

5.9.4. Monitoring Program

5.9.4.1. Monitoring Program for Compliance with Selected Mitigation Measures

Monitoring is proposed with respect to air quality and noise, within **5.1.4** and **Section 5.7.4.1**.

The CESMP developed by the EPC Contractor should include an Environmental Complaint and Incident Register, including any corrective actions taken. Furthermore, the following should be included:

- A Site Accident Register summarising injuries or near misses; and
- Logs of all training and induction activities undertaken on site.

5.9.4.2. Monitoring Program for Cumulative Impacts

No additional monitoring is considered necessary for cumulative impacts. It is considered that the monitoring proposed for identified impacts will be sufficient.

5.9.4.3. Monitoring Program for Residual Impacts

No additional monitoring is considered necessary for residual impacts. It is considered that the monitoring proposed for identified impacts will be sufficient.

5.10. Archaeology and Cultural Heritage

5.10.1. Description of the Environment

5.10.1.1. Baseline Methodology

In order to understand the current potential for archaeological and/or cultural heritage within the Project sites, the following baseline activities were undertaken:

- Request for information to the Historic Environment Department within the Abu Dhabi Department of Culture and Tourism (DCT);
- Desktop review of existing information; and
- Field visual survey carried out by Anthesis.

The Historic Environment Department within Abu Dhabi Department of Culture and Tourism (DCT) has been consulted as part of this ESIA in order to inform the assessment of potential impacts upon archaeology and cultural heritage as a result of the Project. A request for information was made by Anthesis directly via email (**Appendix 6.9**) to the DCT in advance of the application for a No Objection Certificate (NOC) which will be submitted independently of the ESIA process by the Project Owner. The results of the NOC will be provided and incorporated within the CESMP, including site-specific mitigation measures which will be required to be implemented accordingly.

In lieu of an NOC, this ESIA has considered the initial information provided by DCT in relation to known archaeological features within the Project area and the results of a desk-based study on existing archaeological works undertaken within the Project area. On the basis of this available information, this ESIA has assessed the potential for further impacts to occur as a result of the Project.

In addition, a site walkover survey was undertaken on 18-19th January 2022 by Anthesis, which showed that there are no apparent archaeological features or cultural heritage resources within the Project site. However, it is recognised that as this survey was based on visual observations only and the potential exists for buried remains to be present.

5.10.1.2. Baseline Conditions

Desk-based Study

Extensive survey work has been undertaken throughout the Western Regions of Abu Dhabi by Abu Dhabi Islands Archaeological Survey (ADIAS). The areas surrounding Mirfa and Shuweihat Project sites have been identified as containing a rich and diverse history, and a large number of archaeological and historical sites are present. The area has been subject to significant paleontological observations and fieldwork since the start of petrochemical explorations in the 1940’s. The area in which the Project sites are located, at Mirfa and Shuweihat, are considered by ADIAS to be of ‘*very considerable palaeontological significance’* due to the presence of an extensive range of Late Miocene fossils (160). The vertebrate fossils within Abu Dhabi are found exclusively within fluvial sediments known as the Baynunah Formation., which represent the youngest in the Miocene sediments. The fossil finds near to the Project sites include fossils of teeth and jawbones of *Hipparion* (early three toed horse) to hippopotamus bones, freshwater mollusc shells, hyaena bones near to the Shuweihat Project site to the north and on Jebel Dhanna, whilst at Mirfa, a fossil bed river has been discovered with an estimated width of 100m (160). Throughout the wider area other fossils have also been found of crocodiles, turtles fish and elephants. Of most prominent note is the incomplete skeleton of an elephant found at Shuweihat Island. These finds all suggest the likely riverine nature of the area between 6-8 million years ago. The area is clearly extremely valuable in terms of understanding the Miocene environment of Abu Dhabi. (160).

Offshore, although not within the Project study area, is located Marawah Island, within the MMBR. The island has also been surveyed by ADIAS which identified 13 major sites of archaeological interest ranging from Late Stone Age to Late Islamic Period (160).

In addition to the extensive archaeological value contained within the local areas both on and offshore, the town of Mirfa itself if a historical fishing town with long connections to the culturally important Hadrah fishing methods which involved the use of fixed stakes and nets within shallow coastal areas. Further information is provided in **Section 5.9.1**.

Information was also reviewed on the EAD's Enviroportal (161), which includes historic pearl diving sites compiled from old charts and historic visits, as shown in Figure 5-231. Pearl diving was once the driving force of the UAE economy and was the major profession for most of the population. The Gulf pearl industry declined in the late 1920s and early 1930s as a result of the discovery of a way to make flawless artificial pearls in Japan. Whilst the Pearl diving industry is an important part of the UAE's heritage and culture, this is no longer an active industry.

Initial Discussions with DCT

Figure 5-228 to Figure 5-229 below (as well as Figure 4-49 to Figure 4-52 presented in **Section 4.2.4)** show the known locations of archaeological remains and artefacts within the Project study areas at Mirfa, Shuweihat. Additionally, Figure 5-230 shows the known locations of archaeological remains and artefacts near the Project route near Das Island. The locations were provided by DCT. It can be seen that there are no conflicts between the Project and any known archaeological remains. The closest site to the Project footprint is the unknown seabed obstruction near Das Island which is located 160m from the cable route.

Initial discussions with DCT have not identified the presence of any archaeological sites on Das Island, other than the seabed obstruction identified approximately 5km offshore to the south of Das Island. Al Ghallan Island is recently reclaimed and as such has not been considered further in terms of archaeology or cultural heritage.

Figure 5-228: Potential site of archaeological or cultural value in Mirfa

Figure 5-229: Potential site of archaeological or cultural value in Shuweihat

Figure 5-230: Potential site of archaeological or cultural value near Das Island

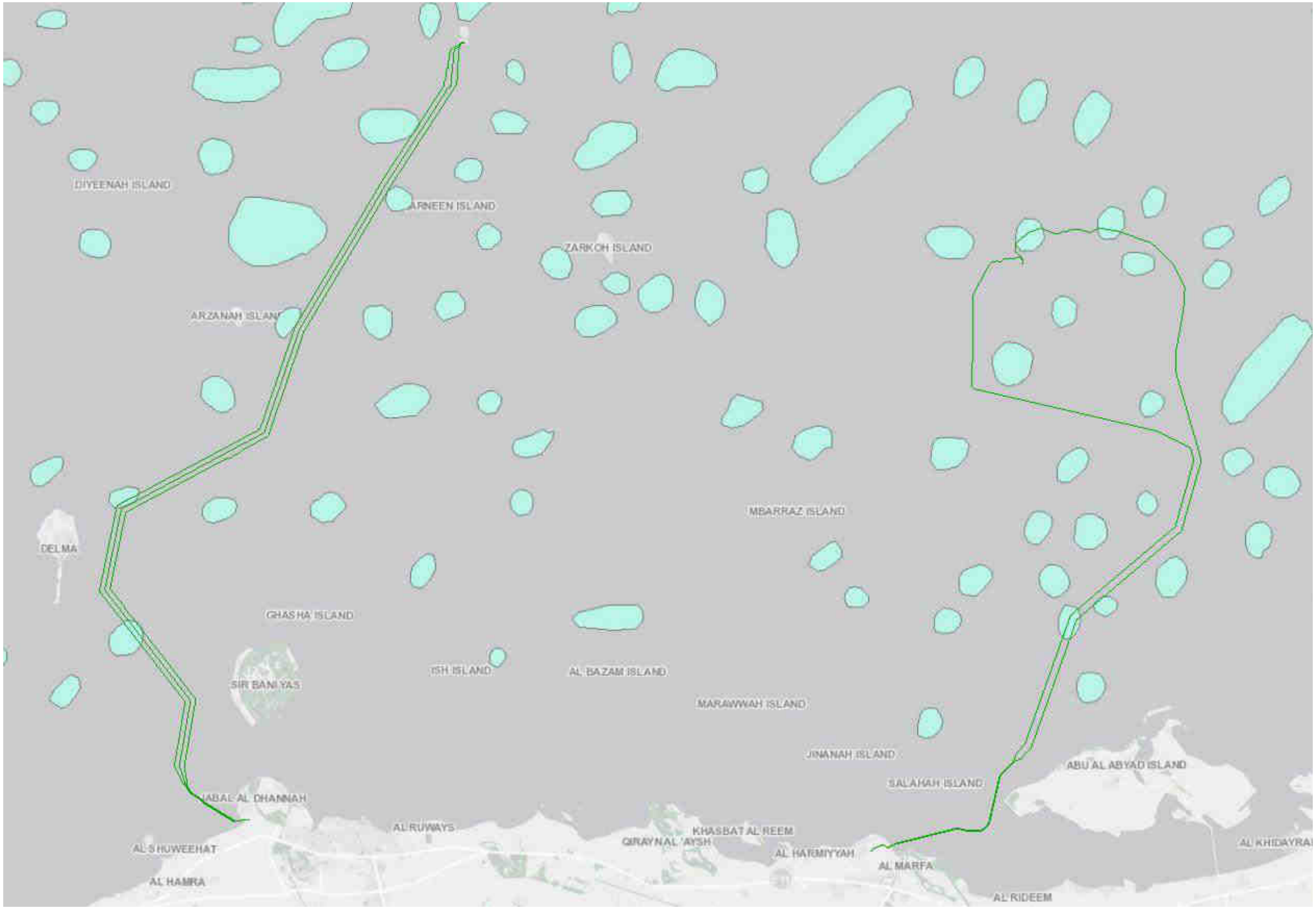


Figure 5-231: Historic pearl diving sites (161)

5.10.2. Environmental Impact Prediction and Evaluation

5.10.2.1. Sensitive Receptors

The identification and value of the sensitive receptors are presented in Table 5-140.

Table 5-140: Sensitive receptors and value within the Project site

Sensitive Receptor	Receptor Class Value	Justification
Identified archaeological features within the Project site and surrounding areas	*High*	All archaeological features are important and have a *high* value.
Unidentified buried archaeological remains within the Project area	*High*	All archaeological features are important and have a *high* value.

5.10.2.1.1. Construction Phase Impacts

Disturbance of Identified Archaeological Artefacts and Structures

No identified structures or artefacts are known to be located within the Project site footprints at Mirfa, Shuweihat, Das Island and Al Ghallan Island. No impacts are therefore predicted.

Historic pearl diving sites are present in some areas along both Route 1 and Route 2, which will be impacted. It is not considered that any features of cultural heritage value would be disturbed and therefore no impacts are predicted.

Disturbance of Buried Archaeological Artefacts and Structures

During the construction phase, significant disruption is expected as a result of excavation, clearing and grading, trenching and general earthworks throughout the footprint of the Project site areas and onshore cable corridors. Based on the information provided by DCT, the presence of buried remains within the Project footprint is considered to be possible and the impact magnitude is therefore considered to be *medium*, upon receptors of *high* sensitivity. The impact upon unidentified artefacts is therefore assessed to be of **major negligible** significance in the absence of mitigation measures.

5.10.2.1.2. Operational Phase Impacts

All detrimental impacts associated with archaeological and cultural heritage will be limited to the construction phase.

5.10.2.1.3. Cumulative Impacts

Construction Phase

Type 1 cumulative impacts on archaeology are possible due to potential soil and groundwater contamination in combination with the potential loss of unknown archaeological artefacts during excavation and earthworks. This will also have an impact on the value of the area as a whole, particularly as it is likely for other valuable sites to be present within the Project area.

Type 2 cumulative impacts are possible since it is understood that Project Wave at Mirfa and Mugharraq Port at Shuweihat are likely to be concurrently under construction which therefore represents a wider possible area for chance archaeological finds to occur during excavations. Given that this area is considered to be rich in Miocene fossils, the possibility for chance finds are significant.

Operation Phase

No cumulative impacts upon archaeology or cultural heritage are anticipated during the operation phase.

5.10.3. Mitigation Measures

5.10.3.1. Potential Mitigation Measures

A range of mitigation measures will be required to offset the archaeological and cultural heritage impacts associated with the Project. The potential mitigation measures are set out within Table 5-141 below.

Table 5-141: Archaeology and Cultural Heritage impacts and potential mitigation measures

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
CONSTRUCTION PHASE								
1	Disturbance of identified archaeological artefacts and structures	Site preparation activities, site clearance, access road construction etc.	Project site	Negligible	– The EPC Contractor will review all information provided within the CESMP which will include feedback from DCT following consultation by the Project Owner with DCT. – Construction managers should be made aware that the potential exists for unidentified artefacts to be present and if any potential above ground find is noted, works should be suspended in that area and DCT informed.	Not applicable	Not applicable	Yes
2	Disturbance of buried archaeological artefacts and structures	Site preparation activities, foundation and excavation works of building structures and cable laying activities.	Project site	Major negative	– The EPC Contractor will include mitigation measures to prevent potential impacts upon archaeological and cultural heritage artefacts and structures present within the Project sites. – Toolbox talks concerning the potential for archaeological finds during earthworks, which will be provided to all construction workers involved in site works such as grading, excavations etc.; – A watching brief shall be implemented during initial phases of ground excavations.	Not applicable	Not applicable	Yes
OPERATION PHASE								
3	Disturbance of any archaeological artefacts and structures	N/A	Project site	Negligible	– No mitigation measures required.	Not applicable	Not applicable	Yes

5.10.3.2. Selected Mitigation Measures

Construction Phase

In order to ensure that archaeological impacts are minimised, it is recommended that the CESMP includes all recommendations and requirements provided by DCT following the consultation process. This may include procedures to protect archaeological resources such as:

- Toolbox talks concerning the potential for archaeological finds during earthworks, which will be provided to all construction workers involved in site works such as grading, excavations etc.;
- A watching brief shall be implemented during initial phases of ground excavations as summarized in Figure 5-232 below.
  - Any chance finds or suspected evidence of archaeological and/or historical materials must be immediately reported by any of the construction workers, or other parties involved in the construction phase, to the HSE representative or Site Manager and all works in the area should be stopped immediately and until further notice; and
  - Department of Culture and Tourism (DCT) should be contacted for advice on how to proceed and work should not recommence within that area until signed off by DCT.

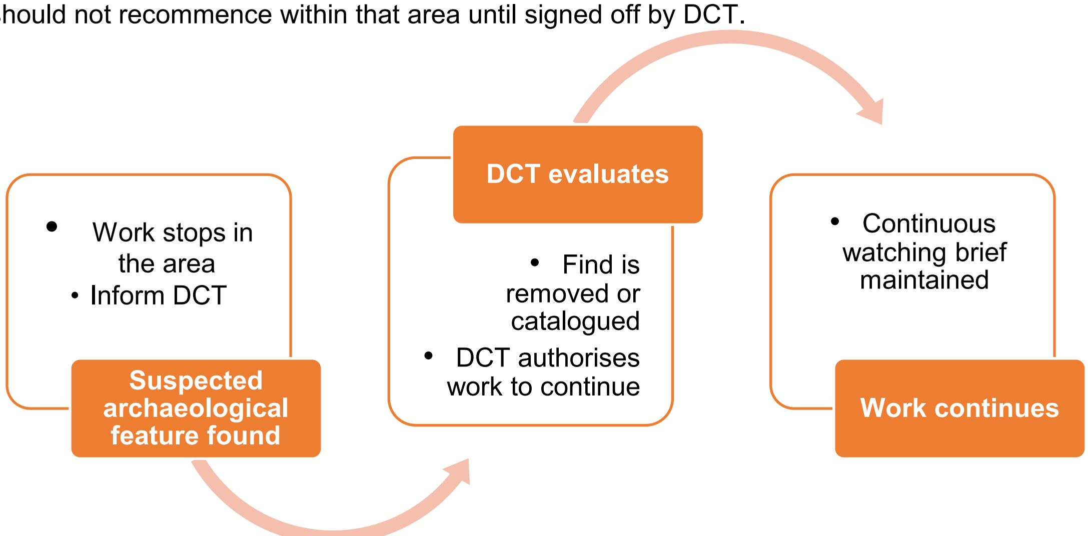


Figure 5-232: Summary of the archaeological watching brief and chance finds procedure

Operation Phase

No mitigation measures are required during the operation phase of the Project.

5.10.3.3. Mitigation Measures to Address Cumulative Impacts

With regard to Type 1 cumulative impacts, it is anticipated that the mitigation measures provided in the preceding sections will serve to address cumulative impacts from multiple impact types soil and groundwater contamination and disturbance to the ground upon a potentially unidentified archaeological sensitive receptor, whereby all parties will be obligated to adhere to the EAD permitting process and implement specific measures to ensure that both construction controls (e.g. through the development of a CESMP by the EPC Contractor).

Mitigation measures are not considered necessary for cumulative impacts during operation.

5.10.3.4. Residual Impacts

The predicted residual impacts following the implementation of mitigation measures as part of the construction and operation phase in relation to archaeology and cultural heritage are identified in Table 5-142 below

Table 5-142: Archaeology and cultural heritage residual impacts

Description of the Impacts	Impact Significance Prior to Mitigation Measures	Residual Impact Significance
Construction Phase		
Disturbance of identified archaeological artefacts and structures	Negligible	Negligible
Disturbance of buried archaeological artefacts and structures	Major negative	Minor negative
Operation Phase		
Disturbance of any archaeological artefacts and structures	Negligible	Negligible

5.10.4. Monitoring Program

5.10.4.1. Monitoring Program for Compliance with Selected Mitigation Measures

It is considered that the Project would not require any monitoring measures within the implementation of the appropriate mitigation measures specified within the CESMP.

5.10.4.2. Monitoring Program for Cumulative Impacts

It is considered that the Project would not require any specific monitoring measures relating to cumulative impacts with the implementation of the appropriate mitigation measures specified within the CESMP.

5.10.4.3. Monitoring Program for Residual Impacts

It is considered that the Project would not require any specific monitoring measures relating to residual impacts with the implementation of the appropriate mitigation measures specified within the CESMP.

5.11. Climate Change

5.11.1. Description of the Environment

5.11.1.1. Baseline Methodology

A desktop survey was conducted to identify the future climatic trends based on climate simulations for the UAE. The Project Team has taken into account the physical climate related risks as prescribed by the Task Force on Climate Related Financial Disclosures (TFCD) (162).

5.11.1.2. Baseline Conditions

5.11.1.2.1. Temperature

In recent decades there has been a notable upward trend in temperatures within the West Asia Region as defined by the Intergovernmental Panel on Climate Change (IPCC) within the Fifth Assessment Report (163). Climate simulations undertaken for the UAE have identified that the extensive coastline of the country, in addition to the rapid growth occurring predispose the country to be more prone to impacts of climate change (164). It is estimated that average temperatures within Abu Dhabi will rise by 2.5°C by 2050, with increasing variations witnessed in temperature and abnormal rainfall events (164).

5.11.1.2.2. Rainfall

Rainfall predications show variable outcomes for the UAE following simulations by General Circulation Models (GCMs), with some simulations indicating a likelihood of higher rainfall by 2080 whilst other simulations conversely indicate a dryer future with less precipitation which supports the prediction of more erratic weather patterns (164).

5.11.1.2.3. Sea-Level Rise

Due to the shallow sloping of the UAE coastline, approximated to be 25cm per kilometre, a large proportion of the UAE coastline is vulnerable to sea-level rise, which when considered in conjunction with the fact that 90% of infrastructure and 85% of the population being located within or extremely close to the coastline areas, renders the country as particularly likely to experience significant sea level rise impacts. Abu Dhabi and Dubai have been identified as particularly vulnerable (164).

5.11.1.2.4. National Policy on Climate Change

Conversely, despite the clear risks, the UAE also represents a country capable of investing and committing to installations and integration of preventative measures against sea level rise, supported by local, regional and national investments in sustainable technologies (165). The UAE has adopted multiple visions and agendas aimed towards tackling environmental issues, with climate change at the forefront of these considerations, with already US$16.8 million invested in renewable energy endeavors in 70 different countries.

The UAE's Climate Change Research Network, established by the UAE Government is aiming to coordinate research efforts, data and information from the wide range of universities and research centres throughout the country to enable advances in policy-relevant research to determine the required current and future actions necessary to enable the country and region to adapt to the impacts presented by climate change.

Of key importance within national policy is The National Climate Change Plan which was prepared to '*consolidate the UAE/s climate change action under a single framework and identifies strategic priorities, covering both mitigation and adaptation measures* (166).

The National Climate Change Plan identifies that local research indicates that climate change is likely to impact upon the UAE's development ambitions, in addition to the threat posed to the extensive amount of infrastructure present within coastal areas in the country (166). Given the nature of the coastal location of the Project and its subsequent vulnerability due to the predicted significant risks posed by climate change to the UAE, consideration must therefore be given within the design of the facility to mitigate against future predicted increases in sea level and temperatures associated with climate change to ensure the future proofing of the Project.

5.11.2. Environmental Impact Prediction and Evaluation

5.11.2.1. Sensitive Receptors

The identification and value of the sensitive receptors are presented in Table 5-143.

Table 5-143: Sensitive receptors and value within the Project site

Sensitive Receptor	Receptor Class Value	Justification
Blue carbon habitats including coastal sabkha, saltmarshes and mangroves	*High*	The storage of carbon within natural habitats is of key importance is managing climate change.

5.11.2.2. Construction Phase Impacts

As identified in **Section 5.6**, a number of habitats present within the Project site areas at Mirfa and Shuweihat are capable of sequestering and storing carbon, including coastal sabkha, saltmarsh and mangroves. The vast majority of blue carbon habitat expected to be disturbed during construction is coastal sabkha, with only relatively small areas of mangroves and saltmarsh expected to be impacted. The combined disturbance and removal of areas of these habitats will result in a carbon cost, which has been approximated below in Table 5-144, based on the following calculation:

$$\text{Total Carbon} = \text{CPH} \times \text{A} \quad (153)$$

(where CPH = carbon per hectare and A = area. The calculations have been made with the assumption that trench/excavation depth will be to 1m only). The calculations also assume a carbon load of circa 100t/ha based on the load of microbial mats and sabkha.

Please note that the areas presented below for the Project footprint are in line **Section 4.3.2.2.2**, however this excludes the construction laydown areas as no excavations are expected within the laydown areas and as such, any amounts of carbon released and/or disturbed within these areas are expected to be **negligible**.

Table 5-144: Estimated blue carbon cost calculation

Blue Carbon Habitats	Loss of Blue Carbon Habitats resulting of the Project			Carbon/ha (in tons) per Type of Habitat	Total Carbon Footprint*
	Within Shuweihat (ha)	Within Mirfa (ha)	Total (ha)		
1010 – Mudflats and Sand Exposed at Low Tide	8.23	2.2	10.43	*100*	1,043
1030 – Saltmarsh	1.2		1.2	*100*	120
1040 – Mangroves	0.2		0.2	*220*	44
3100 – Coastal Sabkha	16.9	1.2	18.1	*80*	1,448
Total (Tons of Carbon) =					**2,655**

On the basis of the calculations provided above, the carbon cost of this project resulting from the disturbance of blue carbon storage is estimated to be approximately 2,655 tons of carbon. Considering the importance of blue carbon in conjunction with the urgent climate crisis, it can be considered that this represents an impact magnitude of *low* severity (due to the relatively low tonnage) upon a receptor of *high* sensitivity, thereby resulting in an overall impact of **moderate negative** significance.

5.11.2.3. Operation Phase Impacts

Impacts of climate change upon a coastal infrastructure Project such as this may include direct impacts upon plant structures caused by flooding or sea level rise. It is understood that the Project will originally be operational for a minimum of 35 years. Over this timeframe it is inevitable that climate change variations will have resulted in sea levels changes and potentially have altered the local environment at the Project site areas. Left unmitigated within the Project design, it is considered that the climate change impact magnitude would be of *moderate* severity, upon a receptor of *high* sensitivity, thereby rendering an overall impact of **moderate negative** significance.

The predicted temperature increase of 2.5°C within Abu Dhabi by 2050 represents the potential for operational and/or maintenance issues in relation to plant equipment. It understood that the Project design will be based on a maximum operational temperature and humidity of 55°C and 37.6% with 100% max, respectively and it is therefore considered that the design has sufficiently factored in for the expected temperature rise between now and 2050. Therefore, the impact magnitude of increasing ambient temperature and extreme temperature events upon the Project infrastructure is considered to be of *low* severity upon a receptor of *low-medium* sensitivity, therefore resulting in an overall impact of **minor negative** significance.

It is expected that the installation and operation of the Project will result in a reduction of 30% of existing emission levels by negating the requirement for the use of GTGs for power sources for offshore activities. The replacement of the GTGs with electricity generated from a range of more sustainable and renewable sources will result in a net **major positive** impact in terms of reducing greenhouse gas emissions and pollutants.

5.11.2.4. Cumulative Impacts

5.11.2.4.1. Construction Phase

Type 1 cumulative impacts are not expected.

Type 2 cumulative impacts may occur since two known projects are likely to be under construction concurrently (at least for a certain period) within the vicinity of both Mirfa (Project Wave) and Shuweihat (Mugharraq Port). Therefore, any additional removal of blue carbon habitats will increase the total carbon cost relating to development within the area.

5.11.2.4.2. Operation Phase

No significant cumulative impacts are predicted during the operational phase.

5.11.3. Mitigation Measures

5.11.3.1. Potential Mitigation Measures

A range of mitigation measures will be required to mitigate climate change impacts. The potential mitigation measures are set out within Table 5-145 below.

Table 5-145: Climate change impacts and mitigation measures

No.	Description of the Impact	Source of Impact	Location of Impact	Impact Significance Prior Mitigation Measures	Potential Mitigation Measures	Applicable Environmental Standards	Maximum Allowable Limits	Can impact be mitigated?
CONSTRUCTION PHASE								
1	Loss of blue carbon reserves	Removal of habitats capable of carbon sequestration and storage e.g. mangroves	Project site	Moderate negative	– Planting of mangroves.	Not applicable	Not applicable	Yes
OPERATION PHASE								
2	Damage to plant structures	Flooding or sea level rise	Project site	Moderate negative	– Incorporation of appropriate Project design measures	Not applicable	Not applicable	Yes
3	Damage to plant structures	Extreme temperatures	Project site	Minor negative	– Incorporation of appropriate Project design measures	Not applicable	Not applicable	Yes
4	Reduction of existing emission levels	Removal of GTG's and utilisation of cleaner electricity sources	Project site and local airshed	Major positive	– No mitigation measure considered necessary.	Not applicable	Not applicable	Not applicable

5.11.3.2. Selected Mitigation Measures

5.11.3.2.1. Construction Phase

The loss of mangroves will need to be mitigated by the planting of mangroves in a suitable area. It is suggested that a mangrove introduction and colonisation programme be developed, and not arbitrary introduction of mangroves in an area.

It can be considered, however, that the reduction in GHG emissions and subsequent reduction in carbon resulting from the decommissioning of the GTGs which will occur during the operational phase will serve to significantly mitigate the carbon released during construction.

5.11.3.2.2. Operation Phase

The Project design process must include an assessment of flooding and sea level rise. In addition, a Hazard and Operability Analysis will be required to assess the potential risks prior to construction. This will include an analysis of the location of electrical facilities in relation of potential flooding events. A Safety Integrity Level study will also be required to prove the safety and integrity of the plant design. The results of all safety related analyses will be submitted to the relevant authorities.

5.11.3.3. Residual Impacts

The predicted residual impacts following the implementation of mitigation measures as part of the construction and operation phase in relation to archaeology and cultural heritage are identified in Table 5-146 below

Table 5-146: Climate change residual impacts

Description of the Impacts	Impact Significance Prior to Mitigation Measures	Residual Impact Significance
Construction Phase		
Loss of blue carbon reserves	Moderate negative	Minor negative
Operation Phase		
Damage to plant structures	Moderate negative	Minor negative
Reduction of existing emission levels	Major positive	Major positive

5.11.4. Monitoring Program

5.11.4.1. Monitoring Program for Compliance with Selected Mitigation Measures

It is considered that the Project would not require any specific monitoring measures in regard to climate changes. It should however be noted that monitoring measures regarding habitat repropagation is detailed in **Section 5.6.4**.

5.11.4.2. Monitoring Program for Cumulative Impacts

It is considered that the Project would not require any specific monitoring measures relating to cumulative impacts with the implementation of the appropriate mitigation measures specified within the CESMP.

5.11.4.3. Monitoring Program for Residual Impacts

It is considered that the Project would not require any specific monitoring measures relating to residual impacts with the implementation of the appropriate mitigation measures specified within the CESMP.

5.12. Impacts, Mitigation, and Monitoring Summary

5.12.1. Selected Impacts

5.12.1.1. Summary of Impacts

The key selected construction and operational impacts identified as part of this ESIA are identified in this section. The summary of the impacts, sources, mitigation measures, monitoring measures and responsible party are presented below in Table 5-147 for construction impacts and Table 5-148 for operational impacts.

Table 5-147: General summary of construction impacts

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
Air Quality				
Increased dust and PM_{10} levels affecting human health	Vehicle movements and construction activities	– The EPC contractor will produce a CESMP including the mitigation measures set out within this ESIA – The CESMP will set specific mitigation and monitoring measures to follow during the Project construction in order to reduce the sources of PM_{10} and dust – All site personnel will be fully trained to understand activities that generate dust and measures that should be undertaken to reduce dust emissions – A trained and responsible manager will be on site during working times to maintain a logbook and carry out daily site inspections – Inform sensitive receptors of the construction works and the programme of the works at the specific work site – Develop a complaints procedure for sensitive communities located principally in Mirfa	– A daily monitoring program should be implemented for the construction phase, as follows: ▪ Daily visual inspection of dust should be conducted. The inspection will focus specifically on dust arising from construction activities or construction related transport activities. Stockpiles of loose material during trenching and earthwork activities should be covered and haul roads should be wetted down (under adverse weather conditions) ▪ Visual inspection for black smoke emissions and proper machine maintenance should be carried out by the approved construction contractor. Equipment emitting significant black smoke should be shut down and serviced immediately ▪ Monitoring of complaints from nearby residential properties – The onsite EPC Contractor manager/foreman will be responsible for carrying out daily visual inspections as per the inspection sheet which will be provided within the CESMP and utilised to record the details of any issues relating to air pollution – Where sensitive receptors are located within 350m of construction activities, a dedicated air quality monitoring program will be developed as part of the CESMP for ensuing that air quality at nearby receptors is acceptable	EPC CONTRACTOR
Health impacts upon construction workers	Dust generating construction activities			
Health impacts upon operational workers	Dust generating construction activities			
Detrimental effect upon terrestrial and intertidal habitats, flora and fauna	Dust generating construction activities			
Emissions of NOx, PM, SO_2, VOCs/HCs and CO affecting human health	Onshore construction plant and equipment	– The EPC contractor will produce a CESMP including the mitigation measures set out within this ESIA – The CESMP will set specific mitigation and monitoring measures to follow during the Project construction in order to reduce the air pollutants emissions from construction vehicles and plant – Ensure the CESMP mitigation and monitoring measures are implemented on-site – Adoption of best working practices to reduce the exhaust emissions – Use of low sulphur diesel on marine vessels – Ensuring the proper use and maintenance of construction equipment – Careful management of construction activities located within close proximity to existing residential receptors		
Emissions of NOx, PM, SO_2, VOCs/HCs and CO affecting human health (construction workers)	Marine vessels and cable laying equipment			
Marine Water				
Spill of hazardous material to the marine environment leading to localised contamination of marine water and sediments	Dredging	– Use non-polluting materials wherever possible (eg. biodegradable oils etc.) – Store hazardous materials at designated containers and appropriate areas on the vessel – Refuelling, oil change and greasing to be done with strict supervision from project engineers and specialists to avoid spills and contamination – Provide appropriate (110% volume) secondary containment system at chemical and fuel storage areas – Containerising and labelling waste – Spill Response Plan to be developed – Appropriate spill kits and spill clean-up material on on-site at all time including on marine vessels and always in the vicinity of chemical, fuel, waste storage areas, maintenance areas, fuelling areas etc. – Correct material refilling and usage techniques	– *In-situ* water sampling will be undertaken as follows: ▪ Daily at seven locations (three locations 50 m, 100, and 300 m away from the sources of the plume in both upstream and downstream corridor and testing will be conducted 500m away from the plume sources taken as reference data – Continuous *in-situ* water sampling will be undertaken as follows: ▪ Continuous monitoring buoys to be deployed at three locations (two on either side of the route and one at reference point) in sensitive habitats within 500m of dredging activities (both Route 1 and Route 2). Buoys will continuously monitor TSS, temperature and salinity. The buoys will include full telemetry set-up with exposure thresholds set to trigger alarms. Minor threshold exceedances will require a slowing of works or for the environmental team to check the status of the implemented mitigation measures (e.g. silt curtains). In the event that moderate or high threshold	EPC CONTRACTOR
Generation of sediments and increased turbidity from activities related to the dredging of the channel resulting in effects to localised water quality		– Minimisation of duration and extent by design – Selection of construction methods / equipment to minimise impacts to marine habitats – Installation of Type IV silt curtain between source of plume and critical habitat receptors. Silt curtains should be deployed to protect sensitive receptor in the area		

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
Reduction in water quality due to re-mobilisation of contaminated marine sediment.		– Minimisation of duration and extent by design – A Dredging Management Plan (DMP) shall be developed as part of the CESMP	criteria are exceeded, all works should be ceased immediately – *Ex-situ* water analysis during construction: four water samples will be taken at midwater level, 50 meters at four points around the vessel or marine works machine on a monthly basis for the duration of the construction work – *Ex-situ* water and sediment sampling and analysis will be undertaken pre and post trenching with interval of 500 meters at floatation dredged channels and every five kilometres along the cable route outside of the floatation channels	
Contamination due to run-off from dredging equipment and vessel washing.	Maintenance of vessels and equipment	– Wastewater collected in sump to be treated as liquid waste and disposed of appropriately – Marine vessels to be washed off-site within appropriate port facilities – Repairs to vessels only on designated mooring and port areas		
Pollution contamination of marine water and sediment from bilge water.	Sanitary or Bilge / Ballast Water Discharges from Marine Vessels	– Strictly no bilge water discharge policy for all vessels assigned to the Project – In cases of accidental bilge and discharge containment measures should be adopted as required and stipulated in the Contractor EMP applicable for construction – It is understood that all sanitary wastes generated onboard Project related vessels will be collected within adequate holding tanks and discharged in accordance with MARPOL regulations – Environmental Management induction shall be conducted to all personnel engaged in the Project with particular emphasis on pollution prevention – Vessel and all its equipment shall undergo inspection to be conducted prior to mobilization for work at Project site		
Temperature impact and potential contamination of seawater from cooling water discharges of dredging equipment.	Pumping cooling water through the moving parts of the dredger.	– Minimisation of duration and extent by design – Selection of construction methods / equipment to minimise impacts to marine habitats		
Waste Management				
Offsite hazardous and non-hazardous waste disposal and landfill capacity	Waste streams generated by construction activities	– EPC Contractor(s) to develop a SWMP within the CESMP, which will facilitate the prevention and management of waste at all stages of the construction resulting from the Project. The SWMP will include: ▪ Excavation Waste Control ▪ Hazardous Waste Control ▪ Storage of Construction Waste Control ▪ Movement of Construction Waste Control – The CESMP will also include projected volumes of C&D waste, key performance indicators (KPIs) for recycling and the identification of recycling facilities to be used.	– In order to enforce and understand the effectiveness of the selected mitigation measures, the SWMP to be developed by the EPC contractor will include the following monitoring and auditing procedures: ▪ Records of raw material wastage ▪ Quantitative records for the generation of each waste stream ▪ Methods by which the waste streams are being handled and stored ▪ Quantifying the wastes diverted from landfill, with records for each treatment method ▪ Monthly collation of waste consignment data from all sub-contractors and receipt at waste treatment/disposal facilities ▪ Review of all waste permits ▪ Records of any waste complaints or incidents; and ▪ Review of effectiveness of SWMP procedures and update as necessary	EPC CONTRACTORS
Wastewater generation				
Generation of excavation waste				
Generation of dredged materials				
Contamination of soil and groundwater due to improper management of hazardous materials	Improper storage and handling of waste materials, including wastewater streams both onshore and offshore			
Detrimental impacts upon terrestrial and intertidal flora and fauna				
Detrimental impacts upon marine ecology and water quality				

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
Exposure of construction workers to harmful materials/fire hazards				
Odour generation and reduction in landscape aesthetics				
Traffic congestion, air and noise impacts	Transportation of construction waste			
Geology, Seismicity, Soil and Groundwater				
Soil Erosion	Land clearance	– Implementation of an Erosion Control Plan as part of a CESMP	– Regular monitoring to be included within and implementation as part of the CESMP – Dewatering: ▪ The EPC Contractor will be responsible for the ongoing monitoring of dewatering effluent discharges; ▪ Appropriate NOCs must be obtained prior to any dewatering effluent discharge into marine environment; ▪ Groundwater quality testing will be undertaking prior to commencing dewatering. – Hazardous materials ▪ Inspect containers to ensure they are all in good condition with no leaks or signs of corrosion; ▪ Take immediate action if any spills are seen; ▪ Make sure all containers are adequately and clearly labelled with all information required; ▪ Monitor activities on site (such as vehicle and machinery refuelling) which have the potential to result in spills and environmental health impacts; ▪ Check that spill prevention is actively being enforced on site; and ▪ Check that site personnel wear adequate PPE when working with chemicals and hazardous materials. – Record keeping: ▪ Material Safety Data Sheets (MSDS); ▪ Quantity in store; ▪ Quantity used per month; ▪ Responsibility Details; and ▪ Such information should be made available to Emergency crews in case of an emergency event or accident. – Transportation documents should be maintained to ensure a chain of custody for transportation of hazardous materials and ensuring that they were appropriately received at the disposal facility.	
Contamination of soil and groundwater via accidental leakages and spillages	Construction works, stockpiling of materials, use and storage of hazardous materials	– Implementation of the CESMP which promote best practice management measures on site in order to avoid and minimise spills, leaks etc. – Implementation of the CESMP which promote best practice management measures on site in order to avoid contact with contaminated materials such as: ▪ Environmental incident reports to be prepared for any spills on site ▪ Use non-polluting materials wherever possible ▪ Store hazardous materials at designated containers and appropriate areas on the vessel; ▪ Provide appropriate (110% volume) secondary containment system at chemical and fuel storage areas ▪ Containerising and labelling waste ▪ Spill Response Plan to be developed for inclusion within EMP for construction ▪ Appropriate spill kits and spill clean-up material available on marine vessels, at chemical, fuel, and waste storage areas, and at re-fuelling and maintenance areas ▪ Correct material refilling and usage techniques ▪ Repairs to vessels only on designated mooring and port areas		
Mobilisation of existing contamination	Unidentified contamination within the soil and groundwater	– Implementation of the CESMP which will include measures such as the following, in the event of suspected contaminated soils and groundwater being identified on site: ▪ an excavated materials management plan. This will describe how uncontaminated and contaminated materials will be dealt with (excavated, temporarily stockpiled and stored and disposed) during construction ▪ hazardous soil and groundwater remediation measures will be implemented by the EPC Contractor to remove the suspected contaminated soil, aggregates and groundwater from site		
Contamination from dewatering and disposal of effluent	Dewatering and disposal of effluent.	– Implementation of the CESMP which promote best practice management measures in regard to dewatering; – If dewatering is required, a dewatering permit from EAD shall be obtained – Control measures shall be taken for testing effluent to ensure compliance with EAD ambient marine water quality standards prior to discharge to ensure no impact to the environment occurs. Where exceedances of the standards are recorded, appropriate treatment measures must be implemented prior to discharge		
Generation of sanitary effluents	Temporary sanitary facilities at construction sites and	– Implementation of the CESMP to ensure that sanitary facilities on site e.g. chemical toilets are regularly emptied, cleaned and maintained and that appropriately licenced wastewater tankers are employed to remove the effluent.		

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
Marine Ecology				
Direct loss of seagrass due to dredging activities Direct loss of corals due to dredging activities Direct loss of medium-valued habitats due to dredging activities Direct loss of low-valued habitats due to dredging activities	General activities associated with trenching and backfilling associated with the cable installation.	– Avoid use of the South Disposal Area – Enable further optimisation of the dredge channel design and the construction methodology where possible to reduce the amount of required dredging wherever possible – A Dredging Management Plan (DMP) will be required to be developed as part of the CESMP – The Project Company will appoint a qualified marine biologist to develop a Biodiversity Action Plan (BAP), which will be developed to achieve a net biodiversity gain. The BAP will include the following as a minimum: ▪ Proposed methods to relocate healthy corals from the dredged corridors to adjacent areas suitable to act as receptor sites; ▪ Proposed methods to reinstate the dredged corridor to enable the recolonisation of seagrass beds; ▪ Allow natural seagrass seeding to occur post construction; ▪ Proposed methods for extended monitoring of the natural re-establishment of seagrass beds, with potential trigger values for further targeted interventions if re-establishment is less successful than anticipated; ▪ Additional actions to provide a net biodiversity gain, such as the placement of reef forming structures within the Project site; ▪ Additional actions to provide a net biodiversity gain, where appropriate; ▪ A long-term management plan; and ▪ A long-term biodiversity monitoring and evaluation program.	– On a daily basis, an MMRO personnel should be on board – On a weekly basis, the following should be undertaken: ▪ DDV / ROV inspection of seagrass and coral habitat near trenching activities to ensure siltation is contained at eight locations (four on each side of the trench) ▪ Deployment of continuous monitoring buoy at strategic locations along critical habitat areas; ▪ Weekly census (DDV / ROV) conducted to ascertain fish species composition ▪ MMRO personnel on board for daily observations of marine mammal and reptile sightings	EPC CONTRACTOR
Indirect loss of localised marine habitat, e.g., seagrasses within Route 1, and individual organisms Indirect loss of localised marine habitat e.g., seagrasses within Route 2, and individual organisms Indirect loss of localised marine habitat, e.g., coral reefs, and individual organisms		– A Dredging Management Plan (DMP) will be required to be developed as part of the CESMP – Prior to construction, the Marine Works Contractor will be required to obtain additional permits for undertaking marine construction works; – No activities shall take place outside of the pre-defined construction corridor; – The type of equipment should be selected carefully to minimise the impact on the surrounding environment; – The Marine Works Contractor's working practices should incorporate the following measures: ▪ Prior to the start of any works in the marine environment, the Marine Works Contractor should install silt screens to minimise the dispersion of marine sediments (see further details below); ▪ Best available techniques to reduce sedimentation and minimise water turbidity should be employed (based on a technical and environmental evaluation); ▪ Consideration of natural variations within the coastal environment, including tidal and other sea level patterns, and the possibility of synchronising the activity with these changes to minimise environmental impacts; and ▪ Monitoring of turbidity by continuous monitoring buoys and multiparameter probe outside of silt curtains and at sensitive locations with dredging to cease if threshold values are exceeded.		
Displacement of marine fauna due to noise pollution..	Generation of noise associated with trenching and backfilling associated with the cable installation	– Slow start up of construction activities; – Selection of equipment and vessels with lower noise and vibration emission where feasible and available; – Limit marine vessel operations to dedicated navigation corridors, when possible – Reduce marine vessel trip frequency – Reduce marine vessel speed within sensitive areas – Deployment of MMRO personnel on marine vessels – Application of JNCC protocols during encounters with marine mammals and turtles – When possible, limit marine vessel trips to daylight hours		

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
		– If the marine construction team identify marine mammals or retiles during noise and vibration generating activities, works should be temporarily suspended until the animal has moved away		
Death or injury of marine mammals and reptiles.	Incidental collision of marine mammals and reptiles due to general activities associated trenching and backfilling associated with the cable installation	– Assuming adherence to mitigation relating to a dedicated on-board Marine Mammal and Reptile Observer (MMRO) and application of JNCC protocols during encounters with marine mammals and turtles, no work restriction period will be required – For Route 1 where the route is located within the MMBR boundary and transition zone as well as works associated with the floatation / dredged channel, it is recommended that the EPC construction programme consider limiting and reducing, where feasible, works during the following periods: ▪ Dugong birthing / calving periods of pre-winter and post winter (October to November and March to April); and ▪ Heightened spawning season of important fish species (March to July (as per Marine Environment Research Centre of MoCCAE)). – Beach Restrictions/Limitations (Turtle Nesting): ▪ Option 1: Construction work does not occur at the landfall areas during the turtle nesting season (April to June); ▪ Option 2: A hatching and nesting survey is undertaken during the turtle nesting season (April to June 2023) to confirm the absence of turtle nesting in the landfall areas.		
Contamination of the surrounding marine environment	Spill of hazardous material to the marine environment due to marine-based activities associated with trenching and cable laying	– Use non-pollution materials wherever possible (e.g. biodegradable oils etc.) – Store hazardous materials at designated containers and appropriate areas on the vessel – Refuelling, oil change and greasing to be done with strict supervision from project engineers and specialist top avoid spills and water contamination – Provide appropriate (110% volume) secondary containment system at chemical and fuel storage areas – Containerising and labelling waste – Spill Response Plan – Appropriate spill kits and spill clean-up material on on-site at all time including on marine vessels and always in the vicinity of chemical, fuel, waste storage areas, maintenance areas, fuelling areas etc. – Correct material refilling and usage techniques – Repairs to vessels only on designated mooring and port areas – Wastewater collected in sump to be treated as liquid waste and disposed of appropriately – Marine vessels to be washed off-site within appropriate port facilities – Strictly no bilge water discharge policy for all vessels assigned to the Project – Environmental management induction shall be conducted to all personnel engaged in the Project with particular emphasis on pollution prevention – Vessel and all its equipment shall undergo inspection to be conducted prior to mobilisation for work at Project site		
Terrestrial Ecology				
Vegetation clearing	Vegetation clearing and trenching in intertidal and terrestrial habitats	– The loss of mangroves will need to be mitigated by the planting of mangroves in a suitable area. It is suggested that a mangrove introduction and colonisation programme be developed as part of a standalone Mangrove Planting Management Plan (MPMP) to be submitted to the EAD for approval prior to the commencement of construction. This document will require separate approval from the ESIA or CESMP	During the construction phase, a qualified environmental officer should be on site at all times to monitor and record impacts. An environmental incident log will be kept in order to keep a record of these impacts.	PROJECT COMPANY

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
		– **Option 1 (Preferred Option): Construction works to commence outside bird breeding season (August to March):** ▪ Vegetation located within the coastal zones identified in Figure 5-210 and Figure 5-211 below should be removed (subject to the necessary Authority permits being in place) and these areas will be considered to be cleared for the remainder of the construction phase and no further consideration with respect to breeding birds is required ▪ A qualified environmental officer should be on site at all times in order to oversee ground-clearing operations; – **Option 2: Construction works commence during bird breeding season (April to July):** ▪ Pre-construction surveys should be undertaken in the coastal zones identified in Figure 5-210 and Figure 5-211 below in order to remove any less-mobile species from the area before vegetation clearing begins and make sure that no species of conservation importance are present and to ensure no bird breeding is occurring in the area ▪ Areas of vegetation where active nests are not present can be cleared immediately after the surveys (subject to the necessary Authority permits being in place) and these areas are now considered to be clear for the remainder of the construction phase and no further restrictions would apply ▪ If any active nests are present, these cannot be disturbed and these areas must be protected, with a 300m stand-off until such time as the nest is no longer active. Once surveys by a qualified ecologist have confirmed that the nests are no longer active, these trees can also be cleared (subject to the necessary Authority permits being in place) and these areas will be considered to be clear for the remainder of the construction phase and no further restrictions would apply ▪ A qualified environmental officer should be on site at all times in order to oversee ground-clearing operations	Implementation of appropriate monitoring measures as required by EAD as part of a Mangrove Planting and Management Plan	EPC CONTRACTOR
Vibration and noise disturbance	General construction activities	– Where possible noise should be limited and any severely excessive noise should be mitigated		
Chemical pollution		– Any chemicals stored on site need to be correctly stored and bunded – A best practice spill response plan be followed during the construction phase of the project, members of staff should be trained to correctly deal with possible chemical spills and spill kits should be available in all areas on site.		
Dust deposition		– Dust suppression measures should be implemented to avoid increased levels of dust deposition on plants adjacent, resulting in decreased growth and fecundity		
Impediment to local migrations	Installation of linear infrastructure perpendicular to the coastline	– Measures to prevent animals becoming trapped in trenches should be implemented where possible		
Noise				
Increased atmospheric noise impacts upon existing operational workers	Construction activities	– Noise from construction activities can be controlled through Health, Safety and Environmental (HSE) Management Plans, such as a CESMP which will include the mitigation measures set out within this ESIA – The CESMP will include a construction noise control plan, which shall be approved and implemented prior to commencement of any construction activity – The CESMP will set specific mitigation and monitoring measures to follow during the Project construction in order to reduce the noise emissions from construction vehicles and plant – Ensure the CESMP mitigation and monitoring measures are implemented on-site – Adoption of best working practices to reduce the exhaust emissions – Ensure the proper use and maintenance of construction equipment	– Noise monitoring should be carried out at the nearest sensitive receptors during critical periods of construction in order to identify non-compliance and the need for additional noise control measures.	EPC CONTRACTOR
Health impacts upon construction workers within the Project site	Construction activities			
Disturbance to residential receptors	Construction activities			

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
		– Careful management of construction activities located within close proximity to existing residential receptors – Orientating noisy equipment such as generators away from noise sensitive receptors – Community grievance mechanism and active information dissemination regarding the construction schedule and noisy activities – The on-site construction supervisor shall have the responsibility and authority to receive and resolve noise complaints. A clear appeal process shall be established prior to construction commencement that will allow for resolution of noise problems that cannot be immediately solved by the site supervisor		
Traffic				
Increase of traffic from construction traffic	Construction activities	– Implementation of a Traffic Management Plan as part of the Project CESMP	– Not applicable	EPC CONTRACTOR
Socio-economic				
Disruption to the local economy and population	Construction dust	– The EPC contractor will produce a CESMP including the mitigation measures set out within this ESIA. The CESMP will set specific mitigation and monitoring measures to follow during the Project construction in order to reduce the sources of PM_{10} and dust – All site personnel will be fully trained to understand activities that generate dust and measures that should be undertaken to reduce dust emissions – A trained and responsible manager will be on site during working times to maintain a logbook and carry out daily site inspections – Inform sensitive receptors of the construction works and the programme of the works at the specific work site – Develop a complaints procedure for the sensitive receptors	– The EPC Contractor will be responsible for ongoing monitoring, as follows ▪ A grievance procedure needs to be established for construction workers and local residents to ensure that any issues are resolved to the satisfaction of all parties. This will include the following: ❖ Clear contact numbers for key construction management staff who can be contacted in the case of complaints, which could be posted on signage near to the site access gates or in leaflets distributed to the local community ❖ A clear grievance procedure which involves studying the basis of complaints, identifying corrective actions and communicating the response to the complainant ▪ Specific monitoring requirements proposed in relation to noise and air quality to ensure that the key nuisance impacts are controlled ▪ A Site Accident Register summarising any injuries or near misses should also be maintained, providing a log of all incidents which occur during a one-month period ▪ An ongoing record of all training and induction activities undertaken on site will be maintained. Training provisions for each member of staff should be noted, including nature of course, date training was undertaken and an authorisation signature	EPC CONTRACTOR
	Emissions from construction equipment and vehicles	– The EPC contractor will produce a CESMP including the mitigation measures set out within this ESIA; – The CESMP will set specific mitigation and monitoring measures to follow during the Project construction in order to reduce the air pollutants emissions from construction vehicles and plant; – Ensure the CESMP mitigation and monitoring measures are implemented on-site; – Adoption of best working practices to reduce the exhaust emissions; – Ensuring the proper use and maintenance of construction equipment; and – Careful management of construction activities located within close proximity to existing residential receptors.		
	Disturbance from construction noise	– Noise from construction activities can be controlled through Health, Safety and Environmental (HSE) Management Plans, such as a CESMP which will include the mitigation measures set out within this ESIA; – The CESMP will include a construction noise control plan, which shall be approved and implemented prior to commencement of any construction activity; – The CESMP will set specific mitigation and monitoring measures to follow during the Project construction in order to reduce the noise emissions from construction vehicles and plant.		

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
	Disturbance to local traffic network	– The main contractor will be required to provide a comprehensive Traffic Management Plan within the CESMP to control traffic impacts. Measures will include but are not limited to: ▪ Timing restrictions to limit night-time traffic movements, where possible ▪ Careful routing to avoid Mirfa and Ruwais settlements where possible to minimise impacts on the most sensitive receptors e.g. by bypassing residential areas and schools ▪ Where possible, construction traffic shall be scheduled in off-peak traffic times and on well-maintained routes ▪ Appropriate traffic safety signage will be provided to warn the public of construction traffic where traffic merges with normal road traffic ▪ Where appropriate, locally sourced materials shall be utilised within the construction phase to minimise driving distances, and workers shall be transported to Project site by bus to minimise external traffic ▪ All construction drivers shall be appropriately licensed and trained in road and traffic safety ▪ Trip durations shall be capped to prevent excessive driving times and driver exhaustion ▪ Appropriate warning signs and flag operators shall be used to warn the public of any adverse driving conditions as a result of construction traffic ▪ Provision of temporary signage to ensure that construction vehicles adhere to the recommended routes and diversions		
	Disturbance to Lansh and Tarad boat fishermen	– A maritime traffic management plan should be prepared and implemented by the EPC Contractor to ensure that disruption to local marine traffic is minimised – Ensure best practice construction methodology employed to minimise sediment plumes etc.		
	Disturbance to local Hadrah fishing activities	– The EPC shall consult with EAD prior the start of the Project construction and removal of the hadrah located within the Project footprint		
	Disturbance to proposed EAD Dalma Sea Cage Aquaculture Project due to cable laying activities near Dalma Island	– Ensure best practice construction methodology employed to minimise sediment plumes etc.		
	Impacts upon local maritime traffic	– A range of mitigation measures will be implemented within a Maritime Traffic Management Plan, including but not limited to: ▪ A notice to mariners (NTM) will be issued prior to the commencement of construction activities to inform all vessels within the area of the exclusion zones ▪ Provision of a VHF radio to all Project vessels ▪ Establishment of a clear emergency response plan ▪ Establishment of a Communication Plan which should be shared with all local ports and appropriate authorities to enable liaison throughout construction and to provide a method for grievances to be received from authorities and local mariners		
	Infrastructure and equipment design and safety	– Ensure that all components are designed and constructed in full accordance with best International practices, codes and standards.		

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
	Hazardous materials management and safety	– Ensure that all hazardous materials transported to the Project site are packaged and appropriately managed to prevent accidents and/or spillages on the local road network.		
Health and safety	Exposure to heat, fire, chemicals, accidents and other occupational hazards	– The development of a Health and Safety and Environmental Policy, in line with the requirements set out within ADNOC CoPs and HSE documentation (listed in full in **Appendix 7.2**), will provide detailed health and safety guidelines for staff, personnel and sub-contractors, including personal safety, site conduct, security, site safety zoning and emergency procedures		
	Working conditions, wages, accommodation and general employment conditions	– The development of a Health and Safety and Environmental Policy, in line with the requirements set out within ADNOC CoPs and HSE documentation (listed in full in **Appendix 7.2**), will provide detailed health and safety guidelines for staff, personnel and sub-contractors, including personal safety, site conduct, security, site safety zoning and emergency procedures; and ensure the proper implementation of a labour accommodation plan to ensure that bedding, safety provisions, cleanliness and well-being are ensured e.g. regular cleaning of bed sheets and regular inspections by EPC Contractor		
Enhancement of local economy	Job generation and increase in local revenue generation for local businesses	– No mitigation measures required since this is a positive impact		
Reduction in landscape quality and visual amenity	Construction activities, hoarding, stockpiles etc.	– Strategic installation of hoarding of an appropriate height within areas along the Project site within close proximity to residential areas and roads in order to shield the view of construction activities from the identified sensitive receptors – Establishment of a grievance mechanism for local and nearby residents – Ensure good housekeeping throughout the construction site and storage areas to minimise unsightly visual impacts – Identify dedicated construction traffic routes, including use of appropriate signage to ensure that construction vehicles are routed away from residential areas where feasible		
Cultural Heritage & Archaeology				
Disturbance of identified archaeological artefacts and structures Potential damage of unknown buried archaeological features caused by earthworks	Excavation works	– No known archaeological artefacts are present within the Project site and therefore no impacts are considered in this regard, and therefore no mitigation is specifically required – The EPC Contractor will include mitigation measures to prevent potential impacts upon archaeological and cultural heritage artefacts and structures present within the Project sites – The EPC Contractor will review all information provided within the CESMP which will include feedback from DCT following consultation by the Project Owner with DCT – Construction managers should be made aware that the potential exists for unidentified artefacts to be present and if any potential above ground find is noted, works should be suspended in that area and DCT informed – Toolbox talks concerning the potential for archaeological finds during earthworks, which will be provided to all construction workers involved in site works such as grading, excavations etc.	– The EPC Contractor will be responsible for the implementation of an archaeological watching brief during ground clearance and earthworks. This watching brief is required generally during site preparation works, or where grading or excavation is expected. Once these ground clearing and earthworks are complete, the watching brief is not considered necessary.	EPC CONTRACTOR

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
Climate Change				
Loss of blue carbon reserves	Removal of habitats capable of carbon sequestration and storage e.g. mangroves	– Mudflats and saltmarshes should be restored after the cables have been laid and covered, a restoration plan should be compiled prior to construction detailing how this will be achieved – The loss of mangroves will need to be mitigated by the planting of mangroves in a suitable area. It is suggested that a mangrove introduction and colonisation programme be developed, and not arbitrary introduction of mangroves in an area	– The compensation for the residual loss of habitats and associated species are as follows: ▪ Repropagation of mangrove trees lost due to the development ▪ Restoration of the mudflats and saltmarshes that may be impacted – The repropagation plan as well as the restoration plan should include monitoring of the repropagation and restoration measures in order to determine the effectiveness of these compensation measures. Success of these compensation measures should be conducted as follows: ▪ A monitoring plan for each of these habitats needs to be developed in order to determine the success of these compensation measures. These monitoring programs should include: ❖ Fixed point photography of each of these habitats in order to show succession of these habitats ❖ Biannual fauna and flora surveys of these habitats in order to determine the colonisation of these habitats by fauna and flora species	EPC CONTRACTOR / OPERATOR

Table 5-148: General summary of operational impacts

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
Air Quality				
Emissions to air from power generation	Use of onshore electricity, which includes renewables and nuclear instead of less efficient GTGs at ADNOC offshore facilities	– The Project will have a positive impact through a reduction of emissions of pollutants by replacing older generating units at ADNOC Offshore facilities with more electricity generated from more efficient conventional power generating facilities, nuclear and renewables within Abu Dhabi. Therefore additional mitigation measures for these aspects will not be required	– No monitoring required	OPERATOR
Emissions to air from emergency generators	Emergency generators at each of the four converter stations	– The following mitigation measures will be implemented with respect to the emergency generators at the converter stations: ▪ Selection of best technology with minimum emissions ▪ Selected equipment will be compliant with emissions standards set out within Cabinet Decree No 12 of 2006 ▪ Use of low sulphur diesel ▪ Appropriate maintenance and testing, in accordance with manufacturers specifications to ensure efficient operation	– No significant impacts have been identified and therefore no ongoing operational monitoring is considered to be necessary, particularly since the diesel generators will be used in emergency situations only	
Reduction in GHG emissions	Use of onshore electricity, which includes renewables and nuclear instead of less efficient GTGs at ADNOC offshore facilities, which will lower carbon intensity of ADNOC Offshore's operations	– The replacement of the GTGs with electricity generated from a range of more sustainable and renewable sources will result in a net positive impact in terms of reducing greenhouse gas emissions and pollutants and therefore no mitigation measures are required	– No monitoring required	
Marine Water				
No impacts predicted	Not applicable	Not applicable	Twice a year (seasonally), ex-situ water and sediment analysis to be completed at monitoring locations previously identified during construction (along the trench line)	OPERATOR
Waste Management				
Generation of wastewater	Sanitary effluents from service buildings and wastewater from operational maintenance activities	– Wastewater will be collected, treated, equalised and discharged for the following wastewater streams: ▪ Sanitary wastewater will be collected within septic tanks at each Project site ▪ Industrial and process wastewater will be neutralised, flocculated, detoxified ▪ Sludge dewatering equipment ▪ Oily wastewater collected at common oil retention tanks at each Project site ▪ Stormwater collection and transfer facilities	– As part of the OESMP, a clear process should be set out for the monitoring and recording of all waste streams, including a schedule of monitoring and periodic audits to inform the OESMP process. This will need to be defined by the Operating Company	OPERATOR
Generation of general waste	Operational activities including office waste, municipal waste, maintenance activities.	– The Operator will be required to develop an OESMP, which will include sustainable waste management practices commensurate with the activities which will be undertaken as part of this major industrial development. This will include, but not be limited to the following general measures as a minimum:		

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
Generation of hazardous wastes	Operational maintenance activities e.g. cleaning and repairs.	▪ Ensuring compliance with national and international best practice guidance, including IFC and Equator Principles ▪ Encouraging opportunities to minimise waste, based upon the principle of the hierarchy of waste prevention and reduction through to reuse, recovery (energy and materials) and disposal via landfill as a final option ▪ Providing suitable waste facilities, including the segregation of waste streams for recycling and general waste for disposal to landfill ▪ Targets for the diversion of waste from landfill ▪ Ensuring good on-site storage practices, including appropriately covered waste storage areas and dedicated hazardous waste storage facilities ▪ Emergency spillage kit will be located at strategic locations and in proximity of the main storage areas ▪ Appointing dedicated personnel responsible for waste management issues ▪ The financial resources necessary to implement and operate a suitable waste management system shall be specified, as well as those people responsible for making those resources available ▪ Capacity building and training needs shall be identified to ensure that waste can be properly managed and controlled ▪ For waste streams which are unavoidable and unrecyclable, development of a waste management strategy for storage, collection and appropriate disposal operational waste streams ▪ The waste disposal routes will need to be clearly identified to ensure that potential impacts associated with the local and regional transport infrastructure are minimised as far as possible ▪ The methods of transportation ▪ Requirements for permits from the relevant authorities for storage, transport and treatment/disposal of wastes ▪ Allocation and development of waste storage areas, with necessary provisions for segregation of waste types and appropriate means of avoiding contamination ▪ The final destination of wastes for treatment or disposal ▪ Identification of which licensed waste management contractors will be used ▪ How the types and quantities of waste generated by the Project and the achievement of targets to avoid landfill will be measures and reported		
Contamination of the surrounding environment e.g. soil and groundwater	Improper storage and/or handling, and accidental spills/leakages			
Health and safety impacts upon operational workers	Flammable materials resulting in a fire event			
Odour impacts upon operational staff and nearby sensitive receptors	Improper storage and handling of sanitary wastes			
Transportation of operational waste resulting in disturbance to nearby sensitive receptors in terms of noise and air impacts	Movement of waste consignments leaving the Project sites			
Geology, Seismicity, Soil and Groundwater				
Contamination from hazardous materials & waste	Operational activities and storage	– The key measures for preventing contamination during the operational phase will be designed into the Project. This includes appropriate designs in relation to the following: ▪ Appropriate containment systems around storage tanks (e.g. fuels, oils etc.) ▪ Leak detection facilities ▪ Fire prevention measures ▪ Appropriate storm water management systems – Additional measures will include but not be limited to: – Storage, handling and disposal of fuels, oils, lubricants and other potentially harmful chemicals (and their containers) will be undertaken under proper supervision in accordance with manufacturer's instructions – Hazardous chemicals and materials stored at the site should be appropriately stored in secure, bunded compounds and located on an impervious surface. The storage areas will need to be clearly labelled and have MSDS maintained and available	*No monitoring program is required as part of the Project operation.*	**OPERATOR**

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
		– Details and properties for each material should be clearly detailed which include its hazard (poisonous, corrosive, flammable), prohibitions on its disposal (dumpster, drain, sewer) and the recommended disposal method (recycle, sewer, burn, storage, landfill) – Systems for acceptance of potentially hazardous goods		
Contamination from stormwater run-off	Stormwater run-off	– The following will be included within the Project design: ▪ Proof bunded cases for oil storage ▪ Caged area for hazardous waste ▪ Bunded areas for any equipment that imply the use of hazardous material ▪ Water / oil separator in the drainage system, etc. – The stormwater drainage system must also include: ▪ Provision of oil / water separators to remove oils and hydrocarbons ▪ Provision of settlement systems or sand traps to remove suspended solids ▪ Regular maintenance of oil / water sediments and sand traps associated with stormwater run-off outfalls will also be required		
Contamination from wastewater treatment facilities	Wastewater treatment facilities	– The Project Proponent will be responsible for the design of the water treatment systems and will therefore ensure that in case of emergencies, raw sewage overflow will not be released into the environment. Further details of the design will be provided in the OESMP		
Structural damage	Seismic activity	– Ensure buildings and roads are designed appropriately to avoid any structure damages from events such as earthquakes, in accordance with ADNOC standards		
Marine Ecology				
Provision of artificial substrate (rock protection and concrete mattresses)	Rock protection and concrete mattresses	– Not applicable.	– Not applicable	-
Impact on marine ecology due to changes in the localised hydrodynamic flow of the channel.	Trenching and backfilling	– Reduction of dredge footprint and depth – Design of channel to work with predominant flow patterns – Habitat compensation and improvement	– Twice a year for three years, the following should be undertaken: ▪ Video inspection of impacted areas to assess habitat succession rates (15 locations along Route 1 and 5 locations along Route 2 dredging area) ▪ MMRO survey to ascertain species and population composition – Annual census (DDV / ROV) conducted to ascertain species composition (15 locations along Route 1 and 5 along Route 2 dredging area)	OPERATOR
Potential impacts from Electromagnetic Field Emissions	Cable operation	– Not applicable.	– Not applicable	-

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
Terrestrial Ecology				
Disturbance to species	Operational activities	– Due to the fact that all the infrastructure should be buried during the construction phase, provided the mitigation measures for the construction phase are implemented, there should be no impacts that require mitigation during the operational phase of the project	– During operation, a monitoring plan will require to be implemented to determine the success of the compensation for the residual loss of the following: ▪ Repropagation of mangrove trees lost due to the development ▪ Restoration of the mudflats and saltmarshes that may be impacted – These monitoring programs should include: ▪ Fixed point photography of each of these habitats in order to show succession of these habitats ▪ Biannual fauna and flora surveys of these habitats in order to determine the colonization of these habitats by fauna and flora species ▪ The Mangrove Planting and Management Plan (MPMP) to be submitted to the EAD for approval prior to replanting mangroves for the area adjacent to Shuweihat in accordance with EAD requirements will provide measurable goals (based on the successional state and species diversity of the lost habitats) for development and implementation for each of the habitats compensated	OPERATOR
Noise				
Noise emissions disturbing operational workers and nearby sensitive receptors	Noise generated by converter stations and associated equipment	– Plant operations should always be carried out using equipment that is in good working order and that meets current best practice noise emission levels	– Noise monitoring should be undertaken during the initial commissioning and early operational stages of the Project in order to determine the operational noise emission levels and to aid the selection of additional noise controls where necessary – Additional noise controls such as portable screening would be employed if monitoring indicates the need or in response to concerns. Ongoing monitoring may be required in future if sensitive receptors are developed / established close to the facility – Developing a mechanism to record and respond to complaints	OPERATOR
Traffic				
Disturbance to local road network	Operational traffic	– It is considered that operational vehicles accessing the Project site areas are insignificant in terms of impacts upon other road users and the local traffic network, as are the number of operational personnel expected to be employed by the Project. Detailed assessment of operational impacts relating to traffic have therefore been scoped out of this ESIA and are not considered further	– *No monitoring program is required as part of the Project operation*	N/A

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
Socio-economic				
Air quality impacts upon human receptors	Gaseous emissions from O&M vehicles	– Of key importance will be the integration of all relevant ADNOC Codes of Practice (CoP), ADNOC HSE Management Systems (HSEMS) processes and ADNOC HSE practices on Health, Safety and Environment. This extensive set of documentation will require to be implemented by the ADNOC HSE Manager for each of the Project sites – To provide the employees with a safe and risk-free environment, it is recommended that a site specific HSE plan is developed and implemented within the wider Project sites OEMP – This framework, in line with Performance Standard 2 and will incorporate the requirements set out by ADNOC CoP documents, will address measures for accident prevention, identification, mitigation and management of hazards (including physical, chemical, and radiological hazards), training of workers and reporting of accidents and incidents.	– *No monitoring program is required as part of the Project operation*	**OPERATOR**
Noise emissions causing disturbance to nearby sensitive receptors	Plant operation and movement of operational traffic			
Increased job opportunities and increased revenue for local businesses	Requirement for workers to fill operational roles and increase in spending in local businesses			
Disruption to local traffic network	Movement of operational traffic	– No specific mitigation is considered necessary since impacts are predicted to be negligible.		
Infrastructure and equipment design and safety	Risks from faulty machinery, catastrophic events involving the plant machinery	– The Project will not comprise any high-risk elements and will be designed and constructed in full accordance with best international practices, codes and standards.		
Exposure to the local community of hazardous materials	Accidents and spillages associated with transportation within the local road network	– A health, safety and security control plan will be implemented to include the following: ▪ All facilities will be designed and constructed in full accordance with International practices, codes and standards ▪ Traffic safety will be maintained as part of a Traffic Control Plan ▪ Appropriate emergency preparedness and response procedures have been developed as part of a HSE Plan ▪ Security access to the Project site is maintained at all times using Abu Dhabi licensed companies and security guard		
Illness, incidents, or accidents occurring to operational workers	Occupational accidents, fire events, emergency incidents			
Reduction in visual amenity and alteration to the landscape character	Presence of the Project facilities	– The Project components will be constructed adjacent to the existing power and water complexes at Al Mirfa and Al Shuweihat and will therefore not result in any significant changes to the local landscape character – No mitigation measures is considered necessary	– *No monitoring program is required as part of the Project operation*	
Archaeology and Cultural Heritage				
NA	NA	– All detrimental impacts associated with archaeological and cultural heritage will be limited to the construction phase	– *No monitoring program is required as part of the Project operation*	**NA**

Environmental Impact	Source	Mitigation Measures	Monitoring Measures	Responsible Party
Climate Change				
Damage to plant structures	Flooding or sea level rise	– Incorporation of appropriate Project design measures	– *No monitoring program is required as part of the Project operation*	**NA**
Damage to plant structures	Extreme temperatures	– Incorporation of appropriate Project design measures	– *No monitoring program is required as part of the Project operation*	**NA**
Reduction of existing emission levels	Removal of GTG's and utilisation of cleaner electricity sources	– No mitigation required as impact is positive	– *No monitoring program is required as part of the Project operation*	**NA**

5.12.2. ESIA Matrix Summary

The ESIA matrices for the Project are provided in Table 5-150 and Table 5-151:, and have been developed to reflect the different components of the environmental impacts before and after the mitigation measures were applied. The scoring criteria from the ESIA matrices for the Project are specified in Table 5-149.

Table 5-149: Scoring criteria for the ESIA matrix

Impact Significance	Score	Criteria
Magnitude	1	Change / Effect only within the Project site
	2	Change / Effect to local conditions and/or areas immediately outside
	3	Regional / National / International change / Effect
Duration / Permanence	1	No change / Not applicable
	2	Temporary
	3	Permanent
Reversibility	1	No change / Not applicable
	2	Reversible
	3	Irreversible
Cumulative Impact	1	No change / Not Applicable
	2	Non-cumulative / Single
	3	Cumulative

Table 5-150: ESIA impact matrix prior mitigation measures

Environmental Impact		Source	Magnitude	Permanence	Reversibility	Cumulative
Construction Phase						
Air Quality	Vehicle emissions impacting receptors including construction workers, operational workers and nearby fauna and flora	Vehicle movements and construction activities, including onshore and offshore equipment (e.g. emissions from marine vessels)	2	2	2	1
	Dust and PM_{10} emissions impacting receptors including construction workers, operational workers and nearby fauna and flora	Dust generating construction activities	2	2	2	1
Marine Water	Spill of Hazardous Material to the Marine Environment	Dredging	2	2	2	3
	Generation of Sediments and Increased Turbidity from Activities Related to Trenching Resulting in Impacts to Localised Water Quality	Dredging	2	2	2	3
	Reduction in Water Quality due to Re-mobilisation of Contaminated Marine Sediment	Dredging	2	2	2	3
	Contamination due to Run-off from Vessel and Vessel Equipment Washing	Maintenance of vessels and equipment	2	2	2	3
	Pollution contamination of marine water and sediment from bilge water.	Sanitary or Bilge / Ballast Water Discharges from Marine Vessels	2	2	2	3
	Temperature Impact and Potential Contamination of Seawater from Cooling Water Discharges of Dredging Equipment	Pumping cooling water through the moving parts of the dredger.	2	2	2	3
Waste Management	Offsite waste disposal and landfill capacity	Result of construction activities	1	3	3	3
	Wastewater generation	Wastewater	2	2	2	3
	Improper management of hazardous materials	Result of construction activities	2	2	3	2
Geology, Seismicity, Soil and Groundwater	Soil Erosion	Land clearance	2	2	2	3
	Contamination of soil	Construction activities and generation of sanitary wastes	2	2	3	3
	Contamination of groundwater	Construction activities and generation of sanitary wastes	2	2	3	3
	Contamination from dewatering and disposal of effluent	Dewatering and disposal of effluent	2	2	2	2
Marine Ecology	Direct loss of high value habitats - corals	General activities associated with trenching and backfilling associated with the cable installation	2	3	3	3
	Direct loss of high value habitats - seagrass		2	2	2	3
	Direct loss of medium value habitats		2	2	2	3
	Direct loss of low value habitats		2	2	2	3
	Indirect loss of localised habitats within Route 1		2	2	2	3
	Indirect loss of localised habitats within Route 2		2	2	2	3
	Displacement of marine fauna due to noise pollution	Noise generating activities associated with trenching and backfilling	2	2	2	3
	Death or injury of marine mammals and reptiles	Incidental collision of marine mammals and reptiles with project related equipment/vessels	1	2	3	3
	Contamination of the surrounding marine environment	Spills of hazardous materials	2	2	2	3
Terrestrial Ecology	Vegetation clearing	Clearance and construction activities	2	3	3	3
	Vibration and noise disturbance	Construction activities	2	2	2	3

Environmental Impact		Source	Magnitude	Permanence	Reversibility	Cumulative
	Chemical pollution	Construction activities	2	2	2	3
	Dust deposition	Construction activities	2	2	2	3
Noise	Noise emissions on nearest receptors	Construction activities	2	2	2	3
Traffic	Congestion	Construction related vehicle activity	2	2	2	3
Socio-economic	Health and safety related impacts and disturbance to sensitive receptors	Emissions from construction equipment and vehicles	2	2	2	2
	Disturbance to nearby receptors from air and noise emissions	Construction related traffic using the local traffic network	2	2	2	3
	Disturbance to fishermen	Cable laying activities onshore and offshore	2	2	2	2
	Disturbance to local businesses including hadrah fishing and Dalma Sea Cage		2	2	2	3
	Impacts on marine traffic	Movement of construction vessels associated with the cable laying activities	3	2	2	3
Cultural Heritage & Archaeology	Potential damage of unknown buried archaeological features caused by earthworks	Earthworks and general construction activities	1	2	3	2
Climate Change	Loss of blue carbon reserves	Removal of habitats capable of carbon sequestration and storage e.g. mangroves and sabkha	3	3	3	3
Operation Phase						
Air Quality	Emissions to air from power generation	Use of onshore electricity	2	3	3	3
	Emissions to air from emergency generators	Emergency generators at each of the four converter stations	2	2	3	1
	Reduction in GHG emissions	Use of onshore electricity, which will lower carbon intensity of ADNOC Offshore’s operations	3	3	3	1
Marine Water	No operational impacts predicted	N/A	-	-	-	-
Waste Management	Overuse of landfill	Operation activities	2	2	2	2
	Contamination of soil and groundwater	Inappropriate storage or handling of wastes	2	2	2	2
	Odour	Operation activities	2	2	2	2
	Wastewater Generation	Wastewater generated including sanitary and oily wastewater	2	2	2	3
	Disruption to traffic network	Movement of waste collection vehicles	2	2	2	3
Geology, Seismicity, Soil and Groundwater	Contamination	Stormwater run-off	2	3	3	2
		Water and waste treatment	2	3	3	2
		Hazardous Materials & Waste	2	3	3	3
	Structural damage	Seismicity, etc.	3	3	3	2
Marine Ecology	Impact on Marine Ecology due to Changes in the Localised Hydrodynamic Flow of the Channel	Changes to habitat based on increased deposition rates	1	3	3	2
	Potential impacts from Electromagnetic Field Emissions	Effect on marine fauna behaviour from from EMF	-	-	-	-
Terrestrial Ecology	No operational impacts predicted	N/A	1	1	1	1
Noise	Noise emissions upon operational workers	Converter stations and associated equipment	2	3	3	3
	Noise emissions on nearest sensitive receptors due to emissions from traffic	Traffic	2	3	3	3
Traffic	No operational impacts predicted	N/A	-	-	-	-

Table 5-151: ESIA impact matrix following mitigation measures

Environmental Impact		Source	Magnitude	Permanence	Reversibility	Cumulative
Construction Phase						
Air Quality	Vehicle emissions impacting receptors including construction workers, operational workers and nearby fauna and flora	Vehicle movements and construction activities, including onshore and offshore equipment (e.g. emissions from marine vessels)	1	2	2	2
	Dust and PM_{10} emissions impacting receptors including construction workers, operational workers and nearby fauna and flora	Dust generating construction activities	1	2	2	2
Marine Water	Spill of Hazardous Material to the Marine Environment	Dredging	1	2	2	2
	Generation of Sediments and Increased Turbidity from Activities Related to Trenching Resulting in Impacts to Localised Water Quality	Dredging	1	2	2	2
	Reduction in Water Quality due to Re-mobilisation of Contaminated Marine Sediment	Dredging	1	2	2	3
	Contamination due to Run-off from Vessel and Vessel Equipment Washing	Maintenance of vessels and equipment	1	2	2	3
	Pollution contamination of marine water and sediment from bilge water.	Sanitary or Bilge / Ballast Water Discharges from Marine Vessels	1	2	2	3
	Temperature Impact and Potential Contamination of Seawater from Cooling Water Discharges of Dredging Equipment	Pumping cooling water through the moving parts of the dredger.	1	2	2	3
Waste Management	Offsite waste disposal and landfill capacity	Result of construction activities	1	2	2	2
	Wastewater generation	Wastewater	1	2	2	2
	Improper management of hazardous materials	Result of construction activities	1	2	2	2
Geology, Seismicity, Soil and Groundwater	Soil Erosion	Land clearance	1	2	2	2
	Contamination of soil	Construction activities and generation of sanitary wastes	1	2	2	2
	Contamination of groundwater	Construction activities and generation of sanitary wastes	1	2	2	2
	Contamination from dewatering and disposal of effluent	Dewatering and disposal of effluent	1	2	2	2
Marine Ecology	Direct loss of high value habitats - corals	General activities associated with trenching and backfilling associated with the cable installation	1	3	3	3
	Direct loss of high value habitats - seagrass		1	2	2	3
	Direct loss of medium value habitats		1	2	2	3
	Direct loss of low value habitats		1	2	2	3
	Indirect loss of localised habitats within Route 1		1	2	2	3
	Indirect loss of localised habitats within Route 2		1	2	2	3
	Displacement of marine fauna due to noise pollution	Noise generating activities associated with trenching and backfilling	1	2	2	3
	Death or injury of marine mammals and reptiles	Incidental collision of marine mammals and reptiles with project related equipment/vessels	1	3	3	3
	Contamination of the surrounding marine environment	Spills of hazardous materials	1	2	2	3
Terrestrial Ecology	Vegetation clearing	Clearance and construction activities	2	3	3	1
	Vibration and noise disturbance	Construction activities	1	2	2	1

	Environmental Impact	Source	Magnitude	Permanence	Reversibility	Cumulative
	Chemical pollution	Construction activities	1	2	2	2
	Dust deposition	Construction activities	1	2	2	2
Noise	Noise emissions	Construction activities	1	2	2	2
Traffic	Congestion	Construction related vehicle activity	1	2	2	1
Socio-economic	Health and safety related impacts and disturbance to sensitive receptors	Emissions from construction equipment and vehicles	1	2	2	1
	Disturbance to nearby receptors from air and noise emissions	Construction related traffic using local traffic network	1	2	2	1
	Disturbance to fishermen	Cable laying activities onshore and offshore	1	2	2	1
	Disturbance to local businesses including hadrah fishing and Dalma Sea Cage	Cable laying activities onshore and offshore	1	2	2	1
	Impacts on marine traffic	Movement of construction vessels associated with the cable laying activities	2	2	2	1
Cultural Heritage & Archaeology	Potential damage of unknown buried archaeological features caused by earthworks	Earthworks and general construction activities	1	2	2	2
Climate Change	Loss of blue carbon reserves	Removal of habitats capable of carbon sequestration and storage e.g. mangroves and sabkha	1	2	2	2
Operation Phase						
Air Quality	Emissions to air from power generation	Use of onshore electricity	1	2	2	2
	Emissions to air from emergency generators	Emergency generators at each of the four converter stations	1	2	2	1
	Reduction in GHG emissions	Use of onshore electricity, which will lower carbon intensity of ADNOC Offshore's operations	1	1	1	1
Marine Water	No operational impacts predicted	N/A	-	-	-	-
Waste Management	Overuse of landfill	Operation activities	2	2	2	2
	Contamination of soil and groundwater	Inappropriate storage or handling of wastes	1	2	2	2
	Odour	Operation activities	1	2	2	2
	Wastewater Generation	Wastewater generated including sanitary and oily wastewater	1	2	2	2
	Disruption to traffic network	Movement of waste collection vehicles	2	2	2	2
Geology, Seismicity, Soil and Groundwater	Contamination	Stormwater run-off	1	2	2	2
		Water and waste treatment	1	2	2	2
		Hazardous Materials & Waste	1	2	2	2
	Structural damage	Seismicity, etc.	2	2	2	1
Marine Ecology	Impact on marine ecology due to changes in the localised hydrodynamic flow of the channel	Changes to habitat based on increased deposition rates	1	3	3	2
	Potential impacts from electromagnetic field emissions	Effect on marine fauna behaviour from EMF	-	-	-	-
Terrestrial Ecology	No operational impacts predicted	N/A	1	1	1	1
Noise	Noise emissions upon operational workers	Converter stations and associated equipment	1	2	2	2
	Noise emissions on nearest sensitive receptors due to emissions from traffic	Traffic	1	2	2	2
Traffic	No operational impacts predicted	N/A	1	1	1	1

5.12.3. Residual Impacts

The EAD definition of a 'residual impact' is as follows: *A potential environmental impact that is associated ith the proposed project that is not addressed as part of the recommended mitigation measures (i.e., is not mitigated as part of the proposed project)*". As part of the development of this ESIA, all potential impacts have been addressed through the application of appropriate mitigation measures**.** Therefore, no significant 'residual impacts' remain.

However please note that the residual impact significance (following appropriate measures) are presented in each technical chapter in the Residual Impacts Section.

5.13. Risk Assessments

In accordance with EAD Technical Guidance for Environmental Impact Assessment (EIA) (167), the risk associated with impacts to the environment could occur as a result of the following:

- Failure of material or equipment;
- Procedures not being followed;
- Unforeseen non-routine process upsets; and
- Mishaps such as spills, leaks, fires, explosions etc.

This risk assessment has been undertaken in accordance with Abu Dhabi Occupational Safety and Health System Framework (OSHAD) (Version 3.0 July 2016) (168) which provides the following:

- Understanding the consequence (C) of hazard as presented in Table 5-152;
- Understanding the likelihood / probability (P) of the event as presented in Table 5-153; and
- Assigning a risk (R) rating as presented in Table 5-154.

In formulating a major incident plan, the task is to have a set of expertise available and to have developed a set of core processes to handle the uncertainty and unpredictability of whatever happens. Co-operation between local regulatory bodies is a necessity and must be addressed when formulating the plan.

The appointed contractor will be required to undertake an extensive risk assessment to identify all hazards and demonstrate implementation of appropriate mitigation measures throughout all stages of construction in line with OSHAD.

5.13.1.1. Methodology of the Risk Assessment

5.13.1.1.1. Understanding the Consequence of a Hazard

It is the nature of major incidents that they are unpredictable, and each will present a unique set of challenges. OSHAD has prepared an evaluating process to understand the extent of harm and level of consequence, this is presented in Table 5-152 below.

Table 5-152: Hazard consequence (168)

Area Impacted	Insignificant Consequence (1)	Minor Consequence (2)	Moderate Consequence (3)	Major Consequence (4)	Catastrophic Consequence (5)
Human Health and Safety	Minor injuries which may require self-administered first aid. Injured personnel can continue to perform normal duties.	Injuries requiring on-site treatment by medical practitioner. Personnel unable to continue to perform duties.	Serious injuries requiring off-site treatment by medical practitioner or immediate excavation to hospital. Potential long-term or permanent disabling effects.	Single fatality.	Multiple fatalities.
Production Loss	Incident event without causing production loss.	Production loss or delay up to one week.	Production loss or delay of one week to one month.	Production loss or delay for over one month.	Loss of licence to operate of ability to produce indefinitely.
Total Cost of Impact or Incident Event	Financial loss (Compensation, fines, cost to repair, plant damage) of less than 5,000 AED.	Financial loss (Compensation, fines, cost to repair, plant damage) of 5,000 – 50,000 AED.	Financial loss (Compensation, fines, cost to repair, plant damage) of 50,000 – 500,000 AED.	Financial loss (Compensation, fines, cost to repair, plant damage) of 500,000 – 10M AED.	Sever financial penalties or legal liabilities. Financial loss (Compensation, fines, cost to repair, plant damage) of greater than 10M AED.

5.13.1.1.2. Understanding the Likelihood of the event

As per OSHAD (168) guidelines, the entity should indicate the likelihood of even occurrence, post the evaluation of the magnitude of consequence above. This is provided in Table 5-153 below.

Table 5-153: Event likelihood (168)

Descriptor	Likely Frequency	Probability
Frequent	Occurs frequently	5
Often	Occurs several times per year	4
Likely	Has occurred more than once	3
Possible	Has occurred	2
Rare	Never occurred	1

5.13.1.1.3. Assigning a Risk Rating

By assessing the scores derived from Table 5-152 Table 5-153 above, the risk is then assigned and defined as per Table 5-154 below.

Table 5-154: Risk (R) rating matrix (168)

Probability (P)	Consequence (C)				
	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
Rare (1)	1	2	3	4	5
Possible (2)	2	4	6	8	10
Likely (3)	3	6	9	12	15
Often (4)	4	8	12	16	20
Frequent/Almost Certain (5)	5	10	15	20	25
Legend:					
15 – 25	Extreme Risk	Activity or industry should not proceed in current form.			
8 – 12	High Risk	Activity or industry should be modified to include remedial planning and action and be subjected to detailed OSH assessment.			
4 – 6	Moderate Risk	Activity or industry can operate subject to management and /or modification.			
1 – 3	Low Risk	No immediate action required unless escalation of risk is possible.			

Table 5-155: Construction phase hazards and effects register

Item	Activity	Impact/Source	Hazard	Unmitigated Risk			Prevention Measures	Mitigated Risk		
				P	C	R		P	C	R
1	Excavation activities / transportation etc.	– Short-term dust emissions to the environment	– Reduction in visibility – Health impacts on workers and nearby communities – Impacts on flora (dust settlement on leaves)	5	2	10	– Vehicles and vessels carrying loose aggregate should be covered at all times; – Vehicles should not be overloaded; – Where vehicle movements are observed to give rise to significant dust emissions, wetting down will be implemented and the contractor will ensure that adequate supply and storage of water is available on site for dust suppression; – Speed of vehicles will be restricted to 15 km/h along the temporary site roads and any unpaved areas of the site to avoid creating excessive dust; – Washing of vehicle tyres to prevent dust emissions during movement outside the project site; – Stockpiles will be located as far as possible from sensitive areas; – Minimize stockpile heights (circa. 3m); – Ensure slope gradients are less than 1:3; – Pile surfaces should be as smooth as possible to reduce wind erosion. An irregular pile surface will create turbulence that aggravates dust; – Application of dust suppression sprays where significant dust emissions are observed; – Conducting a weekly monitoring log; – When reclaiming from stockpiles, loaders should work on the lee side (sheltered side) of the pile where its activity is sheltered from the wind; and – Cover stockpiled materials with tarpaulin type materials when possible to prevent wind blowing off dust from these areas, with additional wetting down where necessary.	3	2	6
2	Material Handling	– Fumes from storage tanks – Misplacement of materials – Leakage from storage tanks	– Respiratory health impact on workers – Burns or irritation on workers skin – Eye injury of workers	3	5	15	– The number of fuel storage areas will be minimised and properly managed; – A full list of all volatile fuels stored on site will be kept by the site supervisor, including accompanying volumes, locations and Material Safety Data Sheets (MSDS); – Ensure proper on-site storage of volatile fuels in appropriately sealed containers, in cool, covered areas with adequate venting; – Personnel using such substances must be trained in the safe handling of such substances; and – Personnel must be provided with the necessary safety equipment to protect against any possible harmful emissions.	2	4	8
3	Dredging in nearshore areas at Mirfa and Shuweihat	– Spill of Hazardous Material to the Marine Environment – Generation of Sediments and Increased Turbidity – Re-mobilisation of Contaminated Marine Sediment – Run-off from Vessel and Vessel Equipment Washing – Sanitary or Bilge / Ballast Water Discharges from Marine Vessels – Temperature Impact and Potential	– Contamination of marine water and sediments – Health impacts to surrounding marine ecosystem – Reduction in water quality	3	3	9	– Store hazardous materials at designated containers and appropriate areas on the vessel; – Refuelling, oil change and greasing to be done away from the coastal areas and critical habitats; – Provide appropriate (110% volume) secondary containment system at chemical and fuel storage areas; – Containerising and labelling waste; – Spill Response Plan to be developed for inclusion within EMP for construction; – Appropriate spill kits and spill clean-up material available on marine vessels, at chemical, fuel, and waste storage areas, and at re-fuelling and maintenance areas;	3	2	6

Item	Activity	Impact/Source	Hazard	Unmitigated Risk			Prevention Measures	Mitigated Risk		
				P	C	R		P	C	R
		Contamination of Seawater from Cooling Water Discharges of Dredging Equipment								
4	Vehicle Traffic	– Traffic Accidents	– Injuries / Death	2	5	10	– All construction drivers and boat crews should be appropriately licenced and trained in road and traffic safety; – Trip durations should be capped to prevent excessive driving times and driver exhaustion; and – Appropriate warning signs and flag operators should be used to warn the public of any adverse driving conditions as a result of construction traffic.	1	4	4
5	General Construction Activities	– Misplacement of soil and potential contaminants – Leakage of contaminated liquids within the stored soil – Soil spills during transportation	– Contamination of soil, groundwater and marine water	3	3	9	– All Material Safety Data Sheets (MSDS) will be retained on-site. In addition, a copy of the MSDS will be retained at proximity of the materials in order to be readily accessible in case of emergency; – All hazardous liquid materials will be stored in a container of sufficient strength and structural integrity to ensure that it is unlikely to burst or leak in its ordinary use; – Incompatible hazardous materials must be segregated and stored separately, e.g.: flammable liquids will be segregated from caustic / acidic materials, if relevant; – Storage, handling and disposal of fuels, oils, lubricants and other potentially harmful chemicals (and their containers) will be undertaken under proper supervision in accordance with manufacturer's instructions; – Storage areas will be clearly marked and signed with regard to the quantity and hazardous characteristics of the materials stored (Material Safety Data Sheets); – Containers will be stored, in designated areas that are isolated from surface water drains, open water and are bunded to contain any spillages; – Emergency spillage kit will be located at strategic locations and in proximity of the main storage areas and the refuelling area; – Leaking or empty oil drums will be removed to the hazardous waste storage area to be treated or disposed of via an EAD approved waste disposal contractor; – Regular checks will be carried out on sanitary facilities to ensure there are no leaks; – All sanitary wastewater should be collected and disposed of to a licensed facility by an appropriately licensed and authorised contractor; and – Water used for dust damping should come from a source that will not risk causing contamination to soil or groundwater.	2	2	4
6	Excavation and soil storage	– Misplacement of soil and potential contaminants – Leakage of contaminated liquids within the stored soil	– Contamination of soil, groundwater and marine water	3	3	9	– The content of any tank will be clearly marked on the tank, and a notice displayed requiring that the valves and trigger guns be locked when not in use; – All containers will be securely stored and labelled, so that appropriate remediation action will be taken; and – All tanks will be located on a drip tray.	2	2	4
7	Refuelling of construction equipment and vehicles Construction equipment maintenance activity Operation of equipment on site	– Oil spills and leaks – Fuel spills and leaks	– Contamination of soil, groundwater and marine water	4	4	16	– Wear protective clothing – Prevent further release at source – Remove sources of ignition – Prevent access to the site – Implement measures described within the relevant Material Safety Data Sheet (MSDS) – Use absorbent materials for clean-up, e.g.: sand or pads to absorb excessive materials and dispose of within plastic bucket so not to transfer spill – Do not rinse away spills	4	2	8

Item	Activity	Impact/Source	Hazard	Unmitigated Risk			Prevention Measures	Mitigated Risk		
				P	C	R		P	C	R
							– If spills migrate, create temporary bunds using soil, sandbags or spill kit materials – Any contaminated materials will be considered as Hazardous Waste			
8	Waste storage	– Misplacement of waste materials – Leakage of liquids from the stored waste – Leachate from waste during raining events	– Contamination of soil, groundwater and marine water	4	2	8	– Waste that is generated during construction will be classified as hazardous or non-hazardous and stored appropriately; and – Waste storage on site will be in designated and appropriately signed area(s). Skips will be clearly labelled to specify the waste streams which can be recycled or disposed of.	2	2	4
9	Waste transport	– Misplacement of waste and potential contaminants – Leakage of liquids from the transported waste – Waste spills during transportation	– Contamination of soil, groundwater and marine water	4	2	8	– The waste containers are clean on the outside, sealed, and not leaking; – The required forms for wastes and other documents required for shipment are completed and correct; and – Waste separation will be done by staff wearing suitable PPE such as gloves and dust masks.	2	2	4
10	Disposal of waste	– Misplacement of waste materials – Leakage of liquids from the disposed waste	– Contamination of soil, groundwater and marine water	4	2	8	– Training should be provided to educate all construction workers regarding best practice waste management practices and recycling initiatives, and to encourage more sustainable working practices. Emphasis should be placed on the waste minimisation hierarchy: reduce, reuse, and recycle; – All workers will be provided with a comprehensive induction to demonstrate which wastes are segregated in adequately labelled containers; and – Specific PPE and training will be provided and PPE must be worn by employees at all times.	2	2	4
11	Workers dealing with waste	– Misplacement of waste materials – Leakage of liquids from the waste	– Respiratory impact on workers' health or nuisance – Burns or irritation of skin	4	2	8	– Training should be provided to educate all construction workers regarding best practice waste management practices and recycling initiatives, and to encourage more sustainable working practices. Emphasis should be placed on the waste minimisation hierarchy: reduce, reuse, and recycle; – All workers will be provided with a comprehensive induction to demonstrate which wastes are segregated in adequately labelled containers; and – Specific PPE and training will be provided and PPE must be worn by employees at all times.	2	2	4
12	Storage and treatment of sanitary wastewater	– Wastewater spills and leakage	– Contamination of soil, groundwater and marine water – Nuisance to staff	4	2	8	– Chemical toilets will be introduced to the site to provide adequate sanitary facilities for the construction workforce; – Functional and well-maintained sanitary facilities must be available on site at all times; – Sludge arising from temporary toilets should be disposed of by an appropriately licensed contractor in accordance with Abu Dhabi Legislation and with an emphasis on preventing risk to public health and safety; – Adequate removal of sanitary liquid waste from temporary toilets, in conjunction with inspections will avoid any overflow and create a zero-leakage site; and – Removal of liquid sanitary waste from temporary toilets should be undertaken by a licensed waste management sub-contractor	2	2	4

Item	Activity	Impact/Source	Hazard	Unmitigated Risk			Prevention Measures	Mitigated Risk		
				P	C	R		P	C	R
13	Storage of hazardous waste	– Misplacement of waste and potential contaminants – Leakage of stored waste – Waste spills during transportation	– Respiratory health impact on workers – Burns or irritation on workers skin – Eye injury of workers	3	5	15	– The HSE Manager will be responsible for managing hazardous materials on site, which includes responsibility for ensuring the correct placing, maintenance and housekeeping of the hazardous materials storage areas; – The following information should be kept up to date for each hazardous material: – Material Safety Data Sheets (MSDS); – Quantity in store; – Quantity used per month; – Responsibility Details (Responsible Operations Engineer); and – This should be available for Emergency crews in case of an emergency event or accident; – Storage areas will be clearly marked and signed with regard to the quantity and hazardous characteristics of the materials stored within; – Each individual drum, package or container will be clearly labelled. Internationally recognised warning signage shall be used to indicate the hazards of the individual hazard materials; – Incompatible, hazardous materials will be segregated and stored separately. For example, flammable liquids and other organics will be segregated from acidic and caustic materials, if relevant; – Covered plastics containers will be provided in the first aid area (for syringes, suturing kits and needles) and also clearly identified bagging for infectious or contaminated items; – Containers must be stored in such a manner that leaks and spillages cannot escape over bunds or the edge of the sealed drainage areas; and – Regular inspection and maintenance of storage areas including drums, vessels, pavements and bunds must take place.	3	3	9
14	General construction	– Fire hazards	– Injuries / Death	2	5	10	– The Project needs to include but not limited to the following: – Means of escape layouts; – Proper maintenance of flammable materials; – Proper compartmentation with fire resistant materials; – Fire alarms and detection systems; – Fire-fighting equipment such as extinguishers, fire blankets, suppression systems, etc.; – Emergency escape lighting; – Fire safety signs and notices; – Evacuation procedures; – Staff training; – Record keeping; – Appropriate housekeeping; and – Protection from threat of arson.	1	4	4

Table 5-156: Operation phase hazards and effects register

Item	Activity	Impact/Source	Hazard	Unmitigated Risk			Prevention Measures	Mitigated Risk		
				P	C	R		P	C	R
1	General operation activities	– Fire hazards	– Injuries / Death	1	5	5	The Project needs to include but not limited to the following: – Means of escape layouts; – Proper maintenance of flammable materials; – Proper compartmentation with fire resistant materials; – Fire alarms and detection systems; – Fire-fighting equipment such as extinguishers, fire blankets, suppression systems, etc.; – Emergency escape lighting; – Fire safety signs and notices; – Evacuation procedures; – Staff training; – Record keeping; – Appropriate housekeeping; and – Protection from threat of arson.	1	4	4
2	General operation	– Traffic accidents	– Injuries / Death	2	5	10	– Appropriate roads signage and traffic signals to lower driving errors; – Appropriate road speed limits; – No vehicle overtaking at school areas; and – Road network equipped with appropriate speed breakers such as speed bumps.	2	3	6
3	General operation	– Accidental release of fuel/oil	– Significant impact to environment and ecosystem	2	3	6	– Establish handling and storage procedures for chemicals, fuel, lubricants, grease and oil; – Minimise quantities of hazardous materials stored onsite; – Provide suitably bunded storage facility; – Regular inspection of storage area, ensuring that appropriate spill kits and fire-fighting equipment (where required) – are available; and – Provide staff with suitable training and PPE.	1	2	2
4	General operation	– Release of poorly treated irrigation water	– Soil and groundwater contamination	2	2	4	– Regular sampling and testing of treated sewerage effluent; and – Regular maintenance of sewage treatment plant	1	2	2
5	Foul sewerage network	– Wastewater spills and leakage	– Contamination of soil, groundwater and marine environment – Nuisance and source of health concern for residents	4	2	8	– Functional and well-maintained sewerage network must be available on site at all times; and – Any suspected or confirmed leaks must have a confirmed response plan for repair or replacement.	2	2	4
6	Stormwater network	– Discharge of oils / chemicals via stormwater outlet	– Contamination of marine water and marine environment – Nuisance and source of health concern for residents	4	2	8	– Proper sewerage network design to ensure that all risk of contamination from spillages are appropriately managed; and – Ensure the implementation of appropriate oil and chemical traps to prevent discharge to marine environment in the event of spillages of leakages.	2	2	4

5.13.1.2. Recovery Plan and Measures

5.13.1.2.1. Overview

It is the nature of major incidents that they are unpredictable, and each will present a unique set of challenges. In formulating a major incident plan, the task is to have a set of expertise available and to have developed a set of core processes to handle the uncertainty and unpredictability of whatever happens. Co-operation between local regulatory bodies is a necessity and must be addressed when formulating the plan.

Table 5-157 below provides an overview of the possible environmental incidents that could be associated with the Project.

Table 5-157: Potential environmental incidents

Potential environmental incidents			
01	Oil / fuel spill or leak	05	Rain & flood
02	Chemical spill or leak	06	Fire
03	Release of excessive dust / bulk powder release	07	Uncontrolled release of effluents
04	Generation of excessive noise emissions		

5.13.1.2.2. Responsibilities

The contractor shall develop and maintain a Site Emergency Plan.

The HSE Manager is responsible for ensuring that local authorities, including Civil Defence and ADM, are contacted in the event of a major incident. Upon notification of an incident, all response procedures should be implemented in accordance with this procedure and as directed by relevant authorities.

The HSE Manager is responsible for ensuring the incident response for minor incidents are implemented and that the Incident Response Form is completed, and Corrective Action Plan prepared, signed off and implemented.

In the event of an incident of medium, severity, the HSE Manager is responsible for ensuring that the incident responses are implemented, and the Incident Response Form is completed, and Corrective Action Plan prepared, signed off and implemented.

It is the responsibility of all site personnel to notify the HSE Manager of all incidents.

5.13.1.2.3. Emergency Management Plan

Emergency Procedures

Incident Classification

The incidents should be classified and categorised using the definitions in the Table 5-158 below.

Table 5-158: Categorisation of environmental incidents

Tier	Definition	Example	Responsibility
Tier A	– Minor Incident – One that is easily brought under control and prevented from re-occurring	– Small, containable spills within the site boundary. – Minor nuisance but controllable and preventable from reoccurrence. – Minimal environmental damage but controllable and preventable from re-occurrence.	– Following the incident response, the Safety officer will be responsible for notifying the Project proponent.
Tier B	– Medium Incident – One that will need to be brought under control and prevented from reoccurrences in consultation with the HSE Manager	– Un-containable or uncontrollable spills within site boundary – Excessive uncontrollable incidents which are likely to cause nuisance or when a complaint is received – Un-rectifiable environmental damage and likely to occur.	– Following the incident response, the Safety officer will be responsible for notifying the Project proponent.
Tier C	– Major Incident – One which cannot be controlled by the Project or that effects local authorities or independent parties	– Un-containable or uncontrollable spills outside the site boundary or which affect local authorities – Massive loss of biodiversity at the site which will re-occur to cause impacts to biodiversity.	– Following the incident response, the Safety officer will be responsible for notifying the Project proponent and statutory authorities.

General Incident Response

Figure 5-233 below provides an overview of the procedures to be implemented with each category of incident.

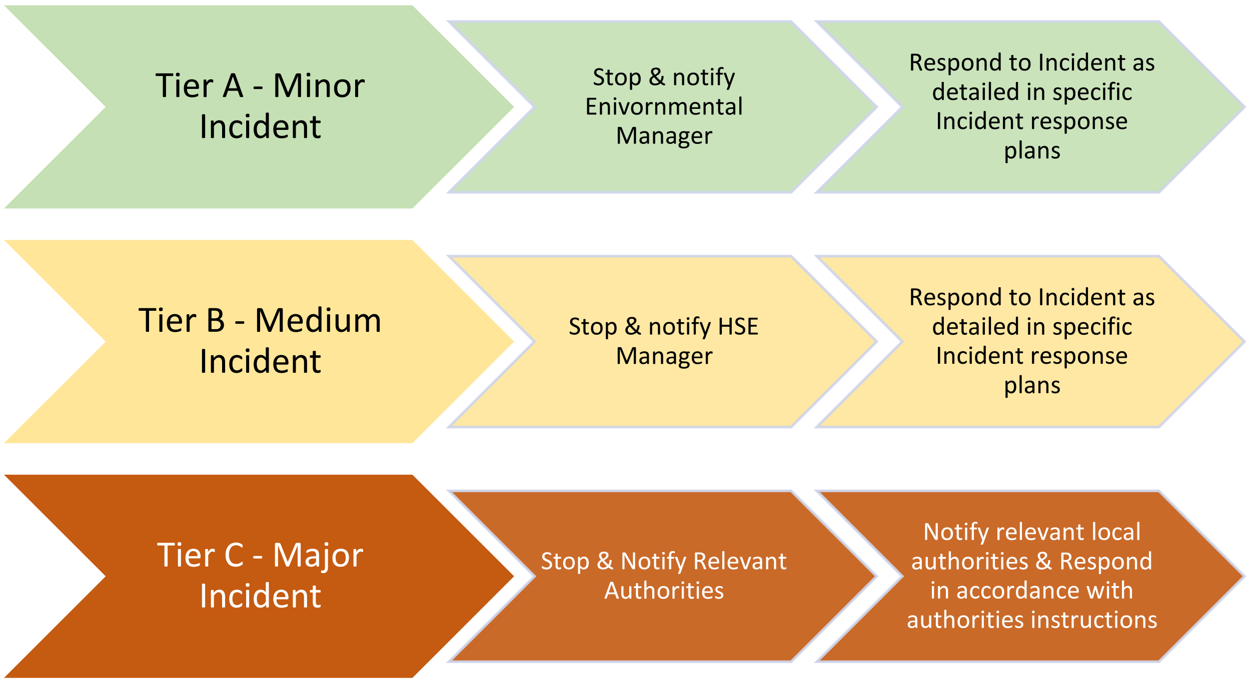


Figure 5-233: General incident procedure

Specific Incident Response

Major incidents must be dealt with in accordance with the relevant authorities' requirements, while responses to minor incidents will be under the responsibility of the HSE Manager. To determine these requirements for major incidents the authority must be notified immediately, and their requirements implemented. The incident response procedure are presented in detail in Table 5-159 to Table 5-165 below.

Table 5-159: Incident response procedure – oil and fuel spill or leak

INCIDENT RESPONSE PROCEDURE OIL & FUEL SPILL OR LEAK	
Initial Response	– Wear protective clothing – Identify the source – Prevent further release at source – Prevent access to the site
Analysis & Notification	– Categorise Incident and notify responsible party ▪ **Tier A**: Refer to Notification Process ▪ **Tier B**: Refer to Notification Process ▪ **Tier C**: Refer to Emergency contacts
Remediation & Recovery	– Implement measures described within the relevant Material Safety Data Sheet (MSDS) – Use absorbent materials for clean-up, e.g.: sand or pads to absorb excessive materials and dispose of within plastic bucket so not to transfer spill – Do not rinse away spills – If spills migrate, create temporary bunds using soil, sandbags or spill kit materials – Any contaminated materials will be considered as Hazardous Waste

Table 5-160: Incident response procedure – chemical spill or leak

INCIDENT RESPONSE PROCEDURE CHEMICAL SPILL OR LEAK	
Initial Response	– Wear protective clothing – Identify the source – Prevent further release at source – Prevent access to the site – Wear protective clothing – Prevent further release at source – Remove sources of ignition – Prevent access to the site
Analysis & Notification	– Categorise Incident and notify responsible party ▪ **Tier A**: Refer to Notification Process ▪ **Tier B**: Refer to Notification Process ▪ **Tier C**: Refer to Emergency contacts
Remediation & Recovery	– Implement measures described within the relevant Material Safety Data Sheet (MSDS) – Use absorbent materials for clean-up, e.g.: sand or pads to absorb excessive materials and dispose of within plastic bucket so not to transfer spill – Do not rinse away spills – If spills migrate, create temporary bunds using soil, sandbags or spill kit materials – Any contaminated materials will be considered as Hazardous Waste and should be appropriately treated as Hazardous Waste – If drains are located nearby, install drain seals

Table 5-161: Incident response procedure – release of excessive dust / bulk powders

INCIDENT RESPONSE PROCEDURE RELEASE OF EXCESSIVE DUST / BULK POWDERS	
Initial Response	– Identify the source – Prevent further release of dust e.g.: if split pipe, stop transferring dust until pipe is replaced / repaired
Analysis & Notification	– Categorise Incident and notify responsible party ▪ **Tier A**: Refer to Notification Process ▪ **Tier B**: Refer to Notification Process ▪ **Tier C**: Refer to Emergency contacts
Remediation & Recovery	– Implement measures described within the relevant Material Safety Data Sheet (MSDS) – Under dry conditions, dampen area using a bowser or similar to prevent wind-blown dust (unless dry dust can be reclaimed immediately for re-use, by use of specialist equipment – When dampening the site down, ensure the resulting mixture/run-off does not enter any drains or groundwater – Deploy dust suppression bowsers (or roads sweepers in wet conditions) on any hard surfaces affected by dust – Cover materials which are being transported or large exposed stockpiles or relocate exposed stockpiles where possible

Table 5-162: Incident response procedure – generation of excessive noise emissions

INCIDENT RESPONSE PROCEDURE GENERATION OF EXCESSIVE NOISE EMISSIONS	
Initial Response	– Identify the source – Assess the situation and associated noise level – If any complaint has been received, it may be necessary to meet the complainant – Make a judgement of what can be done, if anything, to minimise the noise propagating from the site on factors such as remaining duration of the works
Analysis & Notification	– Categorise Incident and notify responsible party ▪ **Tier A**: Refer to Notification Process ▪ **Tier B**: Refer to Notification Process ▪ **Tier C**: Refer to Emergency contacts
Remediation & Recovery	– Initially ensure all plants are maintained, and with correct appliance, to prevent excessive noise – Conduct work near sensitive receptors during daytime hours only

Table 5-163: Incident response procedure – rain and flood

INCIDENT RESPONSE PROCEDURE RAIN & FLOOD	
Initial Response	– Ensure personal safety – If possible, switch off machines to prevent water damage – Rescue and evacuate all personnel & visitors from the affected area – Switch off power mains to affected area
Analysis & Notification	– Categorise Incident and notify responsible party ▪ **Tier A**: Refer to Notification Process ▪ **Tier B**: Refer to Notification Process ▪ **Tier C**: Refer to Emergency contacts
Remediation & Recovery	– Catch or divert water – If contamination; immediate clean-up of spillage – If reduction in bund capacity due to the rain; scheduled release after rain event and regular inspection

Table 5-164: Incident response procedure – fire

INCIDENT RESPONSE PROCEDURE FIRE	
Initial Response	– Ensure personal safety – Rescue and evacuate all personnel & visitors from the affected area
Analysis & Notification	– Categorise Incident and notify responsible party ▪ **Tier A**: Refer to Notification Process ▪ **Tier B**: Refer to Notification Process ▪ **Tier C**: Refer to Emergency contacts
Remediation & Recovery	– Close all doors to the hazard or fire area – Extinguish using the closest fire extinguisher if the fire impedes your evacuation – Evacuate to the designated meeting location

Table 5-165: Incident response procedure – uncontrolled release of effluents

INCIDENT RESPONSE PROCEDURE UNCONTROLLED RELEASE OF EFFLUENTS	
Initial Response	– Identify the source – Assess the situation and associated areas affected – If possible, to stop or minimise release
Analysis & Notification	– Categorise Incident and notify responsible party ▪ **Tier A**: Refer to Notification Process ▪ **Tier B**: Refer to Notification Process ▪ **Tier C**: Refer to Emergency contacts
Remediation & Recovery	– Implement measures described within the relevant Material Safety Data Sheet (MSDS) – Use absorbent materials for clean-up, e.g.: sand or pads to absorb excessive materials and dispose of within plastic bucket so not to transfer spill – Do not rinse away spills – if spills migrate, create temporary bunds using soil, sandbags or spill kit materials – Any contaminated materials will be considered as Hazardous Waste

Environmental Incident Record

In the event of Tier, A, B or C environmental incident, a Non-Conformance Recording Form will be completed. The Environmental Incident Form includes details on the following:

- Details of the witness responsible for reporting the incident;
- Date of the incident;
- Condition on site during the incident;
- Description of location of the incident;
- Cause of the incident;
- Scale of the incident;
- Potential impacts of the incident;
- Confirmation environmental control measures have been implemented;
- Describe non-compliance with reference to the CEMP;
- Proposed corrective actions to correct the incident and prevent re-occurrence;
- Person responsible for corrective action;
- Date the corrective action is to be completed; and
- Signature upon completion.

This information will be provided to ADM within 48-hours of the incident occurring.

Security Plan

The contractor will implement the following measures to ensure that the site is secured:

- Security barrier at site entrance;
- Security guards employed 24 hours per day;
- Identification cards for employees and subcontractors; and
- Visitor's pass system.

All visitors must report to security at the gate to the site office and will be required to supply the following details:

- Date and time of arrival;
- Vehicle registration;
- Company and contact details;
- Reason for visiting the site and site contact; and
- Time of departure.

5.13.2. Control of Major Accident and Hazards Report

As identified in the construction and operational Hazards and Effects Register (HER), no accidental environmental hazards are expected to present a High Risk to the Project or the surrounding environment following mitigation measures as detailed in 5.13.2. Therefore, a Control of Major Accident and Hazards Report (COMAH) report has not been developed for this Project.

5.14. Environmental Management Framework

5.14.1. Environmental Management Program Objectives

This section proposes an Environmental Management Plan (EMP) framework to be adopted during the construction (CESMP) and operation (OESMP) phases of the Project, which is where the most significant impacts are predicted to occur.

The Project represents an infrastructure development which will traverse through MMBR and as identified within the environmental impact assessments detailed in **Section 5: Environment, Impacts, Mitigation, Monitoring and Risk Assessment**, the majority of the impacts are expected to occur during the construction phase, whilst operational phase impacts will be limited. It is recommended that a Construction Environmental and Social Management Plan (CESMP) is developed as part of the Project EMP process. However, due to the sensitivity of the surrounding environment, particularly the marine environment and associated habitats, it is also considered prudent to prepare an Operational Environmental and Social Management Plan (OESMP) to ensure the effective management of all Project components. The ongoing monitoring of compensatory terrestrial ecology measures proposed within this ESIA also require continued assessment for determining their success.

The EMP should be compliant with one of the most widely used environmental management systems, developed by the International Standards Organization (ISO), is the ISO 14001 standard for the environmental management of activities. The standard provides a logical framework within which to prepare and develop the EMP of the Project.

The key element of ISO 14001 which has been embedded into the EMP is one of continual feedback and improvement, whereby the identification of non-conformances together with the results of audits and environmental monitoring are continuously reviewed by the environmental management team and are fed back into the environmental management process. In this way, for example, where exceedances of standards are identified, a review of the environmental management actions being undertaken will be implemented and the EMP updated with alternative or additional actions to work towards continued compliance. The structure of a typical EMS certified to ISO 14001, which demonstrates this cycle of continuous improvement, is shown in Figure 5-234 below.

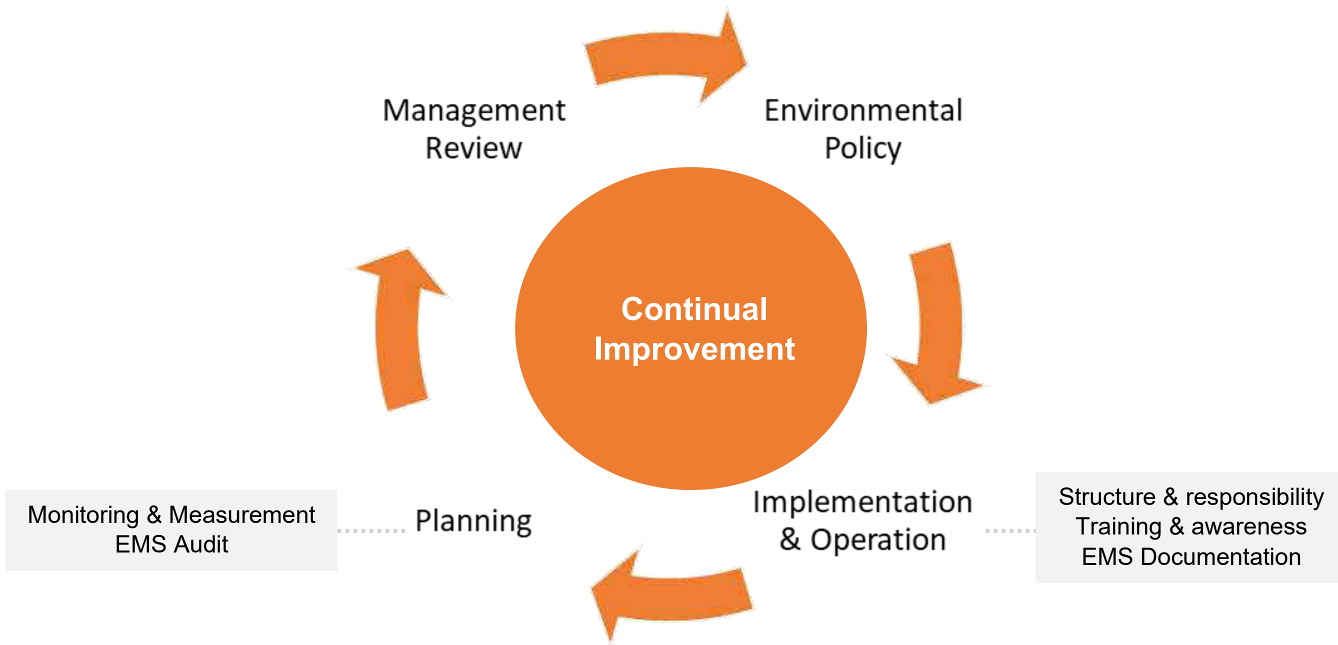


Figure 5-234: ISO 14001 Structure

5.14.1.1. EMP Purpose

The purpose of a EMP is to ensure that all potential environmental impacts are properly considered, controlled and monitored during the implementation of the Project.

The EMP will serve to ensure that the requirements of EAD and other competent authorities are met and serve as a clear and auditable indication as to how those requirements are implemented during the construction and operational phase.

The EMP will be a dynamic document which has to be reviewed, revised or updated as required during the construction phase of the Project.

The key objectives of the EMP are defined as follows:

- Prescribe an overall management structure with clearly defined accountabilities and responsibilities;
- Ensure an environmental management structure responsible for implementing the relevant measures within the EMP;
- Ensure adequate and relevant environmental induction training for all contractors and subcontractors;
- Incorporate Emergency Planning into the management system;
- Stipulate a programme of deliverables, meetings, audits, communication protocols and reporting requirements to monitor and manage the construction works;
- Define objectives and targets for environmental management on the construction activities;
- Implement Mitigation Measures and Monitoring Programmes;

- Prescribe a mechanism for recording and reporting environmental concerns, improvement, complaints or incidents;
- Define the communication protocols for liaison with local communities and regulatory authorities on environmental matters;
- Ensure compliance with all regulatory requirements and guidelines, where relevant; and
- Stipulate a mechanism for periodical review for the EMP.

5.14.2. Roles and Responsibilities

5.14.2.1. CESMP

The CESMP should clearly identify specific roles and responsibilities similar to that proposed in Figure 5-235 below.

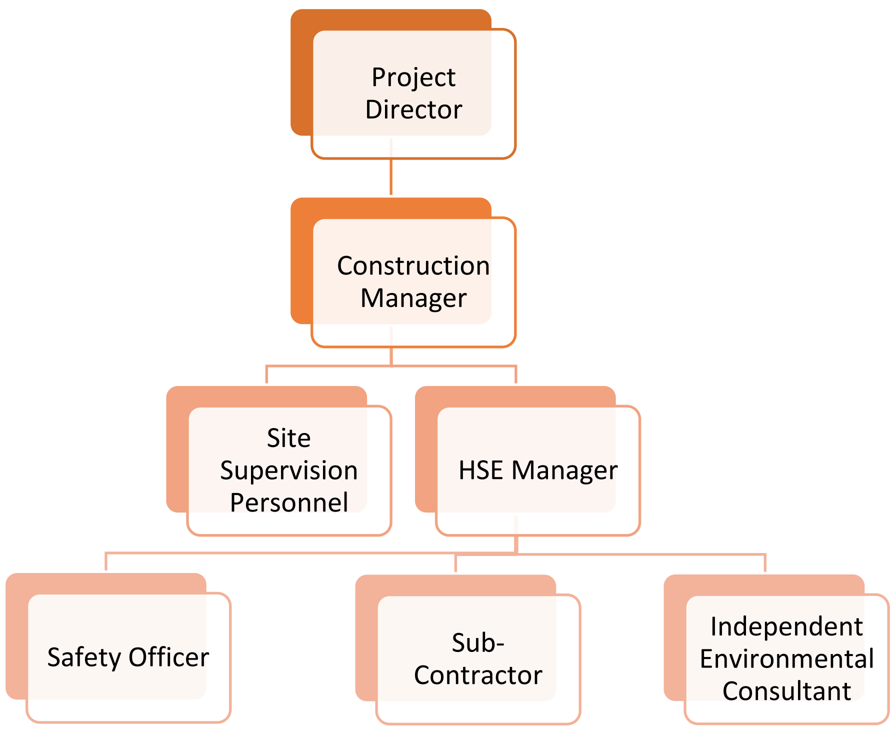


Figure 5-235: Environmental organization chart

It should be noted that the organisational charts have already been provided by the EPC (JDN and SCT) which are shown in Figure 5-236 and Figure 5-237 below. Additionally, Figure 5-238 sets out roles and responsibilities for SCT.

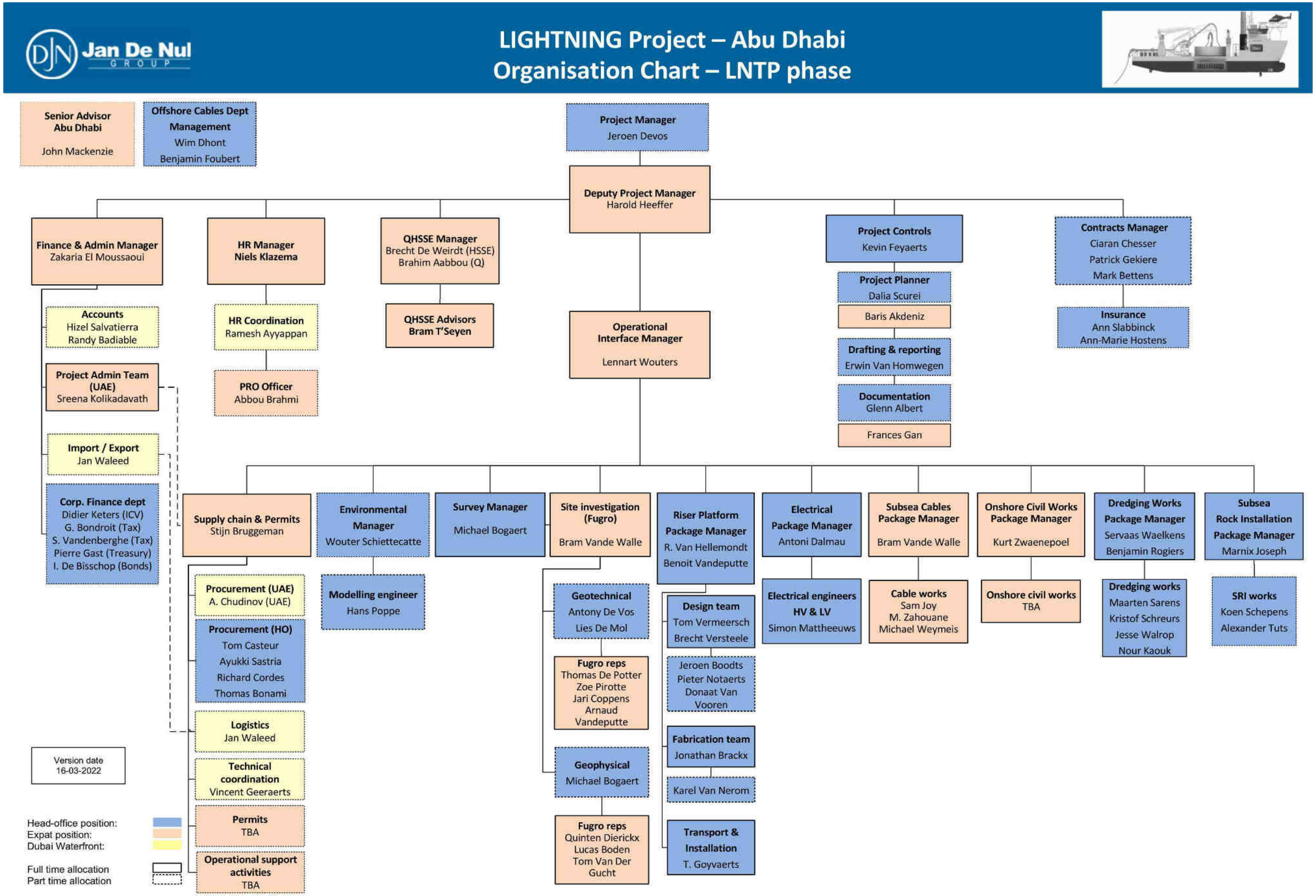


Figure 5-236: JDN Organisational Chart

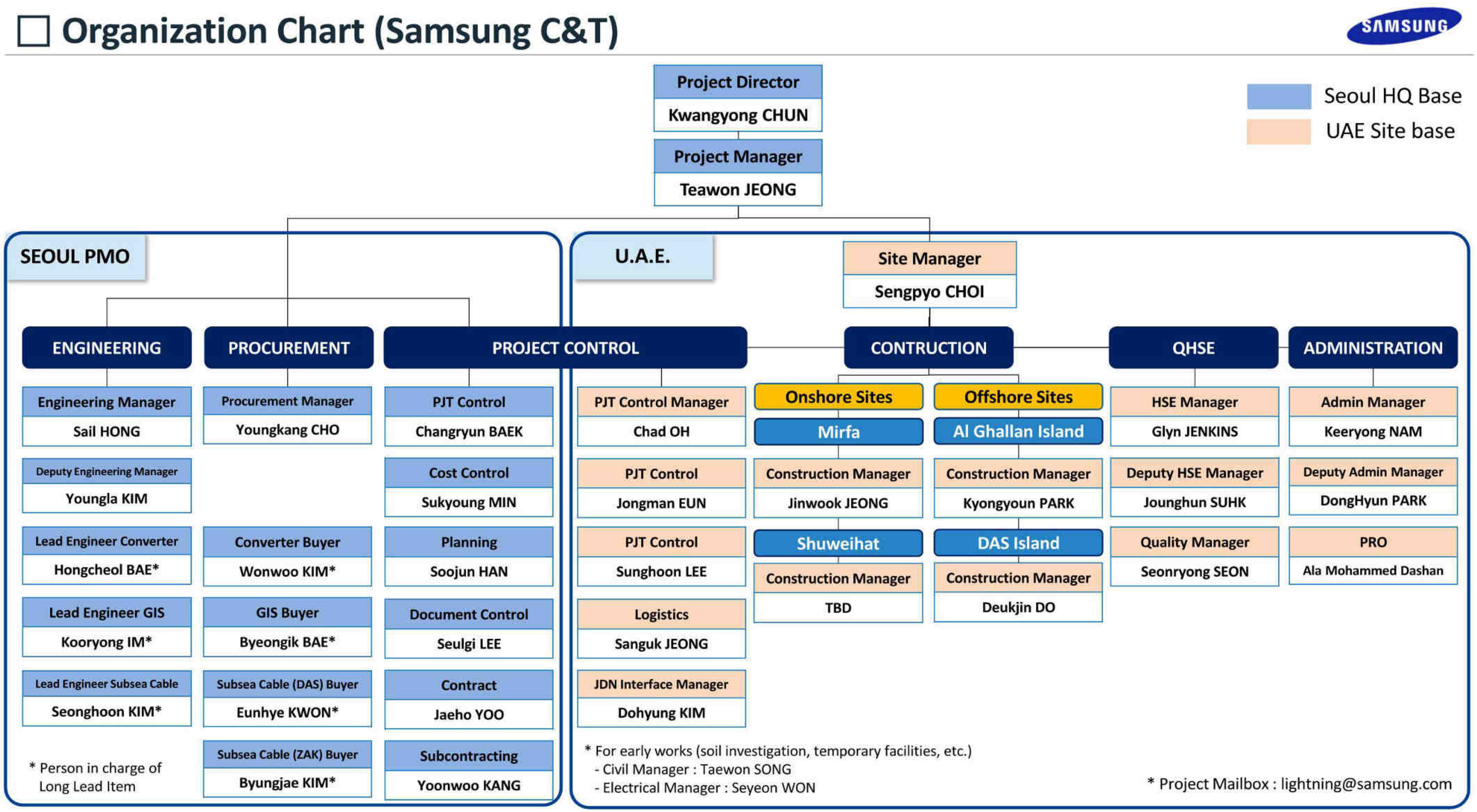


Figure 5-237: SCT Organisational Chart

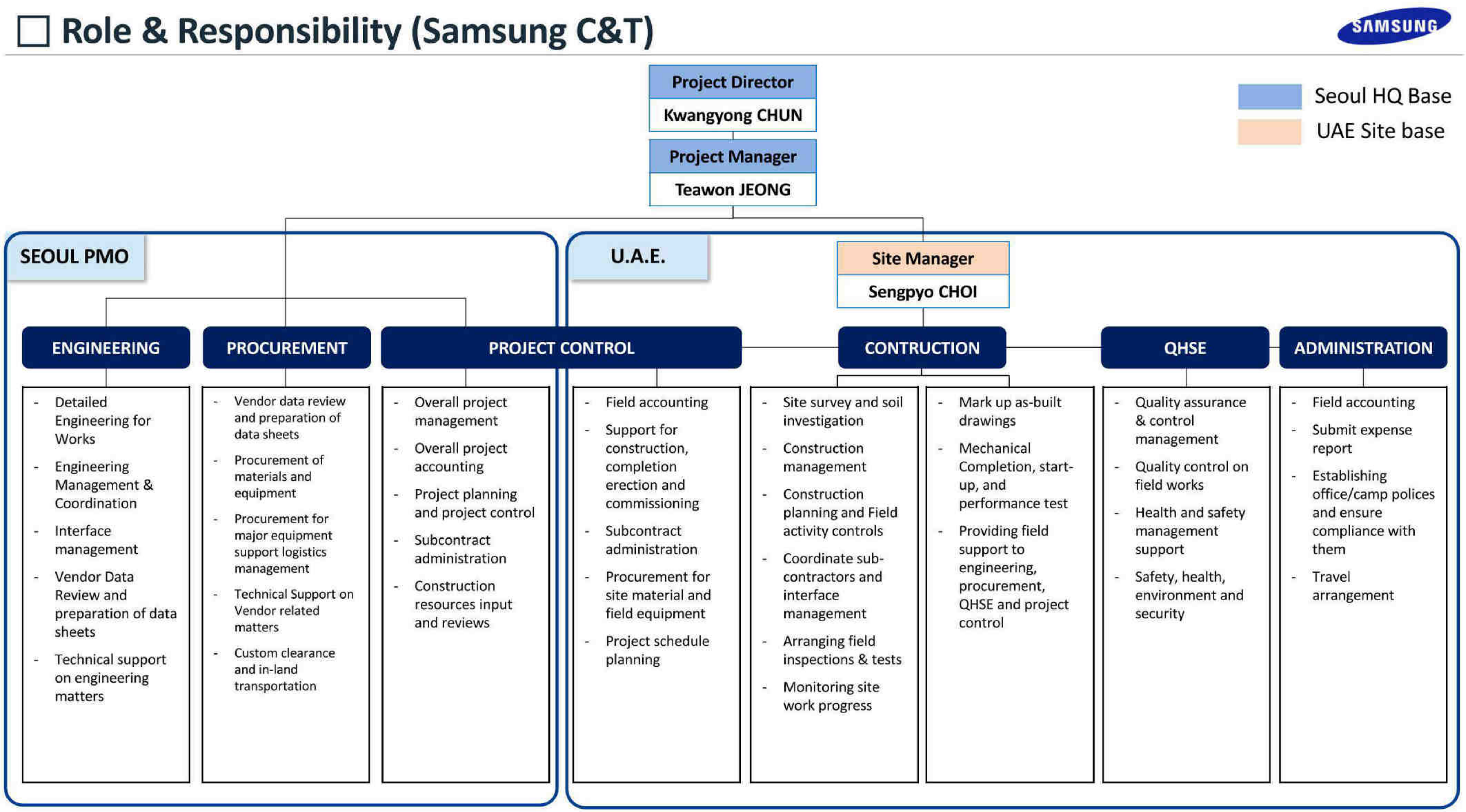


Figure 5-238: SCT Roles and Responsibilities

5.14.2.1.1. Project Director

The Project Director is the most senior person on site accountable to all occupational health, safety and environmental (HSE) matters for the Project. The Project Director HSE responsibilities are detailed as follow:

- Responsible for ensuring a high standard of HSE performance throughout the Project duration. The HSE Manager and his team will provide him assistance in achieving and maintaining the HSE performance in the Project operations;
- Responsible of the overall co-ordination and implementation of the HSE Policy to ensure that HSE protection and welfare consideration are always given priority in design, production, finance, allocation of manpower, provision of equipment, planning, work practices and day-to-day supervision;
- Promote interest, enthusiasm and commitment to HSE issues throughout the Project activities;
- Ensure the provision of an adequately staffed HSE Management Team including the provision of Project HSE manager, environmental engineer or officer as required to meet statutory, contractual and company HSE requirements;
- Ensure that the work is effectively planned and managed including the requirements to minimise risks to HSE matters to all employees and the general public and adoption of appropriate HSE standards;
- Ensure that the operation of the Project HSE management plan is monitored through the Project HSE manager, safety officer(s), assistant(s) and that the plan is reviewed as and when necessary;
- Organise, with the assistance of HSE Manager, a monthly Project HSE Meeting and actively participate to the meeting;
- Possess ultimate authority to issue letter of warning or dismissal to safety offender(s);
- Possess ultimate authority to issue letter of penalty to subcontractors for breach of safety whenever necessary; and
- Lead by good examples in all aspects of HSE practices throughout the Project.

5.14.2.1.2. Construction Project Manager

The Construction Project Manager HSE responsibilities are detailed as follow:

- Carry out implementation of all site environmental requirements;
- Follow Implement the Project HSE Policy and the EMP;
- Carry strictly HSE Targets set for the Project;
- Ensure that appropriate environmental training and education are organised for the employees to meet contractual and statutory requirements;
- Ensure that toolbox talks are given to all the workers at least once a week and their attendance for the toolbox talks are recorded and filed properly;
- Ensure that arrangements are made with subcontractors or suppliers pertaining to their environmental responsibilities;

- Ensure that testing and examinations of all plants, machineries, equipment and the competency of all operators are in accordance with statutory requirements;
- Ensure that the environmental safety procedures spelt-out in the method statements and its safety precautions are clearly disseminated to all concerned parties especially workers who will be involved in the works specified in the method statements;
- Rectify all unsafe acts and unsafe conditions found or reported after each safety inspection so as to eliminate risks to workers as soon as possible; and
- Work towards achieving a good safety culture throughout the project to promote safety as a shared responsibility among all levels in the Project.

5.14.2.1.3. Site Supervision Personnel

The Site Supervision Personnel HSE responsibilities are detailed as follow:

- Promote interest, enthusiasm and commitment to HSE issues throughout the Project;
- Plan and maintain a tidy site and organize it in such a way that the work can be carried out with minimal risk to HSE;
- Together with safety/environmental personnel, carry out specific environmental risk assessments on all work processes (if practicably feasible) for incorporation into the method statements and brief the site engineer(s), general foremen and gangers on the environmental safety precautions by means of a recorded toolbox talks;
- Check whether the proposed methods of work are effective and have recognized the relevant Environmental requirements;
- Ensure that the construction methods are planned and executed with the need to minimise risk to HSE as a requirement;
- Be aware of the Project HSE Management Plan and ensure that it is suitably implemented and propose new ideas to be incorporated for the next revision;
- Promptly respond to the recommendations of the site environmental personnel;
- Ensure that all lifting gear, mobile plant and equipment is in good working order and has the appropriate valid inspection certificate;
- Give all employees and subcontractors that are under their supervision, adequate instructions with regards to their responsibilities for safe and efficient methods of work;
- Provide adequate information and instructions for promoting safe and healthy working methods;
- Ensure that individuals under their control are made aware of the environmental safety precautions associated with their work, and ensure proper induction training and toolbox talks; and
- Ensure that appropriate protective clothing and Personnel Protection Equipment (PPE) are issued, correctly used and maintained.

5.14.2.1.4. HSE Manager

The HSE Manager will head the HSE Department on site. The duties and responsibilities of the HSE Manager are as follows:

- Responsible for the maintenance of high safety standards throughout the execution of the Project;
- HSE Manager have the authority to issue stop work order on site should any imminent danger is not being rectified immediately to his satisfaction;
- Stop work order will be verbally issued to the responsible engineer-in-charge and followed by a written order in a prescribed form addressed to the Project Manager;
- Inspect and audit all site operations to monitor compliance with all statutory regulations and comply with the HSE policy;
- Inspect all relevant files, forms and registers required, which are to be kept at site, ensure the routine tests and inspections required by the HSE plan have duly been carried out and the results properly recorded;
- Monitor observance of site safety and environmental rules and issue warning to workers, work supervisors, site management staff and the subcontractors for rectification purposes, in case of non-compliances and unsatisfactory safety performances. Site improvement notices shall be raised wherever necessary;
- To review each site activity through a standard risk assessment system on all work process and brief those concerns on the precautionary measures;
- Investigate all accidents, incidents and near accidents etc., and make necessary recommendations, review and approve risk assessment report;
- Promote the safe execution of work on site and provide environment and safety induction trainings and briefings to workers;
- Review corrective and preventive actions to ensure the implementation of recommendations made from the audits and site inspections. In the event that a direction is not complied with satisfactorily, the HSE Manager shall escalate the issue to the Project Manager;
- Liaise with the EAD and other competent authorities, Government of Public, Local authorities; and
- Submit monthly HSE reports from the site by the fifth of the following month to the Project Manager and copies to the Senior HSE Manager.

5.14.2.1.5. Subcontractor’s Safety / Environmental Representative

Subcontractor's Safety/ Environmental representative is a person appointed by the subcontractor to supervise their workers in matters related to HSE on site. The Subcontractor's Safety/Environmental duties and responsibilities are as follows:

- Represent the subcontractor and attend to all Project’s Contractor Meetings as and when required;
- Responsible for reporting all accidents involving the workers and shall be readily available for all accident investigations;
- Ensure that all workers meet the HSE Training requires for the sub-contracted works;

- Ensure that all workers are issued with proper and adequate PPE to wear/use them on site;
- Ensure that workers receive toolbox talks related to the subcontracted works at least once a week;
- Promptly rectify all substandard acts and conditions found on sites which is related to his trade; and
- Lead by good examples in all aspects of HSE practices throughout the subcontractor works.

5.14.2.2. OESMP

During the operational phase, it is envisaged that the key objectives of the operation and maintenance will be as follows:

- To integrate a complete O&M team within the operating company for O&M activities, including supervision of the converter, cable and barge LTSA's;
- Teams based locally at the onshore converter stations;
- Internal training centre with training equipment and tools;
- Monitoring and return of experience during the 35 years operation by the operating company;
- Respecting international standards, TRANSCO and ADNOC standards, HSEQ requirements
- Fully based on OEM operation and maintenance manuals; and
- Spare parts management, on-site.

Operational staff and maintenance staff are set out in an overall staff organizational chart shown in Figure 5-239 below.

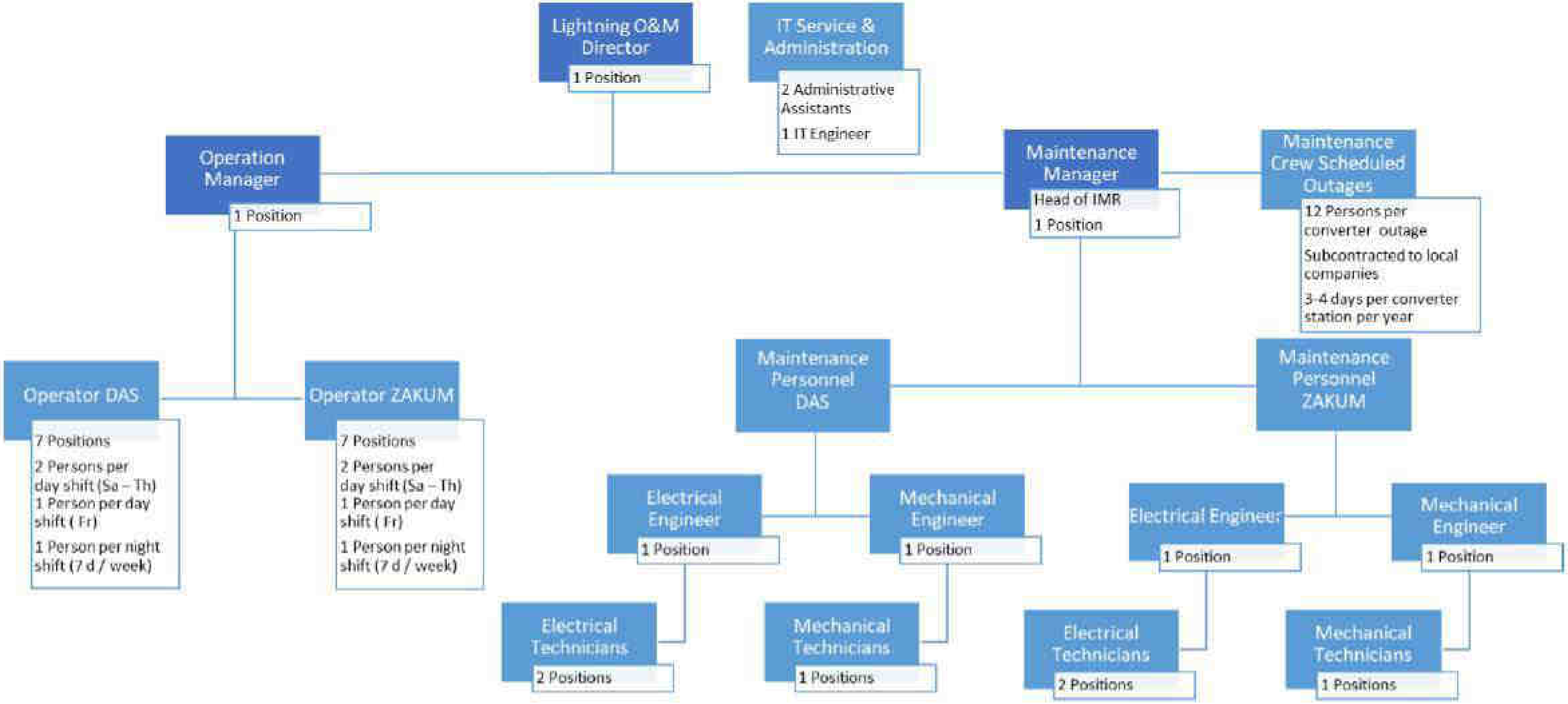


Figure 5-239: O&M Staff organizational chart

5.14.3. Training and Competence

5.14.3.1. Overview

Environmental training is essential for executing construction work in an environmentally sound fashion during the construction phase of the Project. This Environmental Management System Procedure covers all aspects of training. It will be administered by the HSE Manager and authorised assistants.

5.14.3.2. Objective

Training and competence are essential to the effective implementation of the EMP. Training and competencies must be defined to reflect competency requirements for designers, managers, engineers and workers. The HSE Manager shall establish the environmental training programme schedule, and shall be responsible for:

- The development of training materials or the oversight of the preparation of such material by a competent person in order to effectively conduct environmental training;
- Development of an environmental training programme;
- The preparation and updating of the schedule for environmental training;
- Carrying out environmental training for site personnel in accordance with this procedure; and
- Training the subcontractor's nominated trainers; and • The collation and retention of training records.

5.14.3.3. Responsibilities

The HSE Manager will establish the Environmental training programme schedule, and will be responsible for:

The development of training materials or the oversight of the preparation of such material by a competent person in order to effectively conduct environmental training;

Development of an environmental training programme;

The preparation and updating of the schedule for environmental training;

Carrying out environmental training for site personnel in accordance with this procedure; and

The collation and retention of training records.

All site personnel shall be responsible for attending and participating in the scheduled training sessions, as applicable. Arrangements should be made which allow the EPC Contractors to identify each individual who has successfully completed environmental training. Those who cannot be identified shall not be allowed to work on site. Raising awareness of environmental risks to employees is an important preventive measure to avoid environmental incident or non-conformity.

Four types of environmental awareness training will be provided on site:

- Site environmental induction;
- Toolbox talks;
- Specific training; and
- Environmental Management Training.

5.14.3.4. Site Environmental and Awareness Induction

Awareness and training is critical to the effective implementation of the EMP and, therefore Site Induction shall be given to any newcomer arriving on site including subcontractor's newcomers. One part of the induction will be dedicated to health, safety and security matters and the second part will deal with environmental awareness issues and will provide essential information regarding environmental protection, including (but not limited to):

- Environmental responsibilities of all employees;
- ECP Contractor's and Operator's Environmental Policy in addition to all applicable ADNOC policies;
- Significant environmental issues;
- Areas of the site including site boundaries;
- Waste types, segregation method and location of waste disposal containers;
- Location of washing areas, refueling stations and maintenance of vehicles, plant and equipment (for construction phase – CEMP);
- Incident management and spill clean-up process;
- Emergency response plans; and
- Reporting process for environmental incidents, etc.

Awareness and training is critical to the effective implementation of the EMP and, therefore, all personnel including site workers, specialist contractors, drivers etc. shall attend an awareness induction prior to starting work in order to gain a better understanding of the environmental issues and associated main mitigation measures related to the construction phase of the Project.

It will be the responsibility of the HSE Manager to ensure that all staff attend this mandatory awareness induction. Induction will include at least an overview of the environmental aspects related to the main activities of the project, emergency measures, incident reporting, and an overview of the main environmental controls set out within this EMP.

The topics addressed in the induction training are set out in Table 5-166 below.

Table 5-166: Awareness induction content

Awareness Induction Content	
Environmental Management Overview	Duty of Care Concept
Waste Management Procedures	Hazardous Substances Management
Working Rules	Incident Reporting Procedure
Emergency Plan	Site Housekeeping
Disciplinary Action	HSE Team Contacts

5.14.3.5. Toolbox Talks

Toolbox talks shall be held on a weekly basis. Additional toolbox talks can be organized after an accident, incident or a near miss. Toolbox talks are to be held by supervisory staff (HSE staff should assist the supervisory staff). Subject shall be relevant to the work, all incidents, near misses, damages are to be discussed. Toolbox talks will provide the knowledge on environmental aspects, impacts and applicable mitigation measures related to the Project specific activities.

Toolbox meetings take place in the team's work area, provided that the environment is suitable (safe location, absence of noise, disturbances, other teams or work nearby, etc.). The duration is about twenty-five minutes long and takes place during working hours, at the (appropriate) time chosen by the supervision (at the beginning of shift or after a break). It should in no case take place during rest times.

Arrangements shall also be made to ensure that, at the start of each week's work, all workers shall participate in a toolbox talk with their supervisor. Records shall be kept for auditing purposes and to include registration of the subjects discussed and attendants. Guidance on how to present the talks shall be prepared by the HSE Manager and issued to those giving the talk.

Tool box talk training is a cost-effective way to provide targeted information on an environmental issue, for example, in relation to a change in procedures, results of an environmental incident investigation, or changes to environmental conditions on site.

5.14.3.6. Specific Training

Specific induction and training will be delivered to supervisors and specific appointed personnel as part of the environmental induction and toolbox talks for individuals with specific roles and responsibilities, including but not limited to:

- Chemical and fuel handling,
- Handling of organic solvents, handling of toxic materials and hazardous wastes etc.

Specialised training designed to address specific environmental requirements shall be required to be provided as necessary and may include but not be limited to:

- Control of Substances Hazardous to Health (COSHH) Risk Assessment
- Accident and Incident investigation
- Emergency preparedness and response
- Spill control and response

5.14.3.6.1. Specialist Training

Specialist environmental training will be required based on specific requirements of each role and must be arranged by the HSE Manager where relevant. For example, emergency response training may be mandatory for staff involved in activities that have higher environmental risks, including the use of emergency response equipment.

5.14.3.6.2. Environmental Training for Managers

Where required, training will be undertaken for the HSE Manager and authorized representatives. All relevant training materials will be prepared by the Environmental Consultant or a designated person. In addition to the contents of the standard Environmental Induction Training, the environmental items set out in Table 5-167 below will be specifically highlighted at the Environmental Training for the HSE Manager.

Table 5-167: Training content for environmental managers and team leaders

Training Content	
Details of Policies (if applicable)	Format and availability of EMP
Organisation and Responsibilities	Necessity of expanding Environmental awareness
Environmental Incident Procedure (terrestrial and marine)	EMP Compliance Procedure
Management Procedures	Complaints Management Procedure

5.14.3.6.3. HSE training for Workers with Hazardous Materials

Specialist training will be given to all personnel assigned to working with hazardous materials. Such training will be delivered by the HSE Manager before commencing works, and on a periodic basis, and will encompass the topics set out in Table 5-168 below.

Table 5-168: Training content for hazardous materials

Training Content	
Chemical and Fuel Handling	Handling and storage of waste materials
Handling and storage of liquids	Emergency response procedures (terrestrial and marine)

A Training Register will be maintained by the HSE Manager in order to record the training attendance by employees, The Training Register will be developed in order to allow the training history of any employee to be checked.

5.14.3.7. Environmental Management Training & Records

Personnel managing and undertaking tasks that may have a significant impact on the environment and employees with a specific authority or responsibility for environmental management will be required to attend to environmental management training.

The environmental management trainings will aim to achieve a level of awareness and competence appropriate to their assigned tasks. These trainings will deal with:

- Emergency Response procedures,
- Accidental spillage and discharges control (terrestrial and marine),
- Dust control,
- Vehicle operation and maintenance,
- Control of groundwater discharges,
- Noise and vibration control,
- Waste management,
- Hazardous substances handling and disposal,
- Storage of building materials,

- Refuelling procedures, etc.

A training attendance sheet will be developed, and must be completed for all training sessions which includes:

- Training module name;
- Date;
- Location;
- Presenter's name (and company if the presenter is not employed by the contractor); and
- Trainee's details: name, company, position and signature.

Finally, a mechanism will be implemented to ensure that employees receiving environmental management training will be given the opportunity to provide feedback on training courses received. This feedback should be facilitated via a training survey questionnaire. This may be included at the end of a training session for all participants or provided to a selection of individuals at the Environmental Training Managers discretion. Survey responses should be compiled and reviewed by the Environmental Training Manager and, where appropriate, commensurate additions or changes made to training material, as necessary.

5.14.4. Communication

Initial communication regarding environmental management will be provided through the training described within the previous section, supplemented where required by internal news updates, the use of notice boards and regular HSE meetings.

5.14.5. Monitoring and Reporting

5.14.5.1. General Monitoring Requirements

5.14.5.1.1. Daily Inspections

A site walkover inspection of the construction site will be conducted and documented on a daily basis by the Environmental Manager or authorized representative with the main purpose of ensuring continued good environmental housekeeping at the site and compliance with the CESMP. The aspects which will be assessed are as follows:

- General housekeeping;
- Terrestrial, intertidal and marine ecology including any sightings of species of conservation concern;
- Soil and water contamination;
- Dust and air quality (visual assessment);
- Waste management;
- Materials management;
- Traffic management;
- Noise generation;
- Run-off water and erosion;
- Stockpiles; and
- Health and safety issues.

5.14.5.1.2. Weekly Inspections

More detailed weekly walkthrough inspections will be undertaken or organised by the Environmental Manager or authorized representative. These inspections will consist of a visual inspection of all work areas and environmentally-related activities in and around the Project sites in order to check compliance with this CESMP and regulatory conditions. As a minimum, inspections should include the following:

- Terrestrial, intertidal and marine ecology including any sightings of species of conservation concern;
- Excessive noise;
- Air quality, including dust generation and noticeable odour;
- Problems with bunded areas or dangerous goods storage areas; and
- Spillage/issues with solid waste (bins) and liquid waste storage areas, and general site cleanliness; and
- Marine water visual check for contamination.

A Weekly Inspection Checklist will be completed during each weekly inspection. These will be documented, reviewed and retained on-site.

5.14.5.2. Reporting Requirements

Environmental reporting and data management are one of the important parts in the implementation of EMP ensuring that the required information is properly communicated to the concerned party or authority.

5.14.5.2.1. External Communication and Reporting

The HSE Manager and/or Project Environmental Representative will liaise with the Engineer/Employer's Representative concerning environmental issues. The HSE Manager and/or Project Environmental Representative will be the point of contact for discussing any changes to the scope of works, project boundary limits, reporting of incidents, non-conformances, and other environmental issues.

Non-conformance reported by the Engineer/Employer's Representative will be submitted and discuss by HSE Manager and/or Project Environmental Representative to the responsible Project Management for rectification and for closeout. The HSE Manager and/or Project Environmental Representative will also prepare and issue a monthly environmental report or progress to the Employer.

5.14.5.2.2. Incident Reporting

In the event of an environmental incident resulting from the activities performed by the work team, the HSE Manager and Project Manager will be notified and updated. The HSE Manager will then conduct initial investigation and will be reported using Incident Notification Report. All environmental incidents will be reported to the Engineer/ Employer's representative.

5.14.5.2.3. Quarterly Environmental Reporting

Summary of environmental management and monitoring will be compiled on a quarterly basis to be prepared by an Environmental Representative and shall be reported to the Main Contractor of their respective development.

The quarterly environmental report form shall consist of the following information:

- Summary of the construction activities;
- Induction and Toolbox Talks conducted;
- Monitoring result (i.e. noise, discharge. Air and water Quality);

- Waste disposal summary;
- Resources consumption;
- Accidents, incident, near misses and complaints;
- Summary of best management practices on site;
- Audits; and
- Coordination Meetings.

Accurate records relating to chemicals and hazardous materials shall be undertaken regularly or when a new chemical or hazardous material is required. The following information shall be kept up to date for each chemical and hazardous material used on site:

- Material Safety Data Sheets (MSDS);
- Quantity in store;
- Quantity used per month; and
- Responsibility details (e.g. Responsible Engineer).

Such information shall be made available to Emergency crews in case of an emergency event or accident.

A document must be created to establish a chain-of-custody using multiple signed copies to show that all hazardous materials were transported and received by the disposal facility in the correct manner (such as intact, non-leaking labelled containers, licensed transporter, correct handling.

5.14.5.3. CESMP Monitoring and Reporting

This section sets out the specific environmental monitoring and reporting which will be undertaken as a minimum during the construction phase of the Project by the EPC Contractor.

5.14.5.3.1. Air Quality

Introduction

This section provides a framework for key monitoring measures which will be implemented as part of the CESMP to control impacts upon air quality.

Monitoring Requirements

Daily Visual Inspections

At a minimum, visual monitoring should be undertaken by the HSE Manager or nominated representative, to include daily visual inspection of dust. The inspection will focus specifically on dust arising from construction activities or construction related transport activities. Stockpiles of loose material during trenching and earthwork activities should be covered and haul roads should be wetted down (under adverse weather conditions). Observations will also be made of meteorological conditions, primarily high-speed winds, which may impede fugitive dust deposition.

Each of the Project sites (Mirfa, Shuweihat, Das Island and Al Ghallan Island) will be rated according to the categories set out in Table 5-169 below.

Table 5-169: Dust class category

Aspect	Dust Category
Class 1	No visible dust
Class 2	Dust just visible
Class 3	Dust easily visible
Class 4	Very dusty

Where issues are identified, corrective action must be undertaken including amending working procedures, using wetting down or other dust suppression techniques or delaying particular activities until less windy conditions prevail.

In addition, a visual inspection for black smoke emissions and proper machine maintenance should be carried out by the EPC Contractor. Any equipment emitting significant black smoke should be shut down and serviced immediately.

Monitoring of complaints from nearby residential properties will also be ensured.

The onsite EPC Contractor manager/foreman will be responsible for carrying out daily visual inspections as per the inspection sheet which will be provided within the CESMP and utilised to record the details of any issues relating to air pollution.

Where sensitive receptors are located within 350m of construction activities, a dedicated air quality monitoring program will be developed as part of the CESMP for ensuing that air quality at nearby receptors is acceptable.

5.14.5.3.2. Marine Water

Introduction

This section provides a framework for key monitoring measures which will be implemented as part of the CESMP to control impacts upon marine water.

Monitoring Requirements

In situ Measurements

During the marine construction period, in-situ water quality monitoring shall be conducted by the EPC Contractor to determine any impacts related to construction activities. Seawater characteristics will be measured at seven locations daily using a multi-parameter probe, or other suitable equipment, to investigate the following parameters:

- Salinity (ppt) & temperature (°C);
- DO (mg/l and %);
- pH;
- Specific conductivity (mS/cm3);
- TDS (g/l);
- Turbidity (NTU);
- Chlorophyll a (µg/l); and,

- TSS (mg/l).

Concentrations of TSS can be calculated if required (either by the probe or otherwise) with measurements calibrated against ex-situ samples analysed at a laboratory.

Measurements will be taken at midwater and at locations 50, 150 and 300 m away from the source of plume in both upstream and downstream corridor and testing will also be conducted 500 m away from the plume source taken as reference data. This activity is to provide an overview of water column characteristics

Ex situ Analysis

Due to the potential for Project-related activities to accidentally release contaminants into the marine environment during construction period, and for purposes of verifying / calibrating the in-situ analysis (TSS), it is recommended that ex-situ analysis be conducted and analysed at an accredited laboratory (Table 5-30). Samples are to be taken monthly at four locations with source of plume at the centre and sampling points 50 m away. Samples during marine dredging activities will be tested for parameters detailed in Table 5-30.

Monitoring shall commence one week prior to the commencement of marine construction works.

Sediment quality tests shall be carried out using Van Veen grab at the same location as water quality sampling. The point of sampling will be at the trench line before and after backfilling with a sampling interval of 500 meters It is recommended that sediment monitoring will be confined to pre-construction and immediately after post-construction period of all marine based construction activity (trenching). The sediment tests should be tested by an ENAS accredited laboratory and include the parameters presented in Table 5-31.

Summary

A summary of the monitoring program to be implemented during construction is provided in Table 5-170 below.

Table 5-170: Monitoring program for marine water and sediment during construction

Impact	Phase	Monitoring Activity	Frequency and Location	Responsible Party
Water	Construction	In-situ Water Sampling	Daily at seven locations: – three locations 100m, 300m and 500m upstream from dredging activities – three locations 100m, 300m and 500m downstream from dredging activities – One reference point location at a location 1 km away from dredging activities	EPC Contractor
		Continuous In-situ Water Sampling	– Continuous monitoring buoys to be deployed at three locations (two on either side of the route and one at reference point) in sensitive habitats within 500m of dredging activities (both Route 1 and Route 2). Buoys will continuously monitor TSS, temperature and salinity. The buoys will include full telemetry set-up with exposure thresholds set to trigger alarms. Minor threshold exceedances will require a slowing of works or for the environmental team to check the status of the implemented mitigation measures (e.g. silt curtains). In the event that moderate or high threshold criteria are exceeded, all works should be ceased immediately.	EPC Contractor

Impact	Phase	Monitoring Activity	Frequency and Location	Responsible Party
		Ex-situ Water Analysis	– During construction, four water samples will be taken at midwater level, 50 meters at four points around the vessel or marine works machine on a monthly basis for the duration of the construction work; – Pre and post trenching with interval of 500 meters at floatation dredged channels and every five kilometres along the cable route outside of the floatation channels	EPC Contractor
Sediment	Construction	Sediment Sample Analysis	– Pre and post trenching with interval of 500 meters at floatation dredged channels and every five kilometres along the cable route outside of the floatation channels	EPC Contractor

5.14.5.3.3. Waste Management

Introduction

This section provides a framework for key monitoring measures which will be implemented as part of the CESMP to control impacts related to waste management.

Monitoring Requirements

The EPC Contractor will be responsible for the ongoing monitoring of all waste streams, including records of types and volumes of wastes produced, transported and sent for treatment/disposal. The following monitoring and auditing measures will be implemented throughout the construction phase to ensure that any potential impacts relating to waste generated by the Project are minimised and mitigated as far as possible:

- Records of raw material wastage;
- Quantitative records for the generation of each waste stream;
- Methods by which the waste streams are being handled and stored;
- Quantifying the wastes diverted from landfill, with records for each treatment method;
- Monthly collation of waste consignment data and receipt at waste treatment/disposal facilities;
- Review of all waste permits;
- Records of any waste complaints or incidents; and
- Review of effectiveness of waste management programme procedures and update as necessary.

5.14.5.3.4. Geology, Seismicity, Soil and Groundwater

Introduction

This section provides a framework for key monitoring measures which will be implemented as part of the CESMP to control impacts upon soil and groundwater.

Monitoring Requirements

Dewatering

The EPC Contractor will be responsible for the ongoing monitoring of dewatering effluent discharges. Appropriate NOCs must be obtained prior to any dewatering effluent discharge into the marine environment. If authorisation and permits are granted by EAD for the discharge of the dewatering effluent into surface water network, it is expected that the EPC Contractor will need to implement a monitoring and reporting programme in order to ensure compliance with the permit. The following methodology will apply for the testing of groundwater effluent discharges:

- An appropriately accredited laboratory will be engaged by the EPC Contractor to conduct the water quality sampling and testing;
- Samples of groundwater will be tested prior to the commencement of dewatering operations against the relevant standards;
- Samples from the dewatering settling tank will then be tested against the recommended standards on a monthly basis;
- If any pollutant levels exceed the prescribed standards then dewatering will cease entirely, and contaminated dewatering effluent will be:
  - Tankered and transported off site to a sewage treatment plant; or
  - Treated on site to a suitable quality for discharge or re-use.

Hazardous Materials

A visual assessment of the chemical and hazardous material usage areas, delivery areas and store areas should take place on a daily basis involving the following:

- Inspect containers to ensure they are all in good condition with no leaks or signs of corrosion;
- Take immediate action if any spills are seen;
- Make sure all containers are adequately and clearly labelled with all information required;
- Monitor activities on site (such as vehicle and machinery refueling) which have the potential to result in spills and environmental health impacts;
- Check that spill prevention is actively being enforced on site; and
- Check that site personnel wear adequate PPE when working with chemicals and hazardous materials.

Record Keeping

Accurate records relating to chemicals and hazardous materials should be undertaken on a monthly basis or when a new chemical or hazardous material is required. The following information should be kept up to date for each chemical and hazardous material:

- Material Safety Data Sheets (MSDS);
- Quantity in store;
- Quantity used per month; and
- Responsibility Details.

Such information should be made available to Emergency crews in case of an emergency event or accident.

A transportation document must be created to establish a chain-of-custody using multiple signed copies to show that all hazardous materials were transported and received by the disposal facility in the correct manner (such as intact, non-leaking labelled containers, licensed transporter, correct handling).

5.14.5.3.5. Marine Ecology

Introduction

This section provides a framework for key monitoring measures which will be implemented as part of the CESMP to control impacts upon marine water.

Monitoring Requirements

The following monitoring program, detailed in Table 5-171, is recommended for implementation during the construction phase:

Table 5-171: Monitoring program for marine ecology impacts during construction

Impact	Phase	Monitoring Activity and Location	Frequency	Responsible Party
Habitat	Construction	– DDV / ROV inspection of seagrass and coral habitat near trenching activities to ensure siltation is contained. Total of eight locations (four on each side of the trench) at 50m,100m, 150m and 300m from the dredger centerline – Deployment of continuous monitoring buoy at strategic locations along critical habitat areas (refer to Table 5-32 in **Section 5.2**)	Weekly	Contractor
Fish	Construction	– Census (DDV / ROV) conducted to ascertain species composition	Weekly	Contractor
Marine Mammal and Reptiles	Construction	– MMRO personnel on board during construction phase	Daily	Contractor

5.14.5.3.6. Terrestrial Ecology

Introduction

This section provides a framework for key monitoring measures which will be implemented as part of the CESMP to control impacts upon terrestrial ecology.

Monitoring Requirements

During the construction phase a qualified environmental officer should be on site at all times to monitor and record impacts. An environmental incident log will be kept in order to keep a record of these impacts.

Note that a separate monitoring plan will also be required to ensure the establishment of mangroves planted to compensate the loss of individuals from within the Project footprint.

5.14.5.3.7. Noise

Introduction

This section provides a framework for key monitoring measures which will be implemented as part of the CESMP to control impacts resulting from noise emissions associated with the construction phase of the Project.

Monitoring Requirements

Baseline noise measurements should be undertaken at the nearest receptor location off site (boundary of the property located 90m from Project site boundary at Mirfa) to understand the existing noise environment.

Noise monitoring should then be carried out at this receptor and other nearest residential sensitive receptors during critical periods of construction in order to identify non-compliance with UAE and IFC allowable noise limits and identify the need for additional noise control measures.

5.14.5.3.8. Traffic

Introduction

This section provides a framework for key monitoring measures which will be implemented as part of the CESMP to minimise impacts resulting from traffic.

Monitoring Requirements

No specific monitoring is considered to be necessary, and the implementation of selected mitigation measures identified within this ESIA will be sufficient to control any impacts relating to traffic and transportation.

5.14.5.3.9. Socio-economic

Introduction

This section provides a framework for key monitoring measures which will be implemented as part of the CESMP to minimise impacts upon socio-economic sensitive receptors, including residents, commercial businesses and tourism.

Monitoring Requirements

The EPC Contractor will be responsible for ongoing monitoring, as follows:

- A grievance procedure needs to be established for construction workers to ensure that any issues are resolved to the satisfaction of all parties. This will include the following:
  - Clear contact numbers for key construction management staff who can be contacted in the case of complaints, which could be posted on signage near to the site access gates; and
  - A clear workers grievance procedure which involves studying the basis of complaints, identifying corrective actions and communicating the response to the complainant.
- A community complaints procedure will need to be established for local residents and commercial operations. The HSE Manager will maintain an Incident Register. This will log the date of the complaint/incident, provide a brief description of the complaint/incident (with reference to the complaint/incident report) and describe any corrective actions taken. Recording will include the following:
  - Date and time of the complaint;
  - Method by which the complaint was made;
  - Personal details of the complainant;
  - Nature of the complaint;

  - The action to be taken; and
  - Details of the response provided to the complainant

- In addition, the following should also be ensured:
  - Specific monitoring requirements proposed in relation to noise and air quality to ensure that the key nuisance impacts are controlled;
  - A Site Accident Register summarising any injuries or near misses should also be maintained, providing a log of all incidents which occur during a one-month period; and
  - An ongoing record of all training and induction activities undertaken on site will be maintained. Training provisions for each member of staff should be noted, including nature of course, date training was undertaken and an authorisation signature.

All procedures set out above must be in line with Performance Standard 1 (Section 23).

5.14.5.3.10. Archaeology and Cultural Heritage

Introduction

This section provides a framework for key monitoring measures which will be implemented as part of the EMP to control impacts on unknown / buried archaeological artefacts.

Monitoring Requirements

The EPC Contractor will be responsible for the implementation of an archaeological watching brief during ground clearance and earthworks. This watching brief is required generally during site preparation works, or where grading or excavation is expected. Once these ground clearing and earthworks are complete, the watching brief is not considered necessary.

5.14.5.4. OESMP Monitoring

Monitoring and reporting is recommended to be undertaken on the following basis during the operational phase:

5.14.5.4.1. Monthly Site Maintenance and Inspections

Monthly site maintenance and inspections for onshore converter stations at Mirfa and Shuweihat. Monthly maintenance will be based on normal working hours. Normal working hours are 8.30am to 5.30pm and with one hour break. The following will be undertaken at each Project component:

- Converter transformer: visual inspection and recordings;
- Main pumps and motors: Check for noise, leakage and excessive vibration; and
- Diesel generator system: visual inspection and load test.

5.14.5.4.2. Quarterly Site Maintenance and Inspection

Quarterly inspections for the offshore converter stations on Das Island and Al Ghallan Island. The following will be undertaken at each:

- Converter transformer: visual inspection and recordings;
- Main pumps and motors: Check for noise, leakage and excessive vibration; and
- Diesel generator system: visual inspection and load test.

5.14.5.4.3. Six Month Site Maintenance and Inspections

- Main pumps and motors: Visual inspection of bearing grease situation;
- Diesel generator system: Visual inspection and cleaning if necessary;
- Station equipment 110v DC battery system pole 1: Inspection, measure and record. Cleaning if necessary; and
- Station equipment 100V DC battery system pole 2: Inspection, measure and record. Cleaning if necessary.

5.14.5.4.4. Annual Site Maintenance and Inspections

The annual maintenance will be performed each Contract Year for the Term of Agreement. The dates to perform outages are to be confirmed by the Sponsors and the Sponsor is responsible for all the required switching and issue of all the necessary permits for work. The customer should also provide all user privileges for accessing any IT equipment necessary for maintenance.

5.14.5.4.5. Specific Marine Water Monitoring

The potential for impact to the marine environment within the post construction period is relatively low. However, in order to monitor impacts to water quality it is proposed that *ex situ* sampling be conducted twice a year for 1 year (corresponding to summer and winter seasons) to assess the quality of water and sediments within the Project area. Water and Sediment quality sampling shall be conducted at the same location previously sampled during monitoring surveys which is assumed to be along the trench line. Results will be assessed to represent water and sediment quality condition after construction. Parameters to be tested should follow the construction phase monitoring programme.

A summary of the proposed monitoring for marine water and sediment during operation is provided in Table 5-172 below.

Table 5-172: Summary of monitoring for marine water and sediment during operation

Impact	Phase	Monitoring Activity	Frequency and Location	Responsible Party
Water	Operation	Ex-situ Water Analysis	– Twice a year (seasonally) at monitoring locations previously identified during construction (along the trench line)	Operator
Sediment	Operation	Sediment Sample Analysis	– Twice a year (seasonally) at monitoring locations previously identified during construction (along the trench line)	Operator

5.14.5.4.6. Specific Terrestrial Ecology Monitoring

The compensation for the residual loss of habitats and associated species are as follows:

- Repropagation of mangrove trees lost due to the development; and
- Restoration of the mudflats and saltmarshes that may be impacted

The repropagation plan as well as the restoration plan should include monitoring of the repropagation and restoration measures in order to determine the effectiveness of these compensation measures. Success of these compensation measures should be conducted as follows:

A monitoring plan for each of these habitats needs to be developed in order to determine the success of these compensation measures. These monitoring programs should include:

- Fixed point photography of each of these habitats in order to show succession of these habitats; and
- Biannual fauna and flora surveys of these habitats in order to determine the colonization of these habitats by fauna and flora species.

It is likely that at least some management of these compensation measures will be required in order to achieve a successional state that can qualify as compensation for the habitat lost. A management plan with measurable goals (based on the successional state and species diversity of the lost habitats) needs to be developed and implemented for each of the habitats compensated. The monitoring of these habitats should form part of a monitoring – management feedback loop in order to achieve successful compensation.

5.14.5.4.7. Specific Marine Ecology Monitoring

The monitoring program to be implemented during operation to assess the effectiveness of the measures employed to mitigate the impacts on marine ecology as a result of the Project is provided in Table 5-173 below.

Table 5-173: Monitoring program for marine ecology impacts during operation

Impact	Phase	Monitoring Activity and Location	Frequency	Responsible Party
Habitat	Operation	– Video inspection of impacted areas to assess habitat succession rates (15 locations along Route 1 and 5 along Route 2 dredging area)	Twice per year for three years	Operator
Fish	Operation	– Census (DDV / ROV) conducted to ascertain species composition (15 locations along Route 1 and 5 along Route 2 dredging area)	Yearly	Operator
Marine Mammal and Reptiles	Operation	– MMRO survey to ascertain species and population composition.	Twice a year for three years	Operator

5.14.6. Audit and Inspection

Appropriate audit and inspection procedure, which may be delegated to others (for e.g. construction contractors, operators etc.). These would need to be developed and applied during both the construction phase (e.g. through the CESMP) and operational phase (e.g. through the OESMP), if required by the EAD. As a minimum, this should include the following:

- Scope of inspections and frequency;
- Responsibilities for planning and conducting audits and inspections;
- Reporting requirements;
- Non-conformance procedures; and
- Record keeping systems.

5.14.7. Environmental Management and Monitoring Summary

Table 5-174 below provides a summary of environmental management and monitoring, which will be undertaken during construction and operation within all areas associated with the Project site.

Table 5-174: Environmental and monitoring summary during

Monitoring task	Frequency	Responsibility	Reporting
Construction Phase			
– A daily air quality monitoring program should be implemented for the construction phase, as follows: ▪ Daily visual inspection of dust should be conducted. The inspection will focus specifically on dust arising from construction activities or construction related transport activities. Stockpiles of loose material during trenching and earthwork activities should be covered and haul roads should be wetted down (under adverse weather conditions); ▪ Visual inspection for black smoke emissions and proper machine maintenance should be carried out by the approved construction contractor. Equipment emitting significant black smoke should be shut down and serviced immediately; and ▪ Monitoring of complaints from nearby residential properties. – The onsite contractor manager/foreman will be responsible for carrying out daily visual inspections as per the inspection sheet which will be provided within the CESMP and utilised to record the details of any issues relating to air pollution.	Daily	HSE Manager	– Non-Conformance Report
– Where sensitive receptors are located within 350m of construction activities, a dedicated air quality monitoring program will be developed as part of the CESMP for ensuing that air quality at nearby receptors is acceptable.	During key stages of construction, frequency to be determined on a case-by-case basis	HSE Manager / Specialist Consultant	– Air Quality Monitoring Report – Non-Conformance Report (if exceedances recorded)
– MMRO monitoring from construction vessels	Full time	MMRO	– Sightings and collisions – Marine Ecology Monitoring Report

Monitoring task	Frequency	Responsibility	Reporting
– In-situ water sampling at seven locations: ▪ three locations 100m, 300m and 500m upstream from dredging activities ▪ three locations 100m, 300m and 500m downstream from dredging activities ▪ One reference point location at a location 1 km away from dredging activities	Daily	HSE Manager	– Water & Sediment Monitoring Report – Non-Conformance Report (if exceedances recorded)
– Continuous *in-situ* water sampling: ▪ Continuous monitoring buoys to be deployed at three locations (two on either side of the route and one at reference point) in sensitive habitats within 500m of dredging activities (both Route 1 and Route 2). Buoys will continuously monitor TSS, temperature and salinity. The buoys will include full telemetry set-up with exposure thresholds set to trigger alarms. Minor threshold exceedances will require a slowing of works or for the environmental team to check the status of the implemented mitigation measures (e.g. silt curtains). In the event that moderate or high threshold criteria are exceeded, all works should be ceased immediately.	Daily	HSE Manager	– Water & Sediment Monitoring Report – Non-Conformance Report (if exceedances recorded)
– *Ex-situ* water analysis during construction: four water samples will be taken at midwater level, 50 meters at four points around the vessel or marine works machine on a monthly basis for the duration of the construction work	Monthly	HSE Manager	– Water & Sediment Monitoring Report – Non-Conformance Report (if exceedances recorded)
– *Ex-situ* water analysis pre and post trenching with interval of 500 meters at floatation dredged channels and every five kilometres along the cable route outside of the floatation channels	Monthly	HSE Manager	– Water & Sediment Monitoring Report – Non-Conformance Report (if exceedances recorded)

Monitoring task	Frequency	Responsibility	Reporting
– *Ex-situ* sediment analysis pre and post trenching with interval of 500 meters at floatation dredged channels and every five kilometres along the cable route outside of the floatation channels	Monthly	HSE Manager	– Water & Sediment Monitoring Report – Non-Conformance Report (if exceedances recorded)
– DDV / ROV inspection of seagrass and coral habitat near trenching activities to ensure siltation is contained. Total of eight locations (four on each side of the trench) at 50m,100m, 150m and 300m from the dredger centerline – Census (DDV / ROV) conducted to ascertain fish species composition.	Weekly	HSE Manager	– Marine Ecology Monitoring Report
– Baseline noise measurements should be undertaken at the nearest receptor location off site (boundary of the property located 90m from Project site boundary at Mirfa) to understand the existing noise environment. – Noise monitoring should then be carried out at this receptor and other nearest residential sensitive receptors during critical periods of construction in order to identify non-compliance with UAE and IFC allowable noise limits and identify the need for additional noise control measures.	Pre-construction and then during times of critical noise generating construction periods	HSE Manager	– Non-Conformance Report
– Weekly Inspections of Construction Site	Weekly	HSE Manager	– Non-Conformance Report
– Chemicals and Hazardous Materials Visual Inspections	Weekly	HSE Manager	– Non-Conformance Report
– Weekly Inspections of Construction Site	Weekly	HSE Manager	– Weekly Inspection Checklist – Non-Conformance Report
– Waste	Monthly	HSE Manager	– Collation of waste consignment data

Monitoring task	Frequency	Responsibility	Reporting
– Chemicals and Hazardous Materials Inventory	Monthly	HSE Manager	– Up to date MSDS and inventory
– Hazardous Waste	Monthly	HSE Manager	– Collation of chain of custody data
– Worker Welfare	As Required	HSE Manager	– Non-Conformance Report Accident Register – Ongoing Maintenance of Training Records
– Community Complaints	As Required	HSE Manager	– Non-Conformance Report
Operation Phase			
– *Ex-situ* water and sediment analysis at monitoring locations previously identified during construction (along the trench line)	Twice a year (seasonally)	HSE Manager	– Water & Sediment Monitoring Report
– Video inspection of impacted areas to assess habitat succession rates (15 locations along Route 1 and 5 along Route 2 dredging area)	Twice per year for three years	HSE Manager	– Marine Ecology Monitoring Report
– MMRO survey to ascertain marine mammal and reptiles species and population composition	Twice per year for three years	HSE Manager	– Marine Ecology Monitoring Report
– Census (DDV / ROV) conducted to ascertain fish species composition (15 locations along Route 1 and 5 along Route 2 dredging area)	Yearly	HSE Manager	– Marine Ecology Monitoring Report

6. PROJECT ALTERNATIVES

6.1. Introduction

As required by EAD, this section of the ESIA sets out a range of Project alternatives in the form of alternative route and design options which have been considered and assessed in terms of environmental suitability, based on the following criteria, including the following:

- Initial consultations with ADNOC and relevant stakeholders including EAD at the early Project stage;
- The results of terrestrial, intertidal and marine investigations undertaken to inform this ESIA and subsequent identification of critical and environmentally sensitive habitats throughout the Project study area;
- Consideration of existing environmental baseline studies undertaken previously by Fugro for both Route 1 (65) and Route 2 (64);
- Consultations and workshops with JDN, the EPC Contractor responsible for offshore works and cable installations to discuss construction methodologies, constraints and requirements throughout both routes; and
- Discussions with EAD and JDN to enable appropriate route selection in consideration of the information detailed above, in order to minimise impacts upon critical and environmentally sensitive habitats within and adjacent to the footprint of the Project alignment.

To ensure the Project has been correctly chosen, designed and located in order to avoid and minimise any significant impacts, three key questions were considered:

- Do the impacts of the Project construction and operation outweigh the benefits? As a result, **Section 6.2** provides details on the significant positive impacts that the Project will provide in regard to GHG reduction for ADNOC; and
- Is the Project avoiding sensitive areas and using best environmentally and sustainably friendly technology? As a result, **Section 6.3** provides an assessment of alternative locations and technologies and how the Project compares to these locations and technologies.

6.2. No Development Option

If the Project is not developed, none of the terrestrial, intertidal and marine ecological impacts will occur within the Project study area during the Project construction phase. In ecological terms, this can therefore be described as the preferred option. Nevertheless, and as detailed in **Section 5.1.2.3.2**, the installation of the Project will result in a reduction of approximately 30% compared to existing emission levels by negating the requirement for the use of GTGs for power sources for ADNOC's offshore activities. The replacement of the GTGs with electricity generated from a range of more efficient and renewable sources will result in the reduction of greenhouse gas emissions and pollutants.

As detailed in **Section 4.1**, given the substantial focus within the UAE that is placed upon addressing climate change drivers and moving the country towards a greener and more sustainable future, the Project can be considered to provide a significant contribution to this goal, through enabling and facilitating greener electricity sources to be used and creating the opportunity to reduce carbon emissions associated with offshore oil and gas activities. Therefore, the 'no development' option would mean that the identified opportunities for GHG emissions reductions of ADNOC activities would not be realised and that ADNOC GHG abatement initiatives would not be met.

6.3. Alternative Location and Design Option

6.3.1. Mirfa to Al Ghallan Island and Shuweihat to Das Island

The Project objective is to negate the requirement for GTG use in ADNOC offshore facilities at Das Island and Al Ghallan Island, through provision of alternative power sources, namely, electricity from Al Mirfa and Shuweihat Water and Power Complexes onshore, thereby reducing GHG emissions. Therefore, the proposed landfall areas of Mirifa and Shuweihat and the Al Ghallan and Das islands locations for the cable routes are the only viable options to enable supply of power from land to these two islands and consideration of an alternative location is therefore not applicable.

6.3.2. Routes Alignment

6.3.2.1. Route Alignment Selection (Pre-ESIA)

Whilst the main locations cannot be changed as mentioned in the previous subsection, the routes alignment were selected during the early selection process by ADNOC in consultations with a number of stakeholders including EAD. It should be noted that the route alignment selection process occurred before the ESIA process was started and limited information on the historic process is available. Nevertheless, it is understood that the alignments were selected at the time by ADNOC to:

- Avoid EAD critical and sensitive habitats as identified at the time in the EAD Habitat Maps presented in the EAD's Enviroportal Viewer prior the completion of the Project environmental surveys;
- Avoid any archaeological areas;
- Avoid any future projects such as EAD's Project Dalma Sea Cage Aquaculture Project; and
- Avoid existing structures or areas that could cause risk to the cable operation (e.g. continuous dredged channels, anchoring areas etc.).

6.3.2.2. Route Alignment Changes (During ESIA and Prior to Marine Surveys)

Following Anthesis' appointment to prepare this ESIA and in response to the EAD comments on the Mott MacDonald Gap Analysis Report (34) (refer to Table 2-3 in **Section 2.4**), Anthesis noted the requirement to examine the alignments and explore alternative route options to allow the Project to be rerouted to avoid sensitive benthic habitat areas, particularly within the MMBR. This was undertaken to ensure the Project acceptance with EAD, allowing also a limitation of risk of delays for the Project in the instance of EAD rejection on the alignments. As a result, a remote sensing survey was completed via processing aerial imagery to determine sensitive and critical marine habitats near the cable routes as the marine surveys could not occur at the earlier ESIA stage. The purpose of this exercise was to:

- Fully address EAD Comment no.1 on the Mott MacDonald Gap Analysis report;
- Identify possible changes in the nearshore area route to avoid and/or minimise any impacts on sensitive and critical habitats; and
- Address EAD and IFC requirements for analysis of alternatives / selection of least impacting solution.

Following the remote sensing survey results illustrated in Figure 6-1 and Figure 6-2 below, a series of consultations with ADNOC and JDN were held to identify potential re-routing options within the nearshore areas in order to avoid critical and sensitive areas.

The alignment changes occurring as a result of the remote sensing exercise are summarised in the below subsections and further detailed within **Appendix 6.4** which includes a MoM and presentation made to EAD to inform them of these changes.

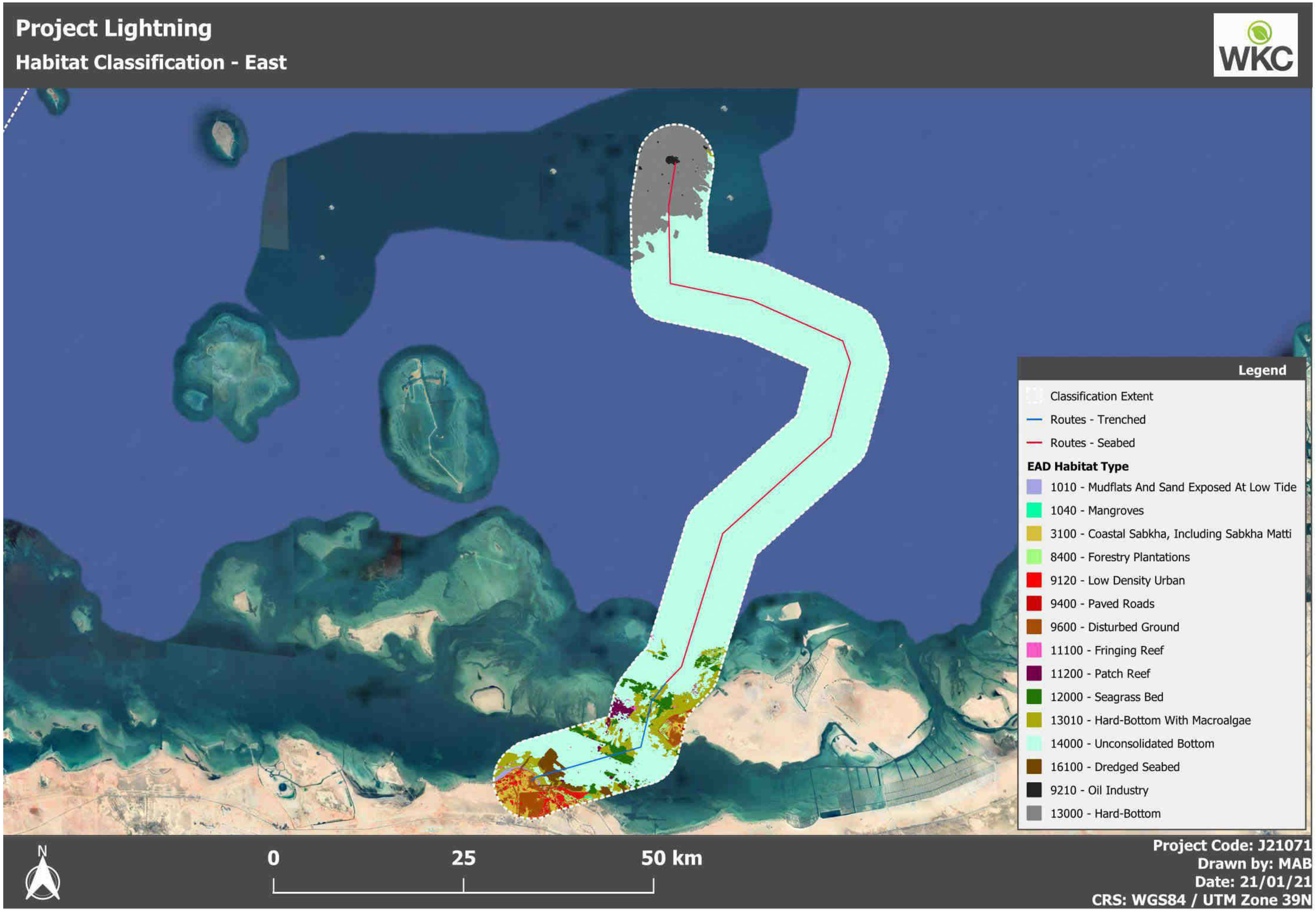


Figure 6-1: **Project habitat classification as per a remote sensing exercise for Route 1**

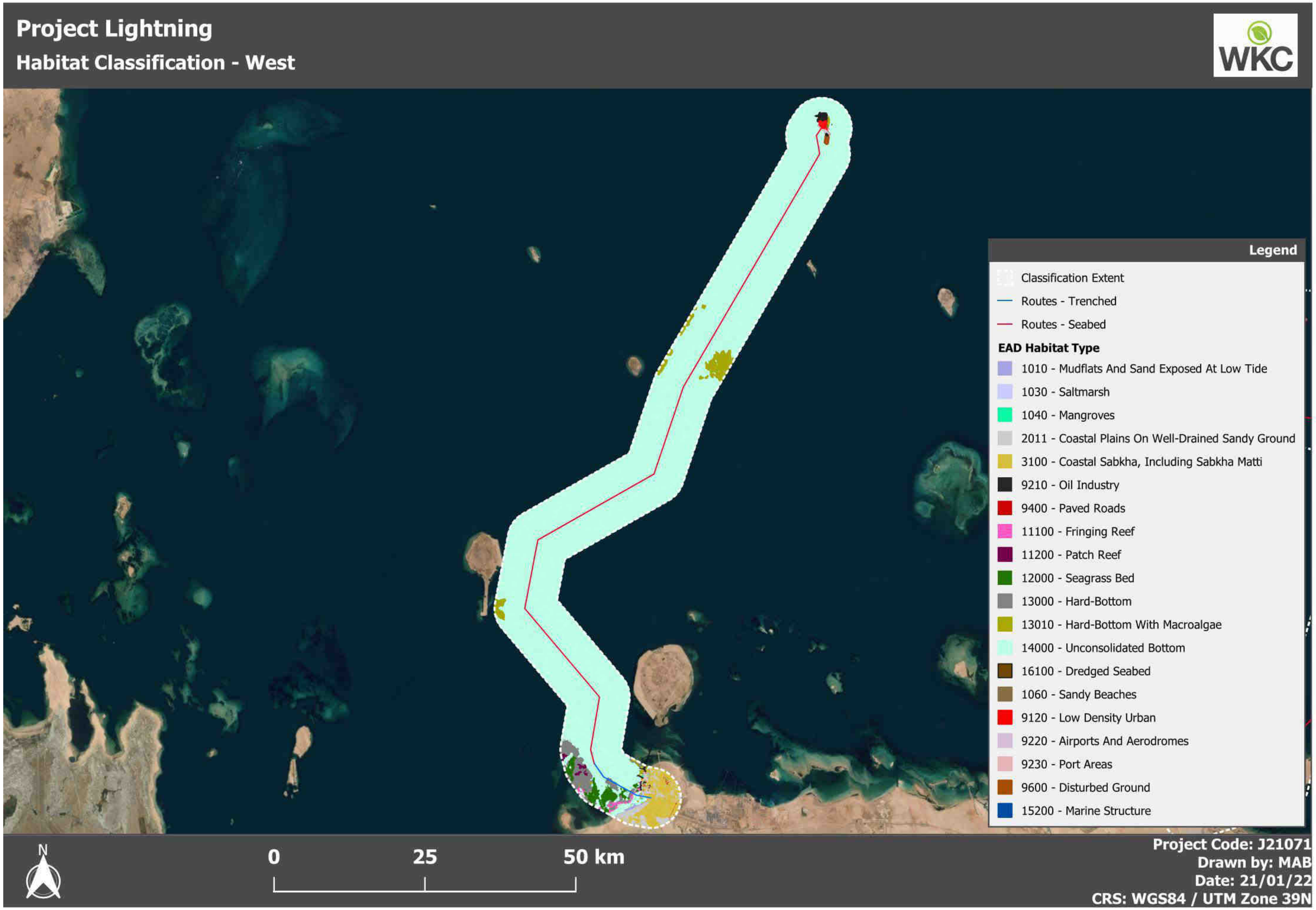


Figure 6-2: Project habitat classification as per a *r*emote sensing exercise for Route 2

Route 1 – Nearshore Areas Re-Routing Options

As a result of the remote sensing exercise, it was identified that the Project cables will cross through two critical habitats: a fringing reef and a patch reef as shown in Figure 6-3 below. These habitats support corals and therefore Anthesis, the developers, the EPC and ADNOC explored various options (refer to Figure 6-4 below) to avoid those areas.

Avoidance of Direct Seagrass and Hard-Bottom with Macroalage Habitat Loss

For this location, the following key constraints were identified:

- Limited surrounding areas without sensitive or critical habitats;
- To limit impacts / alignment within the MMBR;
- Bathymetry: requirement to avoid shallower areas to ensure that no further floatation / dredged channels are required; and
- The Project cables have a maximum provision of cable length which cannot be exceed a certain number.

As a result, an alternative solution was identified which is a diversion of the identified seagrass and hard-bottom with macro-algae habitats which allowed a reduction of direct impacts on these habitats as illustrated in Figure 6-5 and Figure 6-6 below.

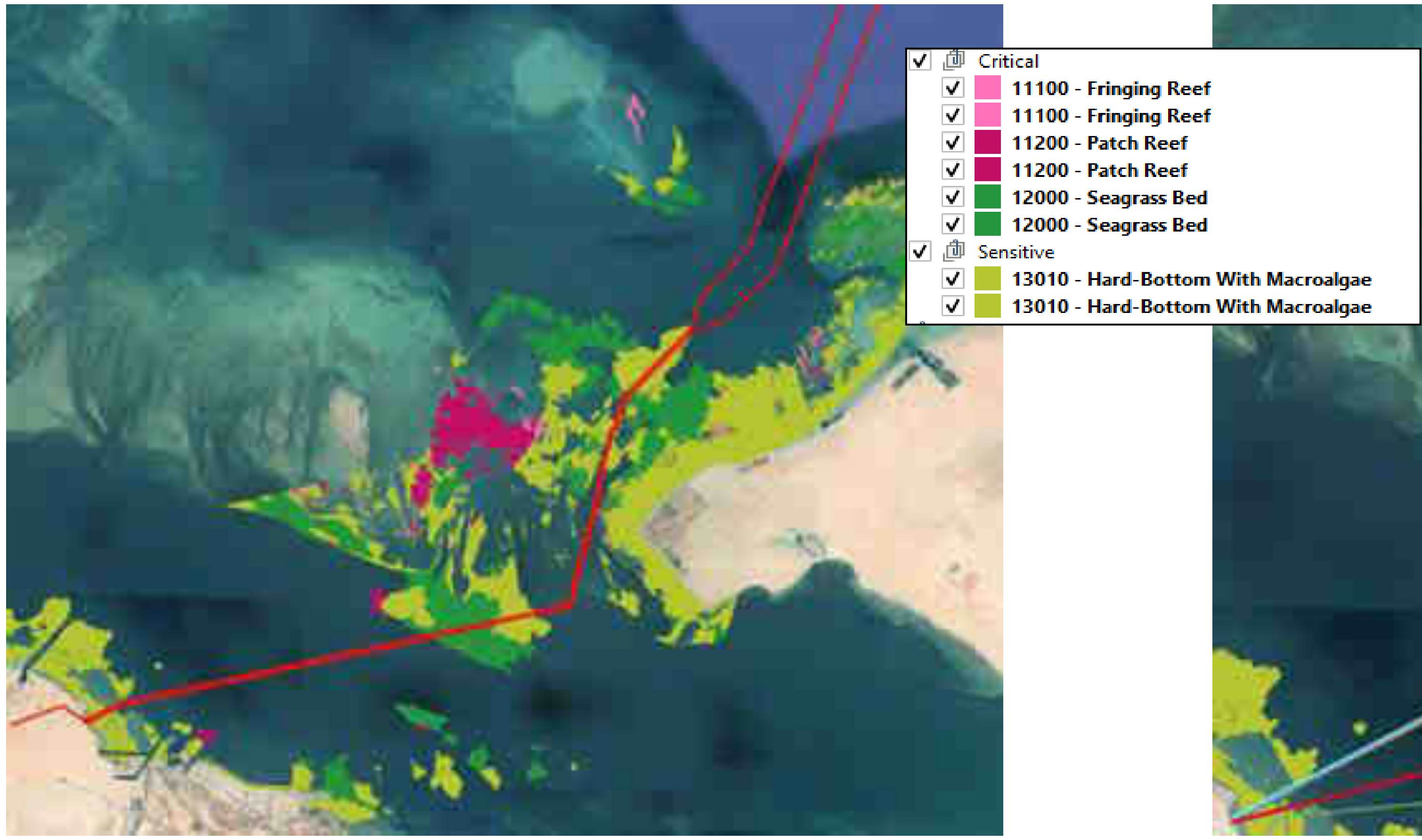


Figure 6-3: Original Route 1 alignment

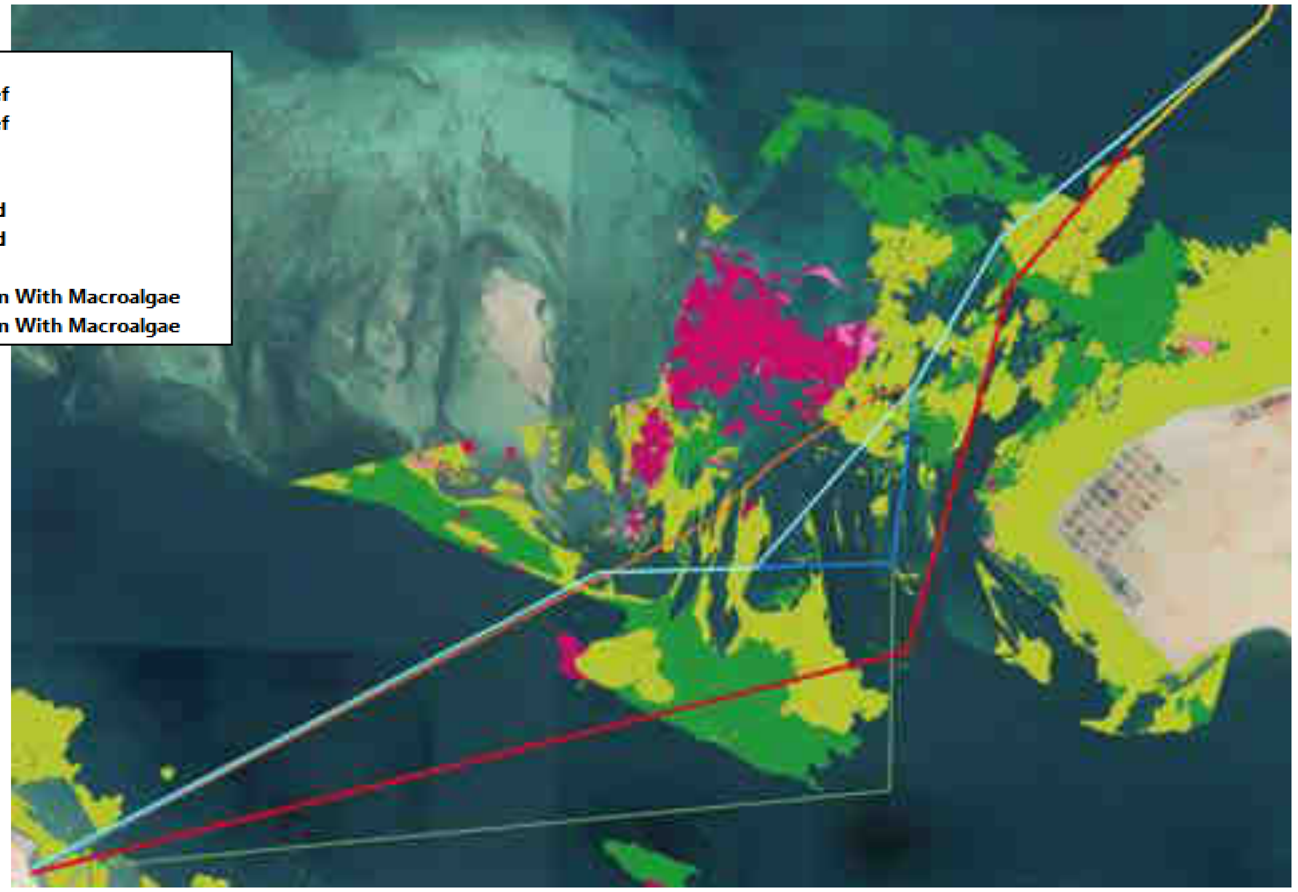


Figure 6-4: Anthesis proposed consideration of alignment changes on Route 1

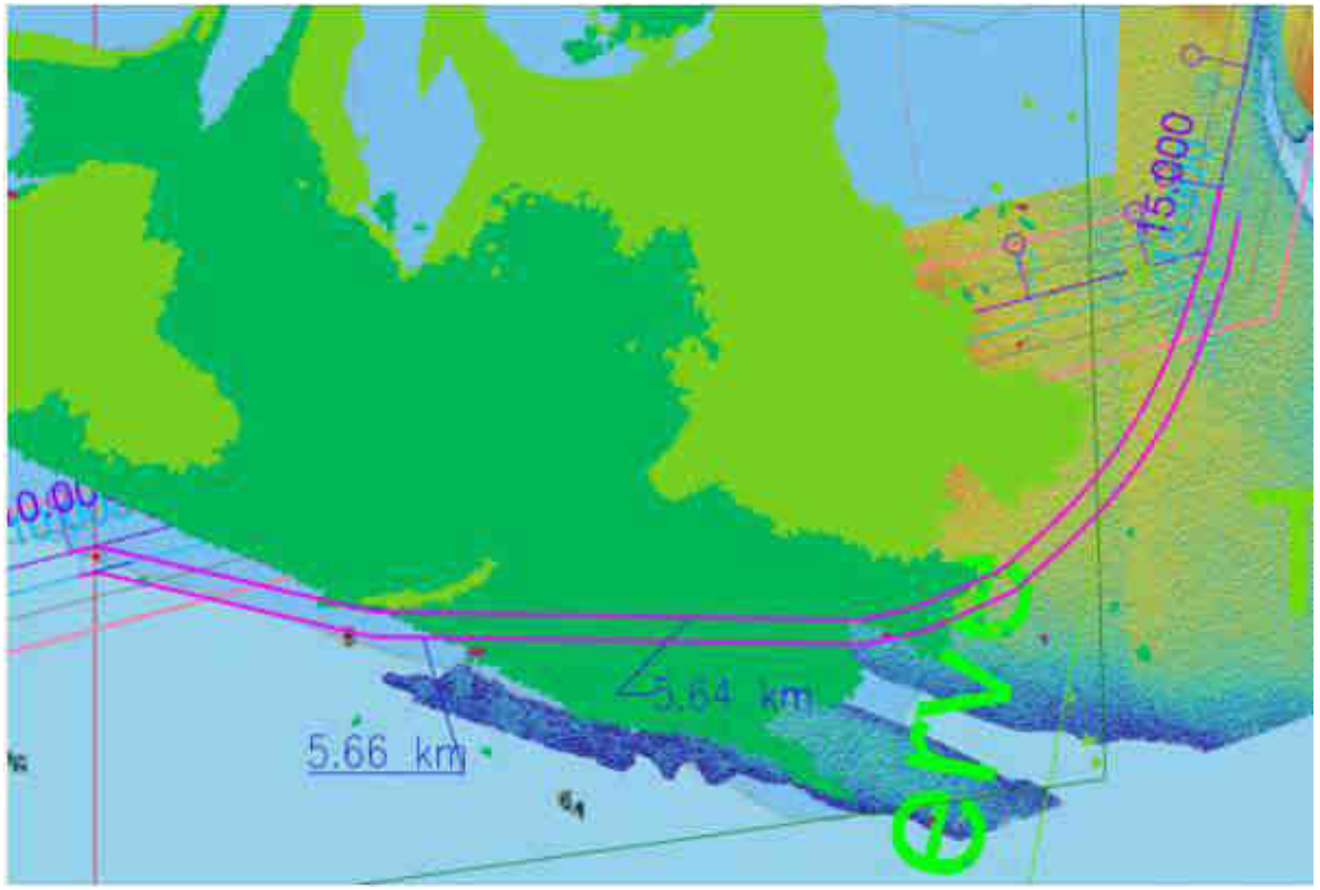


Figure 6-5: Route 1 alignment changes to avoid the seagrass and hard-bottom habitats

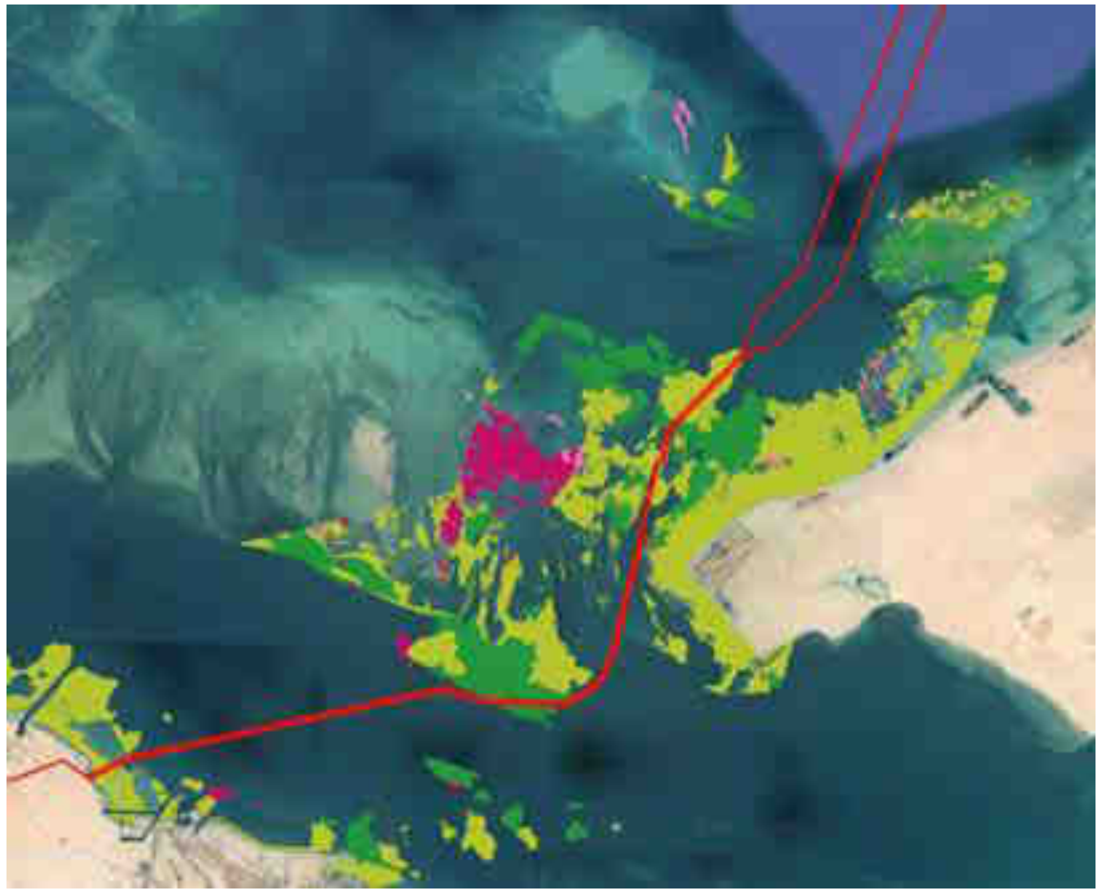


Figure 6-6: Final proposed alignment for Route 1

Route 2 – Nearshore Areas Re-Routing Options

As a result of the remote sensing exercise, it was identified that the Project cables will cross through two critical habitats: a fringing reef and a patch reef as shown in Figure 6-7 below. These habitats supports corals and therefore options were explored (refer to Figure 6-8 below) to avoid those areas.

Avoidance of Direct Coral Reef Patch Habitat Loss

For this location, the following key constraints were identified:

- If the route shifts to the north; the route will fall within anchorage areas which is not feasible due to elevated risk of damage to the cables caused by anchors;
- If the route shifts to the south; the route will cross through shallower areas with nearby seagrass; and
- The Project cables have a maximum provision of cable length which cannot be exceed.

As a result, an alternative solution was identified which is a local diversion of the identified Patch Coral Reef with its closest point located approximately 120m away from Cable 2B as illustrated in Figure 6-9 and Figure 6-10 below.

Figure 6-7: Original Route 2 alignment

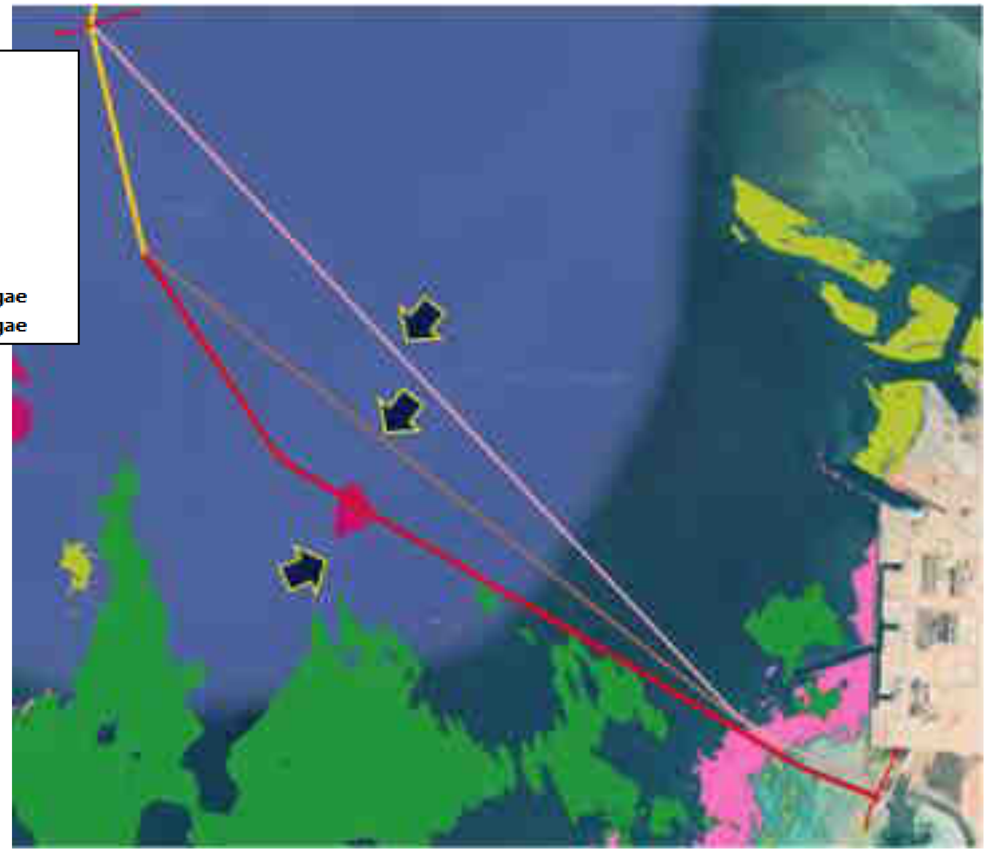


Figure 6-8: Anthesis proposed consideration of alignment changes on Route 2

Figure 6-9: Route 2 alignment changes to avoid the patch reef area and the Mugharraq anchorage areas

Figure 6-10: Final proposed alignment for Route 2

Avoidance of Direct Fringing Reef Patch Habitat Loss

In regard to the fringing reef, a number of alternative considerations were made to attempt to minimise and reduce the impacts on this habitat. This is presented below and this is also detailed within our Comment Response Sheet submitted to EAD submitted on the 28th April 2022 (**Appendix 6.8**) following EAD request to further explore solutions. It was however concluded that no feasible alternative to the current route is possible and therefore no route changes could be implemented.

<u>Option 1: Avoidance of Direct Impacts Through the Use of an HDD Method</u>

Initially, the possibility of utilising the HDD method was suggested by EAD. However, the HDD was not considered feasible for this section of the alignment for the following reasons:

- Construction constraints:
  - The HDD would start in the offshore area and end in intertidal area, creating a very challenging environment for HDD drilling. Additionally, HDD of more than 1km are considered to be pioneering and cannot be considered a proven technology in the industry. Above this length, HDD are considered to be increasingly risky when it comes to collapsing risk or subsoil outburst/spills in underground ‘channels’. If this happens, it would be difficult to finish the HDD work and it may need to be restarted as the drill could experience failures and difficult recoveries. If the HDD requires to be restarted, in addition to significant impacts on the Project schedule and cost, this would cause additional impacts on the marine environment as the construction period will significantly increase in the area causing further underwater noise, sedimentation impacts etc. from the HDD activity. As such, this is not considered acceptable as execution methodology for such a critical project;
  - Considering the long HDD length (>1km), it will be required to sustain a large pressure of the drilling fluid. The larger the pressure, the larger the chance of frac-out of the drilling fluid into the above laying ocean as illustrated in Figure 6-11below. Drilling deeper would mitigate this risk but would increase the ampacity problem;

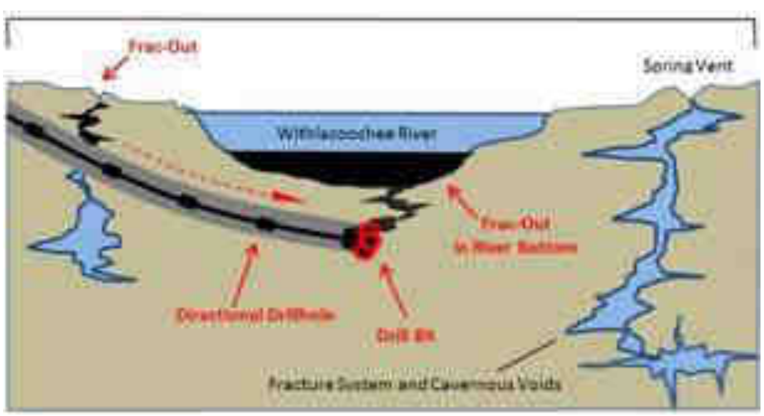


Figure 6-11: Illustration of frac-out

  - In terms of environmental impacts from HDD, it should also be noted that HDD will include a spill of bentonite (drilling mud) when punching out with the drill head (at the end of the HDD section) which will cause sedimentation impacts on the marine environment. The higher the difference between levels on both sides of the HDD, the bigger the spill will be (communicating barrels).
- Operation & Maintenance constraints:
  - In case there is a failure of the cable inside the HDD during its lifetime, a repair will not be possible as the duct will not be replaceable due to corrosion (if steel conduit is used) or grouting, in the case of HDPE. Therefore, a new HDD and a new section of cable inside would be required to perform the repair adding potentially significant environmental impacts to the area during the operation phase. This may take several

months to implement a repair as mobilisation of a drill rig and conduit would be required. Without such HDD, a repair is easier, as the cable is easier to reach, and only the actual damaged section needs to be accessed instead of replacing the whole HDD section;

- The additional burial depth of the cable within an HDD may be thermally limiting in certain portions of the cable, which as a consequence may have an impact on the ability of a cable to carry its rated capacity. If the cable rating cannot be achieved, this will have a long-term impact on the economic performance of the project. For such long HDD (>1km), the cable will probably be installed at a depth of 10 to 20m deep (to avoid frac-out during drilling process) instead of only 1m deep when installed in a trench. The cable size is expected to change due to installation depth that comes along with this type of installation. The deeper a cable is installed, the more difficult it is for the cable to dissipate its heat and at a certain depth, it is simply not possible to achieve.

As the use of HDD for this Project and this section is not considered feasible, the impacts on the fringing reef cannot be avoided and the ESIA therefore has provided recommendations to ensure the following:

- Compensation measures to corals that will be directly impacted: the corals will be relocated near the Project site and additional measures will be studied to provide a biodiversity net gain;
- Mitigation measures to corals that will be indirectly impacted from sedimentation impacts: silt screen curtains will be installed near sensitive identified areas following the results of the ESIA marine surveys and modelling study;
- Monitoring measures to relocated corals: the relocated corals will be monitored after their relocation to ensure the success of the relocation work; and
- Monitoring measures near critical and sensitive areas impacted from indirect impact: monitoring of the water quality near the construction activities via on-site sampling monitoring and via the deployment of buoys measuring in real-time water quality parameters (eg. Turbidity).

<u>Option 2: Avoidance of Direct Impacts by Placing the Cables in Natural Gaps or Corridors in the Fringing Reef Habitat</u>

EAD also requested to explore if any natural gaps or corridors exist in order to enable the cable route to pass through the area without any direct impact upon critical habitats. Initial indications at this stage relied on fringing reef habitat maps generated following the nearshore surveys undertaken by WKC.

Overall, WKC survey results indicated that the fringing reef is an old reef developed by coral species several years back. Nevertheless, massive mortality has occurred within the corals and whilst the cause of mortality cannot be determined, it might be associated with coral bleaching. The survey also shown that some young coral colonies were forming but were sparse in its density and distribution. The age of these young coral colonies found are estimated to be 2-3 years old. Coral Reef as described in EAD classification (11000) ‘*’Areas characterized by a substrate or environment setting largely constructed by the reef building activities of corals and associated organism’’*, therefore the study area is still considered as critical habitat.

As a result, and following EAD comment, a number of options were studied between all parties and are detailed below:

Option 2A – Cables placed within natural fringing reef gaps

As illustrated in Figure 6-12, potential ‘options’ of corridors were identified by the environmental consultants (Anthesis & WKC) and submitted to the EPC to identify the feasibility of these options. It should be noted that the options all presented generally small gaps ranging from a minimum of 17m width to 50m width.

Figure 6-12: Update fringing reef habitat map and re-route considerations for Route 2

This option was analysed by the EPC and found as not viable technically for a number of reasons which are detailed in the below paragraphs.

The EPC anticipates to float-out the cable from the cable lay vessel Isaac Newton towards the mainland. In this method, the stand-off position of the vessel would be around 2.5km before the shoreline. The cable is over boarded by pulling it over the chute by a winch that is positioned onshore. The cable is provided with buoys to make it float. Then the buoys are removed and the cable is sunk into its trench. See below example pictures with the cable floating (left) and submerged in its trench (right).

Figure 6-13: Examples of shore approaches by float-out method

This method does not require a cable lay vessel or cable lay barge to go through the shallow area to lay the actual cable, and as a result avoids the dredging of a floatation channel through the fringing reef. Avoiding this remains the main objective as dredging such a floatation / dredged channel would have much more significant impacts than the trenches of the cables alone. Nevertheless, this method also has his limitations as follows:

- Floating length must be limited to avoid high pulling tensions and weather/current impacts increasing the risk to the product during this already critical operation;
- Since current cable design does not allow for high cable tensions, any increase in pull in lengths may result in cable design changes resulting in significant project impacts; and
- The methodology can only be operated during very good weather windows. A longer cable floating length also implies a longer required good weather windows.

Therefore, in order to avoid having to use a floatation channel for a cable lay barge (such as with Route 1), it is unfortunately not possible to lay the cable in between patches of the reef from an operational point of view.

Furthermore, many of the proposed optional routes would exceed the maximum length of 3km for the floating of the cable as the cable lay vessel's draught does not allow it to position more to the south-west of the current cable route.

Finally, the optional landing points will need to join back to the onshore project location. Some of these options exceed the limits for cable installation/operation and convertor station parameters design. It is therefore not possible to have cables up to this length.

Option 2B – Re-routing to the South of Shuweihat

This option considers re-routing the cables further to the south where (as per EAD map) there is a 500m gap within the fringing reef – refer to Figure 6-14 and Figure 6-15 for illustration. However, this re-routing would include an addition of approximately 11.2km (+1.5km offshore and 12km onshore). This option is not feasible nor considered as a good environmental alternative for the following reasons:

- Technically not feasible: this option exceeds the limits for cable installation/operation and convertor station parameters design. It is therefore not possible to have cables up to this length;
- Environmentally not recommended: if technically this option was feasible, this would have caused additional environmental impacts in undisturbed areas as the detour will add an extra 11.2km of route (+1.5km of impacts in the offshore area and +12km on the onshore area). Whilst the route would not cross onto the fringing reef with this option, it is expected that the proposed route located near the Mugharraq Port Limits and Shuweihat Power Complex is generally more disturbed by the nearby port activities rather than the 9km south route option where habitats are most likely thriving as shown by the large patch of seagrass in the EAD map as illustrated in Figure 6-14.

Option 2C - Re-routing to the north of Shuweihat

Anthesis queried possible options further to the north of the Project as illustrated in Figure 6-16 below. ADNOC confirmed that these options are not viable as the cables are required to be outside Mugharraq Port limits and anchoring areas.

Additionally, the EPC mentioned the following expected construction constraints:

- Landing approach is between the Shuweihat Power Plant water intake and outfall and therefore the buried cables will require to cross the connection between intake and outfall; and
- The subsea and onshore cables arrive in developed/industrial area and therefore the chance on obstructions and existing utilities is much larger than on contractual landing area.

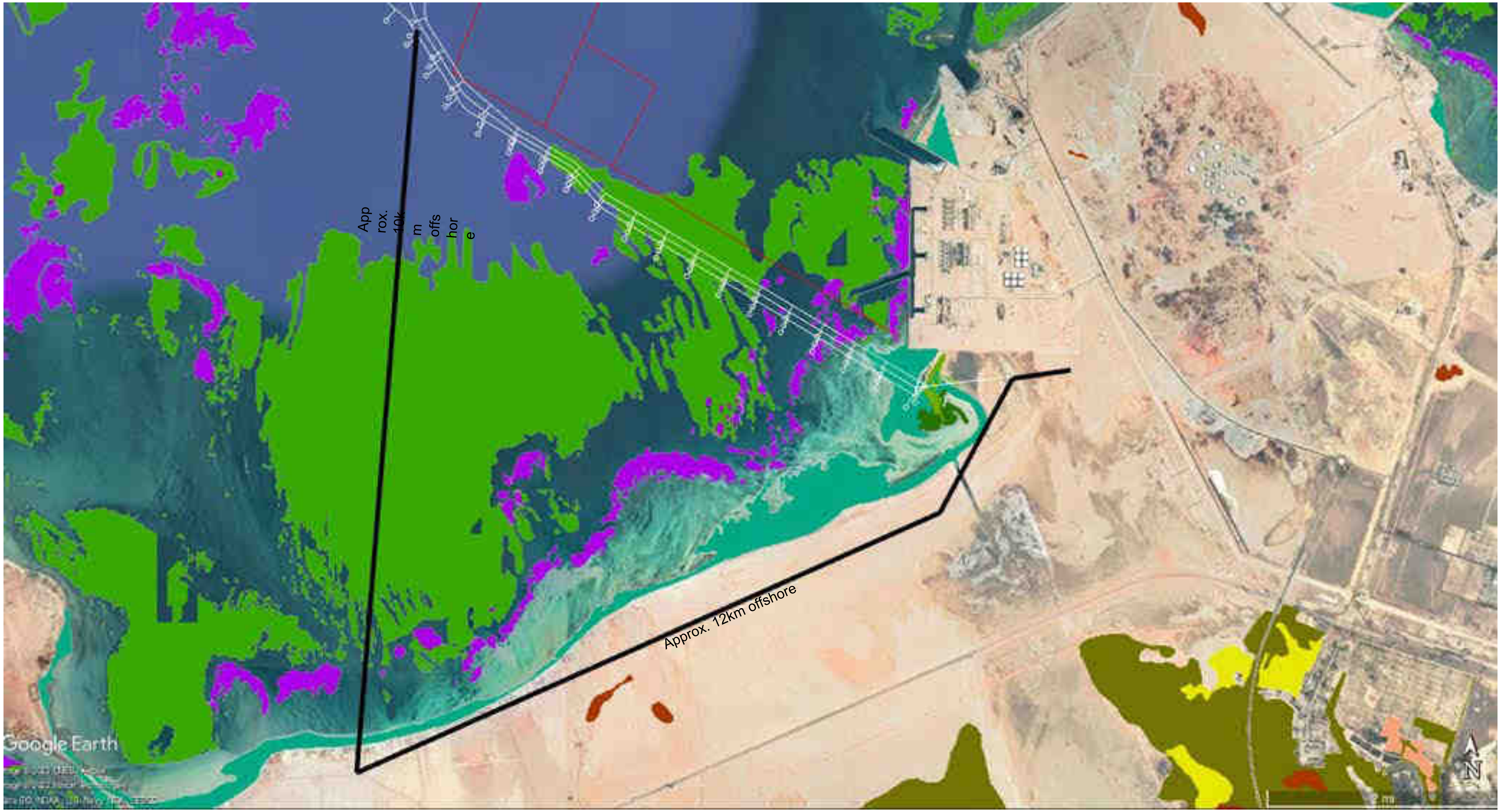


Figure 6-14: Proposed southern reroute option (black line) for Route 2 in relation to sensitive and critical habitats extracted from EAD Habitat Map (Enviroportal data)

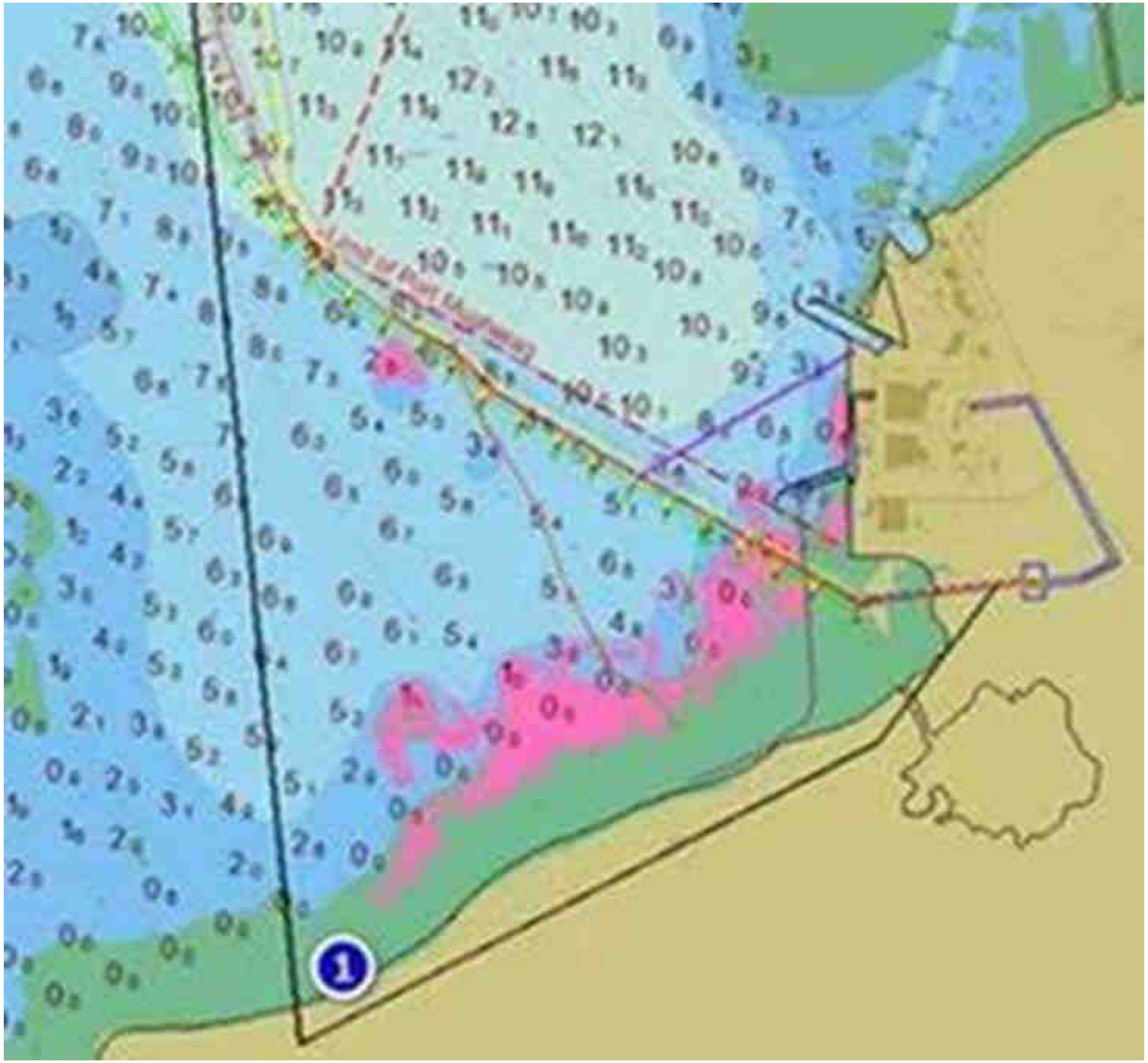


Figure 6-15: Proposed southern reroute option (black line) for Route 2 in relation to depth and identified coral patch (pink area) as per WKC survey)

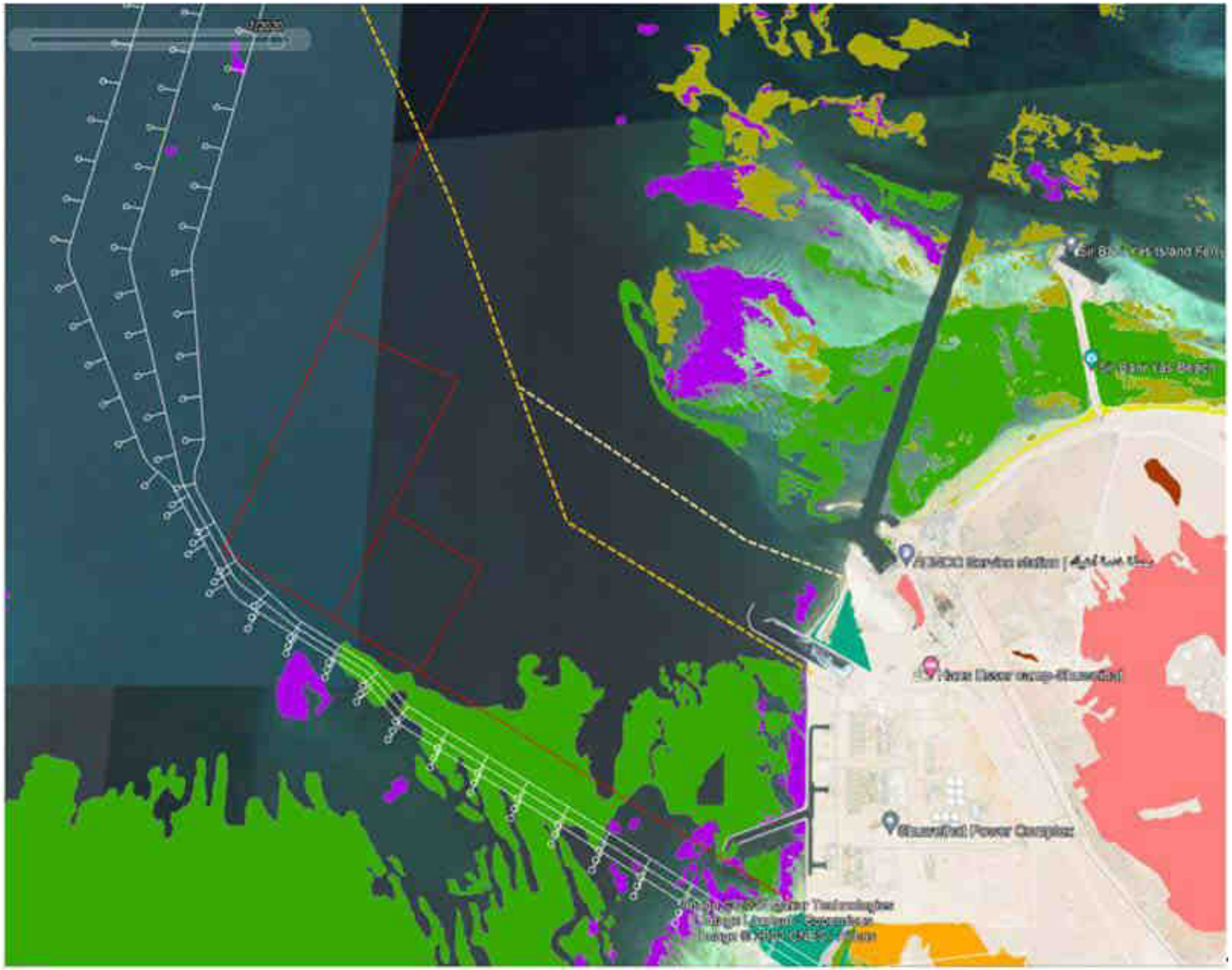


Figure 6-16: Proposed Project and options (yellow lines) falling into Mugharraq Port Limits and anchoring areas in relation to sensitive and critical habitats extracted from EAD Habitat Map (Enviroportal data)

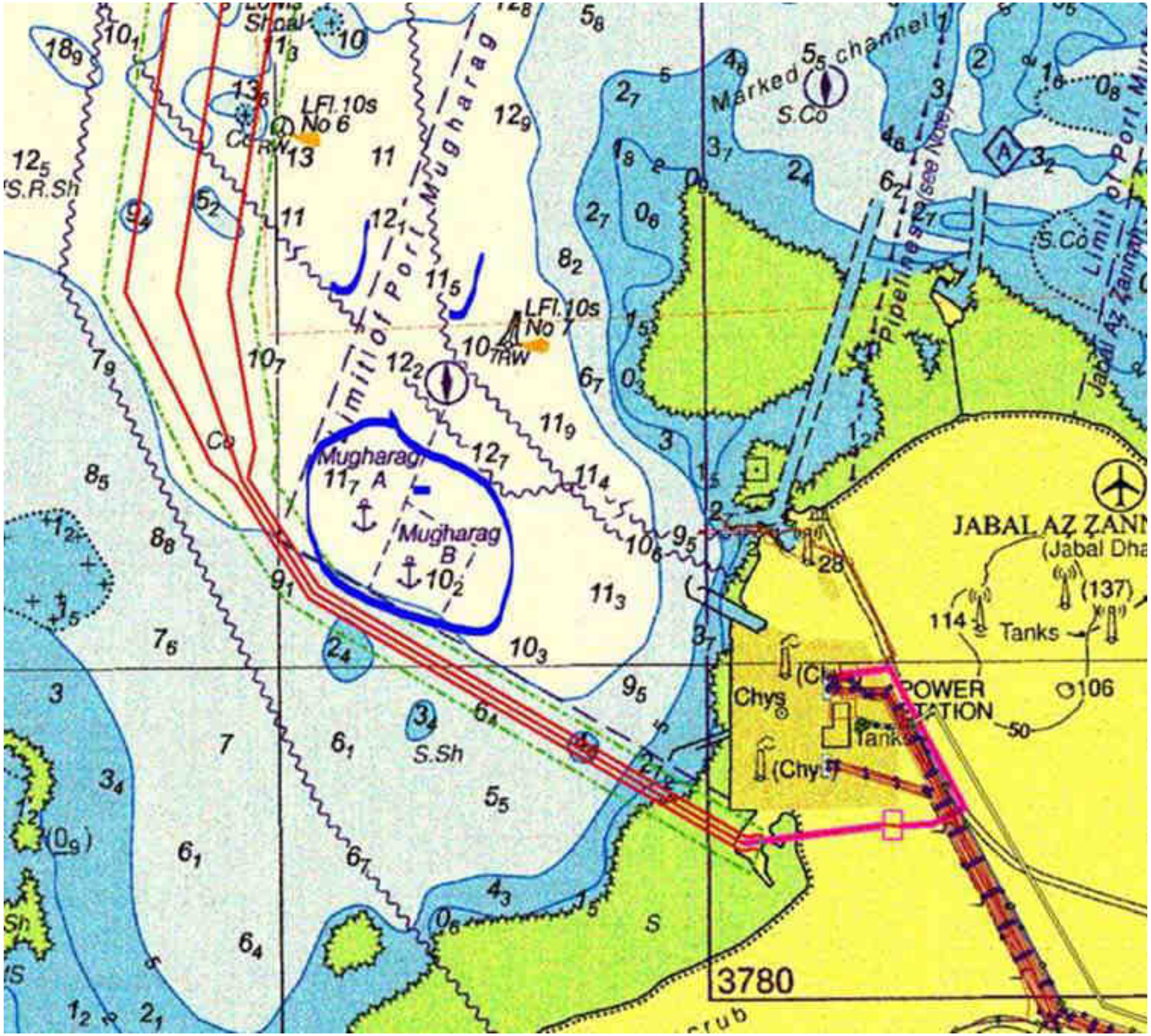


Figure 6-17: Proposed location of the Project and Mugharraq Port limits and anchoring areas

Option 2D - No Re-Routing but Reduction of the Construction Footprint Area

None of the re-routing options were found to be viable for a number of reasons, as discussed above. Therefore, the current proposed route remains the only feasible alignment option. Nevertheless, it should be noted that two new hybrid options are being explored but will require further investigations from the EPC – including EPC site survey data and therefore cannot be integrated in the ESIA and will need to be presented (if viable) within the Project CESMP. These potential options (if feasible) include:

- 2Da – Laying cables directly on top of the fringing reef; and
- 2Db – Minimise the indirect impacts of the cable construction by minimising the construction footprint where possible.

Option 2Da - Cable Laying on Top of the Fringing Reef

This option is highly likely to not be feasible but nevertheless it will be investigated by the EPC in the coming months. Due to the Project schedule constraints, should this solution be found to be viable, it will be presented within the CESMP as a positive alternative methodology to minimise impacts on the fringing reef. However please note that this option also carries significant technical and environmental constraints which are as follows:

- The stability of the cable and fibre are expected to be an issue. Even with cast iron shelves, the cables will be very exposed since the fringing reef will create an increase in water flow and the cable cannot settle on the seabed;
- Installation of mattresses is not easy in very shallow areas and stability needs to be checked as well. The mattresses can be positioned close to the fringing reef area but there will be a need to use a low draft vessel to install the mattress or work with a barge on spuds or anchors which can then again cause more harm to the corals and other critical or sensitive areas;
- ADNOC specifications are very strict towards cable stability and the location is after the wave break zone so there is a large impact on the cable. If a rock berm is installed in this location, the rockberm would be very large;
- There would be higher risk for the cable to be damaged by boats due to the shallow areas as a small vessel can easily hit the stabilised / unburied cable on top of the fringing reef area;
- This option will also damage the existing fringing reef and therefore a long-term operational impact will remain in the cable area; and
- It should be noted that the cable will be dynamic when not fully stabilised. As such this movements can also damage the existing fringing reef; and
- The structure on the cables will be large and overall significant which will impact on the landscape and visual amenity in the area.

Option 2Db – Construction Footprint to be Localised

The current planned construction cross section of the three cables is illustrated in Figure 6-13 below. For each construction footprint area required per cable (approx. 33m width), a 50m width buffer is required as per ADNOC specifications on this Project.

Figure 6-13: Current planned construction cross section

This option is therefore to identify if the 50m gap can be reduced as shown in Figure 6-18 below.

Figure 6-18: Proposed reduced construction cross section

It is clear that the reducing this 50m gap will not reduce the direct impacts on the fringing reef however this would localise the impact further to an area and therefore reduce indirect impacts on the fringing reef during the construction phase. This solution needs to further be explored as a number of technical constraints have been highlighted by ADNOC and the EPC.

It should also be noted that the 33m width required by trenches has been also studied to find a reduction of the construction footprint, however, due to the methodology required for this shallow area, reduction would be limited to a couple meters and this would be depending on the site conditions.

Conclusion

Therefore, no feasible options for avoiding the fringing reef in its entirety have been identified from all parties. However, the following is noted:

- Based on the initial results of the survey done in the Project site area, the estimation of coral loss is expected to be considered relatively minimal due to the high coral mortality that occurred in the area. Further details are provided in **Section 5.5**. Additionally, as mentioned in our initial responses, appropriate mitigation, compensation and monitoring measures have been presented in this ESIA to ensure reduction of impacts to its minimum and to ensure detailed, tailored and successful compensation and monitoring plans. In regard to compensation measures, this ESIA includes requirement of the installation of coral balls and relocation of live corals to ensure the repropagation of the corals in a suitable identified area. Ultimately with the proposed compensation measures, it will be expected that a net gain of corals will be provided as the compensation would be over and above loss;
- Finally, whilst this cannot be explored at the ESIA stage, the options 2Da (Cable Laying on top of the fringing reef) and 2Db (Construction footprint to be localised) are being checked by all parties and if viable, these options will be implemented as an alternative to the current project methodology. Due to scheduling constraints, these best-case scenario solutions will therefore be presented and included in the CESMP if found viable / feasible; and

- Appropriate mitigation, compensation and monitoring measures are all set out within this ESIA to ensure reduction of impacts is maximised and to enable the preparation of detailed, tailored and successful compensation and monitoring plans.

Route 1 – Al Ghallan Northern Areas Routing Options

Initially, seven route options were considered within Route 1 in relation to the approach to Al Ghallan Island as illustrated in Figure 6-19 below. Within these areas, limited environmentally sensitive and critical areas are present within the vicinity in addition to the proposed construction methodology for cable laying which does not include significant trenching nor dredging works in these areas. As a result, the option was selected by the developers, ADNOC and the EPC which is to split Route 1A and 1B in two areas as identified in this ESIA.

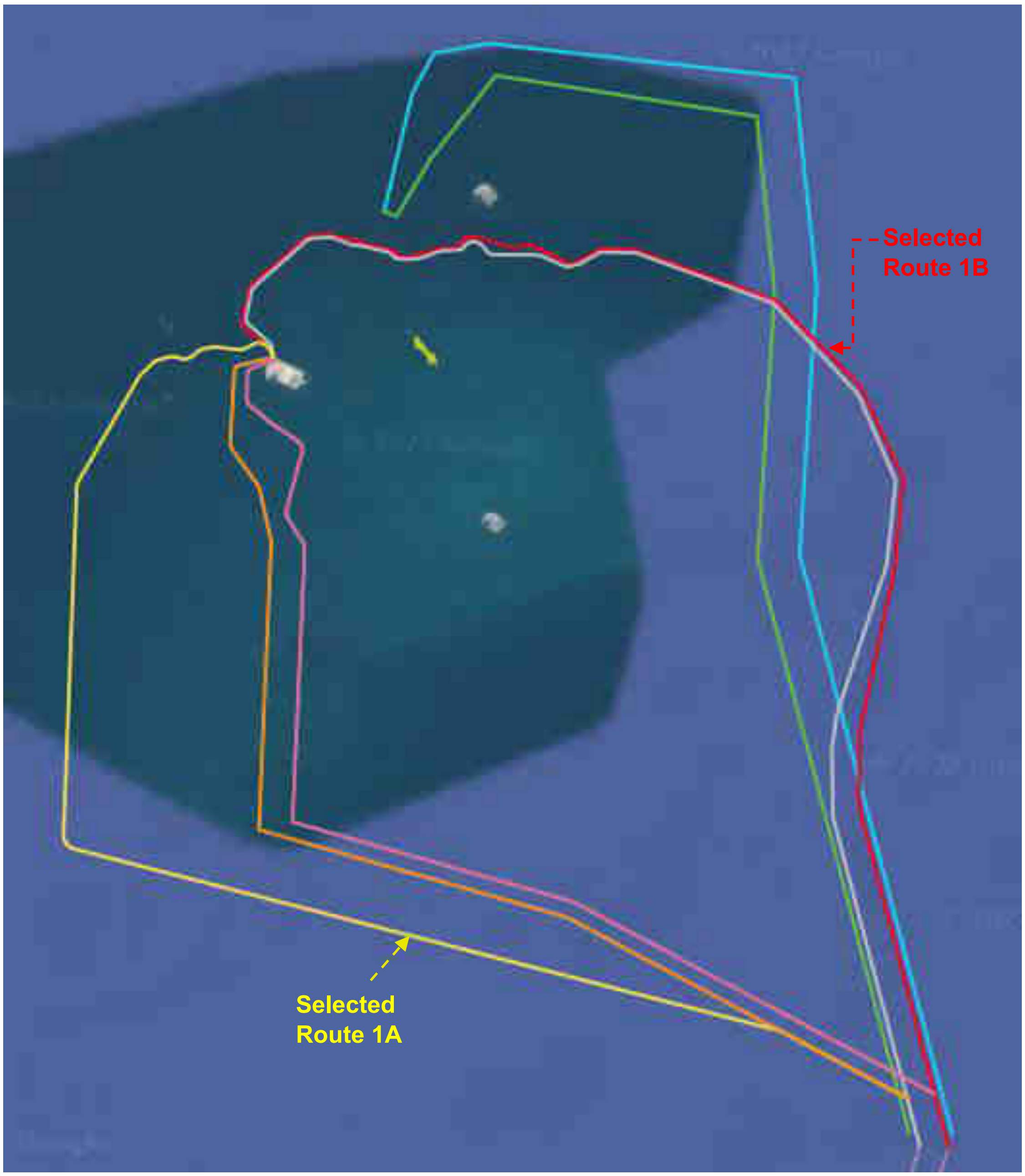


Figure 6-19: Optional routes for Al Ghallan approach (Route 1)

6.3.3. Onshore Disposal

EAD requested for the EPC to consider onshore disposal rather than offshore disposal in order to avoid impacts on the MMBR. Nevertheless, onshore disposal alternatives were not consider feasible which is presented below as well as within our Comment Response Sheet submitted to EAD submitted on the 28th April 2022 (**Appendix 6.8**).

6.3.3.1. Onshore Techniques

There are two ways to transport material from one location to the next: hydraulic or mechanical. Both have significant downsides for this particular case.

- Hydraulic Transportation: With the current foreseen equipment (Backhoe Dredgers (BHD)), hydraulic transport by pumping the material from one location to the next is not possible. This means that the dredging of the floatation channel would have to change from mechanical to hydraulic as well (e.g. Cutter Suction Dredger (CSD)). This in turn has the following downsides:
  - A CSD with sufficient power to break the rock, has a larger draught than the currently scheduled BHD's and even larger than the CLV. Therefore, the floatation channels would have to be wider and deeper resulting in more material to be dredged (refer to our response to Comment A1 above);
  - The dredged material would then need to be pumped ashore. Even the most powerful CSD in the world cannot pump the material over a distance of 15 km. This means additional booster pumps (with pontoons, anchors, generators, logistics) will have to be installed every 4-5km (on the water) over the whole trajectory. There is simply not enough pipeline available to pump the material over such a distance. This means additional pipelines would have to be fabricated which will impact on the Project overall feasibility;
  - Hydraulic transport of dredged material over large distances can only be done at low densities. This means that a lot of water needs to be mixed with the soil and as such will be discharged to shore location. As a result of the fine material dissolving in this water during hydraulic transport, huge settlement ponds would be required to allow the fines to settle before returning the water to the ocean. This would result in a large and significant disturbance of onshore land and terrestrial habitats.

- Mechanical Transportation: With a BHD, hydraulic transport per pipeline is not possible. The only possibility to get the material onshore would be to discharge it onto a flat top barge, bring the barge to a port and discharge it there. This is technically feasible but would lead to the following operational issues:
  - The long sailing distance to shore (>15km) means that a fleet of multiple barges and assisting tugs would be needed to allow for continuous operations. The exact number will depend on size of the available barges and sailing distance. Besides this, a discharge facility for those barges needs to run continuously on the shore (i.e. wheel loaders driving on the barges and discharging the material into trucks). Not having continuous operations will endanger the project feasibility but this would also imply additional noise, light disturbance (24/7) and other environmental impacts on the Mirfa marine area and the onshore discharge location;
  - The EPC team has been on site visit to explore the logistical possibilities, and no port with industrial capacity to allow for this kind of operations seems to exist in the vicinity of the Mirfa landfall. This means either investing time and money to extend the existing ports, or increasing the sailing distance which also increases the number of barges and tugboats would be needed to keep the project running. As above, this would also imply additional noise, light disturbance (24/7) and other environmental impacts on the Mirfa marine area;
  - Considering the above, this solution would significantly increase the amount of vessels (barges, tugboats) on site, increase the working area and area of disturbance by continuous movements of vessels between dredging area and onshore disposal area and most likely result in an increased operational time due to the lower productions; and

– Part of the material needs to be recovered at the disposal area in order to backfill the trench. This means that the same logistic challenges for backfilling would apply as we explained for the dredging activities.

It should be noted that the EPC team has foreseen for the dredging works to be as efficient possible and minimising the environmental impact on the sensitive areas at the dredge area. As mentioned in our presentation **(Appendix 6.4)**, the rerouting on the nearshore location at Mirfa has strongly reduced the requirement of floating / dredged channels in the southern section. If it were technically feasible to transport the material to shore, it would certainly result in a change in dredging methodology which would no longer be the most efficient and therefore have a larger impact at the dredging area, which has been identified as the most environmentally sensitive area.

6.3.3.2. Material Quality

In terms of material quality if the material were to be disposed onshore for reuse, the material will not be considered suitable for the following reasons:

- The material disposed will be very heterogeneous. It is sourced from a stretch of multiple kilometers, with soil varying from rock to silty sand. As such, we cannot see a specific purpose for the material apart from general fill;
- The material is dredged in a marine environment, which means it contains chlorine from the salty water. As such, it is not fit for any purpose where it would come in contact with steel, as the chlorine causes corrosion;
- For landfill purposes, the heterogeneity of the material will result in stability/settlement challenges; and
- The dewatering of the dredged material might result in a burden on the onshore environment (salt water in non-saline onshore environment).

Due to all the above comments, it seems appropriate to keep the material within a maritime environment is the best way to limit a number of significant environmental impacts as bringing it onshore might lead to more environmental issues than benefits.

6.3.4. Offshore Disposal Options

The EPC proposed one optional area for the southern disposal area and two options for the northern disposal areas as illustrated in Figure 6-20 below.

Figure 6-20: EPC proposed disposal areas locations

As illustrated in Figure 6-21 to Figure 6-22, the selection of the disposal area(s) were made to ensure a sufficient area where materials can be deposited and as far as feasible from critical and sensitive marine habitats.

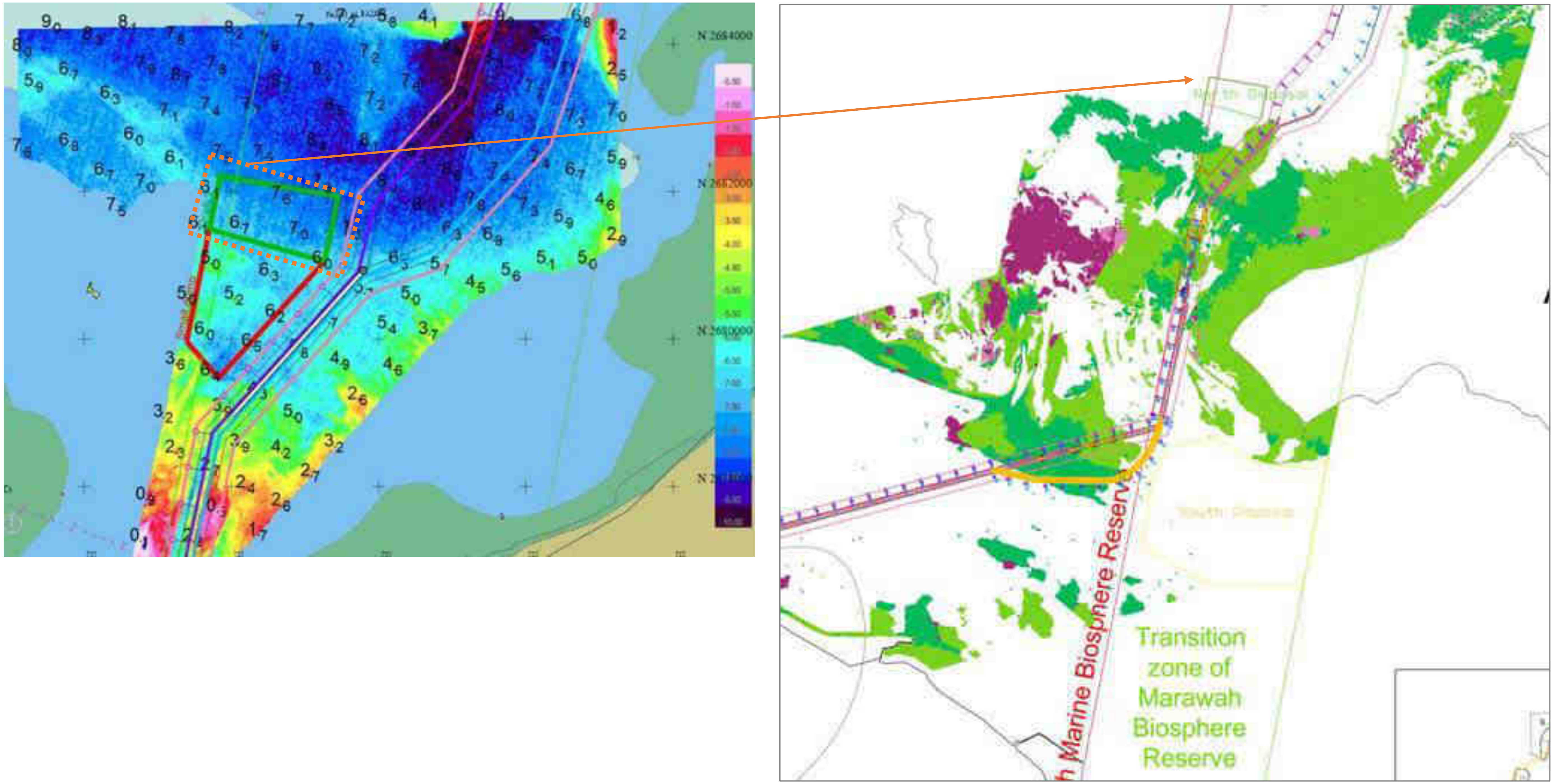


Figure 6-21: Figures illustrating the northern disposal area in relation to the bathymetry and the presence of critical and sensitive areas

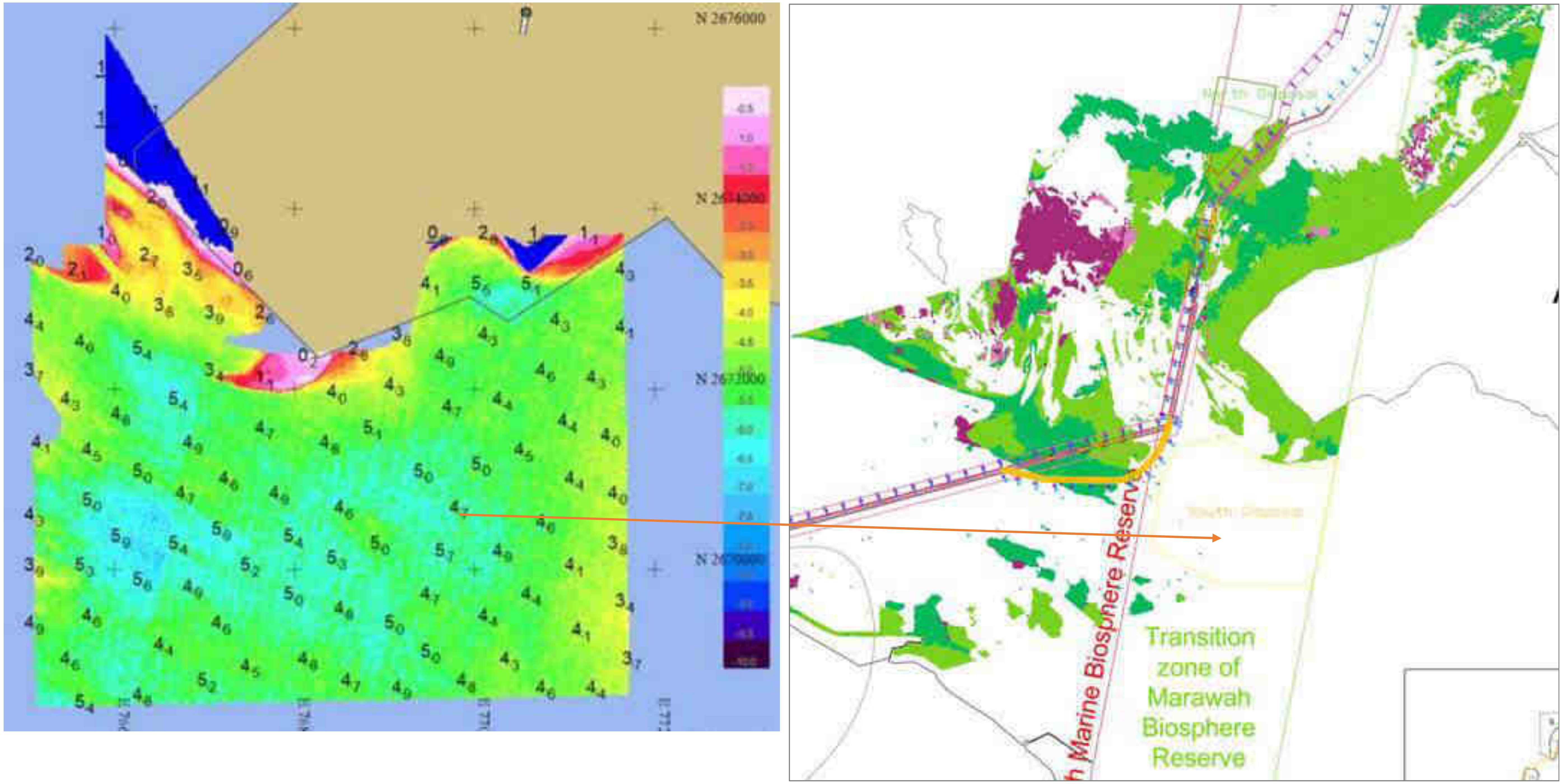


Figure 6-22: Figures illustrating the southern disposal area in relation to the bathymetry and the presence of critical and sensitive areas

7. STATEMENT OF COMMITMENTS

7.1. Introduction

A summary of the identified impacts associated with the Project, together with requirements for mitigation and monitoring is presented in **Section 5.12.**

This section expands further upon this summary to provide a statement of commitments and clear and auditable actions which are required in order to ensure compliance with these commitments, together with responsibility for implementation.

7.2. Overarching Commitments

The Project Proponent commits to the following as part of the implementation of the Project:

- Compliance with all EAD permitting regulations and procedures;
- Compliance with all ADNOC HSE and Environmental policies, guidelines and codes of practice;
- Compliance with all Abu Dhabi and Federal Authority requirements;
- Compliance with all applicable IFC Performance Standards on Environmental and Social Sustainability (Performance Standards), Environmental Health and Safety (EHS) Guidelines and the Equator Principles during both the construction and operation of Project development;
- Conduct all operations in alignment with the Abu Dhabi Occupational Safety and Health System Framework Management System;
- Minimise the environmental impacts of the Project development at all times as part of the planning, construction and operational phases;
- Ensure that all parties involved within the Project development comply with these commitments; and
- Apply the principles of environmental stewardship to protect the environment for future generations.

7.3. Project Specific Commitments

Table 7-1 overleaf sets out the Project specific commitments which will be implemented, based upon the conclusions of this ESIA to minimise environmental impacts. This sets out a clear list of requirements together with responsibilities for implementation.

Table 7-1: Project specific commitments

No.	Aspect	Commitment	Responsible party
1.	Design & Pre-construction	– Avoid the use of the South Disposal Area (wherever possible) as this will significantly reduce the direct loss of seagrass – The design will take account of the adjacent sensitive receptors, particularly within the marine and intertidal environment, and will ensure that impacts are minimised – Enable further optimisation of the dredge channel design and the construction methodology where possible to reduce the amount of required dredging wherever possible	EPC Contractor
2.		– Obtain the appropriate dredging permits, where required.	
3.		– The Project Company will appoint a qualified marine biologist to develop a Biodiversity Action Plan (BAP), which will be developed to achieve a net biodiversity gain. The BAP will include the following as a minimum: ▪ Proposed methods to relocate healthy corals from the dredged corridors to adjacent areas suitable to act as receptor sites; ▪ Proposed methods to reinstate the dredged corridor to enable the recolonisation of seagrass beds; ▪ Allow natural seagrass seeding to occur post construction; ▪ Proposed methods for extended monitoring of the natural re-establishment of seagrass beds, with potential trigger values for further targeted interventions if re-establishment is less successful than anticipated; ▪ Additional actions to provide a net biodiversity gain, such as the placement of reef forming structures within the Project site; ▪ Additional actions to provide a net biodiversity gain, where appropriate; ▪ A long-term management plan; and ▪ A long-term biodiversity monitoring and evaluation program.	Project Company
4.		– The Project Company will appoint a qualified ecologist and landscape contractor to develop a Mangrove Planting and Management Plan (MPMP) for the area adjacent to Shuweihat in accordance with EAD requirements. This will include specific details of: ▪ Area of mangrove loss and estimated number of individuals; ▪ Proposed compensation site; ▪ Proposed method of compensation – presumed at this stage to be planting of mangrove seedlings at a ration of 2:1 for the number of mangrove individuals lost; ▪ Methodology for site preparation and planting; ▪ Requirements for management and replacement during establishment phase; and ▪ Long-term management and monitoring requirements.	
5.		– Obtain the appropriate dredging permits, where required.	EPC Contractor
6.		– The EPC shall consult with EAD prior the start of the Project construction and removal of the hadrah located within the Project footprint. EAD will advise if any compensation is required and EAD's recommendations will be carried out in full.	EPC Contractor
7.	Construction	– Development of a Project specific Construction Environmental and Social Management Plan (CESMP) which will include specific measures for environmental mitigation and monitoring as set out within this ESIA including: ▪ Dust control plan; ▪ Marine works / sedimentation control plan; ▪ Dredging control plan including a Dredging Management Plan (DMP) to be attached with the CESMP; ▪ Marine traffic control plan including a Marine Traffic Management Plan to be attached with the CESMP; ▪ Dewatering control plan; ▪ Contamination control plan; ▪ Spill control plan; ▪ Site waste management plan; ▪ Erosion control plan; ▪ Noise control plan; ▪ Biodiversity management plan for terrestrial and marine environments; ▪ Archaeological chance finds procedure; ▪ Stakeholder engagement plan, to ensure that affected residents are consulted; and ▪ A monitoring programme for each of the above;	EPC Contractor
8.		– Development of a monitoring programme as part of the CESMP, which includes monitoring for the following: ▪ Dust; ▪ Marine water quality – including continuous monitoring during dredging activities; ▪ Dewatering effluent quality; ▪ Noise; ▪ Marine ecology – including MMRO personnel on marine vessels	

No.	Aspect	Commitment	Responsible party
		▪ Waste; ▪ Chemical Storage; ▪ Worker welfare; and ▪ Community complaints.	
9.		– If vegetation requires clearing during bird peak breeding season (August to March), a pre-construction survey shall be undertaken just before the clearance work. If any active nests are present, these cannot be disturbed and these areas must be protected, with a 300m stand-off until such time as the nest is no longer active. Once surveys by a qualified ecologist have confirmed that the nests are no longer active, these trees can also be cleared (subject to the necessary Authority permits being in place) and these areas will be considered to be clear for the remainder of the construction phase and no further restrictions would apply.	
10.		– A qualified environmental officer should be on site at all times. An environmental incident log will be kept in order to keep a record of these impacts.	
11.		– Reinstatement and restoration of disturbed areas to aid habitat reestablishment as follows: ▪ Seabed post-trenching and cable laying ▪ Onshore and intertidal areas	
12.		– Implementation of the Abu Dhabi Occupation Health and Safety System.	
13.		– Adherence to ADNOC Codes of Practice, Guidelines and relevant HSE documentation.	
14.		– Quarterly auditing report to be prepared by an independent EAD registered Environmental Consultant for submission to the EAD.	
15.	**Pre-Operation**	– Development of an Operational Environmental & Social Management Plan, which will include specific control measures in relation to: ▪ Marine works / sedimentation control plan for emergency operations in case of requirements for repair and maintenance; ▪ Contamination control plan; ▪ Spill control plan; ▪ Site waste management plan; ▪ Noise control plan; ▪ Biodiversity management plan for terrestrial and marine environments; ▪ Stakeholder engagement plan, to ensure that affected residents are consulted; and ▪ A monitoring programme for each of the above	Operator
16.	**Operation**	– Environmental monitoring to be undertaken in relation to: – Water and sediment quality; – Video inspection of impacted areas to assess succession rates for: - Seagrass reestablishment; - Coral relocation reestablishment; – MMRO survey to ascertain marine mammal and reptiles species and population composition; – Census (DDV / ROV) conducted to ascertain fish species composition; and – The replanting of mangroves and restoration of mudflats and saltmarshes.	Operator
17.	**Decommissioning**	– Where decommissioning works are planned, registration of the project with the EAD and undertake the required environmental assessments as directed to obtain a NOC as part of decommissioning activities.	