REPORT N^{O} 70029220-*12*/CESIA/TECH

CONSOLIDATED IMPACT ASSESSMENT AND MITIGATION REPORT

DUQM REFINERY PROJECT, OMAN

Part of Consolidated Environmental and Social Impact Assessment




FOR DRPIC ONLY: CONFIDENTIAL DECEMBER 2017

CONSOLIDATED IMPACT ASSESSMENT AND MITIGATION REPORT

DUQM REFINERY PROJECT, OMAN

Duqm Refinery & Petrochemical Industries Company WLL

Confidential

Project No: 70029220
Date: December 2017

WSP
6 Devonshire Square
London, EC2M 4YE

Tel: +44 (0)20 7337 1700

www.wsp.com

TABLE OF CONTENTS

APPENDICES

LIST OF ABREVIATIONS

Abbreviation	Description/Meaning
5OES	Five Oceans Environmental Services
AF	Associated Facilities
AFW	Amec Foster Wheeler
ALARP	As Low as Reasonably Practicable
AOC	Accidentally Oily Contaminated Water Sewer
AoI	Area of Influence
AQ	Air Quality
AQMS	Air Quality Monitoring System
ARU	Amine Regulation Unit
BMP	Biodiversity Management Plan
BPSD	Barrels per Stream Day
BVS	Block Valve Station
CAR	Coker Amine Regulation Unit
CDU	Crude Distillation Unit
CEMs	Continuous Emission Monitors

Abbreviation	Description/Meaning
CESMP	Construction Environmental and Social Management Plan
CH_4	Methane
CHA	Critical Habitats' Assessment
CHMP	Cultural Heritage Management Plan
CIA	Cumulative Impact Assessment
CIMP	Cumulative Impact Management Plan
CLO	Community Liaison Officer
CO	Carbon Monoxide
COPS	Central Oman Palaeolithic Survey
CR	Critically Endangered
CSR	Corporate Social Responsibility
CSS	Clean Storm Water Sewer
CUC	Central Utilities Company
CWAA	Central Waste Accumulation Area
dB	Decibels
DGEA	Directorate General of Environmental Affairs
DHU	Diesel Hydrotreating Unit
DIPWP	Duqm Integrated Power and Water Plant
DR	Duqm Refinery
DRPIC	Duqm Refinery and Petrochemical Industries Company LLC
Duqm SEZ	The Duqm Special Economic Zone
EBRD	European Bank for Reconstruction and Development
EBS	Ecological Baseline Survey
ECAs	Export Credit Agencies
ECoW	Ecological Clerk of Works
EHS	Environmental Health and Safety
EIA	Environmental Impact Assessment
EN	Endangered
EPC	Engineering Procurement Construction
EP	Equator Principles
EPPRP	Emergency Prevention, Preparedness and Response Plan
ESDD	Environmental and Social Due Diligence Report
ESIA	Environment and Social Impact Assessment
ESMP	Environment and Social Management Plan
ESMS	Environmental and Social Management System
EU	European Union
FEED	Front End Engineering Design
FIDOL	Frequency, Intensity, Duration, Odour, Unpleasantness, Location
GCRO	Government and Community Relations Officer
GIIP	Good International Industry Practice
GLC	Ground Level Concentration
GLVIA	Guidelines for Landscape and Visual Impact Assessment
GSS	Gas Supply Station
GT	Gas Turbine

Abbreviation	Description/Meaning
H_2S	Hydrogen Sulphide
HIA	Health Impact Assessment
hr	Hour
HRA	Health Risk Assessment
HSE	Health, Safety and Environment
HSES	HSE and Social
HU	Hydrocracker Unit
IAQM	Institute of Air Quality Management
IAS	Invasive Alien Species
IBA	Important Bird Area
ICV	In-Country Value
IDZ	Industrial Development Zone
IEFs	Important Ecological Features
IEMA	Institute of Environmental Management and Assessment
IESC	Independent Environmental and Social Consultant
IFC	International Finance Corporation
ISO	International Organisation of Standardisation
IUCN	International Union for the Conservation of Nature
Jet A-1	Kerosene Jet Fuel
KEC	Kuwait Export Crude
kg	Kilogram
KPI	Key Performance Indicator
LDAR	Leak Detection and Repair
LPG	Liquid Petroleum Gas
m^3	Square metre
Mbbl	Million Barrels
MD	Ministerial Decision
MECA	Ministry of Environment and Climate Affairs
Microns	Micrometres
NIOSH	National Institute for Occupational Safety and Health
NMHC	Non-methan Hydrocarbons
NO	Nitrogen Monoxide
NO_2	Nitrogen Dioxide
NOC	Non-oil Contaminated Wastewater System
NOx	Oxides of Nitrogen
NPV	Net Present Value
O_3	Ozone
OECD	Organisation for Economic Co-operation and Development
OGC	Oman Gas Company
OOC	Oman Oil Company
OSHA	Occupational Safety and Health Administration
OTTCO	Oman Tank Terminal Company
OWS	Oily Water Sewer
PAH	Poly-aromatic Hydrocarbon
PFD	Process Flow Diagram

Abbreviation	Description/Meaning
PLEMs	Pipeline End Manifolds
PM	Particulate Matter
PM_{10}	Particulate Matter (10 micrometres or less in diameter)
$PM_{2.5}$	Particulate Matter (2.5 micrometres or less in diameter)
PPP	Pollution Prevention Plan
PS	Performance Standards
RAECO	Rural Area Electricity Company
RM	Ras Markaz
RoW	Pipeline Right of Way
SAN	Sanitary Wastewater Sewer
SEP	Stakeholder Engagement Plan
SEZ	Special Economic Zone
SEZAD	Special Economic Zone Authority at Duqm
SGP	Saturated Gas Pit
SO_2	Sulphur Dioxide
SPM	Single Point Mooring
SRU	Sulphur Reduction Unit
STP	Sewage Treatment Plant
SWIP	Sea Water for Industrial Zone Project (term used in previous EIAs)
TLVs	Threshold Limit Values
TNMHCs	Total Non-Methane Hydrocarbons
TWMP	Test Water Management Plan
TWMIP	TWMP and Implementation Plan
USEPA	United States Environmental Protection Agency
UV	Ultraviolet
VEC	Valued Environmental and Social Component
VLCC	Very Large Crude Carriers (i.e. sea-going vessels)
VDU	Vacuum Distillation Unit
VOC	Volatile Organic Compounds
vs.	Versus
WCMC	World Conservation Monitoring Centre
WHO	World Health Organisation
WIMP	Worker Influx Management Plan
WMP	Waste Management Plan
WMIP	Waste Management Implementation Plan
WSP	WSP UK Ltd.
WWTP	Wastewater Treatment Plant
ZOI	Zone of Influence
ZTV	Zone of Theoretical Visibility

1 INTRODUCTION AND APPROACH

1.1 INTRODUCTION

Duqm Refinery and Petrochemical Industries Company LLC (DRPIC) is developing the Duqm Refinery Project (the "Project") located within the Special Economic Zone at Duqm (Duqm SEZ). The Project is a joint venture between Oman Oil Company (OOC) and Kuwait Petroleum (Europe) B.V. (KPE) to develop, build, own and operate an export refinery complex, with each shareholder holding 50% interest. A minority of the Project Company may be owned by one or more strategic or financial investors in the future.

The Project comprises:

- 230,000 barrels per day (BPD) complex refinery and on-site utilities, infrastructure and storage (the "Refinery");
- Product export terminal ("Export Terminal") at the Port of Duqm;
- Crude storage facility at the Ras Markaz crude oil terminal (the "DRPIC Ras Markaz Crude Storage Facility"); and
- 28" 80km Crude pipeline from Ras Markaz to the Refinery (the "Crude Pipeline").

The Project components, Associated Facilities (projects being progressed by third parties but upon which the Refinery is reliant) and alternatives are described in detail in Section 2.

1.2 GENERAL APPROACH

This Report is part of the overall commission that WSP UK Limited (WSP) is carrying out for DRPIC, known as the Consolidated Environmental and Social Impact Assessment (ESIA) package of work. The scope of this overall work was to develop supplementary environmental, social and health assessment documentation that provides a holistic summary of the Project and consolidates its relevant aspects, impacts and mitigation measures, adding to the previous assessments where required.

This Consolidated ESIA has been developed to further assess environmental and social aspects that have been screened and scoped as significant.

The Report therefore provides a fully-updated assessment of the identified potential environmental and socio-economic impacts associated with the Project. Both short-term construction phase impacts and longer-term operational phase impacts are considered and presented. A description of the methodology used to assess the characteristics and significance of impacts, taking into account impact magnitude and sensitivity of receptors and resources affected, is provided in Section 3.

Mitigation measures that DRPIC will implement to avoid and minimise impacts are also presented in this Report.

This summary ESIA document also serves as an overarching disclosure document to satisfy Lender Requirements

Cumulative impacts of the Project are assessed separately and presented in a stand-alone Cumulative Impact Assessment (see DRPIC Report Ref. 08-CL-CESIA/CIA).

1.3 REGULATORY CONTEXT AND STANDARDS

A number of earlier Environmental Impact Assessments (EIA) were prepared for the various components of the Project and its Associated Facilities between 2011 and 2014 to satisfy national Omani legislativerequirements. These are all referenced in the following sections while a complete list is collated in this Report's References.

This report does not replace the previous EIAs, which were submitted to and permitted by the regulatory authorities. However, it serves to supplement them in a way that more comprehensively describes the baseline, aspects and impacts of the Project. In addition, it is needed to assess the potential impacts of the Project in accordance with International Finance Corporation (IFC)/World Bank Standards, as well as other guidance.

1.3.1 Omani legislation and guidance

While the Special Economic Zone Authority at Duqm (SEZAD) is the responsible authority for the Duqm SEZ, the Project is being implemented in compliance with the "Guidelines on Environmental Impact Assessment" issued by the Omani Directorate General of Environmental Affairs (DGEA) at the Ministry of Environment and Climate Affairs (MECA). Since then, SEZAD has developed its own guidelines for EIA, dated April 2017. For aspects for which Omani regulations are not available, applicable international regulations such as the IFC Performance Standards (PS) will be used. Front End Engineering Design (FEED) was executed using the most stringent standard of the Omani regulation and IFC Guidelines. Thus the planning and development of the Project will be in compliance with Omani regulations on environmental protection and pollution prevention and the IFC PSs.

The Duqm Refinery Project will work within with the range of applicable legislation in Oman .Key examples are shown below:

- Environmental Protection and Prevention of Pollution (RD 114/2001);
- Protection of Potable Water Sources from Pollution (RD 115/2001);
- National Air emissions standards for Refineries;
- Wastewater Reuse and Discharge (MD 145/93 and RD 115/2001);
- Handling and Use of Chemicals (RD 46/95);
- Disposal of Liquid Effluents into the Marine Environment (MD 159/2005);
- Noise Regulations (MD 79/94 and MD 80/94);
- Hazardous Wastes (MD 18/93);
- National Heritage Protection (RD 6/80); and
- Ambient Air Guidelines (MD 41/2017).

The Project is also following the relevant Regional and International Conventions and Protocols to which Oman has acceded.

1.3.2 Requirement to meet international standards and guidelines

In addition to the national legislation, the Project also needs to be compliant with guidance in the IFC Sustainability Framework. The following IFC Performance Standards are applicable to the assessment of environmental and socio-economic and health impacts:

- 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 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources; and
- Performenace Standard 8: Cultural Heritage.

Other Project Standards that are applicable include:

- The Equator Principles (EPs) 2013, The EPs applicable to social impact assessment are: Principle 2 (Environmental and Social Assessment), Principle 5 (Stakeholder Engagement) and Principle 6 (Grievance Mechanism); and
- Organisation for Economic Co-operation and Development (OECD) recommendations on Common Approaches to the Environment and Officially Supported Credits (the "OECD Common Approaches") (2012).

In addition, the IFC published a series of Sector Guidelines, of which the following have relevance for the Project and within which the Project is being executed:

- General Environment, Health, and Safety (EHS) Guidelines (2007);
- Petroleum Refining (2007);
- Ports, Harbours and Terminals (2007));
- Onshore Oil and Gas Development (2007);
- Crude Oil and Petroleum Products Terminals (2007); and
- Thermal Power Plants (2008); only applicable for construction in the event of 50MW generator sets being used by Contractors.

1.4 ENVIRONMENT AND SOCIAL CONTEXT

Previous work commissioned by DRPIC between 2014 and 2016 includes the preparation of multiple EIAs for the DRPIC Funded Projects and individual AFs which are in line with Omani national requirements. The EIAs were carried out by different consultancies and these are listed in Section 2.2 and fully referenced in the References Section at the back of this Report.

At this stage, environmental mitigation measures had been proposed and incorporated into design (i.e. an 'Environmental Basis of Design') at the FEED stage. Requirements to deliver plant, process equipment and the buildings/facilities for the Project were incorporated into the procurement process for potential EPC Contractors to participate in tender.

DRPIC prepared a scope of works for a Consolidated ESIA in November 2016 and released an Invitation to Tender (ITT) to international environmental consultants on 1 December 2016.

During late 2016, an Environmental and Social Due Diligence (ESDD) Report was being prepared by the lenders' Independent Environmental and Social Consutlant (IESC) (Ramboll Environ, 2016) which identified omissions in key elements of the EIAs produced and limitations against the IFC requirements. The ESDD concluded, for instance, that baseline data on ecology, socio-economic and health, air quality, noise and cultural heritage needed to be updated and potential impacts associated with those topics needed to be revisited. Such requirements had been included in the ITT released by DPRIC.

In March 2017, WSP was appointed by DRPIC to carry out the Consolidated ESIA package of work and commenced work, reviewing previous EIA Reports and other project documentation. WSP participated in the kick-off meeting in Oman and visited the Project site in Duqm for orientation. An Inception Report and Field Survey Plan followed (April 2017) preceding the deployment of specialists to the Duqm SEZ to carry out surveys on the ground to collect baseline data in May 2017. The exception to this was the deployment of a Continuous Air Quality Monitoring Station at the Sebacic Acidification Plant near the Duqm Refinery site for a period of three months. The WSP team was assisted by specialists from Omani company Five Oeans Environmental Services (5OES) for the household survey/engagement, biodioversity and cultural

heritage activities. To that end, the combined team had the requisite local knowledge and experience of delivering surveys to international standards.

WSP produced Baseline Reports documenting the procedures, methodologies, equipment and results of the baseline survey in Summer 2017. Soon after, the WSP team worked to assess the potential impacts of the Project culminating in draft versions of the Consolidated Impact Assessment and Mitigation Report.

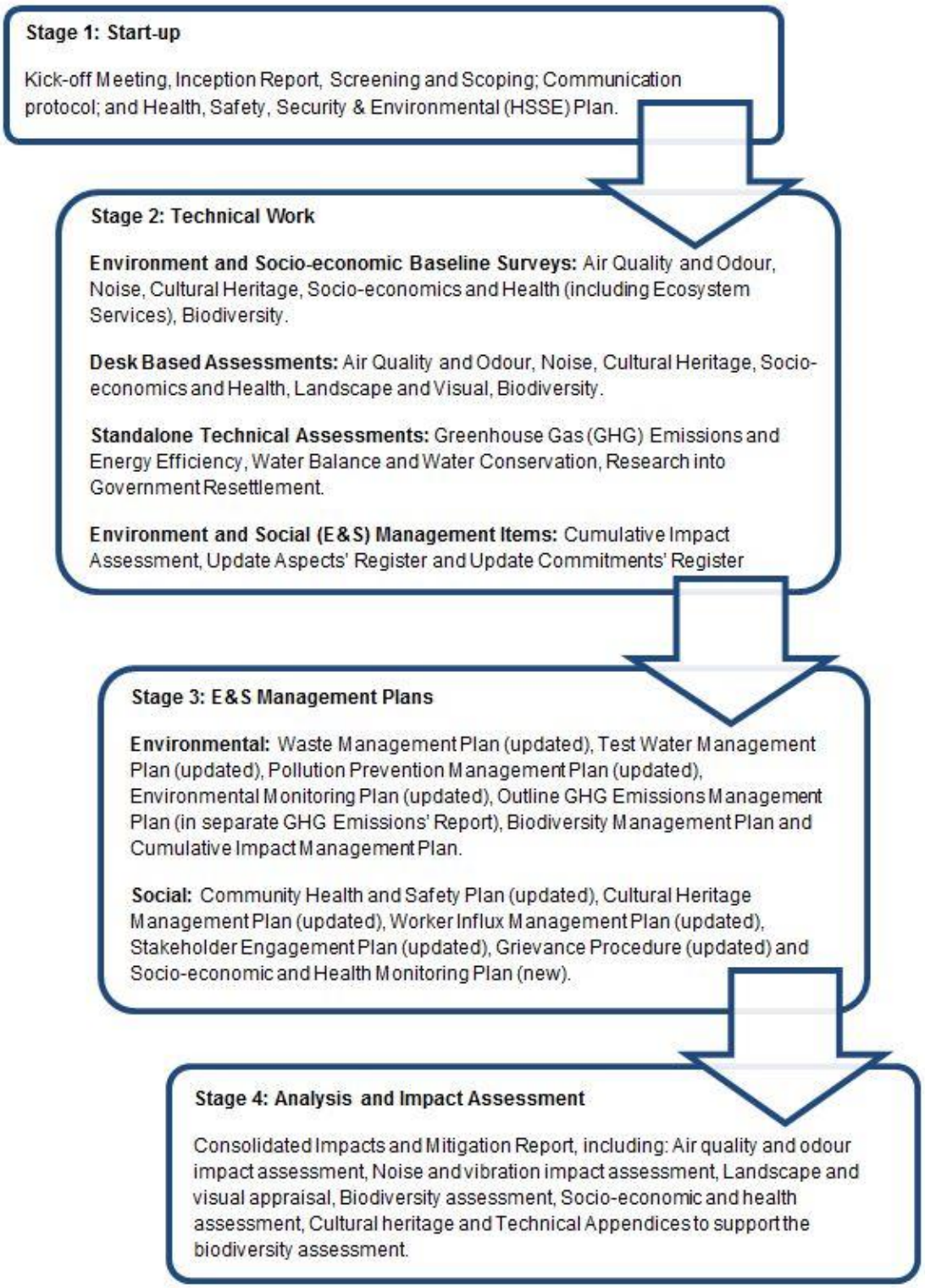
It should be noted that DRPIC's procurement process for EPC Contractors (to build the Project) was proceeding in parallel. It was therefore not possible for any findings of the Consolidated ESIA to make significant changes to the design features of the Project. Instead, there were other ways in which newly identified mitigation measures could influence the Project successfully. One such was is that mitigation measures from the original EIAs and enhancements/additions/clarifications to those, as collated in this Consolidated Impact Assessment and Mitigation Report, have been carried over into the E&S Management Plans. DRPIC's appointed EPC Contractors will use the ESMP and set of sub-plans to proactively manage environmental and social issues during construction. Furthermore, their performance will be checked and audited by DRPIC, SEZAD and representatives of the lenders during construction, and in future operations.

1.5 METHODOLOGY

1.5.1 Key Activities in Consolidated ESIA

Figure 1-1 illustrates the key activities to the approach in compiling this Consolidated Impact Assessment and Mitigation Report.

Figure 1-1: Key Activities in Consolidated ESIA



1.5.2 ESIA to International Standards

For greenfield investment projects involving physical elements, aspects and proposed facilities that are likely to generate potentially significant adverse environmental and social risks and impacts, in the context of the project's 'area of influence', the IFC states that the proponent should carry out a comprehensive ESIA, as is the case for Duqm Refinery.

This area of influence (AoI) encompasses, as appropriate:

- The area likely to be affected by the project and activities and facilities that are directly owned, operated or managed (including by contractors) and that are a component of the project;
- Impacts from unplanned but predictable developments caused by the project that may occur later or at a different location;
- Indirect project impacts on biodiversity or on ecosystem services upon which Affected Communities' livelihoods are dependent;
- Associated Facilities – not funded as part of the project and that would not have been constructed or expanded if the project did not exist and without which the project would not be viable; and
- Cumulative impacts that result from the incremental impact, on areas or resources used or directly impacted by the project, from other existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted.

These elements of ESIA are included in the Consolidated ESIA work and documented and/or referenced, as relevant and appropriate, in this Consolidated Impact Assessment and Mitigation Report.

The key processes involved in the undertaking of an ESIA to international standards consist of:

- Screening of the project and scoping of the assessment process;
- Consideration of alternatives;
- Stakeholder identification and engagement (focusing on those directly affected);
- Gathering of environmental and social baseline data;
- Impact identification, prediction, and analysis;
- Description of mitigation or management measures and actions;
- Assignation of significance to impacts and evaluation of residual impacts; and
- Documentation of the assessment process, i.e., an ESIA report.

The IFC also states that an ESIA must conform to the requirements of the host country's environmental assessment laws and regulations, including the relevant disclosure of information and public consultation requirements, and should be developed following principles of good international industry practice.

The IFC goes in to state that the ESIA process predicts and assesses a project's potential adverse impacts and risks, in quantitative terms where possible. Furthermore, it evaluates environmental and social risks and impacts from associated facilities and other third party activities. The ESIA then identifies and defines a set of environmental and social mitigation and management measures to be taken during project implementation so to avoid, minimize, or compensate/offset for risks and adverse impacts. Any residual negative impacts that cannot be mitigated are identified.

The previous work carried out by DRPIC and the Consolidated ESIA package of work have, together, gathered all the information required to fulfil the stages of ESIA and its content, as required under international standards and guidance.

1.5.3 Overarching Technical Methodology

A summary of the key work activities carried out as part of the Consolidated ESIA is presented below with the full details, including impact assessment presented in Sections 5 to 10.

THE SCOPING APPROACH

The screening and scoping was developed by multiple parties through the analysis of previous EIA work commissioned by DRPIC. As well as DRPIC's own analysis, as Project proponent, the potential content of the Consolidated ESIA was also guided by the findings of and ESDD process, carried out by the lenders' IESC. A scope of works for the Consolidated ESIA was drawn up by DRPIC.

Once engaged, WSP was able to carry its own due diligence, reviewing publicly available information and the suite of previous EIA studies and other Project documentation. A key part of that initial analysis was the identification of gaps between the work that had been carried out to date and requirements of international standards and guidance. The findings of that exercise included the need to fill those gaps in information through new work activities, such as additional desktop research and field survey to collect up-to-date primary data to enhance the baseline. The scopes of work for these additional activities were summarised in an Inception Report (May 2017), that also:

- Summarised early findings from the review of historic EIAs;
- Confirmed gaps relating to environmental and social aspects identified by DRPIC and the lenders IESC and in line with the terms of compliance with the lenders' stated policies and Project Standards; and
- Confirm the approach to new work activities, including surveys and methodologies to be used for each topic

The work involved was the equivalent of a scoping exercise, determining the appropriate spatial and temporal scopes for the subsequent assessment and outlining the approach to suitable surveys, research methodologies and describing the technical assessments required. One benefit of scoping is the targeting of time and resources to focus on the priority needs of the assessment, for instance, delivering new data where the most important gaps existed. The realm of biodiversity was an example where attention was required to enhance the baseline, especially around the area of the Crude Oil Tank Farm at Ras Markaz and its interface into the Crude Pipeline.

At this point, and as a result of this scoping process, the key focus of the Consolidated ESIA going forward, was to address the gaps and consolidate the impact assessment on the following parameters:

- Air quality and odour;
- Noise;
- Landscape and visual;
- Biodiversity;
- Socio-economics, social and health; and
- Cultural heritage.

The details, including information on logistics, equipment, personnel and safety were presented in a Field Survey Plan.

Once survey work was complete, and data collated, that new data/information could be combined with the relevant data collected in previous (i.e. historical) survey activities to form an enhanced baseline. In other words, where reliable and detailed baseline data and the subsequent impact assessment were available from the earlier EIAs, that information is referred to, used, and where necessary, enhanced through further explanation in this Report.

Further assessment of the potential impacts of the Project was then carried out. Section 4 outlines detail behind the methodology employed.

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLANS

Based on the mitigation measures and other requirements from the previous Project EIAs, as well as international lending requirements, DRPIC developed an Environmental and Social Management Plan (ESMP) which included a number of sub-plans. Examples of the sub-plans are a Pollution Prevention Plan, Waste Management Plan and Stakeholder Engagement Plan etc.

This ESMP will be used by the appointed EPC Contractors on the Project. These Management Plans contain a set of aims, outline the roles, responsibilities and standards to which performance on site, training and ongoing monitoring will be carried out.

Mitigation measures and required actions from this Consolidated Impact Assessment and Mitigation Report are also integrated into the existing sub-plans (e.g. Waste Management Plan, Environmental Monitoring Plan) while a number of new sub-plans – covering the topics required to meet international standards (e.g. Biodiversity Management Plan, Workers' Influx Management Plan) – were prepared new. The portfolio of sub-plans form an essential part of DRPIC's Environmental and Social Management System (ESMS). The sub-plans are listed in Figure 1-1 and referenced, where appropriate in each of the technical Sections 5 thought to 10.

CUMULATIVE IMPACT ASSESSMENT

In line with IFC guidelines, cumulative impacts of the Project needed to be assessed separately. While compiling the Consolidated Impact Assessment and Mitigation Report, a CIA was prepared with reference to the guidelines in the IFC Good Practice Handbook: Cumulative Impact Assessment and Management (April 2013). This exercise culminated in a stand-alone CIA Report (see DRPIC Report Ref. 08-CL-CESIA/CIA). The key parts of the CIA included:

- Updating the Project's Area of Influence;
- Addressing impacts in isolation and cumulatively from AFs and from third party facilities and future projects;
- Consideration of a Valued Component-centric approach to identify all potential receptors from cumulative impacts;
- Inclusion of all phases of the Project;
- Coverage of biodiversity and ecosystem services aspects; and
- Consideration of how cumulative impacts, including Associated Facilities, will be managed by DRPIC in laison with third parties.

1.6 STRUCTURE OF THIS ESIA

This Report includes a summary of the previous EIA work and all new activities that together constitute a robust baseline. The work documented in this Report focusses on the assessment of the identified environmental and socio-economic impacts associated with the Project, as scoped-in at the Inception Report stage.

Table 1-1 Structure of this Consolidated Impact Assessment and Mitigation Report

SECTION OF REPORT	DESCRIPTION OF CONTENTS
Non-Technical Summary	A summary of this Consolidated Impact Assessment and Mitigation Report using non-technical language.
1	**Introduction and Approach**, including project context, regulatory context and Project Standards and the context to the Environment and Social work activities. Includes methodology employed in preparing Consolidated Impact Assessment and Mitigation Report.
2	**Baseline Assessment Summary**
3	**Project Overview** – the latest information on the specification of the Project components and Associated Facilities, including alternatives.
4	**Impact Assessment Methodology** – for the scoped-in parameters (following sections, below)
5	**Air Quality and Odour**
6	**Noise**
7	**Landscape and Visual**
8	**Biodiversity**
9	**Socio-economics and Health**
10	**Cultural Heritage**
11	**Combined Impact Assessment and Mitigation, including Conclusions**
Appendices	**Survey Reports and baseline information** – for Sections 5 – 10 (see above). Provision of detailed information on Biodiversity, i.e., Terrestrial Ecology Survey Record, Harmonized Habitat Mapping, Critical Habitats' Assessment, Invasive Alien Species, Biodiversity Offset Framework and Ecosystem Services Assessment.

2 SCOPING ACTIVITIES AND RESULTS

2.1 INTRODUCTION

In accordance with the approach taken to international ESIA, the scoping exercise, introduced above, determined which impacts were likely to be significant and therefore become the main focus of the work.

A brief summary of the information on environmental and social topics from the previous studies used to undertake this scoping is listed in Table 2-1. This matrix shows which environmental and social topics and aspects – by Project Component – were sufficiently addressed in both the existing EIA Reports and DRPIC E&S Management Plans (i.e. and therefore scoped out of this Consolidated Impact Assessment and Mitigation Report). Similarly, those requiring further assessment (i.e. scoped in) and the subject of subsequent Sections (5 to 10) in this Report are shown in the Table.

Table 2-1: Matrix of E&S Topics/Aspects and Project Components Summarising Results of Scoping

		PROJECT COMPONENTS					KEY ASSOCIATED FACILITIES		
Document Reference ➔		Refinery EIA	Ras Markaz Crude Oil Storage Terminal	Crude Pipeline	Export Terminal	Const. Camp	Integrated Power and Water Plant	Sea Water for Industrial Zone Project	Service Corridor
Aspects ⬇									
Biological	Terrestrial Flora & Fauna	✓	✓	✓	✓	✓	✓	✓	✓
	Marine Flora & Fauna	✓	✓	×	✓	×	×	✓	×
Physical	Air Quality	✓	✓	✓	✓	✓	✓	✓	✓
	Noise	✓	✓	✓	✓	✓	✓	✓	✓
	Climate Change	✓	✓	✓	✓	✓	✓	✓	✓
	Groundwater	✓	✓	✓	✓	✓	✓	✓	✓
	Soil	✓	✓	✓	✓	✓	×	✓	✓
	Wastewater/Waste	✓	✓	✓	✓	✓	✓	✓	✓
	Accidental Releases	✓	✓	✓	✓	✓	×	✓	✓
	Landscape	✓	✓	✓	×	✓	✓	✓	✓
	Land Use	✓	✓	✓	✓	✓	✓	✓	✓
	Natural Resources	✓	✓	×	×	✓	✓	✓	✓
Social	Local Settlements	✓	✓	×	×	✓	×	✓	✓
	Local Health and Safety	✓	✓	×	×	✓	✓	✓	✓

		Project Components					Key Associated Facilities		
	Livelihood	✓	✓	✓	✓	✓	✓	✓	✓
	Infrastructure	✓	✓	×	×	✓	×	✓	✓
	Traffic Density	✓	✓	×	✓	✓	✓	✓	✓
	Economy	✓	✓	×	✓	✓	×	✓	✓
Performance Standards	Labour & Working Conditions	×	×	×	×	×	✓	×	×
	Resource Efficiency & Pollution Prevention	✓	✓	×	✓	✓	✓	✓	✓
	Community Health, Safety & Security	✓	✓	×	×	✓	✓	✓	✓
	Land Acquisition	✓	✓	✓	✓		✓	✓	✓
	Biodiversity	✓	✓	✓	✓	✓	✓	✓	✓
	Cultural Heritage	✓	✓	✓	✓	✓	✓	✓	✓

2.2 RELEVANT EIA STUDIES

Key sources of information for the ESIA included the four mains EIAs commissioned by DRPIC for the Duqm Refinery Project components:

- Environmental Impact Assessment Study Report - Duqm Refinery (HMR, May 2015);
- Raz Markaz Oil Pipeline Concept Study & FEED Environmental Impact Assessment Report (WorleyParsons, November 2016);
- ESIA for Ras Markaz Crude Oil Park (HMR, October 2015);
- Environmental Impact Assessment Report: Duqm Liquid Bulk Berths Project (WorleyParsons, September 2015); and
- Environmental Impact Assessment Study Report - Duqm Refinery Construction Camp (HMR, December 2014).

EIA reports for the following AFs were also made available and reviewed as part of the Consolidated ESIA:

- Environmental and Social Impact Assessment, including Scoping Report, for the proposed Duqm Integrated Power and Water Plant (DIPWP), Duqm, Sultanate of Oman (BEYA, November 2016);
- Environmental Impact Assessment (EIA) Report for Duqm Sea Water for Industrial Zone Project (SWIP) (HMR, July 2015); and
- EIA for Service Corridor, Duqm (HMR, August 2015).

Several EIAs for AFs are understood to be in preparation or not started or not available in time for assessment:

- The Natural Gas Spur Line (and non-associated Gas Supply Station); and
- Haul road/lane for solid exports.

2.3 BASELINE ASSESSMENT SUMMARIES

This Section provides a summary of baseline data on air quality, cultural heritage, ecology, landscape, noise, socio-economics and related aspects of the Project. The previous EIA reports are referenced, where applicable, while detailed environmental baseline reports comprising primary data collection/assessment for the following were compiled and are available in separate reports, and also presented as Appendices to this Report:

- Air quality and odour (DRPIC Report Ref. 02-C-Base/AQ);
- Noise and vibration (02-C-Base/N);
- Visual and landscape (02-C-Base/VL);
- Social and health (05-C-Base/Soc);
- Cultural heritage (06-C-Base-Cul); and
- Biodiversity (included in this Report and Appendices).

2.3.1 Air Quality

PREVIOUS BASELINE WORK

Previous baseline air quality and odour survey work has been documented in the following:

- Appendix A of the *Environmental Impact Assessment Study Report for Duqm Refinery* (HMR, 2015);
- Environmental and Social Impact Assessment (ESIA) Scoping Report for the Proposed Duqm Integrated Power and Water Plant (DIPWP), Duqm, Sultanate of Oman;
- Sections 5 (ambient air quality) and 6 (impact assessment), and Appendix 3 of the *Raz Markaz Oil Pipeline Concept Study & FEED Environmental Impact Assessment Report* (WorleyParsons Oman Engineering, 2016);
- Duqm Industrial and Free Zone Masterplan Sultanate of Oman, Final EIA Report;
- Appendices B and E of the *Environmental Impact Assessment Study Report for Duqm Refinery Construction Camp* (HMR, 2014)*;*
- Environmental Impact Assessment (EIA) Study Report, Duqm Refinery;
- Sections 2, 6 and 7 of the *Environmental Impact Assessment Report: Duqm Liquid Bulk Berths Project* (WorleyParsons Oman Engineering, 2015);
- EIA for Service Corridor, Duqm, Environmental Impact Assessment Report;
- ESIA for Ras Markaz Crude Oil Park;
- Environmental Impact Assessment (EIA) Report for Duqm Sea Water for Industrial Zone Project (SWIP); and
- Equator *Principles Supplementary Report on Associated Facilities – Genesis Technip, March 2016.*

The previous baseline air quality studies and odour included measurements in and around Project components and relevant receptors.

FINDINGS OF THE PREVIOUS AIR QUALITY AND ODOUR ASSESSMENTS

Duqm Ras Markaz Oil Pipeline Concept Study & FEED, Environmental Impact Assessment Report - Oman Gas Company, May 2016

As part of the zone development, SEZAD undertook continuous ambient air quality studies at three locations within the Duqm SEZ area between 2012 and 2013, recording concentrations of carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulphur dioxide (SO_2) and particulate matter of diameter less than or equal to ten micrometers (microns) PM_{10}.

In Table 5-16, the monitoring detected exceedances of both the USEPA and Omani provisional standards for Ozone (8 hour average, 177$\mu g/m^3$, Sep 2013); SO_2 (1 hour average, 211 $\mu g/m^3$, Sep 2013) and PM_{10} (24 hour average, 244 $\mu g/m^3$ Mar 2013).

In addition, PM_{10} monitoring was undertaken at 70 locations along the Crude Pipeline for up to 15 minutes at each location. Concentrations ranged from 10 to 339 μg/m^3 as a 15 minute average. High dust levels were recorded during periods of high wind speeds (Ref: Table 5-17).

Ras Markaz Crude Oil Park Project – HMR Consultants, October 2015

Ambient concentrations of CO, NO, NO_2, NO_x, O_3, hydrogen sulphide (H_2S), SO_2, methane (CH_4), Total Non-Methane Hydrocarbons (TNMHCs) and PM_{10} were monitored using a continuous analyser for a period of one month. Monitored concentrations were within the relevant standards with the exception of 24 hr PM_{10} concentrations which reached 244μg/m^3.

Duqm Industrial and Free Zone Masterplan – Jurong Consultants, June 2010

PM_{10} monitoring was undertaken at ten sites for a period of less than one day at each location. Period mean concentrations ranged between 13.4 and 73.0 μg/m^3 and it was stated that gusting wind may have played a role in the higher concentrations measured.

In addition, diffusion tubes for sulphur dioxide and nitrogen dioxide were deployed at four locations for a period of 36 days. Mean SO_2 concentrations ranged from 11.97 to 19.60 μg/m^3 and nitrogen dioxide concentrations ranged between 2.93 and 4.07 μg/m^3.

Duqm Refinery Air Quality Baseline Study Report (HMR, Dec. 2014)

Baseline air quality was assessed using a series of several short monitoring surveys (ranging between 11 to 18 days) at five locations within the Duqm Refinery study area. A Continuous Air Quality Monitoring Station (CAQMS) was used to monitor concentrations of SO_2, NO_x, CO, O_3, H_2S, PM_{10} and total non-methane hydrocarbons (TNMHC). Monitoring locations included the Duqm Refinery site (October 2013 and June 2014), Wadi Dhanjart, the Village of Nafun, the heavily Industrialised area to the north of Duqm town, Duqm Town and the Airport. During the surveys several exceedances of air quality standards were observed, these occurred principally at the Refinery site, and included an exceedance of the O_3 8-hr standard in the June to July 2014 air quality monitoring period, which was not observed during the previous monitoring undertaken at the site in October 2013. Also an exceedance of the PM_{10}, air quality standard was observed at both the Refinery site and in Duqm Town. Ozone exceedances are more likely during summer periods than winter periods due to the higher UV intensities, and elevated PM_{10} concentrations were attributed to the characteristic Shamal winds which occur in the summer months.

Duqm Liquid Bulk Berths Project – Worley Parsons, September 2015

Diffusion tube monitoring was undertaken at eight sites, measuring SO_2, volatile organic compounds (VOC), O_3, oxides of nitrogen (NO_x) – made up of nitrogen monoxide (NO) and nitrogen dioxide (NO_2) concentrations over a period of 21 days. Concentrations of SO_2, VOC, NO_x and NO_2 were all well below the relevant standards (<5μg/m^3 in each case). Ozone concentrations ranged between 59 and 78 μg/m^3 over the period.

Environmental Impact Assessment Report for Duqm Sea Water for Industrial Zone Project – HMR Consultants, July 2015

Concentrations of SO_2, NO_x, CO, O_3, H_2S, PM_{10} and total non-methane hydrocarbons (TNMHC) were monitored using a continuous analyser for a period of approximately two weeks at each of three locations. 24 hr average concentrations of SO_2 exceeded the standard with a maximum value of 160.3μg/m^3 as did 8-hour average concentrations of O_3 with a maximum of 125.2 μg/m^3. All other measured concentrations fell within the relevant standards.

Environmental Impact Assessment Report for Duqm Refinery Construction Camp – HMR Consultants, December 2014

Ambient concentrations of CO, NO, NO_2, NO_x, O_3, H_2S, SO_2, CH_4, Total Non-Methane Hydrocarbons (TNMHCs) and PM_{10} were monitored using a continuous analyser at three separate sites over a total period of 39 days. 8 hr average concentrations of O_3, exceeded the

standard with a maximum value of 193µg/m^3 as did 24 hour average concentrations of PM_{10} with a maximum of 227 µg/m^3 and NMHCs with a maximum value of 266 µg/m^3. All other measured concentrations fell within the relevant standards. Odour sampling was carried out using sorbent tubes. Sorbent tube sampling is NIOSH/OSHA approved method for collecting most hazardous gases and vapours from the air. All VOCs sampled for odour were below the detection limits.

Environmental and Social Impact Assessment Report for the proposed Duqm Integrated Power and Water Plant (DIPWP), Duqm – Marafiq; BEYA 2015

Ambient concentrations of O_3, PM_{10}, SO_2, H_2S, CO, NO_2, CH_4 and NMHC were monitored at five locations for a period of approximately 24 hours at each location. 24 hr PM_{10} concentrations exceeded the 24hr standard at one location, with a maximum concentration of 506µg/m^3. In addition, elevated concentrations of ozone were recorded (a maximum of 68.1µg/m^3 as 24 hr average), indicating a likely exceedance of the 8-hour standard for O_3. All other measured concentrations fell within the relevant standards.

Scoping Report and ESIA[1] for the Proposed DIPWP – ADP Consultants, December 2016

Ambient air quality monitoring was carried out in December 2016 on continuous basis over just 24hrs hours at four separate locations measuring SO_2, H_2S, NO_2, NO_x, CO, O_3, CH_4, NMHC and PM_{10}. Measured concentartions of O_3 over the 24hr period were elevated (between 53.5 to 68.1 µg/m^3) though well within the Omani 8 hr air quality standard of 120 µg/m^3, as the monitoring period was greater than the standard duration, an exceedance of the O_3 standard at these locations were possible. In addition PM_{10} concentrations at all five sample locations were within the 24hr national ambient air standard of 125 µg/m^3 though exceeded the WHO annual standard of 20 µg/m^3, which was not applicable over these very short monitoring durations. All other parameters were well below the Omani nation air quality standards.

SUMMARY OF THE PREVIOUS AIR QUALITY AND ODOUR ASSESSMENTS UNDERTAKEN IN THE DUQM REGION TO DATE

The previous air quality surveys undertaken in the Duqm region detected exceedances of PM_{10}, O_3 and SO_2 concentrations against the then provisional Omani air quality standards. A continuous analyser was deployed for only three of the five air quality surveys and only for a maximum period of one month. In the studies which deployed diffusion tubes exposed over several weeks, the likelihood that a non-compliance against a 24hr air quality standard would have been detected is low. These previous studies, even though short in duration, and in two cases limited to a diffusion tube study, detected several non-compliances of pollutants, two of which (PM_{10} and O_3) would be considered to be as result of natural processes, and not as an consequence of anthropogenic emissions. In a number of the other studies, PM_{10} sampling was conducted over various short durations of between 15 mins to less than 24hrs. These sampling durations do not relate to existing air quality standards or limit values, and therefore cannot be used to adequately assess compliance or otherwise against existing standards or limit values.

ENHANCED BASELINE BASED ON NEW SURVEYS

Continuous ambient air quality sampling of PM_{10}, $PM_{2.5}$, NO_2, SO_2, O_3, CO, H_2S, VOCs, BTEX and Methane was undertaken adjacent the Sebacic Acid plant compound gatehouse between 3rd May until 6th August 2017.

[1] Due to the timing of the availability of an updated ESIA Report (end of July 2017) the results were not available in time for this Report.

In addition to the CAQMS, passive samples were deployed at six locations across the study area for NO_2, SO_2, H_2S and BTEX. Each sample was collected and a new sample deployed each month, providing a total of two months of passive sampling data. This diffusion tube provides a spatial distribution of baseline ambient air concentrations. Appendix A contains a record of the work carried out by WSP on baseline air quality.

This new air quality data provides a consistent medium term (three month) record of high quality air quality data at the Refinery site. Air quality baseline data collected previously does provide a degree of historic context to the air quality baseline, though data coverage was inconsistent, irregular and in some instances outdated. Sampling undertaken by WSP provided a secure continuous record of air quality measurable against current Omani national and international air quality standards and limits' values.

2.3.2 Ambient Air Quality and Odour Monitoring Results, Duqm

Results from the CAQMS are summarised in Table 2-3, as period average and compliances against 24 hourly, 8 hourly and 3 hourly standards, where relevant. More detail on the data recorded at the CAQMS is presented in Appendices A and B, the latter with maximum concentrations.

Table 2-3: Ambient Air Quality Monitoring Station Results – Duqm, May to August 2017

Pollutant	Period Mean	Max concentration (averaged to standard)	Omani AQ standard (MD 41/2017)	Compliant Baseline
O_3 Conc µg/m^3	74.73	172.69 (8 hrs)	120 (8hrs)	No (Exceeds 8hr standard)
CO Conc mg/m^3	0.51	0.0088 (8 hrs)	10 (8 hrs)	Yes
		0.041 (1 hr)	30 (1 hr)	
NO µg/m^3	1.84			
NO_2 µg/m^3	3.32	10.29 (24 hr)	130 (24 hr)	Yes
		58.48 (1 hr)	250 (1 hr)	
SO_2 µg/m^3	6.26	14.46 (24 hr)	150 (24 hr)	Yes
		15.90 (1 hr)	350 (1 hr)	
H_2S µg/m^3	1.34	9.83(1hr)	30 (1 hr)	Yes
$PM_{2.5}$ Conc ug/m^3	64.35	158.92 (24 hr)	65 (24 hr)	No
PM_{10} Conc ug/m^3	151.53	488.92 (24 hr)	150 (24 hr)	No
CH_4 µg/m^3	770.72			-
NMHC µg/m^3	0.00	0.00	160 (3 hr)	Yes
TVOCs µg/m^3	4,174			-
Benzene µg/m^3	0.00	0.00		Yes
Toluene µg/m^3	0.38			-
EthylBenzene µg/m^3	0.00			-
M&P-Xylenes µg/m^3	0.00			-
O-Xylene µg/m^3	0.00			-

*Assuming NMHC = Butane

Air quality and odour monitored by the CAQMS was generally good during the sampling period 3rd May to 6th August 2017, though particulate matter and ozone were both elevated. A power interruption to the CAQMS occurred on 2nd June, which resulted in a four day data gap due to repairs being required to the CAQMS. This sampling period loss was made up be an additional four days sampling by the CAQMS at the end of the third month.

Monitoring results indicate that both NO_2 and SO_2 were both low in concentration during the sampling period, implying that there are no significant industrial emissions sources within the proximity of the CAQMS. However, O_3, PM_{10} and $PM_{2.5}$ all exceeded short-term concentrations limits. In the case of both PM_{10} and $PM_{2.5}$, the period mean exceeded the 24hr air quality standards for both pollutants. O_3 and PM are known to originate as a consequence of natural processes, such as strong sunlight and UV radiation in the case of O_3, and re-entrainment of dust and sand in the case of PM. Therefore, though the baseline survey has detected exceedances of ambient air pollutants, these pollutants are highly likely to originate from natural processes and not as a consequence of existing anthropogenic activity locally.

The periods of elevated particulate matter were extended and not attributable to localised sources. Therefore, though local construction activity would have contributed to the elevated particulate matter concentrations, it was not considered to be the primary source of particulates resulting in the exceedance of both the PM_{10} and $PM_{2.5}$ air quality standard,

Results from the diffusion tube survey are summarised in Table 2-4 below. Concentrations of pollutants monitored by diffusion tube across the study area were all very low, and indicate that none of the pollutants monitored by diffusion tube were likely to be at risk of exceeding any annual average limits (e.g. such as for Benzene or NO_2).

The spatial variation of pollutant concentrations observed by the diffusion tube results can be seen to vary with respect to the proximity to populated areas. With higher concentrations of NO_2 being detected at the Duqm Town sample site and the Rock Garden sample site (within 1km of Duqm Town); whereas the NO_2 concentrations elsewhere were all consistent, even at the CAQMS location (Sebacic Acid Plant). Therefore it can be implied that the current impact of vehicle emissions upon local air quality and NO_2 concentrations within the study low is currently low to negligible.

The concentrations of SO_2 monitored across the study area over the two month diffusion tube survey were low. As the Oman air quality limit value is assessed over a sample duration of 24 hours, no firm assessment of SO_2 limit value or standards compliance can be reached on the monthly diffusion tube samples. However, there is an implication that there is currently no dominating source of SO_2 within the study area, such as the Desalination plant power station, and that baseline concentrations at remote locations to the north of the proposed Refinery site (e.g. Quarry Road locations and Nafoon Village) are likely to remain very low.

Table 2-4: Diffusion Tube Survey Results for Duqm Refinery Baseline Survey

Pollutant	NO_2	SO_2	H_2S	Benzene	Toluene	Ethyl Benzene	m,p-Xylene	o-xylene
Duqm Town	8.33	0.32	-	-	-	-	-	-
Rock Garden	9.74	0.38	1.00	0.37	<0.21	<0.25	<0.25	<0.25
Dry Dock Camp	5.32	1.71	-	-	-	-	-	-
Quarry Road	5.16	0.16	0.22	0.25	<0.21	<0.25	<0.25	<0.25
Refinery Gate house	5.66	0.50	0.12	0.215	<0.21	<0.25	0.315	<0.25
CAQMS	6.56	1.29	-	-	-	-	-	-

2.3.3 Noise

PREVIOUS BASELINE WORK

Previous baseline noise survey work was documented in the following historical documents:

- Appendix A of the *Environmental Impact Assessment Study Report for Duqm Refinery* (HMR, 2015);
- Appendix A of the *Environmental Impact Assessment Study Report for Duqm Refinery Construction Camp* (HMR, 2014);
- Section 6.15 of the *Environmental Impact Assessment Report: Duqm Liquid Bulk Berths Project* (WorleyParsons Oman Engineering, 2015); and
- Section 5.10 and Appendix 3 of the *Raz Markaz Oil Pipeline Concept Study & FEED Environmental Impact Assessment Report* (WorleyParsons Oman Engineering, 2016).

The previous baseline noise studies included measurements in and around Project components and relevant receptors.

FINDINGS OF PREVIOUS WORK

The surveys above collected data during periods of high winds, and the results show high noise levels indicative of measurements taken in windy conditions. These are considered to be invalid measurements. To ensure a robust characterisation of baseline noise levels, a further survey was carried out by WSP to inform a noise baseline.

ENHANCED BASELINE BASED ON NEW SURVEY

The noise environment around the Project components and the surrounding inhabited areas has been characterised over a series of site surveys, carried out to international standards, using calibration equipment. Figure 2-1 shows the surveys locations.

Figure 2-1: Baseline Noise Survey Locations (April, 2017)

In general, there are few existing anthropogenic sources of noise other than infrequent road traffic, sound levels tend to be dictated by natural sources, including wind interaction with obstacles and vegetation, and (at coastal locations) wave break and surf. Measurements of existing baseline levels are summarised in the table below and Appendix B presents the new baseline noise surveys in more detail.

The noise levels measured at each of the noise monitoring locations are shown in Table 2-2. The noise levels are summarised in terms of the range of the measured L_{Aeq} (ambient) and L_{A90} (background) noise levels. The primary noise source and wind speed measured at each location are also indicated. Detailed monitoring records are shown in **Error! Reference source not found.**.

Table 2-2: Summarised Baseline Noise Survey Measurement Results

LOCATION	DATE, dd/mm/yy	TIME PERIOD, hrs	PERIOD DESCRIPTION	L_{Aeq} RANGE, dB	L_{A90} RANGE, dB	WIND SPEED, m/s	PRIMARY NOISE SOURCE(S)
Wadi Saay Location 1	25/04/17	1509 – 1539	Day	50 – 51	45 – 46	2 – 3	Distant construction noise along Highway 32, wind
	26/04/17	0922 – 0952	Day	52	44	2 – 3	Occasional road traffic & construction activity on Highway 32, wind
	24/04/17	1807 – 1837	Evening	52 – 53	45	3 – 5	Very occasional road traffic on Highway 32, wind
	24/04/17	2317 – 2332	Night	45 – 46	41	2 – 4	Wind
Wadi Saay Location 2	25/04/17	1554 – 1624	Day	46 – 47	40 – 41	2 – 3	Wind
	26/04/17	1001 – 1031	Day	44 – 45	39	3 – 4	Wind
	24/04/17	1911 – 1956	Evening	49 – 51	41 – 43	4 – 5	Wind
	25/04/17	0004 – 0034	Night	42 – 44	38	4 – 5	Wind
Wadi Saay Location 3	26/04/17	1038 – 1108	Day	52	43 – 44	2 – 3	Occasional road traffic & construction activity on Highway 32, wind
	26/04/17	1804 – 1834	Evening	49 – 50	44	4 – 5	Very occasional road traffic on Highway 32, wind
	25/04/17	2328 - 2358	Night	51 – 52	40 – 41	4 – 5	Wind
Nafun Location 1	25/04/17	1212 – 1242	Day	41 – 42	39	2 – 3	Wind, very occasional local vehicles
	25/04/17	2217 - 2232	Evening	42	38	2 – 3	Wind, very occasional local vehicles
Nafun Location 2	25/04/17	1303 – 1348	Day	54	52 – 53	4 – 5	Wind, sea
	25/04/17	2241 – 2253	Evening	48	45	4 – 5	Wind, sea – note: measurement cut short for safety reasons
Antoot Fishing Area	25/04/17	1053 - 1123	Day	42 – 44	35 – 36	4 – 5	Wind / sea
Dhahr Location 1	26/04/17	1226 – 1256	Day	46 – 47	38	5 - 7	Occasional local vehicles, wind
Dhahr Location 2	26/04/17	1309 – 1339	Day	46 – 48	39 – 41	4 – 5	Occasional local vehicles, wind
Dhahr Location 3	26/04/17	1403 – 1433	Day	43 – 45	36	2 – 3	Occasional local vehicles, wind

2.3.4 Visual and Landscape

PREVIOUS BASELINE WORK

Amongst the secondary sources of information used as part of the new landscape and visual assessment, the following reports were reviewed.

Table 2.3: Documents Reviewed to Inform Landscape and Visual Baseline

NAME OF REPORT	AUTHOR/YEAR	RELEVANT INFORMATION
ESIA for the Proposed Duqm Integrated Power and Water Plant (DIPWIP)	ADP Consultant/BEYA Environmental Consultancy, 2016	Some geographical, climate and social context.
EIA for Service Corridor, Duqm – Environmental Baseline Report	HMR Consultants, 2015	Some detailed topographical information.
Duqm Refinery EIA Study Report, Appendix A – Environmental Baseline	HMR Consultants, 2015	Site observations about land use.
EIA for Duqm SWIP	HMR Consultants 2015	Description of local Wadi systems. Comparative study of changes in vegetation since commencement of development.
Duqm Industrial and Free Zone Masterplan EIA	Jurong Consultants, 2011	Full landscape and visual assessment including classification of Landscape character areas and detailed assessment of landscape and visual baseline and value. Useful in describing typical coastal areas and landscape character including outside of the SEZ boundary.
Ras Markaz Crude Oil Park Project ESIA	Amec Foster Wheeler, 2015	Includes descriptions of geology, hydrology and ecology of study area, contributing to landscape characterisation.

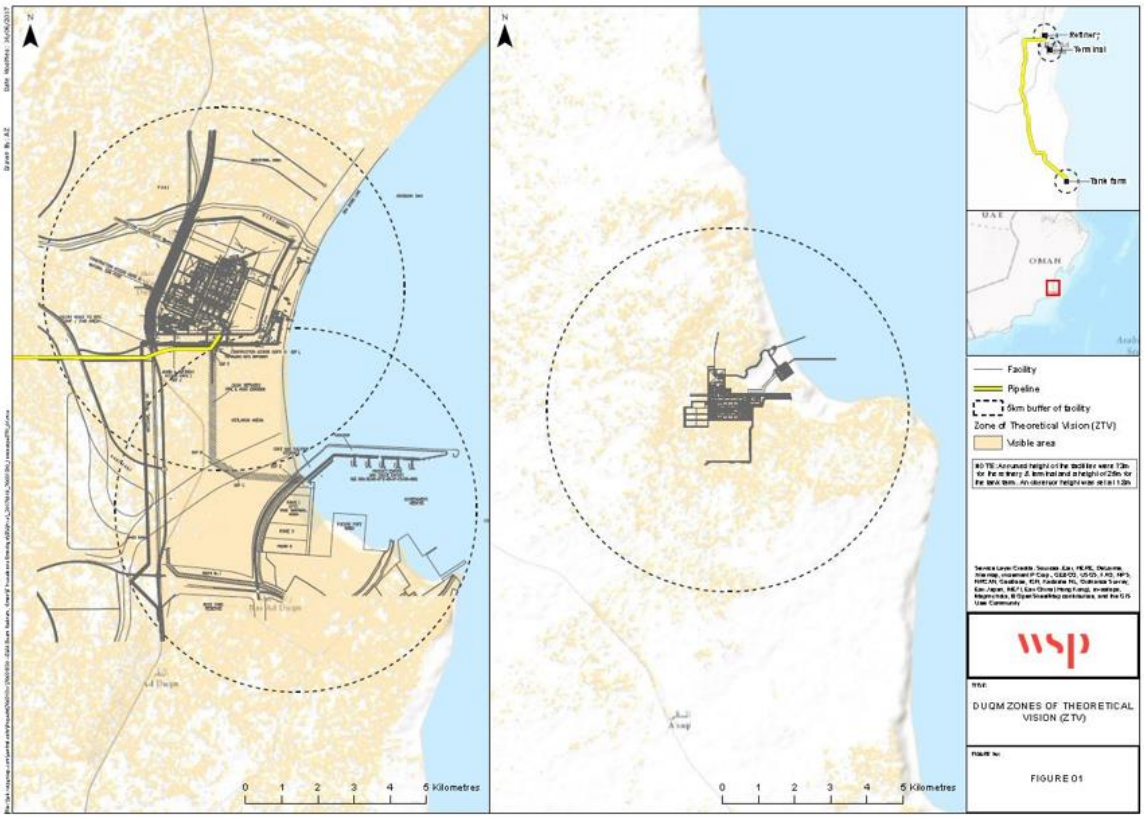
FINDINGS OF PREVIOUS WORK

Information from the geology, ecology and land use sections of these reports contributes to an understanding of the landscape baseline. The Communities' chapters set out a range of potential visual receptors, although there was a lack of consistency, perhaps due to the changeable nature of the local population. The investigations undertaken on socio-economics and health as part of the Consolidated ESIA work also contributed valuable insights into the character of the area, the potential receptors and observations that contributed to this landscape baseline. The Free Zone Masterplan EIA (Jurong, 2011) includes a full classification of local landscape types which have been adopted to apply to the study area of this Report.

ENHANCED BASELINE BASED ON NEW WORK

The study area for visual effects extends to the area from which the Project could be visible, cut off at a distance of 5km from the Project component site areas. The Zone of Theoretical Visibility (ZTV) has been established to show the area of land from which there could be a view of any part of the proposed Project. The ZTV helps to establish the geographical extents of the study area and was determined by digital modelling using specialist GIS software to analyse a Digital Terrain Model (DTM) and the output is shown below.

Figure 2-2: ZTV for Project Components



The study area for landscape effects covers the proposed Project site and the wider landscape context within which the Project may influence landscape character. The study area for both landscape and visual impacts has been cut off at a radius of 5km from each of the Project components, in order to focus on potentially significant effects. This reflects the largely flat, undeveloped landscape, lacking substantial vegetation which would interrupt views towards the Project, which would be of a large scale and therefore readily visible. Atmospheric conditions are generally dry, although occasional sea mists may reduce visibility. It is considered that even though the development may be visible from greater distances, it would not constitute a dominant element in the view, and would therefore be unlikely to cause significant landscape and visual effects.

Factors such as geology, topography, the presence of waterbodies, vegetation and human influence and land use are used to describing the different elements that make up the landscape in the study area. This information is used to define landscape character types within the study area: geographical areas made up of a distinct combination of elements and aesthetic or perceptual aspects.

The assessment of overall landscape sensitivity combines the judgements on the susceptibility of receptors (see below) to the proposed development.

Evaluating 'visual amenity' involves determining the extent of visibility of the development proposals, followed by identification of visual receptors and their sensitivity to changes in their surroundings.

Visual receptors, such as users of buildings, recreational spaces, footpaths and transport routes, have differing sensitivities to their visual environment, which is dependent upon their interest in the visual environment, the viewing opportunity and duration/context the views. Visual receptors have been identified based on existing mapping and previous reports on social impacts.

Settlements in and around Duqm have been static for some time and the nature of the SEZ does not allow for new temporary settlements.

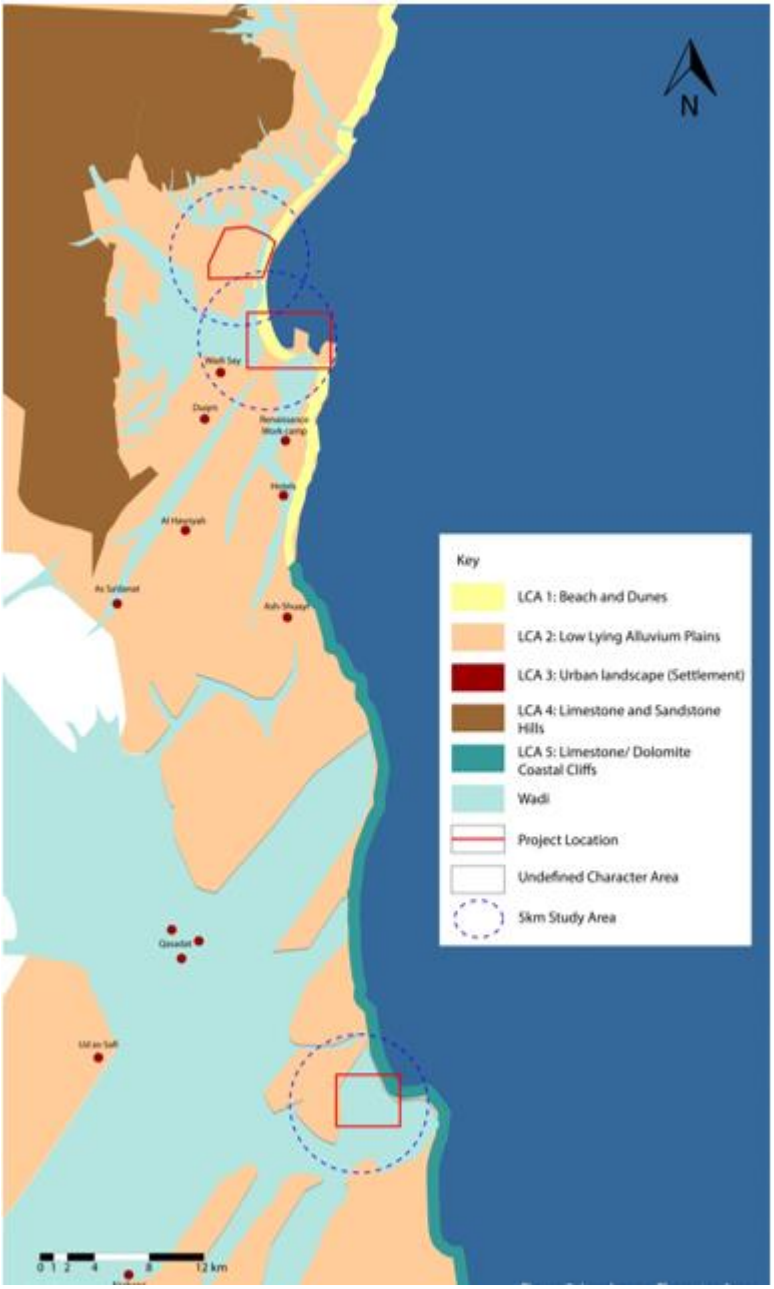
In terms of receptors, the area currently supports a limited population in scattered small settlements. Receptors include people seasonally inhabiting the few local temporary residences and fishermen on the beach and passing at sea.

The development of the Duqm SEZ will boost the population and introduce an increasingly industrial and urban character to the landscape, of which the Project will form a part. The landscape in the wider project area is characterised by a number of other projects that are currently being developed or close to their completion, i.e., Port of Duqm, Ship Repair Yard and Dry Dock, Fishery Harbour, Duqm Airport.

There are no formal landscape designations applicable to this area, although the coast is protected by any development being set inland from its immediate edge. In general, the site can be classified by low-lying coastal and alluvium plains that are enclosed to the north, west and south by sandstone and limestone hills that lie at the foot of the Huqf escarpment. To the east, the site meets the Gulf of Oman, with sandy beaches backed by dunes and khawrs. The area is incised by wadis that flow from the escarpment to the sea. This landscape arrangement is typical of the landscape along the eastern coast of Oman. The topography of the Project site is very variable and ranges up to 190m above sea level. The coastal area is particularly scenic due to the intersection of land and sea which provides increased geological and ecological diversity and extensive views.

The following local landscape character area descriptions LCA1-4 were set out in the Duqm Industrial and Free Zone EIA Report (Jurong Consultants/Five Oceans, 2011) and have been used in the Consolidated ESIA. These are briefly described, below Figure 2-3.

Figure 2-3: Landscape Character Areas in the Project Area



- LCA1: Beach and Dunes – Duqm coastal frontage, featuring beach and back beach, khawrs and intertidal mudflats, it is considered to be of high quality but low rarity so of local importance.

Figure 2-4: View of beach east of Duqm Refinery Plot, Spring 2017

- LCA2: Low lying alluvium plains – naturally fragmented by low rocky outcrops, gravel hills, areas of sabkha and wadi courses. It has been modified by the main highway, and land use activity such as sand-mining and the development of materials sorting areas as well as the onset of new build projects (e.g. Sebacic acid manufacturing plant). The LCA is expansive and provides a sense of space, openness and wildness until it meets Duqm Town, or Wadi Saay (LCA3) and other construction works. It is high quality and high importance but low rarity and thus of local importance.

Figure 2-5: View of Alluvium Plains, Spring 2017

- LCA 3: Urban landscape – located within the low-lying alluvium plain to the south-east of the Industrial Development Zone (IDZ). This landscape is almost exclusively defined by low lying commercial and residential development which is connected by a main highway (R32) and minor arterial access roads.

Development is widely spaced, which provides an incoherent open development type with very little connectivity between areas of development. It is assessed to be of low quality, importance and rarity.

- LCA 4: Limestone and sandstone hills – these are large-scale upland and hillside landscapes lying between around 50m and 190m above mean sea level, backed by the Huqf escarpment. Consisting of exposed rock with pockets of scrub and seasonal grassland, it also has ridges and ravines, and is incised by wadis, This landscape does not contain human features (other than footpaths or small access roads). LCA4 possesses a distinct remote and exposed character and may offer striking views along the surrounding coast and sea. It is assessed as of high importance, high value (when part of the Arabian Oryx Sanctuary) and of regional importance.

- LCA 5: Limestone/Dolomite coastal cliffs – the rocky coast between Shuwayr and Madrakah is bordered by black and white cliffs of 80m average height rising to 200m in places. They are edged by sandy beaches interspersed with a rocky shore line with heaps of eroded material forming dunes at the cliff base. These cliffs make the foreshore inaccessible for much of their length but fishermen use those bays with road connections. The cliffs are assessed to be of high quality, high importance and moderate rarity, and should be considered to be of regional importance.

More details on Visual and Landscape baseline can be found in the baseline report included in Appendix C.

2.3.5 Biodiversity

PREVIOUS BASELINE WORK

Significant study of ecology in the Project area has been undertaken as part of the Project EIAs and the wider development EIAs.

FINDINGS OF THE PREVIOUS WORK

The Project Area includes biodiversity, habitats and receptors, however, impacts on these were not assessed in Project documentation, for example:

- Information on two Important Bird and Biodiversity Areas (IBA) near Duqm Refinery and the Liquids Terminal lacking in those respective EIA Reports
- Lack of assessment of indirect impacts on biodiversity receptors;
- Only a limited impact assessment (i.e. with a focus on loss of habiats) in the Crude Pipeline EIA;
- Limited impact assessment on oil spill with respect to receptors at the Ras Markaz Crude Oil Terminal and potential collions with marine species not mentioned; and
- No consideration of potential impacts on turtles or whales species in the impact assessment of the Liquids' Terminal.

ENHANCED BASELINE BASED ON NEW SURVEYS

The majority of the Project area is represented by arid desert, semi-desert or coastal habitats. The benthic habitat in the immediate marine area adjacent to project activities appears to be composed of fine sand and clayey substrates with little or no hard substrates present.

The presence of the Duqm Important Bird Area (the 'Duqm IBA') as designated by BirdLife International and the significance of the coastal zone from Duqm to Ras Madrakah is well reported across the various EIA/Ecological Baseline Survey (EBS) documents. A second – Jiddat al Harasis IBA – is located to the north and west and considered to be in the indirect AoI. Of the bird species reported to utilise the Duqm IBA, the great majority are marine or shoreline species (62%) and/or migratory (54%). Some species can be included in both categories.

Part of the IBA has already been removed from the development of the Duqm Port and area, the area of sandy, shallow bay habitat for which the IBA is noted has been reduced and inputs of water from inland wadi systems into the IBA have been altered by development of the Port. The Export Terminal is within the Port and the IBA and the Refinery is within one km from Duqm IBA.

27 mammal species may inhabit the area, including six feral/domestic mammal species. Some of these references will be of historical significance only – for example, the Arabian Oryx (*Oryx leucoryx*) which is now confined to the Al Wusta Wildlife Reserve.

Extensive information on the ecological and biodiversity baseline is included in Appendix D, which includes sub-appendices on: the survey record and harmonized habitat mapping. A further summary is included in Section 88.3.1, and Table 8-2, to provide context to the impact assessment.

2.3.6 Social and Health

PREVIOUS BASELINE WORK

A number of earlier national EIAs were prepared for various components of the project and its associated facilities. All of these documents are compliant with the national EIA legislation which does not typically require a robust and site-specific socio-economic and health baseline, surveys or assessment. Most of the earlier EIAs include somewhat limited socio-economic baseline , mainly including the last national census statistic (2010), population density and existing infrastructure. At the same time, some earlier EIAs (e.g. EIA Study for the Duqm Refinery, HMR, 2015, Ref: DRP001-EIA-RPT-Z-000-001 and EIA Study for the Duqm Refinery Construction Camp, HMR, 2014, Ref: 3514-EIA-02) do not include socio-economic baseline information.

The lack of robust and site-specific socio-economic and health baseline in most of the earlier EIAs was noted in Project Due Diligence. To fill in the identified gaps in the earlier socio-economic baseline, the WSP team carried out field surveys as part of their supplementary data collection as part of the Consolidated ESIA scope of work.

ENHANCED BASELINE BASED ON NEW SURVEYS

The socio-economic and health baseline in the Project area is characterised by a sparsely populated desert area where communities historically engaged in fishing and camel rearing/selling. Since mid-2006 and after the creation of the SEZ, the wider Duqm area, as well as some local settlements located in the project area, underwent significant changes and growth in population and development of infrastructure.

The main villages covered by the project area, include: Nafun, Al Tayari, wider Duqm area (which includes smaller settlements), and a smaller, informal settlement Antoot.

The socio-economic survey carried out in the project area revealed that most working-age adults in the project area do not have high levels of education, and are mainly relying on camel selling and property renting activities (renting a house or a fishing boat) as their main livelihood strategies. The average income levels in the project area are generally in line with the average income levels of the rest of the population. The respondents listed the following top three diseases to have affected members of their household in the past three years: diabetes, hepatitis and asthma. More details on socio-economic baseline can be found in the separate Socio-Economic Baseline Report included in Appendix E.

2.3.7 Cultural Heritage

PREVIOUS BASELINE WORK

There have been two prior archaeological surveys (not including the new survey results presented below) of the Duqm area. The first was a general archaeological assessment of the southern Huqf

was conducted by the Central Oman Palaeolithic Survey (COPS) Research Project, directed by Dr. Reto Jagher (University of Basel), 2008 – 2009. Secondly, a targeted assessment of heritage assets within the Duqm IDZ was made in 2010.

The COPS project mapped 16 archaeological findspots in the southern part of their survey area that overlaps with the IDZ. 5OES was subsequently commissioned to assess the rest of the IDZ, identifying 182 heritage sites in and around Duqm. These included cemeteries, enclosures, lithic scatters, graves, shell middens, temporary mosques, potsherds, structures, triliths, and isolated graves.

ENHANCED BASELINE BASED ON NEW SURVEY

Previous surveys in the area did not formally cover the extent of the pipeline Right of Way or the DRPIC Crude Oil Tank area at Ras Markaz. Therefore, a field survey was undertaken by Dr. Yamandú Hilbert from 23rd to 27th April 2017 along the Crude Pipeline Right of Way and at Ras Markaz. The results of this survey have been compiled into the Duqm Gazetteer. The Cultural Heritage Baseline Report (DRPIC Report Ref. 06-C-Base-Cul) - included in Appendix F – provides the detail.

The cultural heritage baseline and assessment was based on best practice (e.g. IFC PS6 on Biodiversity Conservation and Sustainable Management of Living Natural Resources) approach to protecting items, fragments and sites of archaeological (prehistoric), palaeontological, historical, cultural.

During the new field survey, architectural structures were mapped at sites, including circular stone cairns, stone fireplaces, circular stone houses, large anchor stones (perhaps for tent poles or livestock enclosures), and a trilith feature. A total of 24 archaeological features were identified, where nine of the sites are situated within 100m of the development corridor. Most of these standing structures are located within 100m of the development corridor and require mitigation.

The landscapes around the Port, the construction camps, and the Refinery have already been so heavily altered by construction activities that traces of potential archaeology have been erased. No mitigation strategy is required within these zones.

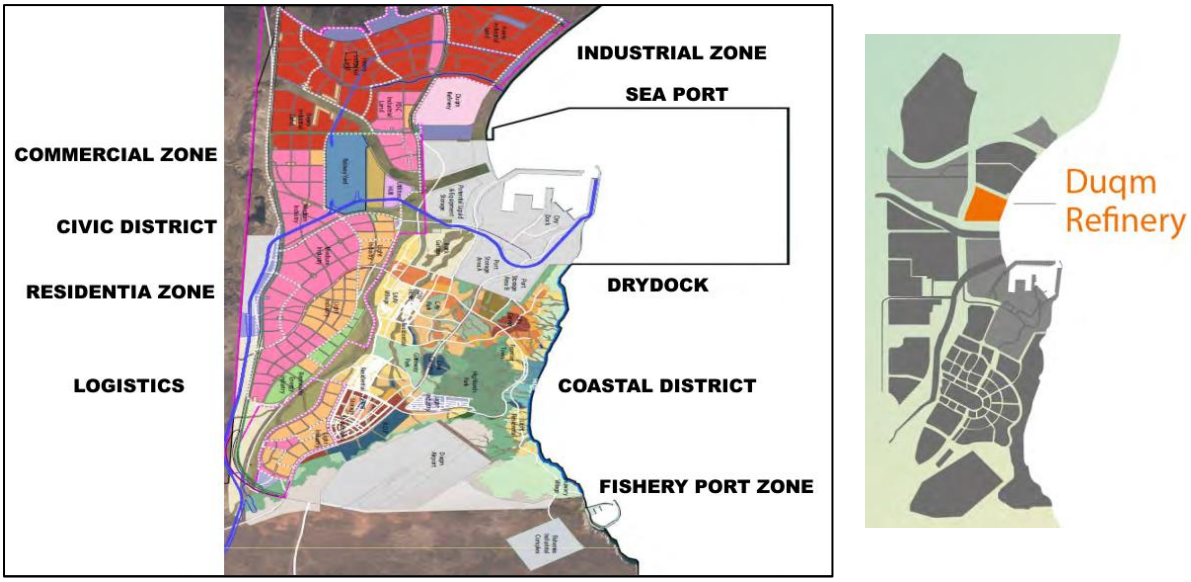
3 PROJECT OVERVIEW

3.1 PROJECT AIMS

Once operational, the Refinery will have the capacity to process approximately 230,000 barrels per day from a variety of crude mixtures. The Duqm area has been earmarked by Government as Oman's next industrial and economic hub. Duqm Refinery is the first major industrial project to be planned and built in the Duqm SEZ and will serve as a springboard for other development in the SEZ.

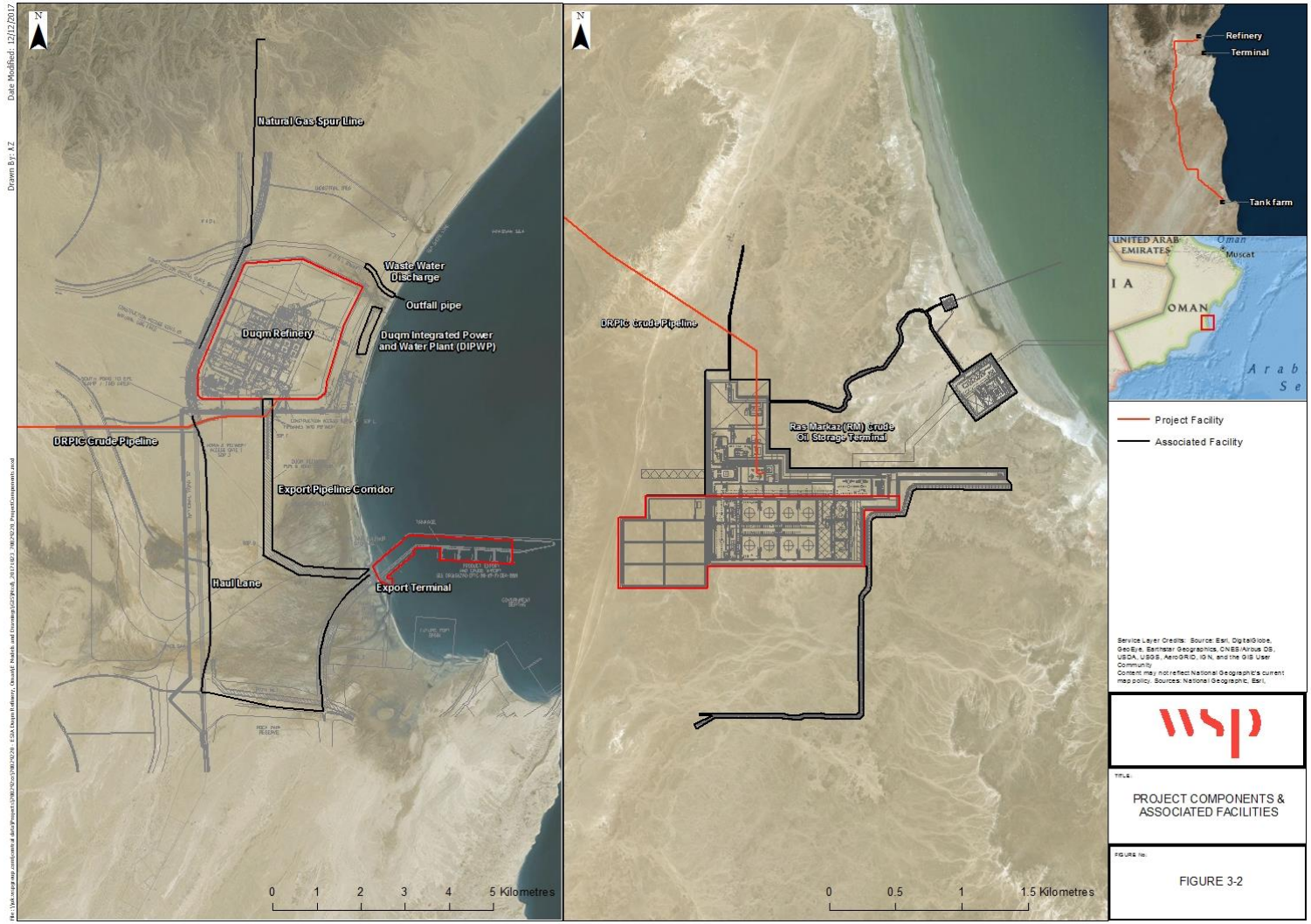
The Duqm SEZ is administered by SEZAD. SEZAD was established pursuant to Royal Decree 119/2011 and the organisation is responsible for devising, regulating and implementing long-term strategies for Duqm SEZ. The long-term intention is to establish a sustainable economic hub at Duqm, with the Project representing one of the first major industrial developments in the area. The Figure below shows a number of key components of the Duqm SEZ.

Figure 3-1: Schematic of Duqm SEZ (SEZAD, July 2017)



The Duqm Refinery Project is comprised of the Duqm Refinery itself, storage tanks at the Ras Markaz Crude Oil Storage Terminal, a connecting Crude Oil Pipeline (approximately 80km in length) and the Duqm Export Terminal close to the Refinery plot. More detail on these components and a number of Associated Facilities is presented in Section 3 while their locations are shown in Figure 3-2 for context.

Figure 3-2: Project Components and Associated Facilities



The involvement of lenders in the Project requires reporting and assessment to the suite of international standards such as the IFC Environment and Social Performance Standards in its Sustainability Framework (IFC, 2012). Under IFC Performance Standard (PS) 1 on the 'Assessment and Management of Environment and Social Risks and Impacts', Associated Facilities (AF) are developments being progressed for a project by third parties. The IESC has also identified the relevant AFs in the Duqm Refinery Project and these are presented (in a third category, 'C') below. EIA Reports have previously been prepared for most of these AFs.

Table 3-1: Duqm Refinery Project and AFs

REF.	PROJECT COMPONENT	DESCRIPTION
A	Duqm Refinery	A 230,000 barrels per day (BDP) complex refinery on a plot of 9km^2 area to the north of the main industrial area within SEZAD's area of jurisdiction. Also includes: • Site clearance and level (already complete) • Product pipelines and service lines to the Duqm Export Terminal • Construction accommodation/workers' camps • Laydown areas.
B	Off-site Facilities	i. **Crude storage facility at the Ras Markaz Crude Oil Terminal**: eight tanks located within, and part of the wider Tank Farm, some 80km from DR. The large-scale Tank Farm (Oman Oil Tank terminal Company, OTTCO) in its entirety is not part of the Project. ii. **'DRPIC Crude Pipeline':** 28-inch diameter crude oil import pipeline, 80km pipeline to transport crude oil from RM to DR. iii. **Product 'Export Terminal'**: on the lee breakwater of Port of Duqm, immediately to the south-east of DR. Topside works only, i.e., to establish storage for products and export handling facilities. For marine works, see Associated Facilities below.
C	Associated Facilities	i. Natural gas spur line/metering station used to supply gas feedstock to DR from the national gas network (Oman gas Company, OGC) ii. Export pipeline corridor – Construction of the corridor and infrastructure (pipe supports, bridges, fencing drainage, etc, including pipeline and services themselves under the refinery) (SEZAD / Marafiq). Note: SEZAD SEZAD have overall responsibility for the Pipeline Corridor, excluding the Duqm Refinery pipelines and cables, extending from the Refinery Boundary Marker fenceline to the Port fenceline. iii. The marine scope including dredging and reclamation and jetty and quay wall construction of the Duqm Export Terminal. (SEZAD). iv. Haul road or dedicated lane (on Existing Road) for solid product from DR to Duqm Export Terminal. (SEZAD). v. Duqm Integrated Power and Water Plant (DIPWP) supplying electricity and desalinated water to DR (and in the future other consumers in Duqm SEZ). (Marafiq, also known as Central Utilities Company, CUC). Note that this now includes items vi and vii below. vi. Seawater supply network (to DIPWP). (Marafiq). vii. Common wastewater outfall. (Marafiq). viii. Offshore oil import facilities (including offshore single point mooring (SPM) and crude oil pipeline to shore at RM. (OTTCO).

3.2 PROJECT DESCRIPTION

3.2.1 Duqm Refinery

The new export refinery complex will be designed and operated by DRPIC on a prepared plot covering 9 km^2 within the proposed Heavy Industry Zone in the wider Duqm SEZ. Once operational, the Refinery will have a nominal capacity of 11.5 million (M) tonnes per annum, i.e., approximately 230,000 barrels per stream day.

The Refinery will generate a number of products for the export market that will conform to international standards, including liquefied petroleum gas (LPG), Naphtha, Diesel, kerosene jet fuel (Jet A-1), Petroleum coke and Sulphur.

Accommodation for the workers will be necessary during the various construction phases of the Duqm Refinery. There are currently two construction camp locations permitted, each containing their own infrastructural support services including, power generation, water supply and wastewater treatment utilities to house workers for the Refinery construction. The Camps will be exclusively for workers on the Duqm Refinery, with the two facilities expected to hold a maximum workforce of 20,000 personnel during activities. The two construction camps will be situated to the west and south-west of the Duqm Refinery in allocated plots within the Duqm SEZ, and others at locations to be determined (and further permitted) as required.

3.2.2 DRPIC Crude Oil Storage at Ras Markaz

The Project will have eight Crude Oil Storage Tanks at Ras Markaz, each with a capacity of 550,000 barrels (BBL), and thus providing a gross holding capacity of up to 4.4 million BBL of crude oil. Imports of crude oil will be delivered to the storage terminal after unloading from ocean-going vessels via a Single Point Mooring (SPM) at the nearby coastal area. It will be pumped and piped to the Storage Terminal. The Duqm Refinery Project will have eight dedicated storage tanks, each one being able to store 0.55 Mbbl.

The location of the overall OTTCO Crude Oil Storage Terminal (an AF) is 70 km south-east of the Duqm Oil Refinery. It will cover an area of some 13 km^2 and have a holding capacity of up to 200M BBL.

A worker camp is planned for the construction of the DRPIC tanks and the OTTCO Crude Oil Storage Terminal at Ras Markaz. Total EPC Contractor (No.3) worker numbers for constructing the Tanks, Terminal and Crude Pipeline is 2,100 so the numbers in Camp here will be significantly less than that.

3.2.3 Ras Markaz Crude Pipeline

A buried 28” pipeline will transport blended crude from the DRPIC crude oil tanks at the Ras Markaz Crude Oil Storage Terminal to Duqm Refinery. The pipeline will be owned, constructed and operated by DRPIC. The Crude Pipeline corridor lies within an area that has already been approved by SEZAD and will not extend outside the boundaries of the Duqm SEZ. The route of the Crude Pipeline will connect the two facilitates over a distance of 80.7km.

3.2.4 Duqm Export Terminal

The Export Terminal involves the development of landward facilities along the length of the current lee breakwater, located in the northern part of the Port of Duqm. The works that are part of the Project will include the construction of the topsides, including storage tanks, sheds and handling equipment for the products produced by the Duqm Refinery, including both bulk liquid and solid exports.

The marine works (e.g. dredging and reclamation) to establish this facility are not a formal part of the Project for the purposes of this Report, but considered an Associated Facility.

A Worker Camp is planned for the construction of the Duqm Liquid Bulk Berth (DLBB) – see Table 2-2 below. This Camp is anticipated to hold a portion of the 2,100 workers included in the EPC Contractor's (No.3) plans referenced above.

3.3 ALTERNATIVES

The historic EIAs documented how the Project had considered alternatives in progressing plans for the Refinery and offsite components. It should be noted that SEZAD allocates the land for all development in accordance with its masterplan.

3.3.1 Duqm Refinery

The Duqm Refinery EIA (HMR, 2014) reported the following were considered in terms of alternatives during the evolution of the project scope:

- No Project Option: this option was considered and dismissed on the grounds that *'No project development precludes the potential financial and social benefits of oil and gas production.'* A No Project Option would significantly hamper the development of Oman with the consequence of 'loss of economic opportunity' to local businesses and communities.

- Project Rationale and Need for the Project: based on a market analysis including the consideration of national, regional and global demand for petrochemical products, it was concluded that the Refinery develops an integrated ethylene cracker, polypropylene and polyethylene units '*as a configuration for overall design with the integration planned for the future'*.

- Utilities and Materials: alternatives for the sourcing of power and water were considered for the construction and operation from both onsite and offsite sources. For the construction phase, power, onsite sources (diesel generator sets) were determined to provide the best solution. For operation, it was determined that sourcing from offsite third party suppliers provided a cheaper supply based on economies of scale. For water supply, the alternatives considered were the use of groundwater versus seawater (via desalination) from either on-site or third parties. The sourcing of a water supply for construction would be the responsibility of an EPC Contractor to investigate and consider. It was considered that the use of groundwater by abstraction is not a resource anyone is currently reliant on so using freshwater was not a viable option. If there are any shallow groundwater lenses, it is thought that they would be of insufficient quality and of limited supply. Should using groundwater become an option in the future, its use would be subject to authorisation and prior impact assessment.

- Analysis of Best Available Techniques (BAT): during the FEED stage, an analysis of the techniques and technologies for Refinery design was carried out to review the applicability of BAT options and assess any gaps in the specifications in order to minimise the Project's environmental impacts to As Low As Reasonable Practicably (ALARP). Further assessment of BAT is made in the separate GHG Emissions Report (WSP, 2017, DRPIC Report Ref. 03-CL-Tech/GHG).

3.3.2 DRPIC Crude Oil Storage Terminal (Ras Markaz)

The current Project component location at Ras Markaz was considered to provide an alternative route to the Strait of Hormuz for the export of crude oil in the region. The development of the entire Crude Oil Storage Terminal was planned to be of strategic importance not only for Oman

nationally, but also for the Arabian Gulf and indeed Asia region, being located on the Red Sea and connected to South East Asian shipping routes.

Moreover, the terminal would attract local, regional and international oil companies, traders and both exporting and importing countries looking for strategic crude storage. The proposed industrial developments at Duqm SEZ are to be part of regional growth that could be serviced by the Facility, most notably Duqm Refinery with whom the cost of development is now being shared and eight tanks earmarked for DRPIC's exclusive use.

The Port of Duqm was considered as an alternative to Ras Markaz, however, the water depth was unsuitable for the berthing of Very Large Crude Carriers (VLCC). Furthermore, installing a Single Point Mooring (SPM) would be cost prohibitive as suitable water depths are 60km offshore of the Port. Dredging and deepening of Duqm Port area was not feasible due to presence of hard rock at shallow depths.

A further siting option was Madrakah, 20km further to the south of Ras Markaz. Coastal Vulnerability Maps designate the coastal areas around Ras Madrakah as "extremely vulnerable" whereas those at Ras Markaz are at the lower risk category (slightly vulnerable).

The Ras Markaz location was chosen for meeting core business objectives, providing sufficient water depth (without the need for significant capital dredging) and represented a better balance of cost and environmental/social impact (HMR and AmecFW, 2015).

In addition to the siting alternatives above, a series of in-depth technical studies were prepared in order to identify the best technological option based on:

- Storage system and technology;
- Selection of sources for utilities;
- Selection of sites for labour camps;
- Wastewater treatment and disposal;
- Vapour emissions during loading/ unloading; and
- Hazardous waste treatment and disposal;

3.3.3 Crude Pipeline

The assessment of alternative export options was a phased process, commencing with a comprehensive assessment of the optimal corridor for the Crude Pipeline from Ras Markaz to Duqm Refinery before looking in greater detail at the exact route alignment. The design of the pipeline system sought to maximise its operability, minimise its cost and minimise environmental impact, where practical.

A "No Development Option" was first considered to assess the result of not developing the pipeline. Early on, it was clear that the only technically feasible and realistic option to transport large volumes of crude oil was through pipelines. The alternate modes of transport of crude were not evaluated. Again, the No Development Option was discounted as it would deny the Omani Government of the opportunity industrial projects would bring in terms of economic development, revenue, employment, etc.

At the Concept and FEED stage of the project, a route optimisation study was undertaken to optimise the initial route proposed for the Crude Pipeline. The route optimisation study considered the environmental and technical feasibility of laying pipeline along a particular route and also various rerouting options. Once a preferred route option was established, a series of configuration studies on pipe/pipeline sizing, number of booster stations, flow rates and pressures were considered and evaluated on cost, constructability and maintenance requirements. The routing and technical option assessed in the ESIA (Worley Parsons Oman Engineering, 2016) was finally chosen on the basis of Net Present Value life- cycle cost.

DUQM LIQUID BERTHS TERMINAL

An alternatives study was undertaken under broad headings as the location was already determined by the Port of Duqm location:

a) No Project Scenario;
b) Tank Farm Location:
- Tanks at Duqm Refinery vs. Tanks at Port;
- Tanks on LBW vs. Onshore.

c) Construction Methodology:
- Dredging methodology;
- Onshore vs. offshore disposal of dredged material;
- Onshore borrow vs. Offshore borrow; and

d) BAT analysis.

The Government of Oman is in the process of further developing the Port of Duqm as a strategic dry dock, free trade zone, industrial and tourism destination. The Port of Duqm is seen as the catalyst gateway for the development of the Al Wusta region. The project is crucial for the viability of Duqm Refinery as it provides a venue for export of the Refinery's products. A No Project Scenario would result in the Duqm Refinery being unable to export product and thus have no business case.

Since the DRPIC related works that fall within the Project only include the topside construction of storage tanks, sheds and handling equipment for the products produced by Duqm Refinery, alternatives for marine works are not considered. Two scenarios were considered for the export of refined products (Naphtha, Jet-A1, and diesel). The first was that the refined liquid products would be pumped directly from the Refinery storage tanks to the berths for loading onto ships with no storage facilities at or near the berths. An alternative to this was to provide storage and terminal facilities close to the berths allowing continuous transfer of product from the Refinery to the tank storage near the jetty using smaller pumps and pipelines. The distance between the Refinery and the berths is around 5km which presents several disadvantages in product handling (e.g. surge, thermal relief, heat leak, etc.), loading and custody metering. Therefore, the second option, i.e., intermediate storage was preferred.

3.3.4 Duqm Refinery Construction Camp

The plot of land for the Refinery was provided by SEZAD based on following general criteria:

- Availability of land within SEZAD and the overall SEZAD Master Plan;
- Proximity to the Refinery area;
- Availability of water;
- Availability of power from the grid (RAECO);
- Current and proposed land use of the site;
- Access and proximity to major roads connecting to Muscat; and
- No other major constraints for the development.

The EPC contractor will be responsible for sourcing power and water that is suitable for the Workers' Camps. The alternatives are likely to be sourcing (e.g. of imported or bottled water) from a third party and/or desalination. The alternatives considered for supplying power to the Workers' Camps is sourcing from the grid and/or using diesel generator sets on site. The power requirements could be met by a mix of above options with generators being an essential part of that.

The fuels required for the construction equipment and vehicles can be stored onsite or can be met by using fuel-dispensing tankers. A fuel storage areas will be located at both Camp sites.

Lastly, the construction materials used in Project construction include aggregates, sand, cement, steel, wood, chemicals, surface-coating materials etc. Many materials can be sourced locally and from adjacent regions in Oman. Since the Project is within an approved industrial area, the supply and transport of materials can be organised through existing vendors and transporters. Major plant equipment and components, which are to be sourced from suppliers outside Oman, will be imported through the Port, which would avoid the need for some long distance road transportation. However, equipment, components and materials which are supplied from vendors in Oman, will have to be transported on road to the Refinery construction area, which has adequate capacity for such movements.

3.4 ASSOCIATED FACILITIES

The following AFs have been identified as third party facilities that will further supplement the DRPIC Project. According to the IFC guidance, such amenities – while not funded as part of the Project – would not be constructed or expanded without the Project, and without which the Project would not be viable.

The AFs locations are summarised in Table 3-2 below. The rationale for the selection as an AF and a note of the services/function provided are included.

Table 3-2: Associated Facilities

Associated Facility	Rationale / Service Provided
Duqm Liquid Bulk Berth (DLBB) jetty – marine scope including dredging, reclamation/ground improvement and berth construction	While the product 'Export Terminal' development is a Project facility (see above), its establishment will include dredging activities on the berth/basin and to the south of the current lee breakwater, which will also consist of ground and foundation improvements. The DLBB EIA includes works for both the marine (AF) and topside (funded) facilities. A section of the jetty will hold the topside part of the DLBB Project facility. SEZAD will be responsible for the marine activities, which will include dredging, reclamation and construction of the jetties and quay wall.
Natural Gas Spur Line from the Gas Supply Station (GSS) to Refinery	The Duqm Refinery will be one of numerous users in the Duqm SEZ supplied by the GSS. It is currently understood that the GSS location and capacity would not be affected by the Duqm Refinery, consuming an estimated 15-20% of the GSS output. A Natural Gas Spur Line will be constructed in order to transport the GSS exports to the SEZ users. With the Duqm Refinery acting as a major consumer, it has influenced (i.e. the Refinery is 20% of the volume) the Spur Line's route direction and as such is identified as an AF.
Export Pipeline Corridor	The 200m wide multifunctional Export Pipeline Corridor will host the export pipelines that will transport exports from the Duqm Refinery to the DLBB. DRPIC will be responsible for the operation and maintenance aspects of the pipelines, but the service corridor itself is owned and maintained by SEZAD and is therefore notified as an AF.
Marafiq Duqm Integrated Power and Water Plant (DIPWP)	The Duqm Refinery will act as the only external customer for the DIPWP at the current time. Due to this, the production rates of power and desalinated water (produced from a dedicated seawater intake) provided by DIPWP will be determined by the requirements of the Duqm Refinery.

Associated Facility	Rationale / Service Provided
Waste water Discharge / Common Outfall	The waste water Common Outfall to the immediate north of the Duqm Refinery plot forms an essential part of the Project, with the water releases from the Duqm Refinery co-mingling with the discharges from DIPWP (primarily brine), forming a portion of the combined outfall.
Ras Markaz Crude Oil Storage Terminal (Phase 1.2 and 1.3 Marine Scope/Infrastructure)	The location of the Crude Oil Storage Terminal will cover a site of some 13 km^2 and is situated along the east coast, 70 km south from the Duqm Oil Refinery. Phase 1.2 and 1.3 of the Crude Oil Storage Terminal is considered an AF.This AF comprises both marine and onshore works. Marine works includes the construction of a Single Point Mooring (SPM) system with connections to an onshore crude oil booster pumping station, seawater intake and outfall systems and potentially a service harbour. Onshore works includes a number of support facilities including power supply, utility systems (seawater pumps, firewater, desalination, potable water, slops system, wastewater collection and treatment), booster pumping station and crude oil metering.
Use of Main Road from Duqm Refinery to the Duqm Export Terminal for transporting solid product.	An upgrade to the road network system in order to facilitate the transport of the Duqm Refinery's solid products will be considered an AF.
DLBB development (by SEZAD)	The DLBB development will also include dredging activities on the bulk berth basin and to the south of the current lee breakwater, which will also consist of ground and foundation improvements to support its accompanying facilities.

4 IMPACT ASSESSMENT METHODOLOGY

4.1 IMPACT IDENTIFICATION

4.1.1 Area of Influence

The spatial extent of the impact of a project is defined as the project Area of Influence (AoI). According to IFC PS 1 on Assessment and Management of Environmental and Social Risks and Impacts, the AoI should include the area affected by:

- The activities related to the Project – direct AoI); and unplanned but predictable development caused by the Project that may occur later or at a different location (indirect AoI);
- The effects of AFs, facilities not part of the Project but are required and would not have been constructed or expanded if the Project did not exist and without which the Project could not be operational; and
- Cumulative impacts that result from the incremental impact on areas or resources directly impacted by the Project and AFs and from other existing, planned or reasonably defined developments. Where no data is available, it is useful to know that a project is being planned and the lack of data will need to be acknowledged.

The areas considered in establishing the baseline and subsequent impact assessment process, while considering the site visit, cover a variety of geographic scales ranging from the local to international. Moreover, different types of Project activities (planned and unplanned) will exert different areas of influence.

Given the nature of the complex Project and its anticipated impacts, the Project AoI for assessing environmental impacts has been assumed to be, as follows:

The Direct AoI comprises:

- The defined Project components (i.e. Duqm Refinery and off-site facilities) where preparation, construction, operational and future decommissioning will take place. This includes connections with utilities, infrastructure and immediate access points (e.g. approach roads, channels for vessels) and towns and settlements in the Duqm SEZ area.

The Indirect AoI comprises:

- The indirect AoI – sometimes referred to as the Project influence area – is adjacent to the direct AoI above, and extends depending on the assessment being carried out and/or resource or receptor being assessed. It is the area affected by activities or influences not directly linked to the Project but which are triggered by the physical presence of the Project and/or the physical presenceassociated activities.

For the purposes of this study such features might include socio-economic impacts in the Al Wusta region and potential national benefits, or the the marine environment for marine animals which would be affected by shipping risks. The AoI for this activity includes Port of Duqm approaches and basin, and the approaches, anchorages and SPM associated with the Ras Markaz facility.

4.1.2 Receptors

Understanding the characteristics of the Project area and socio-economic activities of local communities is an integral part of the ESIA process. This information helps to ascertain whether and how the proposed Project activities:

- Impact on the activities (e.g. socio-economic) of local communities and local industries; and
- Interact with existing environmental, social and cultural receptors, thus informing the required impact assessment and subsequent identification of appropriate mitigation measures.

There are a number of Project area-specific receptors that have been identified as a result of the site visit and review of the available ESIAs and will be subject to focus. These include:

- Natural receptors: for example, sabkha area to the south of the Refinery which is also an Important Bird and Biodiversity Areas (Duqm IBA – designated for wetland habitat and birds populations) and the Jiddat al Harasis IBA to the north and west (this part considered to be in the indirect AoI). Natural receptors in the terrestrial environment at Ras Markaz and in the Crude Pipeline right of way (RoW); and
- Households in the Project AoI:
  - Duqm town communities: based on National Census data, the town population was 11,217 people (2010), including both Omani and expatriate population groups. With the two planned workers' camps accommodating approximately 20,000 personnel at peak construction, the town will be temporarily affected by the influx of a significant number of workers;
  - Fishermen: in the Antoot area on the beach adjacent to the existing power station and new Sebacic Acid Plant who will be moved to the New Fishery Harbour and Fishery Industrial Complex as part of SEZ development; and
  - In the Indirect AoI: this includes Nafun village, north of the DR site due to be resettled to 150 Housing Units nearer the central area of Duqm so falling under the "local community" category (even though the resettlement is not triggered by the Project); potentially included in the direct AoI on environmental parameters such as air quality (to be confirmed from surveys). Also, Al Tayari, also considered as a local community outside of the direct area of influence, including after the move to 150 Housing Units.

4.1.3 Review of Previous Methodologies

WSP has reviewed the methodologies used in previous ESIAs for the Duqm Refinery, Ras Markaz Crude Oil Storage Terminal, Crude Pipeline and Corridor and Duqm Export Terminal.

The review highlighted inconsistencies between the reports in terms of the methodologies used, in particular in defining significance, which is consistent with the IESC ESDD findings.

DUQM REFINERY EIA

For DR, impacts were rated as 'low', 'medium' or 'high' based on two parameters, i.e., severity of impact and likelihood of occurrence of the aspect. Severity of an impact depends on four elements: (i) magnitude of the impact; (ii) duration of impact (reversibility of impacts); (iii) cost of mitigation measures; and (iv) residual impact. The likelihood depends upon the nature of the aspect/impact and the control measures in place.

CRUDE PIPELINE CORRIDOR AND DUQM EXPORT TERMINAL

In these ESIAs, the significance is defined as the severity of impact and the consequence of it. Impact severity is driven by a range of factors including the geographic extent of the impact and the duration of the impact. Consequence or intensity is driven by receptor vulnerability/sensitivity to any given impact and the ecological functional value of the receptor.

RAS MARKAZ CRUDE OIL STORAGE TERMINAL

This ESIA assigned impact ratings based on two parameters, i.e., severity of impact and duration or likelihood of occurrence of the aspects. Severity of any impact depended on three elements (i) the magnitude of the impact; (ii) the nature (reversible/irreversible); and (iii) the sensitivity of the environmental/social receptor. The likelihood of its occurrence depended upon the nature of the aspect/impact and the control measures in place. For impacts resulting from unplanned and accidental aspects/activities, the assessment was based on consideration of the impact severity and the likelihood of it is occurrence. While the impact severity depends on the nature and size of the activity aspects and the environmental sensitivity, the likelihood depends upon the nature of the activity/aspect and the control measures in place.

OVERALL

All the ESIA Reports above provided separate matrices to assess planned aspects versus unplanned events. This is considered to be in line with international best practice and will therefore be acknowledged in the WSP revised methodology. The DR EIA provides a limited description of the criteria used to determine the levels of severity and likelihood, resulting in an assessment that lacks some clarity and transparency. Similarly, the Crude Pipeline Corridor and Duqm Export Terminal ESIAs do not use standard terminology and provide different significance matrices for both planned and unplanned events, resulting in some confusion. It is considered that the Ras Markaz Crude Oil Storage ESIA is more in line with international best practice, clearly defining the criteria for the significance parameters and using consistent terminology.

In terms of application of the methodology, the ESDD noted that there was a lack of differentiation between the different levels of impacts of different components, a lack of adequate use of the baseline and a failure to demonstrate the effectiveness of mitigation through a comparison between pre-mitigation and post-mitigation (residual) effects. The revised methodology described will ensure a methodology in line with the suite of international best practice guidance with the aim of delivering a Consolidated ESIA package of reports that, overall, satisfies the lenders' requirements.

4.1.4 Proposed Methodology

WSP has developed a revised methodology which addresses the issues highlighted in the ESDD while remaining compatible with the methodologies for impact assessment in the previous EIAs. In particular, the assessment will follow a systematic process that predicts and evaluates the impacts that the Project could have on resources and receptors of the physical, biological, social/ socio-economic and cultural environment, and then identifies measures that the Project will take to avoid, minimise/reduce, mitigate, offset or compensate for adverse impacts. It includes Project enhancement via potentially positive impacts where identified. Within each technical topic, however, there are particular requirements, advocated by specialist guidance notes and technical/industry bodies that go into more detail. Where these are used, from Section 4 onwards, these are referenced.

IMPACT DEFINITION

Environmental impacts from planned and non-planned activities during all phases of the Project life-cycle are assessed on the basis of detailed knowledge and industry experience of these activities. For the purpose of the Consolidated ESIA, an environmental or socio-economic impact is defined as:

"Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's activities or services." (ISO 14001)

Prediction of impacts is an objective exercise to determine what is likely to happen to the environment as a consequence of the Project and its associated activities. From the potentially significant interactions identified in previous EIAs and the supplemental assessments being undertaken by WSP, the impacts upon the various resources/receptors will be described further (and consistently) and evaluated. The diverse range of potential impacts considered in the impact assessment process typically results in a wide range of prediction methods being used, including quantitative and semi-quantitative techniques, for example, through predictions of noise impacts expressed in A-weighted decibels (and compared against baseline data) and qualitative methods for assessing certain socio-economic impacts upon communities.

DESCRIPTION OF IMPACTS

Environmental impacts arise as a result of Project activities either interacting with environmental or social receptors directly, or causing changes to the existing environment such that an indirect effect occurs.

Environmental and social impacts from a planned event are those resulting from the routine and intended construction or operational activities Environmental and social impacts from unplanned events occur as a result of incidents and accidents, such as spills, leaks and fires.

NATURE OF IMPACT

The nature of an impact is defined as the type of change (i.e. departure) from baseline conditions. The nature of an impact is described as being either **positive** or **negative**.

TYPE OF IMPACT

Impact type indicates the relationship of the impact to the Project activity in terms of cause and effect, as either:

- **Direct impact** resulting from the direct interaction between a project activity and the receiving environment; or
- **Indirect impact** between the proposed activity and the environment as a result of subsequent interactions within the environment; or
- **Cumulative impact:** where the Project impact acts together with other impacts (including those from concurrent or planned future third party activities) to affect the same resources and/or receptors as the Project.

SCALE OF IMPACT

Impact extent relates to the geographic reach of the impact and is described as:

- **Local impact** would affect local resources or receptors and would be restricted to a single community (i.e. impacts in the footprint of Project activities and the immediate adjacent area);
- **Regional impact** would affect regional resources or receptors and would be experienced at a regional scale such as within the SEZ and Al Wusta geographical areas;
- **National impact** would affect environmental resources or receptors of national interest, such as nationally protected areas/species;

- **International impact** would affect resources or receptors of international interest, such as areas protected by international conventions and endangered species, and

- **Trans-boundary impact** would be those that are experienced in one country as a result of activities in another.

DURATION OF IMPACT

Impact duration refers to the time period over which a resource or receptor will be affected, and includes:

- **Temporary** impacts would last for a short duration, are reversible and intermittent or occasional in nature. The resource or receptor would return to the previous state when the effect ceases or after a short period of recovery;

- **Short-term** impacts would last for the life of the proposed short term activity (e.g. construction of Project component) and a limited short period thereafter (e.g. three months after completion). The impact would cease when the effect ceases following a short period of recovery;

- **Long-term** impacts would continue for an extended period of time after the Project activity ceased (e.g. ten years), or cause a more permanent change in the affected receptor or resource that endures substantially beyond the Project lifetime.

PROBABILITY

The probability of an event occurring and creating an impact on a given receptor is designated using a qualitative scale from 1 to 4, the higher values being more probable that an impact will occur, as follows:

- Rating 1 – Unlikely: never heard of in the industry, or an event with a short duration;

- Rating 2 – Low probability: incident has occurred in the industry and so therefore could occur, or an event lasting up to a day;

- Rating 3 – Medium Probability: incident has (or is) expected to occur during the project or is very likely to, or an event which may occur up to one month; and

- Rating 4 – High probability: incident is expected to happen frequently within a year or is almost certain to happen, or an event which is expected to occur multiple times.

SEVERITY

The severity of an impact, on a given receptor is designated also using a rating scale from 1 to 4 and defined in Table 4-1 below. The high values denoting a more severe impact.

Table 4-1: Definitions of Severity used in the ESIA

CATEGORY	ENVIRONMENTAL RECEPTORS – PHYSICAL AND BIOLOGICAL	SOCIO ECONOMIC RECEPTORS
4 – High	Major, long term national, international or transboundary effects. Deterioration of the existing habitat or ecosystem baseline conditions is significant and rehabilitation is required or the baseline will not	Highly significant, loss or major damage with medium to long-term effect on cultural and/or natural resources of national and regional importance which are essential for communities' livelihood. Highly significant negative impacts on the national

CATEGORY	ENVIRONMENTAL RECEPTORS – PHYSICAL AND BIOLOGICAL	SOCIO ECONOMIC RECEPTORS
	recover. Results in changes/reduction in the abundance and biodiversity of populations which may or may not recover. Such impacts are a major non-compliance with national and international regulatory standards and may result in immediate intervention by governmental bodies and stakeholders.	and international community (regional, i.e. neighbouring countries). Those affected will be able to adapt to changes with some difficulty, and will only be able to maintain pre-impact livelihoods with a degree of support. Immediate intervention by governmental bodies requiring rapid implementation of response measures. National and International media and community concerns and ongoing long term complaints.
3 – Medium	Moderate, medium-term deterioration/ impact on the ecosystem on a local/ national level, leading to observable and measurable changes. Moderate deterioration and changes/ reduction in the abundance and biodiversity of the area with moderate recovery periods to baseline conditions. Non-conformance with national and international regulatory standards which may result in the intervention by governmental bodies and stakeholders.	Moderate damage to archaeological, cultural or key natural resources of local or national importance. Moderate negative impacts on the regional or national population. Vulnerable groups significantly affected. Changes affecting livelihoods, amenity values, convenience and quality of life of study population; National and potentially international media and community concerns and ongoing long term complaints.
2 – Low	An effect will be experienced but they will be minor, short term and local, leading to observable and measurable changes recoverable within short durations Potential non-conformance with regulatory standards. Unlikely to result in concerns being raised by governmental bodies or stakeholders Minor deterioration of ambient environmental conditions and recovery requires little or no intervention.	An effect will be experienced but they will be Minor, short term effects recoverable within short durations. Unlikely to result in concerns being raised by governmental bodies or stakeholders. Measurable negative impacts that are intermittent or effect a small minority of the local population and / or vulnerable groups. May result in concerns from local communities.
1 – Very Low	Deemed 'imperceptible' or indistinguishable from natural background conditions.	Deemed 'imperceptible' or indistinguishable to current social norms and variations. No public interest.

4.2 ASSESSMENT OF SIGNIFICANCE

Based on the above methodology, the impacts resulting from the project are classified within this ESIA as:

- Positive: indicating whether the impact will have a positive (beneficial) effect; or

- Negative: indicating whether the impact will have a negative (adverse) effect on the environment and/or biodiversity.

All environmental and social impacts identified based on the information collated for the Consolidated ESIA will have their significance assessed and classified by combining the probability and severity scores (see Table below). The resulting scores from the risk classification matrix will be presented in the Aspects' Register in the Consolidated ESIA Report.

In assessing whether an impact is significant, reference will be made, where appropriate, to criteria on which the evaluation is based. These may include legislative requirements, policy guidance or accepted practice and past experience.

A convenient way of representing the overall significance is through a matrix of severity versus probability (shown below).

Table 4-2: Significance Matrix

SIGNIFICANCE			PROBABILITY RATING			
			Very low	Low	Medium	High
			1	2	3	4
Severity Rating	Very low	1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low	2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium	3	3 Minor	6 Moderate	9 Moderate	12 Major
	High	4	4 Minor	8 Moderate	12 Major	16 Major

CATEGORIES OF IMPACT SIGNIFICANCE

The different significance categories reflected by the colour scheme used above, and that will be used in the Consolidated ESIA, reflect the following:

- Negligible – very little change from baseline conditions. No additional action is required and the impact is already reduced as far as practicable;
- Minor or moderate – additional mitigation is required and/or further studies are needed to investigate the risk and impact to a greater extent; and
- Major – changes to the Project are required which requires a re-assessment of applicable mitigation and/or reconsideration of alternatives and options by the engineering design team.

UNPLANNED EVENTS

In its technical assessments, the Consolidated ESIA will assess the potential from non-routine activities (i.e. incidents or accidents). These are unlikely to occur if all the correct control and management measures and good industry practices are implemented. Such impacts have the potential to be significant if they do occur and the assessment therefore focusses on the proactive measures (e.g. pollution prevention strategies) aimed at preventing their occurrence.

4.3 DESCRIPTION OF MITIGATION AND MONITORING

4.3.1 Identification of Mitigation and Enhancement Measures

A key component of the Consolidated ESIA process will be to carry through existing mitigation measures identified in the previous E(S)IAs as well as explore any additional practical ways of avoiding or reducing potentially significant impacts of the Project. These are commonly referred to as mitigation measures and are incorporated into the proposed Project as commitments. Mitigation is aimed at preventing, minimising or managing significant negative impacts to ALARP and optimising and maximising any potential benefits of the Project, where applicable.

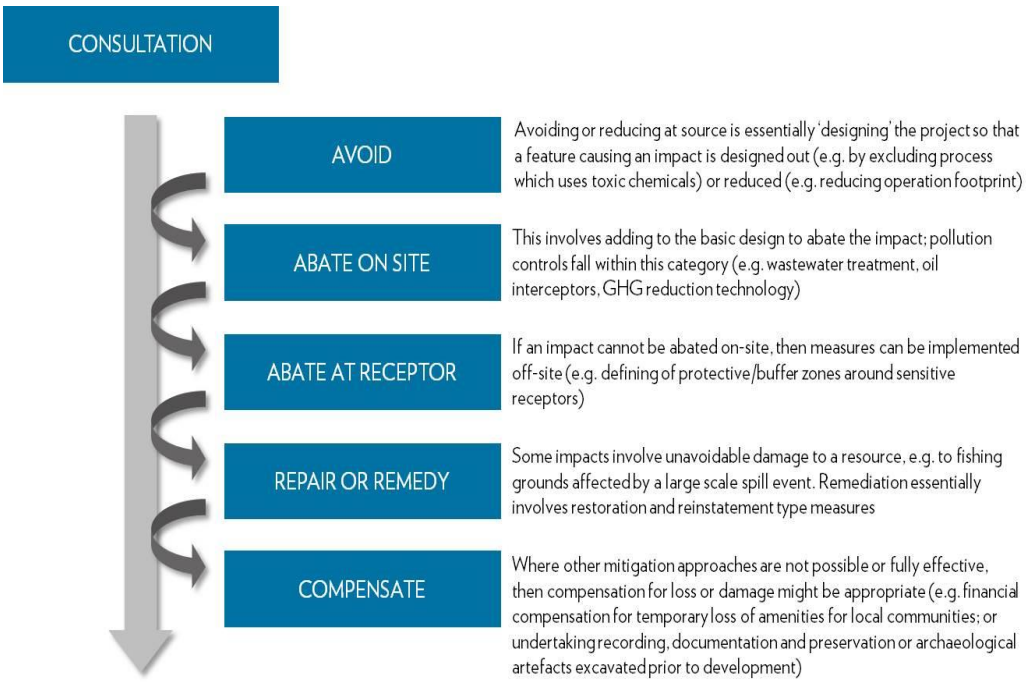
The approach taken to identifying and incorporating mitigation measures into the Project is based on a typical hierarchy of decisions and measures, as described in Figure 4-1. This is aimed at ensuring that wherever possible potential impacts are mitigated at source rather than mitigated through restoration after the impact has occurred. Thus, the majority of mitigation measures fall within the upper two tiers of the mitigation hierarchy and are effectively built into the planned project (in this case, refinery plant) implementation.

All negative impacts assessed as having a Major (H) or minor/moderate (M) risk to the environment and socio-economic context are considered to be significant and mitigation measures must be put in place to reduce the risk to ALARP.

A number of both preventative and mitigation measures, considered as current industry good practice, have been incorporated into the project design. These measures will be highlighted as industry standard good practice in the Project Aspects' while DRPIC Project-specific commitments will also be identified.

Positive impacts will be stated and information on their enhancement provided, where possible.

Figure 4-1: Mitigation Hierarchy



4.3.2 Evaluating Residual Impacts

Following the identification of potential environmental and social impacts, their significance is assessed, taking into account those proposed mitigation measures already incorporated into the design of the Project and, where appropriate, any further mitigation measures that are considered feasible and justified. Mitigation measures are applied to reduce impacts to ALARP and as such may not be eliminated entirely. These remaining impacts are thus termed residual impacts.

One objective of the Consolidated ESIA is to understand the significance of these residual impacts that will remain after mitigation measures have been designed into the intended activity and so some form of monitoring or measurement might be justified.

The evaluation of the significance of residual impacts in the Consolidated ESIA and CIA, and their subsequent management and monitoring will be included in the ESMP, (and technical sub-plans) which will also take into consideration the mitigation measures that DRPIC has committed to implement. The titles of the sub-plans are listed in Figure 1-1.

4.3.3 Dealing with Uncertainty in the Assessment of Impacts

ESIA is a process that deals with the future and there is inevitably uncertainty that arises between the predictions made and what will actually happen during the course of the Project. However, for the Project, the process is widely practiced, the sources of impacts are well-understood and the areas of interaction with the receiving environment have been well-characterised by past projects in the Duqm area. Impact predictions have, wherever practicable, been made using available data, but where significant uncertainty remains, this will be acknowledged and an indication of its scale provided. Where the sensitivity of a resource to any particular activity is unknown and the significance of impacts cannot be predicted, the team will use professional experience to judge whether a significant impact is likely to occur or not and report that accordingly.

4.3.4 Presentation of Environmental, Social/Socio-economic and Health Information

In the following Sections, the technical topics that have been scoped-in and required further study, research, baseline assessment and analysis are presented.. Within each discrete Section, an introduction is provided before descirptions of applicable standards and relevant guidance is described. The methodology adopted for assessment is included along with summary of how impact significance was assigned, especially where it deviates from that described above. Impacts and mitigation measures are then described in EIA/ESIA parlance.

5 AIR QUALITY AND ODOUR

5.1 INTRODUCTION

This Section presents the assessment of environmental Air Quality and odour impacts with reference to the relevant parts of the Omani Provisional Ambient Air Quality Standards and IFC EHS Guidelines. A glossary of technical terms is included after the Contents pages of this Report.

The assessment consolidates existing information on noise from previous reports and addresses the gaps identified by DRPIC and in the ESDD Report. These gaps and the way in which additional air quality Survey data and emissions modelling for Air Quality and Odour assessment for this Project is summarised in Table 5-1, and the summary of gap analysis and consolidation action summarised in Table 5-2.

A baseline air quality survey was carried out to inform the assessment, and the key information is included in Appendix 4-1.

Project due diligence recommended further investigation of elevated baseline levels including analysis of whether the airshed is degraded. Some of the other particular inconsistences we have identified are summarised in the table below.

Table 5-1 Feedback on Gaps in relation to Air Quality

Gap	Recommendation (in ESDD REPORT)	Implication/(our) response
Identification of risks and impacts; in particular air quality impacts are not considered on a pollutant-specific basis	Develop revised methodology, baseline and summary impacts and risks (as part of the ESMS)	Risk assessment for air quality will include a breakdown of risks by pollutant.
Baseline air quality monitoring reveals some inconsistencies	Update to required	Additional monitoring proposed which should enable more detailed analysis to be undertaken
Air quality impacts only consider short term time averaging		Short-term and annual average impacts will be considered in the updated and consolidated work.
Odour baseline studies undertaken but no specific consideration of nuisance undertaken		Odours will be considered in the assessment using qualitative methods, though Hydrogen Sulphide will be quantitatively assessed.
Impact assessment considers only CO, PM10, SO2 and NOx; No consideration of ozone, benzene, PM2.5		Benzene, Ozone and PM2.5 all included in monitoring plan.
Refinery impacts considered 'low' during operation – this is considered surprising		Pollutant specific impacts will be provided explicitly
Process upset conditions do not include flaring		Use of flares will be considered in updated AQ assessment
Cumulative Impacts not considered adequately		Cumulative impacts of AFs and third party projects will be considered quantitatively (in the CIA Report)

Table 5-2 Summary of Gap Analysis and Consolidation Action

ISSUE	GAP	NOTES	ACTION TAKEN
Criteria	Shorter-term averaging only considered. Unclear use of Omani vs IFC criteria; missing time-bases in level descriptors	Longer-term and annual average concentrations for PM_{10} and NO_2 should be considered.	Annual and longer-term averaging concentrations have been assessed, as well as short-term averaging standards.
Baseline	Baseline monitoring survey insufficient to inform whether existing airshed is degraded.	Duration, pollutants and their averaging insufficient to determine compliance against Omani or IFC EHS standards.	Three month CAQMS and two month diffusion tube survey undertaken. Degraded airshed for some pollutants have been expanded upon within the assessment.
Prediction	Emissions during construction and operation unclear, as construction	Clarity required as to specific predicted emissions during each stage of the assessment.	Emissions type and their sources have been clarified within the assessment methodology.
Prediction/ Assessment	Emissions from larger future power plant smaller than current smaller power plant.	Justification of changes in emission factors within the power plant need to be addressed.	Changes in power plant emissions have been justified within the assessment. Nafun village too far a distance to be impacted by power plant.
	Upset conditions assumptions not justified.	Upset condition scenarios to should have been developed and assessed.	Assumptions surrounding upset conditions, including commissioning and flaring, have been justified within the assessment.
Assessment	Assessment not conducted upon a degraded airshed.	Baseline concentration suggests IFC AQ Guidelines exceeded at certain locations.	Three month CAQMS and two month diffusion tube survey undertaken.
	AQ cumulative impacts not addressed within Duqm refinery EIA	Cumulative AQ impacts to be addressed within the assessment.	Cumulative impacts of full Refinery addressed using latest available information from SEZAD (in CIA Report).
	Degraded airshed would require a lower IFC/ EHS AQ standards criteria.	Further consideration and explanation of the elevated baseline AQ pollutants is required before compliance with the IFC EHS Guidelines.	Compliance against degraded airshed standards for some pollutants has been taken into account.
	Odour nuisance not assessed	Odour nuisance needs to be included in the assessment	Odour nuisance has been assessed as H_2S and VOC emissions.
Mitigation	AQ offsets are required if airshed is degraded and there is non-compliance	Assessment concluded AQ impacts were compliant, though airshed degraded for some pollutants, no mitigation or off-setting for pollutants.	Mitigation requirements have been defined for some key pollutants.

5.2 RELEVANT AIR QUALITY AND ODOUR STANDARDS

5.2.1 Omani Ambient Air Quality Standards

Formal Omani standards for air quality were released in April 2017 under Ministerial Decision 41/2017; these thresholds are presented alongside the Provisional Ambient Air Quality Standards that were in place, in order to explain the recent changes(Table 5-3 below).

The Omani Provisional Ambient Air Quality Standards will be required to be met. Where a limit value for a pollutant is not presented within the Omani standards compared to the the IFC (WHO) standards, the IFC (WHO) value for that pollutant will be considered the project specific air quality standard. Other international limit values are presented for reference in the sections below.

Table 5-3 Ambient Air Quality Standards, Oman

POLLUTANT	NEW OMANI AIR QUALITY STANDARD (MD 41/2017) µg/m^3	AVERAGE PERIOD FOR MEASURING THE POLLUTANT	PREVIOUS PROVISIONAL OMANI AMBIENT AIR QUALITY STANDARD µg/m^3	AVERAGE PERIOD FOR MEASURING THE POLLUTANT
Sulfur Dioxide (SO_2)	350	1 hour		
	150	24 hours	125	24 hours
Hydrogen Sulfide (H_2S)	30	1 hour		
			40	24 hours
Nitrogen dioxide (NO_2)	250	1 hour		
	130	24 hours	112	24 hours
Ozone (O_3)	120	8 hours	120	8 hours
PM_{10}	150	24 hours	125	24 hours
$PM_{2.5}$	65	24 hours		
Carbon Monoxide (CO)	30000	1 hour		
	10000	8 hours	6000	8 hours
Non-methane Hydrocarbon (NMHC)	160	3 hours	160	3 hours
Lead (Pb)	1.5	3 months		3 months
Ammonia (NH_3)	200	24 hours		

5.2.2 IFC EHS Guidelines

For pollutants where no Omani standards apply, air quality guidelines IFC general (WHO) international standards are used for reference . These criteria are shown in Table 5-4.

Table 5-4: , IFC/WHO International Ambient Air Quality Standards

POLLUTANT	AVERAGING PERIOD	IFC GENERAL (WHO)	
PM_{10}	24 hour	50	µg/m^3
	1 Year	20	µg/m^3
NO_2	24 hour	-	-
	1 hour	200	µg/m^3
	1 year	40	µg/m^3
SO_2	24 hour	20	µg/m^3
	1 hour	-	-
	3 hour	-	-

POLLUTANT	AVERAGING PERIOD	IFC GENERAL (WHO)	
	10 minutes	500	µg/m^3
CO	8 hour	-	-
	1 hour	-	-
H_2S	24 hour	-	-
O_3	8 hour	100	µg/m^3
NMHC	3 hour	-	-
Lead	3 month	-	-
	1 year	-	-
$PM_{2.5}$	24 hours	25	µg/m^3
	1 year	10	µg/m^3
Benzene	1 year	-	-
Arsenic	1 year	-	-
Cadmium	1 year	-	-
Nickel	1 year	-	-
PAH	1 year	-	-

5.2.3 USEPA and EU Air Quality Standards

Where a limit value for a pollutant is not presented within either the Omani or the IFC (WHO) standards, the lowest international limit value for that pollutant will be referred to from the United States Environmental Protection Agency (USEPA), United Kingdom and European Union (EU).

For reference, these air quality standards have been highlighted in bold in Table 5-5 below.

Table 5-5: USEPA, United Kingdom and European Union (EU) Air Quality Standards

POLLUTANT	AVERAGING PERIOD	US EPA		EU		UK	
PM_{10}	24 hour	150	µg/m^3	50	µg/m^3	50	µg/m^3
	1 Year	-	-	40	µg/m^3	40	µg/m^3
NO_2	24 hour	-	-	-	-	-	-
	1 hour	0.1	ppm	200	µg/m^3	200	µg/m^3
	1 year	0.053	ppm	40	µg/m^3	40	µg/m^3
SO_2	24 hour	-	-	125	µg/m^3	125	µg/m^3
	1 hour	**0.075**	ppm	350	µg/m^3	350	µg/m^3
	3 hour	**0.5**	ppm	-	-	-	-
	10 minutes	-	-	-	-	-	-
CO	8 hour	9	ppm	10000	µg/m^3	10000	µg/m^3
	1 hour	-	-	-	-	-	-
H_2S	24 hour	-	-	-	-	-	-
O_3	8 hour	0.07	ppm	120	µg/m^3	120	µg/m^3
NMHC	3 hour	-	-	-	-	-	-
Lead	3 month	0.15	µg/m^3	-	-	-	-
	1 year	-	-	**0.5**	µg/m^3	0.5	µg/m^3
$PM_{2.5}$	24 hours	35	µg/m^3	-	-	-	-
	1 year	12	µg/m^3	25	µg/m^3	25	µg/m^3
Benzene	1 year	-	-	**5**	µg/m^3	5	µg/m^3

Arsenic	1 year	-	-	**6**	ng/m3	-	-
Cadmium	1 year	-	-	**5**	ng/m3	-	-
Nickel	1 year	-	-	20	ng/m3	-	-
PAH	1 year	-	-	1	ng/m3	-	-

5.2.4 Odour Nuisance Standards

No nuisance thresholds exist for odour in Oman. Therefore any complaints of odour nuisance are assumed to be equivalent to the odour detection thresholds at receptors from known odorous emission from the refinery activities.

Odour thresholds for VOC and other anticipated emissions from refinery activities (USEPA, 1992) are provided in Table 5-6 below. These odour detection values represent a conservative assessment, as they are from the lower end of the detection range of odour threshold values.

Table 5-6: Odour Thresholds for Refinery Emissions to Air[2&3]

COMPOUND	ODOUR SOURCE	ODOUR THRESHOLD	
		mg/m^3	ppm
Hydrogen Sulphide	Crude Oil, Sulphur tanks, desulpurisation & Waste Water Treatment	0.014	0.01
Ammonia	Reimpregnation and Waste Water Treatment	3.48	5
Dimethyl Disulphide	Crude Oil, Sulphur tanks, desulpurisation	0.002	0.001
Benzene	Crude Oil and Refined Natha	2.50	0.78
Toluene	Crude Oil and Refined Natha	7.6	28.6
Ethylbenzene	Crude Oil and Refined Natha	0.40	0.092
Xylenes	Crude Oil and Refined Natha	0.60	0.14
Hexane	Crude Oil and Refined Natha	459	130

5.3 APPLICATION OF GUIDANCE TO ASSESSMENT

5.3.1 Air Quality Impact Significance

The air quality impacts have been assessed using the general approach followed within the IFC guidelines[4] whereby projects which are considered to be a significant source of air emissions, and

[2] Occupational Safety and Health Guideline for Methyl Mercaptan, US Dept Health and Human Services, 1988
[3] Occupational Safety and Health Guideline forHexane, US Dept Health and Human Services, 1988
[4] IFC, Environmental, Health, and Safety Guidelines GENERALGeneral EHS Guidelines: Environmental Air Emissions and Ambient Air Quality

thereby have the potential for significant impacts to ambient air quality, should prevent or minimize impacts by ensuring that:

- Emissions do not result in pollutant concentrations that significantly exceed the Project standards, which are based upon Omani national ambient air quality and standards (Tables, above), or in their absence, the current WHO Air Quality Guidelines, or other internationally recognized sources;
- Emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. As a general rule, this Guideline suggests 25 % of the applicable air quality standards to allow additional, future sustainable development in the same airshed; and
- The prevention of significant deterioration increments limits (<25%) are considered applicable to non-degraded airsheds only.

Baseline air quality survey results indicate that the airshed is degraded for the pollutants O_3, $PM_{2.5}$ and PM_{10}, compared against the relevant guidelines of Oman and IFC/WHO. However, elevated particulate matter within the study area was almost exclusively due to the re-entrainment of sand from either the movement of vehicles or as a consequence of wind sweeping dust into the atmosphere.

Therefore, any contributions of either $PM_{2.5}$ or PM_{10} will be assessed as exceeding the Air Quality Assessment Level. Regardless of the source of air pollutants, where air quality standards have been exceeded, then the airshed is considered to be degraded, as impacts on the human health are likely to be adverse.

Ozone is generated from the reaction of strong sunlight with VOCs and NO_x . Due to latency of reaction, ozone mainly forms on a sub-regional scale and the associated VOCs and NO_x emissions cannot be attributed to a single source. Coastal ground level ozone is known to reach elevated concentrations in the Middle East in spring and summer when its photochemical formation by the oxidation of VOCs (and catalysed by NO_x), is most efficient, and when tropospheric mixing of polluted air is constrained. Elevated ozone concentrations are therefore a combination of local meteorology, strong sunlight and sub-regional pollutant emissions, and it is highly unlikely to be directly emitted from the Refinery. Therefore direct emissions of O_3 from refinery for the purposes of this assessment have been assumed to be negligible.

5.3.2 Construction Impacts

Emissions to air resulting from construction activities are likely to result in elevated particulate matter. Therefore any contributions of $PM_{2.5}$ and PM_{10} during construction will be considered to have potential to have significant impacts during construction, primarily during earth works.

5.3.3 Operational Impacts

Emissions to air resulting from operational activities are unlikely to result in elevated O_3, though may result in elevated particulate matter. Therefore any contributions of $PM_{2.5}$ and PM_{10} will be considered to have potential to have significant impacts during the operational phase.

SUMMARY OF ASSESSMENT CRITERIA

As set out above, the application of assessment criteria follows the IFC guidance in taking the local standards, or in their absence, the IFC (WHO) Guidelines as the benchmark. Significance is

applied to any contribution which is greater than 25% of the relevant Air Quality Standard for pollutants which do not contribute to the degraded air shed. A degraded airshed is defined as where air quality is poor if nationally legislated air quality standards or in their absence, the WHO Air Quality Guidelines are exceeded significantly[5]. This Project has made the assumption that a degraded airshed is where the air quality standard is exceeded by 25% or more.

For a development within a degraded airshed, the significance of the pollution contribution of a project located near to an ecologically sensitive area (sabkha, part of the Duqm IBA lies 1km to the south of the Refinery plot), has been defined as where pollution levels increase by more than a 'fraction of the applicable' air quality standard or guideline. For project purposes, the 'fraction' has been determined by professional judgement as 5% of the air quality standard.

To clarify the project specific approach in assessing significance for air quality, significance criteria to be applied to a pollutants contributing to the degraded airshed and other polluants are summarised in Table 5-7.

Table 5-7: Summary of Assessment Criteria Thresholds of Project contribution to Air Pollutant Concentration

ASSESSMENT ELEMENT	APPLICABLE SIGNIFICANCE CRITERIA	
	O_3, PM_{10}, $PM_{2.5}$	**All other Pollutants**
Construction	>5% of ambient air quality standard (>5%)	>25% of Standards
Operation	>5% of ambient air quality standard	>25% of Standards

5.3.4 Assessing Air Quality Impact Significance for Non-Degraded Pollutants

In addition to the significance threshold of project related pollutant contribution at >25% of the air quality standard and guideline value above, an assessment of absolute air pollutant concentrations is to be undertaken. This follows the general method methodology set out in Section 4, though a combination of severity of air quality impacts against the change in air polluants concentration will be applied to determine significance of air quality impacts. The Severity and magnitude of change in air pollutant concentrations criteria thresholds are set out below.

1. Air Quality impacts will be assessed as:
   - **High** in severity if an air quality standard is exceeded by 110% or more;
   - **Medium** in severity if an between 100% to 109% of an air quality standard is reached;
   - **Low** in severity if they result in between 76% to 99% an air quality standard; and
   - **Very low** in severity if less than 75% of an an air quality standard is reached.
2. Magnitude changes in air quality pollutant concentrations as a result of the Duqm Refinery will be classified into the following criteria:
   - **Very Small** in magnitude if the Project contributes < 1% change in concentration relative to Air Quality Assessment Level (AQAL);

[5] Environmental, Health, and Safety Guidelines General EHS Guidelines: Environmental Air Emissions and Ambient Air Quality- Footnote 14.

- **Small** in magnitude if the project contributes between 2-5% change in concentration relative to AQAL;
- **Medium** in magnitude if the project contributes between 6-10% change in concentration relative to AQAL; and
- **Large** in magnitude if the project contributes >10% change in concentration relative to AQAL.

The above magnitude thresholds are based upon the United Kingdom Institute of Air Quality Management Planning Development Guidance (Moorcroft and Barrowcliffe et al., 2015).

Table 5-8: Significance Criteria

Significance			Magnitude Change in Air Polluants in relation to Air Quality Assessment Level (AQAL)			
			Very Small (1)	Small (2)	Medium (3)	Large (4)
			<1% AQAL	2-5% AQAL	6-10% AQAL	>10% AQAL
Severity Rating	Very low	1	1 Negligible	2 Minor	3 Minor	4 Minor
	Low	2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium	3	3 Minor	6 Moderate	9 Moderate	12 Major
	High	4	4 Minor	8 Moderate	12 Major	16 Major

5.3.5 Methodology

RECEPTOR IDENTIFICATION AND CLASSIFICATION

An air quality receptor selection process was undertaken, which selected receptors on the basis of their sensitivity, proximity to the refinery, the off-site facilities, haulage road and the port, and their typical representation of the potentially affected area, specific to air quality. Initially area maps and satellite imagery were used along with local knowledge from the wider project team, information gathered from the ESIA study visit during April 2017 and finally the baseline air quality survey visit during May 2017, allowed confirmation of receptors to be finalised.

The receptors used in the air quality assessment are shown in Figure 5-1 and listed in Table 5-9.

Table 5-9: Sensitive Receptor Locations

Receptor Name	Receptor Type Location	Location	
		X	Y
Wadi Al Khaban	Zero population	568363	2184049
Wadi Ad Dishayshah	Zero population	562123	2184981
Wadi Dhanjart	Small population	563747	2183480
Wadi Quadih	Zero population	564547	2182308
Wadi Say	Small population	569311	2173730
Duqm Town	Large population	566460.2	2170498
Port of Duqm	Small population in workers' residential accommodation	570534.7	2167524

Receptor Name	Receptor Type Location	Location	
Nafun	Medium size village/population, 13 km to the north of the site	575066	2189521

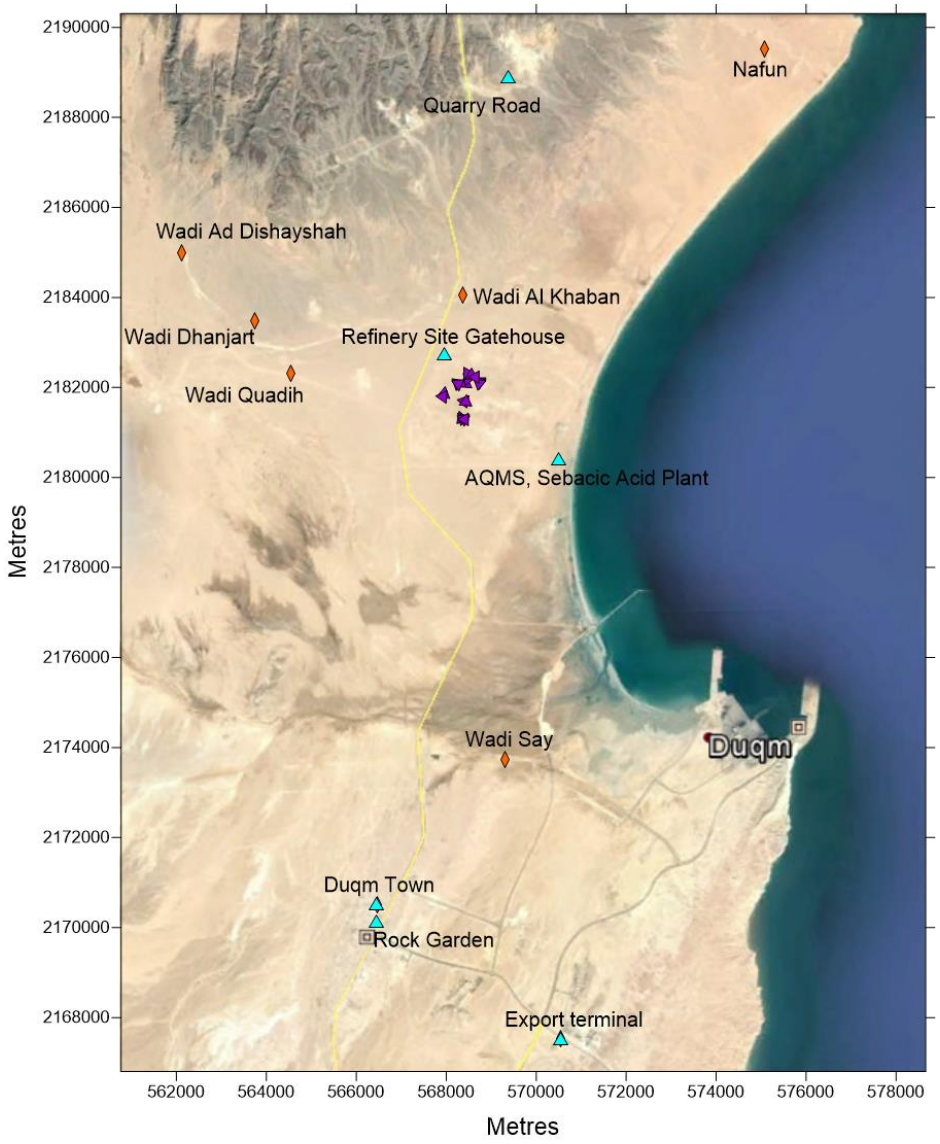


Figure 5-1: Map of Study Area Showing Monitoring Locations (blue triangles), Sensitive Receptor Locations (orange diamonds) and Pollutant Sources on Site (purple triangles)

5.3.6 Baseline Characterisation

Air Quality Baseline: The air quality baseline has been characterised around the potential areas to be affected by the project components using air quality data gathered between 3rd May 2017 to 15th August 2017. Details of the measurement locations are included Figure 5-1.

The baseline monitoring indicates that both NO_2 and SO_2 were both low in concentration during the sampling period, implying that there are no significant industrial emissions sources within the proximity of the CAQMS. However, O_3, PM_{10} and $PM_{2.5}$ all exceeded short-term concentrations limits. In the case of both PM_{10} and $PM_{2.5}$, the period mean either exceeded or came very close to exceeding the 24hr air quality standards. O_3 and PM are known to originate as a consequence of natural processes, such as strong sunlight and ultraviolet (UV) radiation in the case of O_3, and re-

entrainment of dust and sand in the case of PM. Therefore, though the baseline survey has detected exceedances of ambient air pollutants, these pollutants are highly likely to originate from natural processes and not as a consequence of existing anthropogenic activity locally. Results from the CAQMS are summarised in Table 5-10, as period average and compliances against 24 hourly, 8 hourly and 3 hourly standards where relevant.

Table 5-10: Ambient Air Quality Monitoring Station Results – Duqm, May to August 2017

Pollutant	Period Mean	Monitored max	Omani AQ standard	WHO International Standard	Compliant	Significantly Exceeded Standard (>25%)
O_3 Conc µg/m^3	74.73	172.69 (8hr	120 (8hr)	100	**No**	**Yes**
CO Conc mg/m^3	0.51	0.88 (8hr)	10 (8hr)	-	**Yes**	
NO µg/m^3	1.84		-	-		
NO_2 µg/m^3	3.32	10.29 (24hr)	130 (24 hr)	-	Yes	
				200 (1 hr)		
				40 (1 year)		
SO_2 µg/m^3	6.26	15.90 (24hr)	125.0 (24 hr)	-	Yes	
		58.48 (1hr)	350 (1hr)	-		
				500 (10 min)		
H_2S µg/m^3	1.34	15.90 (1hr)	30 (1 hr)	-	Yes	
$PM_{2.5}$ Conc µg/m^3	64.35	158.92 (24hr)	65 (24hr)	25 (24 hrs)	**No**	**Yes**
				10 (1 year)	**No**	**Yes**
PM_{10} Conc ug/m^3	151.53	488.92 (24hr)	150 (24hr)	50 (24 hr)	**No**	**Yes**
				20 (1 year)	**No**	**No**
CH_4 µg/m^3	770.72		-	-	-	
NMHC µg/m^3	0.00	0	160 (3hr)*	-	Yes	
TVOCs µg/m^3	4,174		-	-	-	
Benzene µg/m^3	0.00			5 (1 year)	Yes	
Toluene µg/m^3	0.38			-	-	
EthylBenzene µg/m^3	0.00			-	-	
M&P-Xylenes µg/m^3	0.00			-	-	
O-Xylene µg/m^3	0.00			-	-	

5.3.7 Construction

The estimation of emissions to air involved the following steps:

1. Identification of potential sources;
2. Quantification of each source;
3. Temporal representation of each source in the model on a typical work day; and
4. Geographical representation of each source in the model.

With the geographical coverage and duration of the Project components assessed, a worse year scenario was selected to assesses potential impacts against the relevant annual mean standards. The worse case year has been evaluated from the outline construction programme and information in the existing ESIAs concerning the construction activity phases for each of the Project components and form the basis of this assessment. The assessment will focus on the worst case year, i.e., the year with the most coincident activities. The outline construction programme used as a basis of this assessment was based on the latest available from DRPIC.

Table 5-11 summarises the principal sources of emissions identified for the Project component works.

Table 5-11: Principal Emission Sources for Construction Works

CONSTRUCTION ACTIVITY	NITROGEN OXIDE EMISSIONS	PARTICULATE MATTER (PM_{10} & $PM_{2.5}$)
Site Preparation – Breaking, crushing, grading	Plant Emissions (e.g. breaker Crushers, dozers, dump-trucks, face shovels, compactors)	Plant Emissions Material movement
Groundworks – disptribution of material, reclamation	Plant Emissions (e.g. dozers, excavators, dump-trucks and graders)	Non-combustion emissions from earthworks and movement of spoil; Plant emissions Dust raised by vehicle movements
General Site activities - piling	Plant emissions (e.g. piling rigs)	Plant emissions Material handling
General Site Activties – Concrete batching, precast moulding, foundations	Plant emissions (e.g. concrete batching, vehicles and cranes)	Non-combustion related emissions from concrete batching, material handling and movement; Plant emissions
General Site Activties – installation of steel structures,	Plant emissions (e.g. trucks and cranes)	Plant emissions Dust raised by vehicle movements
Construction Camps Operation – concrete batching, diesel generators, movement of materials on layout areas	Plant emissions (e.g. concrete batching, vehicles and cranes)	Non-combustion related emissions from concrete batching, material handling and movement; Plant emissions Dust raised by vehicle movements

Plant emissions are quantified on the assumption that exhaust emissions meet current USEPA standards for small diesel powered engines. The applicable standards are Tier IV emissions [US EPA CFR 40 – Part 1039, 2011].

At this stage, it is not possible to provide a definitive list of plant to be used on each Project component and the operating times. As such, indicative major or frequently used items of plant have been identified in consultation with WSP Engineers for each phase of work and assigned a percentage use (during the working day). During operation, the average load of all equipment has been assumed to vary between 20% and 100% depending on the item. Details of plant operation on site are presented in Appendix 4.4.

Non-combustion related emissions from construction works including material handling, material crushing, movement of vehicles, etc., have been, in the absence of detailed information, assessed qualitatively following UK Institute for Air Quality Mangement (IAQM) guidance on the assessment of dust from demolition and construction. The guidance provides distance based criteria for qualitatively assessing dust/particulate matter impacts from construction activities and their significance. The assessment criteria consider the scale and nature of the works, classified as small, medium or large, as well as the proximity of sensitive receptors. For the purposes of assessment, activities on construction sites are divided into the following three types:

- Earthworks;
- Construction; and
- Trackout (the movement of dust/mud offsite on haulage vehicle wheels and bodies onto the public road network where it may be resuspended by other vehicles).

The potential effects of dust arising from construction activites are defined in the guidance in the following three ways:

- Annoyance/loss of amenity due to soiling;
- The risk to health due to an increase in PM_{10} exposure; and
- Eutrophication/smothering of ecological sites.

The assessment has five stages:

- Definition of the potential dust emission magnitude for the works (termed dust emission class);
- Definition of the sensitivity of the area including the proximity and number of sensitive receptors and background PM_{10} concentrations;
- Assessment of the potential risk of impacts in the absence of mitigation;
- Definition of mitigation measures; and
- Assessment of whether significant effects are likely following mitigation.

Emissions of SO_2, CO, NMHCs and $PM_{2.5}$ during the construction phase have not been assessed, as emission factors during construction activities are largely unknown, and details of the exact construction-related activities are still uncertain at this stage. However as the baseline concentrations for SO_2, CO, NMHCs are very low, and emission to air during construction will be dispersed, it is highly likely that potential effects during construction will not be significant for SO_2, CO and NMHCs. However the significance of effects for $PM_{2.5}$ during construction is highly likely to replicate that for PM_{10}.

Piling works themselves are not considered a source of dust from non-combustion related emissions since little material is brought to the surface. Emissions during this phase are, therefore, dominated by plant emissions. Similarly, architectural works are not considered a

significant direct source of dust emissions but are taken into account through plant emissions during general site activities.

The construction of the Construction camps has not been included in the assessment as it occurs outside of the worse year of coincident activities. During operation, the impacts of vehicle movement has been evaluated using the information provided in the Off-Site Construction Traffic Assessment (AmecFW, 2015) which provides an indication of vehicle movements from the Construction camps to the Project site.

Emissions of all sources, with the exception of the concrete batching plants and worksites in the construction camps, were assumed to occur within a 12 hours working day. It has been assumed that the concrete batching plants and worksites work on a continuous 24 hour schedule.

5.3.8 Operational Air Quality Impacts

Emission sources from the Duqm Refinery Project and AFs have previously been identified as process heaters, incinerators, boilers, and flaring (HMR, Refinery EIA, 2015). The impact from these stationary sources has been quantified and assessed using US EPA approved model AERMOD. This model predicts maximum Ground Level Concentration (GLC) for pollutants such as NO_2, CO, SO_2, PM_{10}, $PM_{2.5}$ and NMHCs.

Fugitive emissions from storage tanks have been quantified using US EPA's TANKS 4.0 software model. The inputs for the TANKS 4.0 model were taken from the data provided by Duqm refinery, which was extracted from a previous assessment of tank emissions.

Pollutant emission rates are given in Appendix 4.2. Combustion source emissions were assumed to be at the regulatory emission limits, allowing for worst case scenario. This can be updated, should specific emission data become available.

The provenance of model input data, including emission rates, and sources from which operational emissions were derived, as based on the design features which were outlined in the previous air quality assessment of the Refinery and associated facility emissions are all provided within Appendix 4.2 of this Report.

Due to the lack of available traffic data for the operational phase of the Project and its AFs, and the low number of sensitive receptors in close proximity to the majority of haulage routes to and from the Refinery, assessment of emissions from Refinery-associated vehicle movements, during operations, was not undertaken.

Table 5-12: Current Refinery Design in place to Reduce Emissions

POLLUTANT EMISSIONS	DESIGN MITIGATION MEASURE
NO_2	Fuel gas and natural gas is used as fuel which is low in nitrogen.. All furnaces and boilers are designed to use low NO_x burners.
CO	CO is mainly generated from incomplete combustion due to poor combustion process control A modern burner management system will be installed for process heaters and boilers, to optimize the combustion process. This will ensure complete combustion and achieving design thermal efficiency.
SO_2	Use of low sulphur content fuel. The natural gas is imported commercial grade which contains maximum 5ppmv sulphur. The fuel gas generated by the refinery is treated

POLLUTANT EMISSIONS	DESIGN MITIGATION MEASURE
	in dedicated amine treatment processes to remove sulphur, prior to being distributed to the fuel gas header for use. The design total sulphur content of the refinery fuel gas is 40ppmv.
PM	Use of gas fuel in combustion process will intricately generate negligible level of particulates. It shall be noted that the particulates level used in the air dispersion modelling is estimated using the regulatory emission limits which is very conservative considering the nature of the combustion process using fuel gas. Burner management system to optimize the combustion process for complete combustion.

The operational air quality assessment utilised the USEPA AERMOD detailed dispersion model to calculate ground level concentrations of emitted NO_2, CO, SO_2, PM_{10}, $PM_{2.5}$ and NMHCs across the study area. The contribution of emissions from the Project and AFs to total pollutant levels was calculated at the specific receptors identified (Table 5-9 and shown in Figure 5.1 above), as well as at a grid of receptors spaced 100m apart extending 10km from the refinery site. Pollutant concentrations were calculated to an averaging period relevant to the ambient air quality standard for each pollutant as detailed in Tables 5-3 to 5-5.

In order to account for variations in meteorological conditions over time, the air quality model was run for each of five years of the most recent available meteorological data sets (meteorological data between 2012 to 2016). The modelling results presented in this report relate to the worst case of those five years (i.e. the year in which the highest pollutant concentrations were calculated at sensitive receptor locations, 2016).

Emissions of nitrogen oxides (NO_x) from combustion sources include both nitrogen dioxide (NO_2 and nitric oxide (NO), with the majority being in the form of NO. In ambient air, NO is oxidised to form NO_2, for which the ambient air quality standards apply. For this assessment, the rate of conversion of NO to NO_2 was estimated using the 'worst-case' assumptions set out in UK Environment Ageny guidance, namely that:

- For the assessment of long-term (annual mean and 24hr mean) impacts at receptors, 70% of NO_x is NO_2; and
- For the assessment of short-term (hourly) impacts at receptors, 35% of NO_x is NO_2.

The emission rate of NMHCs from storage tanks on site were derived from USEPA TANKS v4.0 and a throughput of 230,000 barrels per stream day.In order to account for periods during which plant on site, in particular emission control devices, are not operating normally, an assessment of pollutant concentrations during upset conditions was undertaken in accordance with USEPA Emissions Estimation Protocol for Petroleum Refineries V3. A factor is applied to plant emissions such that it is assumed that emission control devices are not operational. The factor is derived on the basis of estimated control device efficiency as taken from the USEPA guidance. Outputs from modelling of NMHCs from storage tanks using USEPA TANKS v4.0 were then incorporated into the site-wide dispersion model.

Full details of the input parameters and model set up are presented in Appendix 4.2.

5.3.9 Operational Odour Impacts

Sources of odorous emissions from the refinery and its associated facilities are known (Table 5-13). However frequency, magnitiude and duration of odorous emissions are unknown at this stage

of the project design. Therefore the likelihood of odour nuisance arising as a outcome of activities of the refinery and its associated facilities has been qualitatively assessed, using odour emissions threshold and probability of emissions of odorous compounds.

Table 5-13: Refinery and AF Odour Emission Sources

COMPOUND	ODOUR EMISSION SOURCE	PROBABLE FREQUENCY OFEMISSION
Hydrogen Sulphide	Crude Oil, Sulphur tanks, desulpurisation & Waste Water Treatment	Monthly
Ammonia	Reimpregnation and Waste Water Treatment	Weekly
Dimethyl Disulphide	Crude Oil, Sulphur tanks, desulpurisation	Quarterly
Benzene	Crude Oil and Refined Natha	Daily
Toluene	Crude Oil and Refined Natha	Daily
Ethylbenzene	Crude Oil and Refined Natha	Daily
Xylenes	Crude Oil and Refined Natha	Daily
Hexane	Crude Oil and Refined Natha	Daily

Likelihood of the emissions of odorous compounds has been evaluated as being directly related to whether the compound is likey to be continuously held on-site, the scale of the compound on-site, and whether the emissions are likely to be fugitive and / or as a direct outcome of a discrete process.

Selection of Odour Sensitive Receptors: Guidance published by the Institute of Air Quality Management (IAQM) provides details regarding receptors and their sensitivity to odour. Further details are provided in Table 5-14 below.

Table 5-14: Receptor Sensitivity to Odours

SENSITIVITY	DESCRIPTION
High	Surrounding land where: • Users can reasonably expect enjoyment of a high level of amenity; and • People would reasonably be expected to be present here continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land. Examples may include residential dwellings, hospitals, schools/education and tourist/cultural.
Medium	Surrounding land where: • Users would expect to enjoy a reasonable level of amenity, but wouldn't reasonably expect to enjoy the same level of amenity as in their home; or • People wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land. Examples may include places of work, commercial/retail premises and playing/recreation fields.

SENSITIVITY	DESCRIPTION
Low	Surrounding land where: • The enjoyment of amenity would not reasonably be expected; or • There is transient exposure, where the people would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land. Examples may include industrial use, farms, footpaths and roads.

The location and sensitivity of receptors has been taken into account when assessing the potential effect of the refinery and associated activities.

In order to establish the significance of a potential odour impact the IAQM guidance provides descriptors which describe a general relationship between the level of odour exposure (impact) experienced by a receptor of a given sensitivity and the magnitude of adverse effect that is likely to result. The IAQM suggested significance criteria are reproduced in Table 5-15, although the definition of 'impact' has been adapted to reflect the qualitative, i.e., FIDOL (Frequency – Intensity – Duration – Odour Unpleasantness – Location) approach.

Table 5-15: Significance Descriptors

IMPACT[A]	RECEPTOR SENSITIVITY[B]		
	Low	**Medium**	**High**
Very Large	Moderate Adverse	Substantial Adverse	Substantial Adverse
Large	Slight Adverse	Moderate Adverse	Substantial Adverse
Medium	Negligible	Slight Adverse	Moderate Adverse
Small	Negligible	Negligible	Slight Adverse
Negligible	Negligible	Negligible	Negligible

a) The impact has been determined from the FIDOL assessment, taking into account the findings of the sniff tests, historic complaints data and meteorological data.
b) Receptor Sensitivity: Low – transient exposure (e.g. footpath, road); Medium – people not present continuously or regularly for extended period (e.g. workplaces, retail premises); High – high level of amenity expected (e.g. housing or schools). For further details see **Table14.10** above.

A significant impact is considered to be that which is greater than moderate adverse as according to the significant descriptors.

The IAQM Guidance describes the FIDOL assessment process. The likelihood of an odour causing a nuisance depends on a number of factors which are outlined in Table 5-16 below.

Table 5-16: Description of the FIDOL Factors

FIDOL	DESCRIPTION
Frequency	How often an individual is exposed to odour
Intensity	The individual's perception of the strength of the odour

FIDOL	DESCRIPTION
Duration	The overall duration that individuals are exposed to odour over time
Odour Unpleasantness	Odour unpleasantness describes the character of an odour as it relates to the 'hedonic tone' (which may be pleasant, neutral or unpleasant) at a given odour concentrations/intensity. This can be measured in the laboratory as the hedonic tone, and when measured by the standard method and expressed on a standard nine-point scale it is termed the hedonic score.
Location	The type of land use and nature of human activities in the vicinity of the odour source. Tolerance and expectation of the receptor. The 'location' factor can be considered to encompass the receptor characteristics, receptor sensitivity, and socio-economic factors.

Within a FIDOL assessment, the scale of likely exposure (impact) is assessed by taking into account the location of the source (distance and direction) and the likely effectiveness of dispersion/dilution. Meteorological conditions play an important part in whether or not offensive odour will be experienced (wind direction and speed being particularly important), and consequently, appropriate meteorological data have been considered as part of this assessment.

5.3.10 Air Quality Assessment Results

CONSTRUCTION

As discussed in Section 5.3.7, prediction of ground level pollutants concentrations during construction was limited to NO_2 and $PM_{10,}$ and presented in Table 5-17 and 5-18. Exceedances of the standard for PM_{10} occur across the study area as a result of the baseline mean concentrations being in slight exceedance of the annual standard, though maximum 24 hourly concentrations exceeded the daily air quality standard. No other exceedances are predicted as a result of construction activities. The contribution of construction activities on site to pollutant concentrations at sensitive receptors is greatest for hourly NO_2 concentrations, where process contributions reach a maximum of 7.8% of the standard. Contributions to particulate matter concentrations at sensitive receptors are <1% for annual mean PM_{10} and <2% for 24hr PM_{10} in all cases.

IFC/WHO guidance requires that the contribution of pollutants from a project located where those pollutant concentrations are such that the airshed is not degraded should not increase by more than 25% of the air quality standard to be determined as not significant. As the concentrations of hourly NO_2 during construction has been predicted to reach a maximum of 7.8% of the air quality standard. Therefore the emissions of NO_2 during the construction phase of the project, has been assessed as not significant.

IFC/WHO guidance requires that the contribution of pollutants from a project located where those pollutant concentrations are such that the airshed is degraded should not increase by more than a 'fraction of the applicable' air quality standard or guideline to be determined as not significant. For project purposes, the 'fraction' has been determined as 5% of the air quality standard. The concentrations of annual PM_{10} and 24hrly PM_{10} have been predicted to reach a maximum of <1% and <2% respectively of the air quality standard for $PM_{10,}$ during construction, therefore emissions of PM_{10} during the construction phase of the project, has been assessed as not signigifcant.

The receptor location most affected by construction activities is Wadi Al Khaban, as a result of both it's proximity to construction activities as well as local meteorological conditions. The former hamlet (identified via Google Earth) and in previous EIAs has zero population. All emissions to air resulting from construction are well below 25% of the Air Quality Assessment Level for each pollutant.

Table 5-17: Modelled NO_2 Concentrations During Construction (µg/m^3)

Receptor	24hr nitrogen dioxide			1hr nitrogen dioxide			Annual mean nitrogen dioxide		
	Process Contribution	% of standard	Total	Process Contribution	% of standard	Total	Process Contribution	% of reference standard	Total
Wadi Al Khaban	1.32	1.0%	11.61	15.62	**6.25**%	36.2	0.94	2.36%	5.92
Wadi Ad Dishayshah	0.15	0.1%	10.44	5.09	**2.03**%	25.67	0.11	0.28%	3.09
Wadi Dhanjart	0.33	0.3%	10.62	9.34	**3.74**%	29.92	0.24	0.59%	3.35
Wadi Quadih	0.52	0.4%	10.81	9.00	**3.60**%	29.58	0.36	0.90%	3.68
Wadi Say	0.15	0.1%	10.44	2.54	**1.02**%	23.12	0.10	0.26%	2.97
Duqm Town	0.05	0.0%	10.34	1.67	0.**67**%	22.25	0.04	0.10%	2.89
Export Terminal	0.05	0.0%	10.34	0.90	0.**36**%	21.48	0.04	0.10%	2.96
Nafun	0.11	0.1%	10.4	1.32	0..**53**%	21.9	0.08	0.21%	3.38

Table 5-18: Modelled PM_{10} Concentrations During Construction (µg/m^3)

Receptor	Location Coordinates		24 hr PM_{10}			Annual Mean PM_{10}		
	X	Y	Process Contribution	% of standard	Total	Process Contribution	% of Reference standard	Total
Wadi Al Khaban	568363	2184049	2.14	1.4%	**193.66**	0.08	0.2%	151.61
Wadi Ad Dishayshah	562123	2184981	0.70	0.5%	**192.22**	0.01	0.0%	151.54
Wadi Dhanjart	563747	2183480	1.27	0.8%	**192.79**	0.02	0.1%	151.55
Wadi Quadih	564547	2182308	1.22	0.8%	**192.74**	0.03	0.1%	151.56
Wadi Say	569311	2173730	0.36	0.2%	**191.88**	0.01	0.0%	151.54
Duqm Town	566460.2	2170498	0.26	0.2%	**191.78**	0.00	0.0%	151.53
Export Terminal	570534.7	2167524	0.13	0.1%	**191.65**	0.00	0.0%	151.53

Receptor	Location Coordinates		24 hr PM_{10}			Annual Mean PM_{10}		
	X	Y	Process Contribution	% of standard	Total	Process Contribution	% of Reference standard	Total
Nafun	575066	2189521	0.18	0.1%	**191.7**	0.01	0.0%	151.54

Emissions from construction works including material handling, material crushing movement of vehicles and earthworks on site have been assessed qualitatively using the IAQM guidance on the assessment of dust from demolition and construction.

The assessment of the magnitude of dust emissions from construction activities is presented in Table 5-19. The largest emission of dust occurs due to earthworks on site and is largely the result of the site area (>10,000m^2) and the existing levels of dust and sand. Emissions from construction are Medium – Large due to the large volume of structures to be constructed and large site area. Emissions from vehicle trackout are medium for the haulage routes as a result of the dusty surface and likely length of unconsolidated surface and unpaved roads. This assumes that best practise will be followed during construction, with tarmacked areas and frequent dampening down.

Table 5-19: Assessment of Construction Dust Emission Magnitude

Construction Area	Earthworks			Construction		Trackout	
	Dust Emission Magnitude	**Comment**		**Dust Emission Magnitude**	**Comment**	**Dust Emission Magnitude**	**Comment**
Export Terminal	Minimum	Site Area >10,000m^2	>10 heavy earth moving vehicles	Minimum	total build vol - >100,000	Low	Already made ground
Refinery	Large	Site Area >10,000m^2	>10 heavy earth moving vehicles	Medium	large area but mainly steel structures	Low	Already at final elevation. No site preparation.
Service Corridor	Large	Site Area >10,000m^2		Medium	large area but mainly steel structures	Low	Site preparation required only
Heavy Haul Roads/Highways	Large	Site Area >10,000m^2		Medium	large area but road construction or earthworks only (haul roads)	Medium	Dusty surface
Construction Camps	N/A			Medium	Concrete batching plants	Medium	Dusty surface with unpaved road >100m
Raz Markaz Storage Facility	Large	Site Area >10,000m^2		Medium	large area but mainly steel structures	Medium	

The sensitivity of the surrounding area was then assessed, considering the background PM_{10} concentration, the number of sensitive receptors in the study area and their proximity to construction activities. The IAQM construction dust guidance uses a distance of 350m as the assumed drop-out distance for dust from construction activities. Therefore sensitive receptors at a distance of greater than 350m are assumed not to be at risk of dust nuisance. Despite the high background concentration of PM_{10}, the lack of sensitive receptors in close proximity to any of the areas of principal construction activities limits the sensitivity of the area. There are a low number (<100) of receptors along construction traffic routes to and from the site, which are sensitive to dust from vehicle trackout. This sensitvity declines with both distance from the construction site and with distance from the roadside. Existing ecological sites within the study area are not sensitive to dust, as the study area natural state is an existing elevated dust baseline. The assessment of the sensitivity of the area to both dust soiling/loss of amenity, human health impacts and ecological impacts is presented in Table 5-20.

Table 5-20: Assessment of the Sensitivity of the Area to Construction Dust Impacts.

POTENTIAL IMPACT	SENSITIVITY OF THE SURROUNDING AREA		
	Earthworks	Construction	Trackout
Dust soiling	Low	Low	Medium
Human health	Low	Low	Medium
Ecological	Low	Low	Low

The assessment of the magnitude of dust emission from construction activities was then combined with the assessment of the sensitivity of the area to determine the risk of impacts to human health and dust soiling/loss of amenity as a result of construction dust which is presented in Table 5-21. Due to the medium sensitivity to dust trackout and the medium magnitude of emissions from vehicle trackout, there is a medium risk of dust impacts to both human health and loss of amenity due to trackout. Despite the large magnitude of dust emissions, the lack of receptors within 350m of construction areas leads to a low risk of construction dust impacts from earthworks and costruction activities.

Table 5-21: Assessment of the Risk of Construction Dust Impacts

	RISK OF DUST IMPACTS		
	Earthworks	**Construction**	**Trackout**
Export Terminal	Low	Low	Low
Refinery	Low	Low	Low
Service Corridor	Low	Low	Low
Heavy Haul Roads/Highways	Low	Low	Medium
Construction Camps	Low	Low	Medium

It should be noted that dust risk levels do not remain constant at all times. Actual risks on any given day will depend on the activities being undertaken, the meteorological conditions and the proximity of activities with a high dust generating potential to sensitive receptors. This variability is particularly relevant given the large area of the site which will not have construction activities across the whole site for the whole construction period. In order to minise the risk of impacts due to construction dust, a series of mitigation and best practice measures have been identified including the installation of hard surfacing as soon as practicable, the covering of potentially dusty meterial and the availability of wheel washing facilities or trackout pads or plates. It is anticipated that with these measures, as outlined in Section 5.4.1, the risk of construction dust impacts will be minimised.

SIGNIFICANCE

The construction phase air quality impacts identified would be negative, direct, local and long-term. Emissions of NO_2 during the construction phase would be of very low severity, though emissions of PM_{10} would all be of high severity. The magnitude of change for in air pollutants during the construction phase would be considered to be small to medium for NO_2 and very small to small $PM_{10.}$ Therefore the significance of the impacts in the absence of mitigation measures would be negligible to minor for PM_{10} and NO_2. Mitigation measues are discussed in Section 5.4 below.

OPERATION OF REFINERY AND ASSOCIATED FACILITIES

Predicted ground level concentrations (GLCs) for CO, NO_2, SO_2, PM_{10}, $PM_{2.5}$ and NMHCs were derived from modelled predictions combined with mean concentrations from baseline monitoring data (Tables 5-22 to 5-.27). Ozone concentrations were exluded as there is no method of deriving ozone generation, and it has no known direct source. Of the GLCs, the only exceedances of the regulatory limits were for PM_{10} and $PM_{2.5}$ annual mean and 24hourly means, due to their high

existing baseline concentrations For the remaining pollutants, the emissions resulting from the projectactivities were predicted to result in concentrations well below the ambient air standards. Project contributions to air pollutants were predicted to be less than 25% of the ambient air standard.

For a degraded airshed (where the baseline exceeds the relevant standard), the significance of the pollution contribution of a project located within or near to an ecologically sensitive area, should increase by no more than a fraction (assumed to be 5%)of the air quality standard. Project contributions to air pollutants for those contributing to a degraded airshed were predicted to be less than 5% of the ambient air standard. For a non-degraded airshed, the significance of the pollution contribution should be less than 25% of the ambient air standard. Project contributions to air pollutants were predicted to be less than 25% of the of the ambient air standard for non-degraded airshed pollutants.

Air quality emissions during operation of the Project and AFs are seen to be larger for NO_2 and smaller for PM_{10} than emissions within the construction phase. This is in part due to the combustion sources associated with the Refinery and associated operations, as well as the emissions associated with additional vehicle movements. In addition, activities during the operational phase are associated with multiple sources of particulate matter emissions.

These results were for a 100% Refinery operation of all process units throughout the year at full capacity, including the contribution from flaring (as defined by AP42[6]).

The concentrations plots in Appendix 4.3 illustrate the local receptor locations to the Refinery boundary.

Table 5-22: Dispersion Modelling Results for NO_2 for Scenario 1 (100% operative capacity)

Receptor	24hr Nitrogen Dioxide			1hr Nitrogen Dioxide			Annual Mean Nitrogen Dioxide		
	Process Contribution	% of Omani standard (130 µg/m³)	Total	Process Contribution	% of Omani standard (250 µg/m³)	Total	Process Contribution	% of IFC reference standard (40 µg/m³)	Total
Wadi Al Khaban	8.55	6.6%	18.84	28.47	11.4%	49.05	1.60	4.0%	4.92
Wadi Ad Dishayshah	1.75	1.3%	12.04	14.33	5.7%	34.91	0.28	0.7%	3.6
Wadi Dhanjart	2.44	1.9%	12.73	17.98	7.2%	38.56	0.35	0.9%	3.67
Wadi Quadih	3.85	3.0%	14.14	20.52	8.2%	41.1	0.50	1.3%	3.82
Wadi Say	1.83	1.4%	12.12	18.46	7.4%	39.04	0.19	0.5%	3.51
Duqm Town	1.24	1.0%	11.53	23.72	9.5%	44.3	0.18	0.5%	3.5
Export Terminal	3.63	2.8%	13.92	23.62	9.4%	44.2	0.23	0.6%	3.55
Nafun	3.53	2.7%	13.82	30.86	12.3%	51.44	0.48	1.2%	3.8

[6] https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emission-factors

Table 5-23: Dispersion Modelling Results for SO_2 for Scenario 1 (100% operative capacity)

Receptor	24hr SO_2		
	Process Contribution	% of Omani standard (150 µg/m^3)	Total
Wadi Al Khaban	1.14	0.8%	59.62
Wadi Ad Dishayshah	0.22	0.1%	58.7
Wadi Dhanjart	0.29	0.2%	58.77
Wadi Quadih	0.49	0.3%	58.97
Wadi Say	0.23	0.2%	58.71
Duqm Town	0.20	0.1%	58.68
Export Terminal	0.36	0.2%	58.84
Nafun	0.57	0.4%	59.05

Table 5-24: Dispersion Modelling Results for CO for Scenario 1 (100% operative capacity)

Receptor	Location		8hr CO		
	X	Y	Process Contribution	% of Omani standard (10,000 µg/m^3)	Total
Wadi Al Khaban	568363	2184049	4.41	0.04%	4.42
Wadi Ad Dishayshah	562123	2184981	1.57	0.02%	1.58
Wadi Dhanjart	563747	2183480	2.08	0.02%	2.09
Wadi Quadih	564547	2182308	2.28	0.02%	2.29
Wadi Say	569311	2173730	1.82	0.02%	1.83
Duqm Town	566460.2	2170498	1.25	0.01%	1.26
Export Terminal	570534.7	2167524	2.86	0.03%	2.87
Nafun	575066	2189521	2.94	0.03%	2.95

Table 5-25: Dispersion Modelling Results for PM_{10} for Scenario 1 (100% operative capacity)

Receptor	Location		24 hr PM_{10}			Annual Mean PM_{10}		
	X	Y	Process Contribution	% of Omani standard (150µg/m^3)	Total	Process Contribution	% of IFC standard (20µg/m^3)	Total
Wadi Al Khaban	568363	2184049	0.30	0.20%	191.82	0.05	0.26%	151.58
Wadi Ad Dishayshah	562123	2184981	0.06	0.04%	191.58	0.01	0.06%	151.54
Wadi Dhanjart	563747	2183480	0.08	0.05%	191.60	0.01	0.06%	151.54
Wadi Quadih	564547	2182308	0.12	0.08%	191.64	0.02	0.10%	151.55
Wadi Say	569311	2173730	0.06	0.04%	191.58	0.01	0.06%	151.54
Duqm Town	566460.2	2170498	0.05	0.03%	191.57	0.01	0.06%	151.54
Export Terminal	570534.7	2167524	0.10	0.07%	191.62	0.01	0.06%	151.54
Nafun	575066	2189521	0.14	0.09%	191.66	0.02	0.10%	151.55

Table 5-26: Dispersion Modelling Results for $PM_{2.5}$ for Scenario 1 (100% operative capacity)

Receptor	Location		Annual Mean $PM_{2.5}$			24hr $PM_{2.5}$		
	X	Y	Process	% of IFC	Total	Process	% of Omani	Total

Receptor	Location		Annual mean $PM_{2.5}$			24hr $PM_{2.5}$		
			Contribution	standard ($10\mu g/m^3$)		Contribution	standard ($65\mu g/m^3$)	
Wadi Al Khaban	568363	2184049	0.02	0.20%	64.37	0.13	0.20%	159.05
Wadi Ad Dishayshah	562123	2184981	0.00	0.00%	64.35	0.03	0.05%	158.95
Wadi Dhanjart	563747	2183480	0.01	0.10%	64.36	0.04	0.06%	158.96
Wadi Quadih	564547	2182308	0.01	0.10%	64.36	0.05	0.08%	158.97
Wadi Say	569311	2173730	0.00	0.00%	64.35	0.03	0.05%	158.95
Duqm Town	566460.2	2170498	0.00	0.00%	64.35	0.02	0.03%	158.94
Export Terminal	570534.7	2167524	0.00	0.00%	64.35	0.04	0.06%	158.96
Nafun	575066	2189521	0.01	0.10%	64.36	0.06	0.09%	158.98

Table 5-27: Dispersion Modelling Results for NMHC's for Scenario 1 (100% operative capacity)

Receptor	Location		3 hr NMHC			Annual Mean Benzene		
	X	Y	Process Contribution	% of Omani standard ($160\ \mu g/m^3$)	Total	Process Contribution	% of EU standard ($5\ \mu g/m^3$)	Total
Wadi Al Khaban	568363	2184049	7.89	4.93%	7.89	0.07	1.39	1.39
Wadi Ad Dishayshah	562123	2184981	1.85	1.16%	1.85	0.01	0.21	0.21
Wadi Dhanjart	563747	2183480	2.01	1.26%	2.01	0.01	0.28	0.28
Wadi Quadih	564547	2182308	2.90	1.81%	2.90	0.02	0.43	0.43
Wadi Say	569311	2173730	18.29	11.43%	18.29	0.01	0.25	0.25
Duqm Town	566460.2	2170498	7.70	4.81%	7.70	0.01	0.15	0.15
Export Terminal	570534.7	2167524	30.57	19.10%	30.57	0.01	0.21	0.21
Nafun	575066	2189521	5.70	3.56%	5.70	0.01	0.23	0.23

Predictions from air dispersion modelling indicate that the likelihood of impacts on the current air quality baseline at sensitive receptors is very low for SO_2, CO and low for NO_2. Contributions from both PM_{10} and $PM_{2.5}$ are both below 1 $\mu g/m^3$ representing a maximum 0.26% and 0.20% of the of the national standard

Residential receptors at the entrance to the Export Terminal (Complexes Street) have been predicted to experience the most significant increase in air quality concentrations as a consequence of VOC emissions from the topside storage tanks, with NMHCs predicted to reach 19.20% of the Omani air quality Standard (160 $\mu g/m^3$) at that location.

Nafun has been predicted to experience the most significant increase in concentrations of NO_2 as a consequence of emissions from the Refinery, with predicted hourly NO_2 contribution of 30.86 $\mu g/m^3$ which is 12.34% of the 250 $\mu g/m^3$ national standard.

SIGNIFICANCE

The predicted concentration of the projects operational contribution to pollutants which were not responsible for the degraded airshed (CO, NO_2, SO_2 and NMHCs) were all below 25% for all air relevant quality standards. Therefore the emissions of CO, NO_2, SO_2 and NMHCs during the operational phase of the project, have been assessed as not significant.

The predicted concentration of the projects operational contribution to pollutants which were responsible for the degraded airshed (PM_{10} and $PM_{2.5}$) were all below 5% for all air quality standards. Therefore emissions of PM_{10} and $PM_{2.5}$ during the operational phase of the project, have been assessed as not significant.

UPSET CONDITIONS

During device malfunctions/upset conditions, emissions from Refinery plant can be orders of magnitude higher than during normal operation. Under such conditions, the emission rate of PM_{10} is a factor of 12.5 times greater than under normal conditions, and the emission of SO_2 is a factor of 20 times greater than under normal operating conditions. These are the two significant pollutant changes associated with flaring. This scenario was tested for upset conditions lasting 48 hours, the results of which are presented in Table 5-28.

Table 5-28: Dispersion Modelling Results During Upset Conditions

RECEPTOR	LOCATION		24 HR PM_{10}			24 HR SO_2		
ID	x	y	Process contribution	% of Omani standard (150 µg/m^3)	Total	Process Contribution	% of Omani standard (150 µg/m^3)	Total
Wadi Al Khaban	568363	2184049	0.56	0.37%	192.08	19.64	13.09%	78.12
Wadi Ad Dishayshah	562123	2184981	0.14	0.09%	191.66	4.75	3.17%	63.23
Wadi Dhanjart	563747	2183480	0.20	0.13%	191.72	4.30	2.87%	62.78
Wadi Quadih	564547	2182308	0.27	0.18%	191.79	7.80	5.20%	66.28
Wadi Say	569311	2173730	0.11	0.07%	191.63	3.20	2.13%	61.68
Duqm Town	566460	2170498	0.08	0.05%	191.60	2.42	1.61%	60.90
Export Terminal	570534	2167524	0.06	0.04%	191.58	1.70	1.13%	60.18
Nafun	575066	2189521	0.20	0.13%	191.72	8.78	5.85%	67.26

Under upset conditions the PM_{10} contributions are still considered to be fractional, at a maximum contribution of just of 0.37% of the Omani air quality standards.

SIGNIFICANCE

The operational phase air quality impacts identified would be negative, direct, local and long-term. Emissions of NO_2, SO_2, CO, NMHCs would all be of very low severity, though emissions of PM_{10} and $PM_{2.5}$ would all be of high severity. The magnitude of change for in air pollutants would be considered to be medium to large for NO_2 and NMHCs and very small for SO_2, CO, $PM_{10,}$ $PM_{2.5}$. Therefore the significance of the impacts in the absence of mitigation measures would be negligible to minor for all pollutants. Mitigation measues are discussed in Section 5.4 below.

5.3.11 Odour Nuisance Assessment Results

The probability of odour nuisance has been qualitatively assessed using the IAQM approach to FIDOL, receptor sensitivity and impact significance, as presented in Table 5-29.

For sensitive receptors close to the refinery (assumed to be the principal source of odorous emissions) the impacts are greater than at distances further away. This is due to the probability of greater concentrations of odour compounds still being within the above the threshold concentration at these locations. Residential locations in areas of high amenity away from the principal highways were considered to have high odour sensitivity. Locations close to industrial sources were considered to be of low sensitivity. Locations close to other sources of odour, such as roads or town centre were considered to be of moderate odour sensitivity.

Table 5-29: Probable Odour Impact upon Sensitive Receptors

Receptor Name	Receptor Type Location	Sensitivity	Distance from centre of Refinery / km	Odour Impact
Wadi Al Khaban	Zero population	Low	2.2	Slight Adverse
Wadi Ad Dishayshah	Zero population	Low	6.3	Slight Adverse
Wadi Dhanjart	Small village population	High	2.2	Moderate Adverse
Wadi Quadih	Zero population	Low	1.4	Moderate Adverse
Wadi Say	Small population	High	9.8	Negligible
Duqm Town	Large population	Medium	4.3	Negligible
Export Terminal	Small population in workers residential accommodation	Low	5.0	Negligible
Nafun	Medium size population	High	13km	Negligible

Two locations were considered to be at a moderate adverse risk of odour nuisance as a consequence of potential odour emissions from the Refinery and its AFs, these were Wadi Dhanjart and Wadi Quadih, both were within 2.5km from the centre of the Refinery, and considered to be highly sensitive odour receptors, although the latter has zero population. Two receptors locations Wadi Al Khaban and Wadi Ad Dishayshah were considered to be of slight adverse risk of odour nuisance as a consequence of emission from the Refinery and its AFs as they were either slightly further from the Refinery, or of a lower odour sensitivity and both have zero population. The remaining receptors were all considered to be at negligible risk of odour nuisance as a consequence of emission from the Refinery and its AFs.

5.3.12 Limitations and Uncertainties

Assessment of O_3 from the refinery activities were not undertaken due to the refinery not representing a source of O_3. However the baseline air quality survey found that O_3 was in exceedance within the study area, likely to be due to natural generation as a consequence natural processes, such as strong sunlight and ultraviolet (UV) radiation. Therefore the airshed could be considered to be degraded as a consequence of elevated O_3 concentrations, though Refinery activities were not predicted to have a direct contribution upon elevated O_3 concentrations. Emissions of ozone-precursors are likely to occur from the Refinery, though due to the nature of ozone generation, these are unlikely to have an impact upon elevated O_3 concentrations within the study area.

The assessment of exposure of sensitive receptors to risk of odour nuisance has taken no account of local meteorology, and has assumed a uniform Gaussian dispersion of odorous compounds from the refinery. Therefore any long-term chronic exposure of odorous compounds which would be dictated by the prevailing conditions may have been unnecessarily discounted. However such chronic exposures to odorous compounds are likely to be prominent at receptors in closest proximity to the principal emission source, the Refinery. These receptors are already considered to be at a moderately adverse risk of odour nuisance, which is unlikely to increase. Odour mitigation measures are simple to retrospectively install, such as use of enclosures and carbon filtration to abate odours, and can be adapted to the odour type and intensity post-installation.

5.4 MITIGATION

5.4.1 Construction Phase

In order to minimise any risk from construction dust impacts, as part of the ESMP, a number of standard mitigation measures will be implemented in order to ensure that good construction practices are followed. Suggested measures include:

Site Management

- Records of dust and air quality complaints to be kept, including likely causes and mitigation measured to reduce impacts if appropriate;
- Adequately sized construction yard and laydown areas will be planned and provided for storage of construction materials, equipment at the refinery site in order to reduce the number of vehicle trips and travel distance;
- Project Standards and construction plant specification to be defined to ensure that the release of air pollutants from equipment operation is minimized.
- Onsite fuel storage tanks shall be designed to meet applicable regulations and as per respective Material Safety Data Sheet (MSDS). Fuel storage tanks to be provided with submerged loading facilities as feasible to minimise fugitive emissions;
- Construction staff to be properly trained as appropriate in order to follow suitable measures to minimise emissions; and
- Keep site perimeter, fences etc. clean.

Site Planning

- Consideration of weather conditions;
- Consideration of dust generating potential of material to be excavated prior to the commencement of works;
- Plan site layout to maximise distance from plant/stockpiles etc. to sensitive receptors;
- Standard construction equipment, DG units (with proper stack) and in compliance with Project Standards and vehicles shall be used and/or;
- Periodic audits to be conducted to assess implementation of the control measures and results of audits to be reviewed and corrective actions to be taken;
- Periodic maintenance such as engine tuning, lubrication, filter cleaning/replacement, oil changes, replacement of required spares etc., of equipment such as onsite DGs, air compressors and other construction equipment to be conducted so as to reduce emissions and maintain efficiencies;
- Periodic monitoring of emissions for critical pollutants such as CO, NO_X, SO_2, and PM_{10}, $PM_{2.5}$ to be conducted at emission sources as appropriate; and
- Periodic monitoring of ambient air quality using CAQMS to be conducted for critical pollutants at at least two locations around the construction site (considering the location of various activities, wind direction and location of receptors). The monitoring reports to be submitted quarterly to SEZAD/MECA, providing compliance status with applicable regulations.

Construction Traffic

- Loads entering and leaving the site with dust generating potential should be covered and hardstanded exits, trackout pads, plates or wheel washing facilities made available;
- No idling of vehicles;

- Install hard surfacing as soon as practicable on site and ensure that they are maintained in good condition;
- Speeds of vehicles moving within the site to be controlled to reduce dust suspension; proper road sign boards must be installed to increase onsite traffic awareness;
- Trucks carrying spoil loads shall be covered at all times except during loading and unloading.

Site Activities

- Minimise dust generating activities, particularly near residential receptors/sensitive ecosystems during prolonged dry, dusty weather unless damping/other suppressants are used;
- Ensure any site machinery is well maintained and in full working order;
- Ensure equipment available for cleaning spills etc. Available at all times;
- Sand and aggregates should be stored away from sensitive receptors and screened shielded. Similarly concrete batching should take place away from receptors;
- Dusty materials should be removed from site as soon as possible;
- Fabrication activities such as welding, gas cutting, grit blasting and surface coating/painting to be done in a designated area/coating booths;
- Water to be sprayed on dust prone graded roads and work sites. Treated water used for dust suppression will be sourced from the onsite STP or sourced from outside, as feasible;
- Dedicated areas with pollution control devices to be planned and allocated for fabrication, surface coating, etc.

5.4.2 Operation Phase

Emissions from the refinery operations will contribute to ambient air pollutants locally. Predicted impacts of ambient air quality emissions upon sensitive receptors from the refinery operations have been predicted as insignificant. Further mitigation of emissions is therefore not considered mandatory to the compliant operation of the refinery.

The following mitigation measures (Table 5-30) put forward within the air quality assessments (e.g. EIA Study Report, Duqm Refinery, HMR, 2014, Dec.), and enhanced below, would assist with achieving the Project's overall objective to minimising emissions. .

Table 5-30: Air Quality Mitigations Measures during Project Operational Phase

MITIGATION COMPONENT	MITIGATION DETAIL	ASSUMED IN PLACE WITHIN ASSESSMENT MODELLING
Mitigation Measures considered at Design	NO_X reduction measures such as Low NO_X and ultra-low NO_x burners for NO_x control in flue gases from various process units, air preheating in the heaters to maximise efficiency;	Yes
	Firing fuel gas with only low sulphur content for controlling SO_2 emissions; monitoring the amount of O_2 in flue gas for controlling CO emissions; vacuum system and filter are used during loading to prevent dust/fines from spent catalyst; hydrogen stripping of catalyst to reduce carbon and H_2S release	Yes

MITIGATION COMPONENT	MITIGATION DETAIL	ASSUMED IN PLACE WITHIN ASSESSMENT MODELLING
	Adequate stack heights to be provided according to requirements of MD 118/2004 and good engineering practices for stationary point sources to be followed to ensure effective dispersion of the pollutants (with exceptions obtained from MECA);	Yes
	Adequate sampling ports, platforms and facilities required for flue gas sampling to be provided at all the stacks;	Yes
	Continuous Emission Monitors (CEMs) to be installed for monitoring critical pollutants such as NO_X, CO, SO_2, and PM_{10} at the stacks;	Yes
	A suitable leak and gas detection system to be provided to enable immediate response to accidental releases of flammable and toxic gases / vapours. Detection of gases in excess of acceptable levels by the gas detectors can be followed by fault repair/ maintenance programmes;	To be developed
	The design of the bulk storage tanks for liquid materials and fuel to consider the requirements for controls such as submerged loading facilities, conservation vents, floating roofs, etc., in order to reduce fugitive emissions.	Yes
Mitigation by O&M Control	Periodic inspection, integrity checks and maintenance of major piping, equipment, fittings such as valves, flanges, etc., storage tanks (seals, tank shell and roof) and vapour recovery systems are to be scheduled and conducted to ensure reliability and to minimise leaks and fugitive emissions.	N/A
	Periodic inspection, maintenance and calibration of the CEMs to be carried out in order to ensure accurate measurements of pollutant concentrations; The operating parameters critical to ensuring efficient combustion such as air to fuel ratio, temperature, etc., of heaters, GT and steam boilers are to be constantly monitored in order to ensure efficient operation and to reduce emission levels of pollutants;	N/A
	Periodic maintenance of combustion units is to be carried out in order to ensure efficient operation and to reduce emission levels;	N/A
	Establishment of a Leak Detection and Repair (LDAR)	N/A

MITIGATION COMPONENT	MITIGATION DETAIL	ASSUMED IN PLACE WITHIN ASSESSMENT MODELLING
	program	
Corrective Action	The following will constitute an incident or failure to comply in regard to air quality management: • Receipt of a justifiable fugitive emissions complaint • Observation of excessive air pollutant levels generated on site	N/A
	The HSE Manager will investigate all incidents and complaints and will implement the following actions as appropriate:	N/A
	To assess operations to determine the source of the emissions and identify any upset condition regarding the air pollution prevention equipment and to act accordingly to reduce emission.	N/A

Additional mitigation measures (Table 5-31) put forward within EIAs of Associated Facilities would also contribute to achieving these objectives. These have been added to the Project ESMP.

Table 5-31 Additional Air Quality Mitigation measures put forward in Duqm Associated Facilities EIAs

MITIGATION COMPONENT	MITIGATION DETAIL
Dust Suppression Measures	After clearing, grading, earthmoving, or excavation is completed, the disturbed area should be treated by re-vegetating, or spreading soil binders until the area is paved or otherwise developed to the point where dust will not be generated under natural conditions; Placement of dust suppression units upwind of construction works; Only modern, well maintained machinery would be used so to minimise mobile source emissions; and Use of closed conveyors; Dust extraction on stockpiles and conveyors; Cascade chute at vessel load point.
Traffic Emissions	Implementation of measures that reduce the movement of traffic across the area through well managed pedestrian access, cycle routes across the site, eco-industrial clustering to limit the distance of transport of material and sourcing construction material locally wherever possible (as is acceptable with respect to other environmental considerations); The design should ensure that major traffic flows are in areas where receptors are likely to be lowest and where the potential for cumulative impacts is also lowest; Vehicles will be fitted with pollution control to minimise emissions; and Vehicles and plant not operational will be switched off to minimise emissions.
Operation of DGs and heavy plant machineries	Provide stacks or flue pipes on DG sets so that the combustion gases from the generators are emitted at least 3 m above the ground level; Use of ozone depleting substances shall be prohibited per MD 243/2005; Dedicated and enclosed painting booths and fabrication yards shall be provided, wherever possible;

MITIGATION COMPONENT	MITIGATION DETAIL
	Procure diesel fuel from approved refined petroleum product retailers in Oman and ensure sulphur content in diesel fuel is less than 0.05%.; and Periodically monitor dust levels and source emissions to demonstrate compliance with applicable standards
Site Preparation activities	Minimise the height of dropped material into truck and restrict the drop height to not more than 1m during loading and unloading, to minimise wind-blown dust emissions and spillages; Avoid or minimise dust generating activities (particularly cutting and excavating) during dry and windy conditions. Temporarily suspend dust generating construction works when instantaneous gust wind speeds exceed 25 knots (or 12 m/s); Provide appropriate PPE like goggles, face / nose mask, safety shoes and helmet to the workers according to their work or the place of their work; and Ensure proper usage of appropriately issued PPE by all workers on site.

5.5 MONITORING REQUIREMENTS

In order to retain an understanding of the impacts and effects of the Refinery in relation to any changes in baseline or cumulative effects, a continuous monitoring programme is recommended. Monitoring is required during both the construction and operational phase of the Refinery and is defined in the ESMP.

5.5.1 Construction Phase

Construction phase monitoring would consist of continuous emission monitoring of particulates and nitrogen dioxide in ambient air, at site boundary locations and a location representative of a nearby sensitive receptor adjacent to the principle construction traffic route. A reporting schedule and standard approach to corrective actions are also recommended to allow all air quality and emission alerts or complaints to be recorded and actioned (Table 5-32).

Table 5-32: Air Quality Monitoring during the Project Construction Phase

MONITORING COMPONENT	MONITORING DETAIL
Monitoring and Auditing	During construction of Duqm Refinery air quality monitoring at three locations are recommended. These monitoring sites will sample for particulate matter and nitrogen dioxide. Particulate matter (PM_{10}, $PM_{2.5}$) will be sampled at all three locations, two of which will be sited at the boundary of the construction site. It is proposed that nitrogen dioxide will be monitored at a nearby sensitive receptor adjacent to the principle construction traffic route, to assess changes in vehicle emissions. Changes in air quality pollutants during construction will be monitored against air quality limits, and any exceedance risk will be communicated to the construction site manager and specific mitigation measures will be incorporated where necessary. Monitoring results will be reported to SEZAD in accordance with permit requirements. Periodic audits will be conducted to assess implementation of the specific mitigation measures, results of audits to be reviewed and corrective actions to be taken for any deviations.
Reporting	All justifiable dust and emission complaints will be recorded in the complaint register by the HSE Manager Significant air quality performance information will be reported to the MECA in

MONITORING COMPONENT	MONITORING DETAIL
	accordance with the regulatory requirements and permit conditions.
Corrective action	The following will constitute an incident or failure to comply in regard to air quality management: Receipt of a justifiable fugitive emissions complaint Observation of excessive air pollutant levels generated on site The HSE Manager will investigate all incidents and complaints and will implement the following actions as appropriate: To assess operations to determine the source of the emissions and identify any upset condition regarding the air pollution prevention equipment and to act accordingly to reduce emission

5.5.2 Operation Phase

Monitoring in operations would consist of both continuous emission monitoring of the process emissions, an ambient air survey of the Refinery plant site and an ambient air monitoring survey at a location representative of a nearby sensitive receptor. A reporting schedule and standard approach to corrective actions are also recommended to allow all air quality and emission alerts or complaints to be recorded and actioned (Table 5-33).

Table 5-33: Air Quality Monitoring during Project Operational Phase

MONITORING COMPONENT	MONITORING DETAIL
Monitoring and Auditing	Periodic monitoring of emissions using portable stack monitoring instrument to be conducted at all major stacks in order to validate the monitoring data from CEMs. Such monitoring data to be compared with applicable standards and reported to SEZAD as required. The frequency and method of such monitoring will be determined in consent with SEZAD; Duqm Refinery will install continuous ambient air monitoring stations at two locations considering the locations of emission sources, wind direction and locations of receptors (with consensus from MECA), for monitoring of ambient air concentrations of significant air pollutants such as NO_X, SO_2, CO, PM_{10}, etc. The results of monitoring to be compared with applicable standards and submitted to SEZAD as required; Monitoring of fugitive emissions (using portable instruments) from pipes, equipment, fittings, flanges, etc., handling hazardous / toxic materials is to be conducted periodically, which is to be followed by appropriate repair programmes to eliminate such emissions; and Periodic audits to be conducted to assess implementation of the control measures and results of audits to be reviewed and corrective actions to be taken for any deviations.
Reporting	All justifiable dust and emission complaints will be recorded in the complaint register by the HSE Manager Significant air quality performance information will be reported to SEZAD in

MONITORING COMPONENT	MONITORING DETAIL
	accordance with the regulatory requirements and permit conditions.
Corrective action	The following will constitute an incident or failure to comply in regard to air quality management: Receipt of a justifiable fugitive emissions complaint Observation of excessive air pollutant levels generated on site The HSE Manager will investigate all incidents and complaints and will implement the following actions as appropriate: To assess operations to determine the source of the emissions and identify any upset condition regarding the air pollution prevention equipment and to act accordingly to reduce emission

5.6 RECOMMENDATIONS

Elevated concentrations of O_3, PM_{10} and $PM_{2.5}$ were detected during the baseline air quality survey. These pollutants at elevated concentrations have the potential to be harmful to human health. Therefore it is recommended that an exposure reduction plan is put in place during the construction phase and operation phase of the Refinery to limit exposure of both construction and site staff to O_3 and PM_{10}/$PM_{2.5}$ during period of elevated concentrations. Mitigation and monitoring measures herein are incorporated into the Project ESMP, which forms part of the Environmental and Social Management System (ESMS).

6 NOISE

6.1 INTRODUCTION

This section presents the assessment of environmental noise impacts with reference to the relevant parts of the IFC EHS Guidelines. A glossary of technical terms is also included in Appendix 5.1.

The assessment consolidates existing information on noise from previous reports and addresses the gaps identified by DRPIC and in the ESDD Report (Ramboll Environ, 2016). These gaps and the way in which new noise work has enhanced the record for noise on this Project is summarised in Table 6-1.

A baseline noise study was carried out to inform the assessment, and is included as Appendix 5.1.

Table 6-1: Summary of Gap Analysis and Consolidation Action

ISSUE	GAP	NOTES	ACTION TAKEN
Criteria	Unclear use of Omani vs IFC criteria; missing time-bases in level descriptors	IFC requires local criteria to be applied where these are more stringent than IFC EHS Guidelines (and vice versa) – IFC EHS Guidelines are based on WHO (1999).	Criteria have been reviewed and applied in accordance with the IFC Guidelines as set out below
Baseline	Survey data shows high noise levels, attributed to high winds – data is unreliable; measurement time periods may not be sufficient	Surveys carried out during seasonal periods when high winds are common, with standard (ie not augmented) microphone wind-shielding	Fresh baseline noise data acquired during acceptable wind conditions using more suitable equipment, and for longer periods
Prediction	Construction assessment approach and outcome unclear	Construction noise source assumptions and predictions not detailed and not linked to impact classification	Construction assessment revised, linked with scheme programme and source data acquired from standardised database
Prediction/ Assessment	Flaring noise scenarios should be considered in assessment Operational noise levels not evaluated at off-site receptors	Noise levels considered at boundary only	Flaring operations have been clarified and addressed Operational assessment addresses representative off-site receptor locations
Assessment	No assessment of solids export haul traffic noise	Solids export route is an associated facility, addressed in CIA	Prediction of haul traffic noise has been undertaken to inform CIA
Mitigation	Mitigation requirements where limit exceedances are expected should be defined	Noise predictions indicated possibility of areas in refinery exceeding 85 dB $L_{Aeq,8h}$ without quantifying mitigation	Mitigation requirements have been defined

6.2 RELEVANT GUIDANCE

6.2.1 IFC EHS Guidelines

PART 1: ENVIRONMENTAL

Noise impact management for off-site receptors is addressed in Section 1.7 of the IFC General EHS Guidelines Part 1: Environmental (2007). Two sets of criteria are given:

- A relative noise increase limit; and
- Land-use, period-dependant absolute noise limits.

These criteria are shown in Table 6-2.

Table 6-2: IFC EHS Noise Impact Level Guidelines

RECEPTOR CLASSIFICATION	RELATIVE NOISE INCREASE (Δ) LIMIT[1]	ABSOLUTE NOISE LIMIT	
		DAYTIME 07.00-22.00 HRS	NIGHT-TIME 22.00-07.00 HRS
Nearest off-site receptor	≤ 3 dB $\Delta L_{Aeq,1h}$	N/A	N/A
Residential, institutional, educational	N/A	≤ 55 dB $L_{Aeq,1h}$	≤ 45 dB $L_{Aeq,1h}$
Industrial, commercial	N/A	≤ 70 dB $L_{Aeq,1h}$	≤ 70 dB $L_{Aeq,1h}$

Notes:
1. Relative limit applicable where existing noise levels exceed absolute limits

PART 2: OCCUPATIONAL HEALTH AND SAFETY

The physical hazard of noise and vibration in the workplace is addressed in section 2.3 of the IFC General EHS Guidelines part 2: Occupational Health and Safety (2007). The relevant noise criteria are shown in Table 6-3.

Table 6-3: IFC EHS Worker Noise Exposure Guidelines

LOCATION/ACTIVITY	NOISE ACTION THRESHOLD LEVEL (WITHOUT PROTECTION / MITIGATION)[1]		
	8H AVERAGE (EQUIVALENT)	MAXIMUM (MEAN VALUE)	PEAK
Heavy industry	≤ 85 dB $L_{Aeq,8h}$	≤ 110 dB $L_{AFmax(mean)}$	≤ 140 dB L_{Cpeak}

Notes:
1. Noise levels exceeding these thresholds entail hearing protection and/or further mitigation is required to reduce levels at the worker ear to no higher than the limits (ie incorporating the attenuation provided by hearing protection, where relevant)

The worker vibration exposure limits refer to the Threshold Limit Values (TLVs) defined by the American Conference of Governmental Industrial Hygienists (ACGIH, 2006). The TLVs address exposure to both hand-arm and whole-body vibration due to interaction with machinery and within buildings and are included in Appendix 5.2.

6.2.2 Omani Noise Regulations

MINISTERIAL DECISION 79/94

The Regulations set out in MD 79/94 (Sultanate of Oman, 1994a) concern control of noise pollution in public environments generated by sources including industrial and commercial operations, roads and aviation. The land-use-specific limits defined under Article 7 for industrial noise sources are shown in Table 6-4.

Table 6-4: MD 79/94 Industrial Noise Limits

LAND USE TYPE	NOISE LIMIT			
	WORKDAYS DAY 07.00-18.00HRS	WORKDAYS EVENING 18.00-23.00HRS	WORKDAYS NIGHT 23.00-07.00HRS	HOLIDAYS 00.00-00.00HRS
Rural residential recreational	≤ 45 dB $L_{Aeq,11h}$	≤ 40 dB $L_{Aeq,5h}$	≤ 35 dB $L_{Aeq,8h}$	≤ 35 dB $L_{Aeq,24h}$
Suburban residential	≤ 50 dB $L_{Aeq,11h}$	≤ 45 dB $L_{Aeq,5h}$	≤ 40 dB $L_{Aeq,8h}$	≤ 40 dB $L_{Aeq,24h}$
Urban residential	≤ 55 dB $L_{Aeq,11h}$	≤ 50 dB $L_{Aeq,5h}$	≤ 45 dB $L_{Aeq,8h}$	≤ 45 dB $L_{Aeq,24h}$
Urban residential with some workshops or business; city hub	≤ 60 dB $L_{Aeq,11h}$	≤ 55 dB $L_{Aeq,5h}$	≤ 50 dB $L_{Aeq,8h}$	≤ 50 dB $L_{Aeq,24h}$
Industrial and commercial	≤ 70 dB $L_{Aeq,11h}$	≤ 70 dB $L_{Aeq,5h}$	≤ 70 dB $L_{Aeq,8h}$	≤ 70 dB $L_{Aeq,24h}$

The land-use-specific limits for road noise defined under Article 8 are shown in Table 6-5.

Table 6-5: MD 79/94 Road Noise Limits

LAND USE TYPE	NOISE LIMIT			
	WORKDAYS DAY 07.00-18.00HRS	WORKDAYS EVENING 18.00-23.00HRS	WORKDAYS NIGHT 23.00-07.00HRS	HOLIDAYS 00.00-00.00HRS
Rural residential recreational	≤ 60 dB $L_{Aeq,11h}$	≤ 55 dB $L_{Aeq,5h}$	≤ 50 dB $L_{Aeq,8h}$	≤ 50 dB $L_{Aeq,24h}$
Suburban / urban residential with/without workshops or business; city hub	≤ 50 dB $L_{Aeq,11h}$	≤ 45 dB $L_{Aeq,5h}$	≤ 40 dB $L_{Aeq,8h}$	≤ 55 dB $L_{Aeq,24h}$
Industrial and commercial	≤ 70 dB $L_{Aeq,11h}$	≤ 65 dB $L_{Aeq,5h}$	≤ 60 dB $L_{Aeq,8h}$	≤ 60 dB $L_{Aeq,24h}$

In addition, under Article 4, MD 79-94 states that noise containing tonal or impulsive characteristics must be subject to an adjustment as shown in Table 6-6.

Table 6-6: MD 79/94 Noise Character Adjustments

NOISE CHARACTERISTIC	ADJUSTMENT TO A-WEIGHTED LEVEL
Tonal	5 dB
Impulse	5 dB
Combined tonal and impulse	7 dB

MINISTERIAL DECISION 80/94

The Regulations set out in MD 80/94 (Sultanate of Oman, 1994b) concern control of noise pollution in working environments.

Table 6-7: MD 80/94 Worker Noise Exposure Guidelines

LOCATION/ACTIVITY	NOISE ACTION THRESHOLD LEVEL (WITHOUT PROTECTION / MITIGATION)[1] 8H AVERAGE (EQUIVALENT)
Unspecified	≤ 85 dB $L_{Aeq,8h}$
Notes: 1. Noise levels exceeding this threshold entail hearing protection and/or further mitigation is required to reduce levels at the worker ear (ie incorporating hearing protection attenuation, where relevant)	

6.2.3 Other Standards

ISO 9613-2:1996 Acoustics – Attenuation of Sound During Propagation Outdoors – Part 2: General Method of Calculation

This standard details an empirical engineering prediction methodology for general environmental sound propagation (ISO, 1996).

BS 5228-1+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites. Part 1: Noise

This standard sets out a methodology for predicting construction noise propagation, and includes a database of construction noise source levels. It also provides guidance on construction noise mitigation techniques (BSI, 2014).

BS 6472-2:2008 Guide to Evaluation of Human Exposure to Vibration in Buildings. Part 2: Blast-induced Vibration

This standard provides guidance on controlling human exposure and tolerability of vibration from blasting activity (BSI, 2008).

CONCAWE - The Propagation of Noise From Petroleum and Petrochemical Complexes to Neighbouring Communities

This report presents an empirically-based prediction model for environmental sound propagation specific to petroleum industrial areas. This calculation method has been developed specifically from measurements of petrochemical industrial sites, including elevated sources and over long distances (Manning, 1981).

6.2.4 Application of Guidance to Assessment

CONSTRUCTION IMPACT

Article 2 of MD 79/94 does not refer to noise from temporary construction activities; it is therefore assumed the limits do not apply to such sources, and the IFC Guidelines are instead applicable.

Noise source data for construction activities have been assigned from the database in BS 5228-1+A1:2014 wherever possible. The calculation method in BS 5228-1+A1:2014 has been used to estimate levels of construction noise at relevant receptors.

Control and mitigation for construction phase blasting is referred to adherence with the limits in BS 6472-2:2008.

OPERATIONAL IMPACT

The results of the baseline noise survey (Appendix 5.1) show that, in general, noise levels around the surveyed area are typically below the IFC Guideline limits shown in Table 6-2. This means that the absolute limits are applicable, and not the limit on a relative increase in noise levels (which applies only where the absolute limits are already appreciably exceeded by anthropogenic noise).

Comparison of Table 6-2 and Table 6-4 shows that, while the time-bases used are different, the IFC EHS Guideline limits are broadly equivalent to the MD 79/94 industrial noise limits for 'urban residential' areas. Making the assumption that the noise under assessment is effectively continuous throughout the diurnal assessment period resolves the time-base discrepancy. Given that the majority of receptors under assessment can be considered either 'rural' or 'urban residential', it is considered that these MD 79/94 noise limits are equal to or more stringent than the IFC Guidelines and are therefore applicable to the operational noise impact assessment.

Comparison of Table 6-2 and Table 6-5 shows that the MD 79/94 road noise limits are less stringent than the IFC Guidelines (making the same assumption of effectively continuous average noise levels throughout each period). Therefore, for road noise impacts (e.g. from haul traffic associated with the refinery), the IFC Guidelines are applicable.

Compliance with the IFC Guideline vibration TLVs will be demonstrated by suppliers during the detailed design and specification phase, which includes equipment procurement.

Operational noise from the Refinery sources has been calibrated to the boundary levels estimated in the ESIA Noise Assessment Report ref DRP001-FED-RPT-M-000-001 using the ISO 9613-2 method, for consistency. General operational industrial noise propagation from the Project components to off-site locations has been estimated using the CONCAWE calculation method, which is more suitable over the distances involved and for the types of noise sources considered. Road noise from solids export haulage vehicles associated with the operational phase has been estimated using the method in BS 5228-1.

SUMMARY

As set out above, the application of assessment criteria follows the IFC guidance in taking the more stringent of local or IFC Guidelines as the benchmark. The criteria applications are summarised in Table 6-8.

Table 6-8: Summary of Assessment Criteria Application

ASSESSMENT ELEMENT	APPLICABLE GUIDELINE CRITERIA
Construction noise	IFC EHS
Operational noise (industrial)	MD 79/94
Operational noise (solids export route)	IFC EHS

6.2.5 Noise Impact Significance

The assessment of noise impact follows the general methodology set out in Section 4, with two clarifications:

i. Noise impacts are considered 'Very Low' in severity if they conform to the applicable regulatory/guideline criteria set out in Table 6.8; and

ii. Noise impacts designated 'Very Low' severity are rated 0, which results in the significance matrix set out below:

Significance			Probability Rating			
			Very low	Low	Medium	High
			1	2	3	4
Severity Rating	Very low	0	0 Negligible	0 Negligible	0 Negligible	0 Negligible
	Low	2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium	3	3 Minor	6 Moderate	9 Moderate	12 Major
	High	4	4 Minor	8 Moderate	12 Major	16 Major

6.3 CONSOLIDATED IMPACT ASSESSMENT

6.3.1 Methodology

RECEPTOR IDENTIFICATION AND CLASSIFICATION

A receptor screening stage has been carried out to identify relevant locations. Initially, SEZAD area maps were used to highlight potential receptor locations. Satellite imagery was then examined for evidence of settlement, and cross-referenced against national base mapping issued by the Sultanate of Oman. The identified potential receptors were checked with DRPIC and local consultants to filter any spurious locations (such as temporary shelters). A site reconnaissance was used to examine relevant areas. Finally, receptors were reconfirmed during the baseline survey work.

The receptors selected to represent the areas affected are shown in Figure 6-1, and listed in Table 6-9.

Table 6-9: Representative Receptor Locations

Receptor ID	receptor location	UTM(40N) Coordinate East	UTM(40N) Coordinate North
R01	Saay village – north	567632	2172865
R02	Saay village – south	565291	2167942
R03	Saay village – west	564607	2170536
R04	Nafun village – west	575426	2190842
R05	Nafun village - east	577032	2190027
R06	Frontier town	572040	2165207
R07	Frontier town - hotels	573561	2164098
R08	Renaissance workcamp	570982	2169128
R09	150 Villas	565435	2162472
R10	Shuwayr village	574005	2155963
R11	Proposed residential area	567102	2165752

RECEPTOR ID	RECEPTOR LOCATION	UTM(40N) COORDINATE EAST	UTM(40N) COORDINATE NORTH
R12	Royal Oman Police	566180	2160193
R13	Dhahr village - northwest	563379	2132097
R14	Dhahr village - northeast	566744	2130791
R15	Dhahr village – east	567532	2129212
R16	Dhahr village - south	566336	2126120

6.3.2 Baseline Characterisation

The baseline noise environment around the areas affected by the Project components has been characterised with survey data. Details of the methodology employed and the measurement locations are included in Appendix B and Figure 6-1.

To summarise, the baseline noise environment is generally characterised by natural sound sources, generated by surf/wave and wind/vegetation mechanisms, and contributions from road traffic noise generated by sporadic local vehicle movements, and construction activity. Due to the small contributions from anthropogenic sources, ambient noise does not vary substantially between day, evening and night. A compiled summary is shown in Table 6-10; more details are included in Appendix 5.1.

Table 6-10: Summarised 2017 Baseline Noise Survey Measurement Results

AREA	PERIOD DESCRIPTION	L_{Aeq} RANGE, dB	L_{A90} RANGE, dB	PRIMARY NOISE SOURCE(S)
Wadi Saay / Duqm	Day	44 – 52	39 – 46	Wind, distant construction noise along Highway 32, occasional road traffic
	Evening	49 – 52	41 – 45	Wind, occasional road traffic
	Night	42 – 52	38 – 41	Wind
Nafun	Day	41 – 54	39 – 53	Wind, sea, very occasional local vehicles
	Evening	42 – 48	38 – 45	
Antoot	Day	42 – 44	35 – 36	Wind, sea
Dhahr	Day	43 – 48	36 – 41	Wind, occasional local vehicles

6.3.3 Construction Noise Model

The construction noise assessment utilises the same geographic base mapping to estimate noise emissions during peak work stages. Peak activity periods have been evaluated from the outline construction programme and the information in the existing ESIAs concerning activity phases for each Project component, and form a basis for the assessment, i.e. the assessment focuses on the worst-case coincident activities. The outline construction programme used as a basis for the assessment is included in Appendix 5.3, which indicates the selected peak activity periods denoted P1, P2 and P3.

The main noise-generating plant items required for each phase have been determined, with required simultaneous plant quantities estimated, and representative noise source data assigned from the BS 5228-1 database. The plant assumptions are listed for each Project component in Table 6-11.

DUQM REFINERY

Table 6-11: Duqm Refinery Construction Phase Plant

ACTIVITY	PLANT	BS 5228-1 ID	# SIMULTANEOUS	PROPORTION ON-TIME	ACTIVITY LEVEL AT 10M, dB $L_{Aeq,T}$
Ground excavation/earthworks	Excavator	C2-14	2	80%	79
Distribution of material	Dumpers	C2-30	2	80%	79
Distribution of material	Tippers	C2-32	2	80%	74
Rolling and compaction	Vibrators	C2-42	1	80%	78
Rolling and compaction	Compactors	C2-42	1	80%	78
Lifting	Mobile cranes	C4-52	3	80%	75
Breaking road surface	Motors and compressors	C5-5	4	80%	65
Power for site cabins	Diesel generators	C4-84	4	80%	74
Distribution of material	Trucks	C2-30	2	80%	79
Sheet steel piling-Hydraulic jacking	Pipe flushing	C3-13	2	80%	63
Clearing site	Shovels	C2-3	2	80%	78
Welding/cutting steel piles	Welding + metal cutting	C3-31	2	80%	73
ACTIVITY	**PLANT**	**BS 5228-1 ID**	**#/HR**	**SPEED, KM/H**	**PASSBY LEVEL, dB L_{AFmax}**
Materials distribution	Dump truck	C2-31	70	40	87

DUQM REFINERY – CONSTRUCTION CAMPS

The construction of the Workers' Camps is assumed to take place during the first construction peak activity phase. The operational phase of the Workers' Camps forms part of the second and third construction peak activity phases, during construction of other Project components.

Table 6-12: Duqm Refinery Construction Camps Construction Phase Plant

ACTIVITY	PLANT	BS 5228-1 ID	# SIMULTANEOUS	PROPORTION ON-TIME	ACTIVITY LEVEL AT 10M, dB $L_{AEQ,T}$
Site preparation	Rock drilling	C2-43	1	80%	74
Site preparation	Breaker / crusher	C1-15	1	80%	84
Site preparation	Dozers	C2-13	2	80%	81
Ground excavation/earthworks	Moto-scrapers	C2-17	1	80%	76
Site preparation	Dump-trucks	C2-30	2	80%	79
Site preparation	Face shovels	C2-3	1	80%	78
Ground excavation/earthworks	Excavators	C2-18	1	80%	75
Site Preperation	Graders	C2-42	1	80%	78

Activity	Plant	Bs 5228-1 ID	# Simultaneous	Proportion on-time	Activity level at 10m, dB $L_{Aeq,T}$
Road Construction	Compactors	C5-29	1	80%	82
General Site Activities	Concrete batching	C4-25	1	80%	82
Site Preparation	Trucks	C2-32	2	80%	74
General Site Activities	Mobile crane	C4-52	1	80%	75
General Site Activities	Crawler Crane	C4-38	1	80%	78
Ground excavation/earthworks	Excavator	C2-18	1	80%	75
Site Preparation	Dump truck	C2-30	1	80%	79
Hard Rock Quarries	Flat-bed lorries	C9-25	2	80%	82
General Site Activities	Road paving	C4-73	1	80%	84
Piling and Ancillary Operations	Piling Rig	C3-8	1	80%	88
Site Preparation	Face shovel	C2-3	1	80%	78
General Site Activities	Wheeled excavator	C4-10	1	80%	66

Table 6-13: Duqm Refinery Construction Camps Operation Phase Plant

Activity	Plant	Bs 5228-1 ID	# Simultaneous	Proportion on-time	Activity level at 10m, dB $L_{Aeq,T}$
Welding/cutting steel piles	Welding equipment	C3-31	2	80%	73
Mixing concrete	Concrete mixer	C4-22	2	80%	76
Pumping concrete	Motors and compressors	C4-25	3	80%	82
Power for site cabins	Diesel generators	C4-84	5	100%	74
Distribution of material	Trucks	C2-32	4	80%	74

DUQM PRODUCT EXPORT TERMINAL

Table 6-14: Duqm Product Export Terminal Construction Phase Plant

Activity	Plant	Bs 5228-1 ID	# Simultaneous	Proportion workday on-time	Activity level at 10m, dB $L_{Aeq,T}$
Construction	Batching plant	C4-25	3	80%	82
Earthmoving	Bulldozer	C2-12	1	80%	81
Construction	Concrete mixer	C4-22	1	80%	76
Construction	Concrete pump	C4-25	2	80%	82
Construction	Crane mobile/barge mounted	C4-52	1	80%	75
Construction	Diesel generators	C4-84	1	100%	74

Activity	Plant	Bs 5228-1 ID	# Simultaneous	Proportion workday on-time	Activity level at 10m, dB $L_{Aeq,T}$
Dredging	Dredger	C7-1	2	80%	78
Earthmoving	Dumper	C2-30	1	80%	79
Piling	Piling rig	C3-6	1	80%	68
Earthmoving	Excavator/loaded (wheeled/tracked)	C2-18	1	80%	75
Dredging	Tug boat	C7-2	1	80%	52
Construction	Water pump	C4-88	1	80%	68
Activity	Plant	Bs 5228-1 ID	#/hr	Speed, km/h	Passby Level, dB L_{AFmax}
Materials distribution	Dump truck	C2-31	70	40	87

DUQM REFINERY CRUDE PIPELINE

Table 6-15: Duqm Refinery Crude Pipeline Construction Phase Plant

Activity	Plant	Bs 5228-1 ID	# Simultaneous	Proportion on-time	Activity level at 10m, dB $L_{Aeq,T}$
Earthworks	Air compressor	C5-5	2	80%	65
Earthmoving	Bulldozer	C2-12	2	80%	81
Construction	Concrete mixer	C4-22	2	80%	76
Construction	Concrete pump	C4-25	2	80%	82
Construction	Crane mobile	C4-52	2	80%	75
Construction	Diesel generators	C4-84	1	100%	74
Earthmoving	Dumper	C2-30	2	80%	79
Earthmoving	Excavator/loaded (wheeled/tracked)	C2-18	2	80%	75
Earthworks	Rock drill, crawler mounted (hydraulic)	C9-2	1	80%	92
Earthworks	Rock drill, hand held (pneumatic)	C6-35	1	80%	86
Construction	Water pump	C4-88	1	80%	68
Lifting	Mobile Crane	C4-50	1	80%	71

In addition, there may be a need in some areas for use of explosives to remove rock by blasting.

RAZ MARKAZ CRUDE STORAGE FACILITY

Table 6-16: Raz Markaz Crude Storage Terminal Construction Phase Plant

ACTIVITY	PLANT	BS 5228-1 ID	# SIMULTANEOUS	PROPORTION ON-TIME	ACTIVITY LEVEL AT 10M, DB $L_{AEQ,T}$
Power for site cabins	Diesel Generators	C4-84	5	100%	74
Breaking road surface	Compressors	C5-5	1	80%	65
Face shovel loading dump trucks	Engines	C9-5	3	80%	83
Miscellaneous	Drillers	C4-92	2	80%	87
Mixing concrete	Cement / concrete mixers	C4-20	3	80%	80
Rolling and compaction	Compactors	C2-42	2	80%	78
Ground excavation/earthworks	Excavation	C2-14	2	80%	79
Ground excavation/earthworks	Bull dozing	C2-10	1	80%	80
Rotary bored piling-cast in situ	Piling	C3-14	3	80%	83

6.3.4 Operational Noise Model: Project Components

The operational noise assessment employs a computer-generated 3D prediction model to estimate noise emissions and propagation to relevant receptors using the routines set out in CONCAWE (Manning, 1981) and implemented in CadnaA software. Key elements of the model are described in detail below.

BASE MAPPING

The underlying geographical base for the noise model includes topographic data from the USGS GMTED2010 database in 7.5 arc-second resolution, combined with satellite imagery from Google Earth.

ATMOSPHERIC CONDITIONS

Over long distances, the local atmospheric conditions have a large influence on the propagation of sound. In particular, the temperature gradient, wind shear profile and wind direction must be considered. Based on observational data for Duqm for 2010-2017, the prevailing wind direction over March-November is south-westerly, south-south-westerly in December, and north-easterly January-February (Windfinder, 2017). Conditions most conducive to sound propagation comprise downwind, atmospheric stability and inverted temperature gradients. On this basis, two atmospheric conditions representing different typical worst-case operational scenarios with respect to the nearest receptors are considered as shown in Table 6-17 and described as follows:

a. Winter worst-case (January-February): north-easterly winds place Duqm/Saay receptors downwind of the nearest Project components, and Nafun receptors upwind; minimal night-time cloud cover combined with moderately-high wind speed encourages a neutral atmosphere with moderately-high wind shear; and

b. Typical worst-case (March-December): south-westerly winds place Duqm/Saay receptors upwind of the nearest Project components, and Nafun receptors downwind; minimal night-time cloud cover combined with moderately-low wind speed encourages a very stable atmosphere with high wind shear.

Table 6-17: Summary of Atmospheric Condition Operational Scenarios

Scenario	Months	Prevailing Wind Direction	Average Wind speed	Min temperature (night-time)	Relative humidity (night-time)	Stability class (night-time)
A: Winter worst-case	Jan-Feb (2)	45° (NE)	5 ms^{-1}	20°C	70%	D
B: Typical worst-case	Mar-Dec (10)	225° (SW)	2 ms^{-1}	20°C	80%	F
Sources of information: https://www.worldweatheronline.com/duqm-weather-averages/ash-sharqiyah/om.aspx https://www.windfinder.com/windstatistics/duqm						

DUQM REFINERY

The Refinery area of the model is based on the information in the Noise Assessment Report (DRPIC Report Ref. DRP001-FED-RPT-M-000-001;Amec Foster Wheeler, 2015a). Noise sources have been inserted to represent each work zone identified in the Report using the assigned noise data.

The operation of the Refinery flares has been clarified with the DRPIC Engineering design team; the following operation will apply:

- During normal operation, the Refinery is designed to capture and recirculate all gas releases during routine plant upsets for re-use. In this scenario there will be no flaring combustion, and no associated gas combustion noise emissions; and
- Under emergency conditions, which cover total plant power failure, the flare systems are designed to combust gases at a high rate and discharge from the stacks. Under these conditions there would be noise generated, but an emergency situation is not considered part of the normal operation of the refinery – any emergency situations that arise would be sporadic and atypical, and any additional noise impact for off-site receptors would therefore be both limited and exceptional. In this scenario, the main concern would be for limiting the risk of hearing damage to workers on the refinery site.

DUQM PRODUCT EXPORT TERMINAL AND RAZ MARKAZ CRUDE STORAGE FACILITY

Operational noise generated by the Export Terminal and the Crude Storage Facility has been estimated from the noise limits specified in the relevant ESIAs, reports SEZAD-DPTC-00-WP-EV-REP-3001-B2 (Worley Parsons, 2015) and 5440-8150-RP-000-0016 (HMR Consultants, 2015a) respectively. The ESIA noise limits are 85 dB LAeq,T in any work area, and 70 dB LAeq,T at the project fence line.

It is anticipated that operational noise from the Crude Pipeline will be negligible, as noise will be generated by periodic maintenance activities only.

6.3.5 Operational Noise Model: Associated Facility – Coke and Sulphur Solids Export Route

Noise from haul vehicles on the coke and sulphur solids export route has been estimated using traffic data reported in the Site Road Access Functional Specification ref DRP001-FED-IFD-U-000-008 (Amec Foster Wheeler, 2015), which allows for up to 19 transport vehicles per hour.

The model employs the BS 5228-1 calculation method, with an indicative heavy transport vehicle source sound power level from the BS 5228-1 noise database. The prediction assumes the maximum hourly number of vehicles using the route during either day or night periods, travelling at an approximate average speed of 60 kmh-1.

6.3.6 Assessment

CONSTRUCTION NOISE IMPACT

OFF-SITE RECEPTORS

The predicted noise level estimates for each peak activity period at representative receptor locations are shown in Table 6-18. Indicative noise contours are shown in Figure 6-2.

Table 6-18: Estimated Construction Noise Levels during Peak Activity Periods

RECEPTOR ID	RECEPTOR LOCATION	LIMIT CRITERIA, DB $L_{AEQ,1H}$ DAY / NIGHT	PEAK PERIOD P1, DB $L_{AEQ,1H}$	PEAK PERIOD P2, DB $L_{AEQ,1H}$	PEAK PERIOD P3, DB $L_{AEQ,1H}$
R01	Saay village - north	55 / 45	30	35	36
R02	Saay village - south	55 / 45	30	33	32
R03	Saay village - west	55 / 45	33	33	33
R04	Nafun village - west	55 / 45	23	33	33
R05	Nafun village - east	55 / 45	22	34	34
R06	Frontier town	55 / 45	23	30	30
R07	Frontier town - hotels	55 / 45	22	25	25
R08	Renaissance workcamp	55 / 45	26	33	33
R09	150 Villas	55 / 45	24	32	30
R10	Shuwayr village	55 / 45	19	26	25
R11	Proposed residential area	55 / 45	26	32	32
R12	Royal Oman Police	55 / 45	23	32	30
R13	Dhahr village - northwest	55 / 45	17	18	34
R14	**Dhahr village - northeast**	55 / 45	18	20	**49**
R15	Dhahr village - east	55 / 45	19	19	37
R16	Dhahr village - south	55 / 45	19	19	29

The results in Table 6-18 show that, with the exception of one receptor (highlighted in bold), noise levels at all other receptors are expected to be below the IFC Guideline day and night-time noise limits during all peak activity periods.

At the receptor representing the northeast dwellings in Dhahr village, predicted noise levels are below the IFC daytime limit for each peak activity period, but 4 dB above the IFC night-time limit for activity period P3. During this period, the Crude Pipeline construction activities will be taking place at the closest distance to Dhahr village, approximately 750m from the site boundary. Rock drilling plant constitutes the largest proportion of the noise emissions estimated during these works, so the impact assessment indicates that night-time rock drilling, if undertaken, could exceed the IFC noise limits. Therefore, in order to ensure noise limits are met, any rock drilling necessary in the area near to Dhahr village should be carried out during the daytime only. Alternatively, temporary barriers or local enclosures could also be used to provide sufficient noise reduction to enable night-time rock-drilling work to proceed in this area.

The potential requirement for blasting is not certain at this stage, but may be necessary to remove rock in some areas of the Crude Pipeline construction. Due to the impulsive and highly sporadic nature of blasting activities, the main concerns comprise vibration and air overpressure (airborne shock wave) damaging buildings or causing disturbance. However, at the distances involved, off-site receptors are highly unlikely to be impacted significantly by vibration or air overpressure from blasting from the Pipeline construction site. Nonetheless, blasting noise can be audible at very long ranges, and may cause unnecessary concern amongst communities unless informed of the planned operations. This is discussed under mitigation below.

SIGNIFICANCE

The off-site construction noise impacts identified would be negative, direct, local, short-term and of low to medium severity. Given the variable nature of the construction activities and worst-case assumptions adopted, the probability of the impacts occurring is medium (i.e. there is a fair chance the impacts would be lower than predicted). The significance of the impacts is therefore considered to be moderate.

ON-SITE EXPOSURE

The indicative construction plant lists above show that operation of some equipment may give rise to worker exposure to sound pressure levels higher than 85 dB LAeq,T, depending on proximity to the plant. The 8hr average exposure will also depend on the exposure duration, which will not be known until detailed plans for construction activities have been prepared. Exposure to maximum levels exceeding 110 dB LAFmax may also occur, depending on proximity of workers to the noisiest plant. In particular, rock drilling, breaking, crushing and foundation piling activities can give rise to very high noise levels at close range, with strong impulsive components.

The actual noise emissions from construction plant will depend on the plant selections, which can only be indicative at this stage. Suppliers of mechanised plant must declare the noise emissions to enable detailed construction and mitigation plans to be prepared. Methods for mitigating worker exposure to construction noise are outlined below.

SIGNIFICANCE

The on-site construction noise impacts identified would be negative, direct, local, short-term and of low to medium severity. The probability of the impacts occurring would depend on detailed work plans and equipment selections, and is therefore considered to be medium. The significance of the impacts in the absence of mitigating measures would therefore be considered to be moderate. Mitigation is discussed further below.

OPERATIONAL NOISE IMPACT

OFF-SITE RECEPTORS

PROJECT COMPONENTS: REFINERY AND OFF-SITE FACILITIES

The noise levels predicted at off-site receptors during normal operation of the Refinery and off-site facilities are summarised in Table 6-19. Indicative noise contours are shown in Figure 6-3.

Table 6-19: Estimated Operational Noise Levels (Project Components)

RECEPTOR ID	RECEPTOR LOCATION	LIMIT CRITERIA, dB $L_{Aeq,T}$ DAY / EVE / NIGHT & HOLIDAYS	SCENARIO A: WINTER WORST-CASE dB $L_{Aeq,T}$	SCENARIO B: TYPICAL WORST-CASE dB $L_{Aeq,T}$
R01	Saay village - north	55 / 50 / 45	40	35
R02	Saay village - south	55 / 50 / 45	16	13
R03	Saay village - west	55 / 50 / 45	24	21
R04	Nafun village - west	45 / 40 / 35	<0	14
R05	Nafun village - east	45 / 40 / 35	3	21
R06	Frontier town	55 / 50 / 45	14	11
R07	Frontier town - hotels	55 / 50 / 45	4	0
R08	Renaissance workcamp	55 / 50 / 45	32	28
R09	150 Villas	55 / 50 / 45	1	0
R10	Shuwayr village	45 / 40 / 35	<0	-19
R11	Proposed residential area	55 / 50 / 45	11	8
R12	Royal Oman Police	55 / 50 / 45	<0	-1
R13	Dhahr village - northwest	45 / 40 / 35	<0	5
R14	Dhahr village - northeast	45 / 40 / 35	2	13
R15	Dhahr village - east	45 / 40 / 35	9	18
R16	Dhahr village - south	45 / 40 / 35	17	14

The predicted levels in Table 5.19 indicate that operational noise is expected to meet the industrial noise limits set out in MD 79/94 at all receptors for all periods. Furthermore, if activities contain impulsive or tonal components, the limits would still be met.

SIGNIFICANCE

The off-site operational noise impacts identified would be negative, direct, local, and long-term In consideration of the baseline noise environment, the predicted levels are expected to be imperceptible at all locations with the exception of the area around the north of Saay Village and the Renaissance Workcamp. At all receptors the predicted levels are below the applicable guideline criteria, and the impact severity is therefore considered very low. Given the dependence on weather conditions and the worst-case assumptions adopted, the probability of the impacts occurring is medium (i.e. there is a fair chance the impacts would typically be lower than predicted). The significance of the impacts is therefore considered to be negligible.

ASSOCIATED FACILITY: COKE AND SULPHUR SOLIDS EXPORT ROUTE

The noise levels predicted at off-site receptors for solids export transport vehicle movements are summarised in Table 6-20.

Table 6-20: Estimated Operational Noise Levels (AF: Solids Export Vehicles)

RECEPTOR ID	RECEPTOR LOCATION	LIMIT CRITERIA, dB $L_{AEQ,1H}$ DAY / NIGHT	NOISE LEVEL, dB $L_{AEQ,1H}$ DAY / NIGHT
R01	Saay village - north	55 / 45	37
R02	Saay village - south	55 / 45	25
R03	Saay village - west	55 / 45	29
R04	Nafun village - west	55 / 45	19
R05	Nafun village - east	55 / 45	19
R06	Frontier town	55 / 45	21
R07	Frontier town - hotels	55 / 45	15
R08	Renaissance workcamp	55 / 45	29
R09	150 Villas	55 / 45	23
R10	Shuwayr village	55 / 45	13
R11	Proposed residential area	55 / 45	24
R12	Royal Oman Police	55 / 45	21
R13	Dhahr village - northwest	55 / 45	5
R14	Dhahr village - northeast	55 / 45	5
R15	Dhahr village - east	55 / 45	6
R16	Dhahr village - south	55 / 45	4

The predicted levels in Table 6.20 indicate that solids export vehicles are expected to meet the IFC Guideline noise limits at all receptors for all periods, and the impact severity is therefore considered very low.

The significance of environmental impacts from Associated Facilities is considered in the Cumulative Impact Assessment report that accompanies the Consolidated ESIA.

ON-SITE EXPOSURE

DUQM REFINERY

Predictions of on-site worker exposure to noise during the Refinery operation have been carried out as documented in reports DRP-001-EIA-RPT-Z-000-001 (HMR Consultants, 2015b) and DRP001-FED-RPT-M-000-001 (Amec Foster Wheeler, 2015a), as shown in Appendix 5.5. The predictions show that the majority of work areas are expected to have noise exposure levels below the IFC Guidelines action threshold of 85 dB LAeq,8h. No mitigation or hearing protection would be required under these circumstances.

There are also relatively small areas within the Refinery complex where predicted noise levels are higher than the action threshold. In these areas, mitigation and/or hearing protection is required. These areas are listed as follows:

- Unit 100;
- Unit 120;
- Unit 130;
- Unit 160;
- Unit 340 Train 1, 2 and 3;
- S660 adjacent to sulphur tanks; and
- Flare sterile areas (emergency conditions).

SIGNIFICANCE

The on-site operational noise impacts identified would be negative, direct, local, long-term and of low to medium severity. The probability of the impacts occurring would depend on detailed work plans and equipment selections, and is therefore considered to be medium. The significance of the impacts in the absence of mitigating measures would therefore be considered to be moderate. Mitigation is discussed further below.

6.4 MITIGATION

6.4.1 Construction Phase

OFF-SITE RECEPTORS

The construction noise impact assessment indicates that the indicative plant and activity programme is unlikely to give rise to significant adverse impacts at off-site receptors.

Construction of the Crude Pipeline is expected to result in the highest noise impact at off-site receptors, specifically as the pipeline construction passes by Dhahr village at around 750m proximity. During this period, some limitations on night-time working may be required, and/or noise attenuation measures put in place to reduce noise from the noisiest plant. Mitigation for construction noise is outlined in BS 5228-1, and suitable measures (where necessary and practicable) are listed in Table 6-21.

Table 6-21: Construction Noise Mitigation Measures

MEASURE	DETAILS	TRANSMISSION HIEARCHY
1	Prioritisation given to selection of low-noise equipment, especially for noisy activity such as piling, and rock removal and processing	SOURCE
2	Use available silencers on vehicle exhausts, and noise reduction devices on machinery and heavy equipment	
3	Maintain all equipment in accordance with manufacturer's instructions	
4	Acoustic enclosures for diesel generator units in accordance with manufacturers' recommendations	
5	Operational management to avoid unnecessary use of equipment (e.g. idling engines) or engine revving	
6	Maintain haul routes and minimise gradients to reduce noise from vehicle engines	
7	Scheduling of noisier activities during least sensitive periods of the daytime and avoidance of high noise activities (e.g. piling, dredging and rock processing) at night	
8	Limit blasting activities to the daytime and specify charge sizes to ensure adherence with 'maximum satisfactory magnitudes of vibration' in accordance with BS 6472-2:2008, as shown in Table 5-22.	
9	Localised noise barriers or enclosures – efficient use where possible (and necessary) of site spoilage to erect temporary earthen bunds to screen noisy areas	PATH
10	Inform nearby communities at least one day in advance of any planned blasting activity that may be audible, including anticipated times and durations	RECEPTOR

Table 6-22: Satisfactory Magnitudes of Blasting Vibration Affecting Buildings, from BS 6472-2:2008

PLACE	TIME	PEAK PARTICLE VELOCITY LIMIT FOR UP TO 3 EVENTS PER DAY*, MMS^{-1}
Residential	Daytime	≤ 6.0 to 10.0**
	Evening	≤ 4.5
	Night-time	≤ 2.0
Offices or workshops†	Any	≤ 14.0

*For operations exceeding 3 vibration events per day, the limits should be multiplied by a modifying factor F depending on the number of events N, and the blast duration T (in seconds): $F = 1.7N^{0.5}T^{d}$ where the exponent d is 0 for $T < 1$, 0.32 for wooden floors or 1.22 for concrete floors (for $T > 1$).

**Within residential properties people exhibit a wide variation of tolerance to vibration. Specific values are dependent upon social and cultural factors, psychological attitudes and the expected degree of intrusion. In practice the lower limit should be used with the higher limit being justified on a case-by-case basis.

†Critical working areas where delicate tasks impose more stringent criteria than human comfort are not considered.

Once detailed, location-specific construction requirements and final plant requirements are known, it will be necessary to re-examine which specific mitigation measures are required to meet the noise limits, in particular where the Crude Pipeline construction site passes relatively near to existing receptors, such as around Dhahr. An indicative noise limit for the boundary of the pipeline construction area to meet the IFC limits at all off-site receptors is shown in Table 5.23.

Table 6-23: Crude Pipeline Construction Boundary Noise Limit

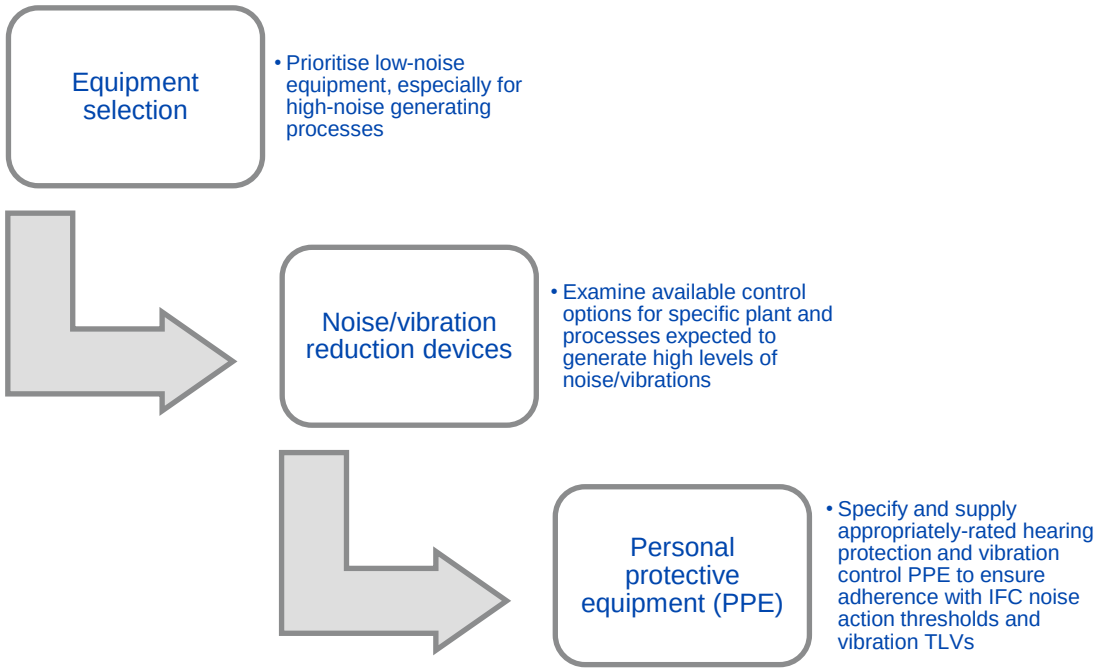
LOCATION	CONSTRUCTION SITE BOUNDARY NOISE LIMIT, DB $L_{AEQ,1H}$ DAY / NIGHT
Construction site within 750m residential area (Dhahr)	80 / 70

Where noise levels exceed or are expected to exceed these limits after equipment selections and work plans are proposed, further mitigation such as localised barriers, temporary earthen bunds or other suitable measures as outlined in Table 5.21 will be specified to reduce noise.

With implementation of suitable measures and operational management steps as described, it is expected that construction noise impacts at all receptors will be controlled to very low severity, and negligible significance.

ON-SITE EXPOSURE

Mitigation for on-site construction noise exposure will follow a similar process as for on-site operational noise exposure:



Again with adoption of suitable measures as described, it is expected that construction noise impacts will be controlled to meet the IFC Guidelines. The probability of negative impacts on workers' hearing occurring is therefore expected to be very low, and therefore considered of negligible significance.

6.4.2 Operation Phase

OFF-SITE RECEPTORS

Inherent noise mitigation is included in the boundary noise limit applicable to the Project component sites, which is defined as 70 dB $L_{Aeq,T}$.

The predicted noise emissions from the Project components during normal operations are expected to comply with the relevant noise limits at off-site receptors, and the significance of effect has been assessed as negligible. No further mitigation has therefore been considered. Monitoring is required to ensure noise limits are adhered to, as described below.

ON-SITE EXPOSURE

Control of noise at source is generally preferable to control at the ear for reasons of both health and safety (the need to ensure audibility of alarm signals when operating potentially dangerous machinery) and effectiveness (hearing protection is easily bypassed and only protects the wearer). During the EPC Contractors' detailed design and procurement, suppliers will need to submit noise data for equipment along with any available options for noise reduction. If equipment noise cannot directly be reduced to below the action threshold, hearing protection devices must be supplied to all workers operating in the affected areas, and visible signage erected to instruct and inform employees of mandatory hearing protection zones (i.e. 'Noise Hazard Areas'). Periodic hearing checks should also be offered to all employees working in high-noise areas.

Hearing protection devices issued to workers must reduce exposure to below the threshold action levels of 85 dB $L_{Aeq,8h}$, 110 dB $L_{AFmax(mean)}$ and 140 dB L_{Cpeak}. An appropriate attenuation rating system to use for specification is found in the EN 352 standard series. Workers should also be provided with adequate training to ensure the correct use of the hearing protection is understood.

The noise limits for the other Project components should ensure that average levels will not normally exceed 85 dB $L_{Aeq,8h}$. In any cases where noise is expected to exceed the IFC Guidelines, the same mitigation process will be adopted, i.e. first examine options available from equipment suppliers to reduce noise at source; secondly supply suitably-rated hearing protection and training for workers within Noise Hazard Areas.

Subject to suitable plant selection, design and noise hazard area designation as described, it is expected that the probability of impacts occurring (i.e. impacts on workers' hearing) can be reduced to very low, and therefore the significance of impact would be considered negligible.

6.5 MONITORING REQUIREMENTS

6.5.1 Construction Phase

Monitoring of construction noise will be carried out within the site and at the site boundary to ensure noise levels are within acceptable limits. Monitoring will be conducted on a monthly basis, or in response to any complaints reported concerning noise.

Monitoring of sound levels must employ suitable measurement equipment, i.e. conforming to the class 1 or 2 specifications of IEC 61672-1:2013. Surveys should be planned and executed with reference to the relevant guidance in ISO 1996 Part 1 (ISO, 1982) and Part 2 (ISO, 1987).

A detailed monitoring programme will need to be determined and finalised in consultation with SEZAD. The guidance in the referenced standard, ISO 1996 Parts 1 and 2, includes selection of time intervals for monitoring. These should be selected by a qualified acoustician based on judgement of the noise environment at each measurement location. As a general guideline, it is common for environmental noise measurements at any given location to be taken at intervals of a minimum of 10-15 minutes, up to around an hour. According to IFC Guidelines, 48 hours should be taken as a guideline for the overall monitoring period in this case.

Regarding density and frequency of measurements, the measurements should be taken at locations on the site boundary that are closest to the nearest receptors. This will vary depending on each site of course.

6.5.2 Operation Phase

Measurements of noise emission levels will be carried out during commissioning of the Refinery at the Project boundary, to confirm noise levels are within the limits set out in this ESIA.

Monitoring of operational noise at off-site receptors is unlikely to be meaningful, due to the relatively small contribution expected to be generated by the Project components compared with other sound sources, such as natural mechanisms and local vehicles, and the anticipated large-scale development expected to be taking place around the SEZ, which would significantly alter the noise environment during construction and operation. Therefore it is recommended that monitoring take place at the Project component boundaries, with levels propagated to designated receptors by extrapolation using appropriate calculation models, such as that employed in this assessment (i.e. CONCAWE or ISO 9613-2).

Following commissioning, further monitoring will be conducted in response to any noise complaints received. In the case of complaints about noise, it is appropriate to conduct measurements at properties relevant to the complaint, with intermediate and site boundary measurements taken to establish probable noise contributions from Project components.

Monitoring of sound levels must employ suitable measurement equipment, i.e. conforming to the class 1 or 2 specifications of IEC 61672-1:2013. Surveys should be planned and executed with reference to the relevant guidance in ISO 1996 Part 1 (ISO, 1982) and Part 2 (ISO, 1987).

6.6 RECOMMENDATIONS

Subject to the limitations of the assessment, including assumptions on noise sources and operation of equipment, the consolidated noise impact assessment has shown that with adequate mitigation, the Project can be constructed and operated within the relevant noise criteria.

For any workers exposed to high noise or vibration levels, i.e. levels exceeding the IFC Guidelines action thresholds shown in Table 6-3 and the vibration TLVs in Appendix 5.2 (entailing provision of PPE), it is recommended that, in order to ensure PPE is used appropriately:

- Mandatory training is provided in the effective use of supplied PPE; and
- Periodic (e.g. annual) hearing tests conducted by qualified medical personnel are offered.

7 VISUAL AND LANDSCAPE ASSESSMENT

7.1 BACKGROUND

7.1.1 Scope of Report

This report is intended to be read in conjunction with the Landscape and Visual Context Report (see Appendix C) which sets out the consolidated baseline for landscape and visual receptors in proximity to the Project. This Appraisal Report continues the process of evaluation to consider the likely effects on the landscape resource and visual amenity from the construction and operational phases of the Project (and in the case of the CIA, also the AFs) and thereafter to assess the likely effects on receptors identified in the baseline study.

The Study Area for both landscape and visual effects has been cut off at a radius of 5km from each of the Project components, in order to focus on potentially significant effects. This reflects the largely flat, undeveloped landscape, lacking substantial vegetation which would interrupt views towards the proposed Refinery Project, which would be of a large scale and therefore readily visible. Atmospheric conditions are generally dry, although occasional sea mists may reduce visibility. It is considered that even though the development may be visible from greater distances, it would not constitute a dominant element in the view, and would therefore be unlikely to cause significant landscape and visual effects.

7.1.2 Sources of Information

This report is based on secondary sources of data and information, as follows:

- Satellite imagery (Google Earth);
- World Mapping Project Oman Map (Reise Know-How Verlag, Bielefield, 2017);
- Site survey photographs by WSP team visiting March 2017; and
- Previous EIA reports for this and related projects (See References).

7.2 APPROACH AND METHODOLOGY

This methodology for the landscape and visual appraisal is generally in accordance with guidance set out in the 'Guidelines for Landscape and Visual Assessment' (GLVIA) published by the Landscape Institute (LI) and the Institute of Environmental Management and Assessment (IEMA), 3rd edition (2013).

Landscape and visual appraisals are separate although linked processes, describing closely related but distinct sets of effects.

Landscape effects are the result of direct physical changes to the landscape caused by the development (e.g. the introduction of new buildings or structures, or the reshaping of the land to accommodate the development) or indirect changes to landscape character and how the landscape is perceived following the development. Landscape appraisal considers both the individual components of the landscape and the structure, coherence and character of the landscape as a whole.

Visual effects are the result of changes in the composition and character of views available in the area affected by the Proposed Development. Visual appraisal considers the response of the people who experience these changes, people who may be living or working in the area, enjoying recreational activities or simply passing through. The assessment considers the overall

consequence on the visual amenity, i.e. the pleasantness of the view or outlook that the people affected may experience.

This assessment is the result of desk-based study of the site conditions, using the secondary sources set out above.

The evaluation and assessment of landscape and visual receptors is based on professional judgement of established criteria set out in the methodology below.

7.2.1 Landscape

The assessment follows the process outlined in the subsections below:

- Define landscape character areas within the study area: geographical areas made up of distinct combinations of elements and aesthetic or perceptual aspects;
- Consider the nature and magnitude of changes to landscape elements and character, with reference to project design, scale, geographical extent and duration of change;
- Judge the sensitivity of the landscape with reference to its capacity to accommodate change arising from the Project;
- Identify potential mitigation to avoid, reduce and where possible remedy adverse effects; and
- Evaluate the significance of landscape effects.

LANDSCAPE SENSITIVITY

The capacity of the landscape to accept development is determined by the degree to which it is able to accommodate change (arising from a specific development or land use change) without significant adverse effects on its character. Sensitivity will vary according to the value of the existing landscape and the extent and nature of the development proposed.

MAGNITUDE OF LANDSCAPE IMPACT

The nature, or magnitude, of impacts (which could be either adverse or beneficial) has been estimated on the basis of professional judgement. In assessing the magnitude of any landscape impact, due regard is given to the scale, type and duration of the change. Impacts are rated on a scale of High, Medium, Low, Very Low and No Change.

SIGNIFICANCE

The evaluation of the significance of the landscape effects of the Project is derived by combining the sensitivity of the landscape with the magnitude of impact (allowing for mitigation) as shown in the matrix below. Significance is described on a scale of Major, Moderate, Minor and Negligible.

Table 7-1: Significance Matrix

		MAGNITUDE				
		No change	**Very Low**	**Low**	**Medium**	**High**
Sensitivity	**High**	Negligible	Minor	Minor or Moderate	Moderate or Major	Major
	Medium	Negligible	Negligible or Minor	Minor	Moderate	Moderate or Major
	Low	Negligible	Negligible or Minor	Negligible or Minor	Minor	Minor or Moderate

Typical descriptors of these significance categories are set out in Table 7-2 below.

Table 7-2: Landscape Effects Significance Descriptors

SIGNIFICANCE CATEGORY	TYPICAL DESCRIPTORS
Major negative	The Project would: • Be at considerable variance with the character (including quality and value) of the landscape; • Degrade or diminish the integrity of a range of characteristic features and elements; and • Damage a sense of place.
Moderate negative	The Project would: • Conflict with the character (including quality and value) of the landscape; • Have an adverse impact on characteristic features and elements; and • Diminish a sense of place.
Minor negative	The Project would: • Not quite fit the character (including quality and value) of the landscape; • Be at variance with characteristic features and elements; and • Detract from a sense of place.
Negligible effect	The Project would: • Maintain the character (including quality and value) of the landscape; • Blend with characteristic features and elements; and • Enable a sense of place to be retained.
Minor positive	The Project would: • Compliment the character (including quality and value) of the landscape; • Maintain or enhance characteristic features and elements; and • Enable some sense of place to be restored or created.
Moderate positive	The Project would: • Improve the character (including quality and value) of the landscape; • Enable the restoration of characteristic features and elements partially lost or diminished as a result of changes from inappropriate management or development; and • Enable a sense of place to be restored or created.

7.2.2 Visual Amenity

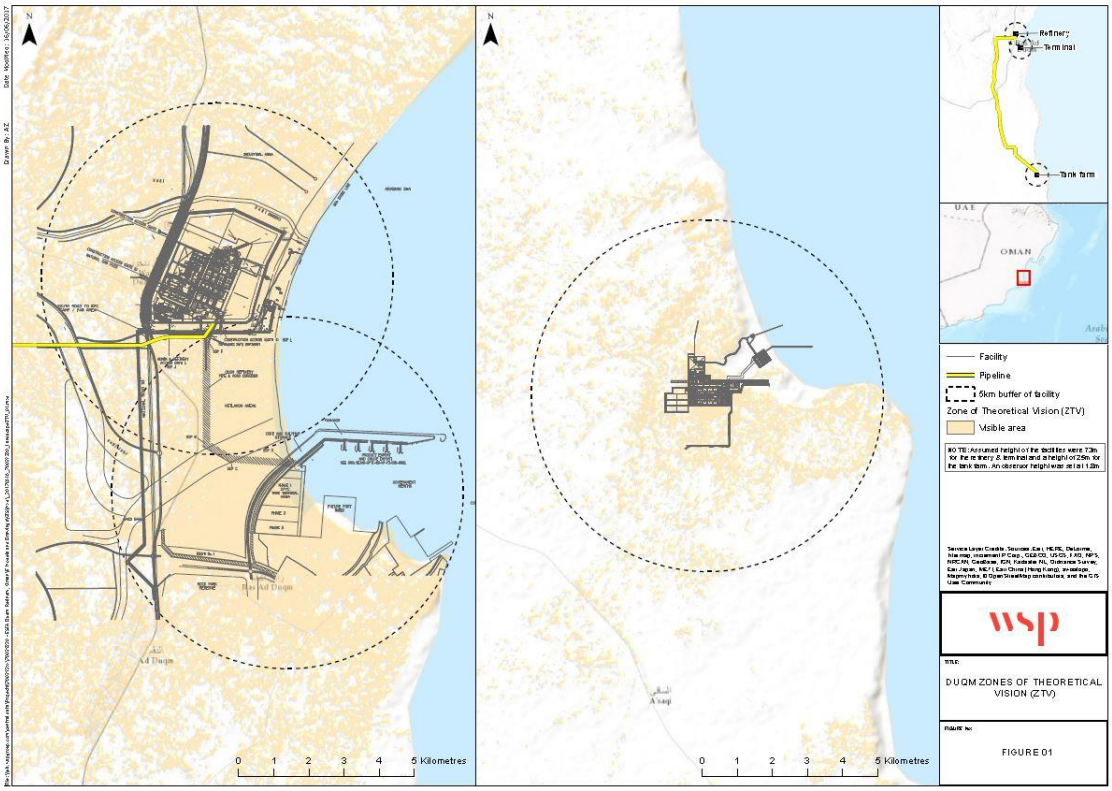
Evaluating visual amenity involves:

- Determining the extent of visibility of the proposed Project;
- Identifying the visual receptors (the people who may see the proposed development or the places they may occupy);
- Making judgements about the receptors' sensitivity to the anticipated change in their surroundings;
- Assessing the magnitude of change – the degree of change likely to be caused by the proposed development; and
- Combining receptor sensitivity and magnitude of change to draw conclusions about the significance of the visual effects (using professional judgement to apply the matrix in Table 7-1).

As part of this process, mitigation to avoid, reduce and where possible remedy adverse effects is identified and, where appropriate, incorporated in the design.

The Zone of Theoretical Visibility (ZTV) – the area from which the Project would be visible is determined by computer modelling (see Figure 7-1).

Figure 7-1: Zone of Theoretical Visibility



VISUAL RECEPTOR SENSITIVITY

Visual receptors: people living, working, travelling through or enjoying recreational activities in the area have differing sensitivities to their visual environment. Generally, this is dependent upon their interest in the visual environment, their viewing opportunity and duration, and the context of the views. These factors may be expressed in terms of:

- The value of the view/viewpoint;
- The importance of the viewpoint; and
- The nature of the viewer.

The sensitivity of visual receptors is categorised on a three point scale: high, medium and low. Residents at home and those engaged in recreational activities which involve appreciation of the landscape are generally considered to be of high sensitivity. Road users are generally considered to be of medium sensitivity and people in their workplace to be of low sensitivity. The sensitivity of the receptor is also influenced by the value of the view and the perceived quality of the scene being viewed.

Visual receptors have been identified based on existing mapping, previous reports on social baseline and new information collated from the Consolidated ESIA work..

MAGNITUDE OF VISUAL IMPACTS

The magnitude of change or visual impact is judged with reference to:

- Project design (contrasting or integrating with existing features);
- Scale (changes in the composition of the view, the proportion of the view occupied by the project);
- Geographical extent (distance from viewer, extent of area from which change would be visible); and
- Duration of change (temporary or permanent).

Table 7-3 describes the typical criteria to be used in ascertaining magnitude.

Table 7-3: Typical Criteria for Judging the Magnitude of Visual Impacts

MAGNITUDE OF IMPACT	TYPICAL CRITERIA DESCRIPTORS
High	The Project, or a part of it, would become the dominant feature or focal point of the view. The Project is of a scale or design which detracts from the appreciation of features in the existing view.
Medium	The Project, or a part of it, would form a noticeable feature or element of the view which is readily apparent to the receptor. The project is of a scale or design which contrasts with the features in the existing view
Low	The Project, or a part of it, would be perceptible but not alter the overall balance of features and elements that comprise the existing view.
Very Low	Only a small part of the Project would be discernible, or it is at such a distance that it would form a barely noticeable feature or element of the view.
No change	No part of the Project, or work or activity associated with it, is discernible.

SIGNIFICANCE

As with landscape, the significance of visual effects is derived by professional judgement from combining the sensitivity of visual receptors with the magnitude of change in the view, as set out in the matrix in Table 7-1 (above).

Table 7-4 below gives typical descriptors for the categories of visual effect significance.

Table 7-4 Describing Significance of Visual Effects

SIGNIFICANCE	TYPICAL DESCRIPTORS
Major Negative	The Project would cause a major deterioration to the view from a highly sensitive receptor.
Moderate negative	The Project would cause obvious deterioration to the view from a receptor of medium sensitivity, or perceptible damage to a view from a more sensitive receptor.
Minor negative	The Project would cause limited deterioration to a view from a receptor of medium sensitivity, or cause greater deterioration to a view from a receptor of low sensitivity.
Negligible	No easily perceptible change in the view.
Minor positive	The Project would cause limited improvement to a view from a receptor of medium sensitivity, or cause greater improvement to a view from a receptor of low sensitivity.
Moderate positive	The Project would cause obvious improvement to a view from a moderately sensitive receptor, or perceptible improvement to a view from a more sensitive receptor.
Major positive	The Project would lead to a major improvement in a view from a highly sensitive receptor.

7.3 LANDSCAPE AND VISUAL APPRAISAL

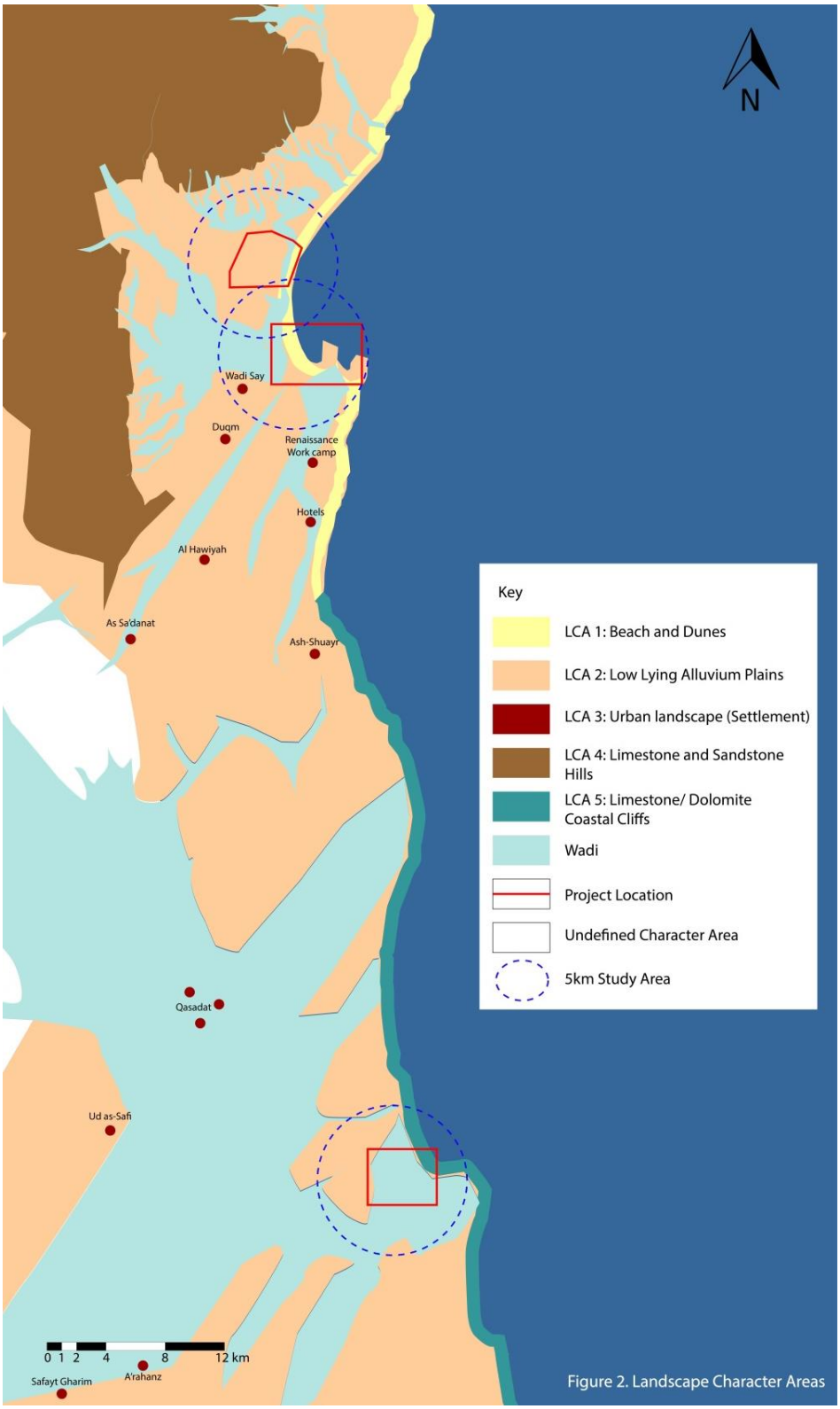
7.3.1 DRPIC Ras Markaz Crude Oil Storage Terminal (Project Facility)

SITE CONTEXT

The Project Facility consisting of eight tanks storing crude oil for supply to Duqm Refinery is set back from the cliff edge by 1.7km. It therefore lies within LCA 2: Low Lying Alluvium Plains (see Figure 7-2). This area is judged to be of high sensitivity to this type of development, given its currently largely undeveloped nature and wild and open qualities.

Visibility of the Project Facility is likely to be largely limited to a 2km radius on the landward side, but potentially partly visible from some maritime areas.

Figure 7-2: Landscape Character Areas



CONSTRUCTION PHASE

The DRPIC portion of the Tank Farm will comprise eight tanks at Ras Markaz. Site preparation and access will be needed to commence and carry out the construction of the tanks and associated infrastructure.

LANDSCAPE EFFECTS

LCA2: LOW LYING ALLUVIUM PLAINS

Changes to the local topography, a distinctive feature of this character area, especially where it includes wadi courses, during the construction of foundations and access roads to the tank farm would have a low magnitude of impact, given the scale of the project and the relatively extensive area of LCA2.

Construction of the Tank Farm in a high sensitivity landscape would therefore be considered to produce a minor significance of effect. In that it would be at variance with characteristic features and elements and detract from a sense of place.

VISUAL AMENITY

The following visual receptors have been identified:

- People that inhabit local individual residences, which are anticipated to be temporary and seasonal only; and
- Fishermen at sea.

There are no settlements apparent in the study area, however there are some indications of individual buildings and there is a fishing landing site (Ras Markaz) 4km north-east of the Project's tanks).

The above receptors can all be considered to be of medium sensitivity to changes in their local environment due to the temporary nature of their view and their primary focus not being related to viewing the landscape. It is apparent that such receptors would be widely scattered and of a transitory nature. Views of the tanks area would be limited beyond approximately 2km.

Construction activities would give rise to a change in visual amenity of medium magnitude, with movement of plant and vehicles forming a noticeable feature in views within the 2km study area It is considered therefore that a small number of receptors would experience intermittent, low visual impacts and overall the construction phase effect on visual amenity would be of temporary minor negative significance.

OPERATIONAL PHASE

Once operational, the eight storage tanks would become part of the overall Crude Oil Storage Terminal with its ancillary facilities (piping, booster stations) and supporting services/infrastructure (e.g. building for visiting staff, access roads, entry gate, security fence).

LANDSCAPE EFFECTS

LCA2: LOW LYING ALLUVIUM PLAINS

The changes to the landscape character described for the construction phase would be largely permanent impacts. Some integration may be achieved through sympathetic landscaping of the Crude Oil Storage Terminal. The tanks area would not be in keeping with the existing landscape character, quality and value of LCA 2. It is considered that magnitude of impacts would continue to be low.

As LCA2 has been judged as of high sensitivity to this type of development, the change (relating to the eight tanks) would be considered to be an effect of minor negative significance.

LCA5: LIMESTONE/DOLOMITE COASTAL CLIFFS

The wider Crude Oil Storage and associated marine/beach-landing facilities are considered in the section on the AF below.

VISUAL AMENITY

Views of the Project Facility (eight tanks) would be limited to within approximately 2km. Activities onshore would consist of occasional checking of the integrity of the tanks. The tanks are likely to be 24m in height and arranged in a grid pattern. Overall, due to the limited activity and relatively small scale of the Project, it would be considered to have a low magnitude of visual impact.

It is considered therefore that a small number of receptors would experience effects on visual amenity of minor negative significance.

7.3.2 Overall Crude Oil Storage Terminal at Ras Markaz (AF)

SITE CONTEXT

As well as the eight crude oil storage tanks for DRPIC, and the future addition of new storage tanks, the beach area below will also be used for the siting of a single point mooring (SPM) and beach-landing facilities. These are all part of the Associated Facility (AF).

The AF will lie within two landscape character areas: LCA2 Low lying Alluvium Plains; and LCA5: Limestone/Dolomite Coastal Cliffs; both are considered to be of high sensitivity to this type of development.

Visibility of the overall AF is likely to be limited to a 2km radius on the landward side, but potentially widely visible from maritime areas.

CONSTRUCTION PHASE

The construction phase of the wider AF is anticipated to last for three years (Amec Foster Wheeler, 2015) with the following activities taking place in this phase:

- Construction of access roads;
- Clearance of brush, excavation of rock and unsuitable soils, filling and compaction of voids with construction fill;
- Dredging;
- Excavation of foundations and construction of the various structures;
- Construction of the service Harbour; and
- Marine works for the Harbour, sub-sea pipeline and pipe end manifold etc

LANDSCAPE EFFECTS

LCA2: LOW LYING ALLUVIUM PLAINS

A distinctive characteristic of this area is the variable topography, particularly where intersected by wadi courses which additionally form elements of increased vegetation and biodiversity. The manipulation of the ground plane involved in providing surfaces for roads and structures and the consequent loss of wadi elements would constitute a change of this characteristic. Further to this the open and exposed nature of the area will be altered by the large-scale infrastructure

proposed. Given the relatively small area of change over this extensive landscape character area however, these changes can be considered to be of a low magnitude.

As LCA2 has been judged as of high sensitivity to this type of development, the effect of constructing the overall Crude Oil Storage Terminal would be considered to be of moderate negative significance.

LCA5: LIMESTONE/DOLOMITE COASTAL CLIFFS

Construction of the harbour and dredging and installation of pipelines will introduce new and incongruent features to a relatively natural landscape, acknowledging the existing interruption of the access road to the beach. These impacts would be considered to be of medium magnitude, given the comparative rarity and vulnerability of the landscape elements.

As LCA5 has been judged as of high sensitivity to this type of development, the effect would be considered to be of moderate negative significance.

VISUAL AMENITY

The following visual receptors have been identified:

- People that inhabit seasonal/temporary residences; and
- Fishermen at sea.

There are no settlements apparent in the study area, however there are some indications of individual buildings and there is a fishing landing site (Ras Markaz) 2.5 km to the north of the marine facilities (and 4 km north-east of the Project tanks).

The above receptors can all be considered to be of medium sensitivity to changes in their local environment. However, it is apparent that such receptors would be widely scattered and of a transitory nature. Construction activities, including the presence of vessels e.g. for dredging and infrastructure placement) would be a change of medium magnitude, forming a noticeable feature in the views within this area.

It is considered therefore that a small number of receptors would experience effects on visual amenity of temporary moderate negative significance.

OPERATIONAL PHASE

The Terminal will include the following facilities during its operational phase:

Marine/Offshore Facilities:

- SPM;
- Pipeline End Manifolds (PLEMs);
- Potential (future) Service Harbour; and
- Subsea Pipelines.

Onshore Facilities:

- Booster Pump Station;
- Metering Packages;
- Onshore piping; and
- Pumps and utilities.

It would also include supporting infrastructure such as access roads and administration buildings.

LANDSCAPE EFFECTS

LCA2: LOW LYING ALLUVIUM PLAINS

Changes to the landscape character described for the construction phase (above) would be largely permanent, applying equally to operations. Proposed landscaping works are of an ornamental and small-scale nature and unlikely to support integration into the wider character area of such a large-scale project in a meaningful way. Overall however, given the relatively small area of this extensive landscape character area affected, the changes are considered to be of low magnitude.

As LCA2 has been judged as of high sensitivity to this type of development, the landscape effect would be considered to be of moderate negative significance.

LCA5: LIMESTONE/DOLOMITE COASTAL CLIFFS

The marine facilities cover a wide area and consist of multiple medium-scale components linked by hidden linear elements (pipelines). It is assumed that disruption to the local landscape would be minimised by this stage and therefore impacts would have reduced.

Although there will be no direct impacts on the cliff face, the changes might potentially affect the hydrodynamics (e.g. sediment movement) potentially altering the morphology of the beach and its characteristic features.

Overall, this would be a change of low magnitude to a highly sensitive landscape, giving rise to a landscape effect of minor negative significance.

VISUAL AMENITY

Views of the Crude Oil Storage Terminal would be limited to within approximately 2km. Activities onshore would be contained within a smaller site footprint than during the construction phase.

Shipping activity (i.e. importing crude oil to the SPM) will eventually be present but offshore. Floodlighting (for safe operational activities and security mast lighting) at night on the marine structures and movements of shipping would form a more active and industrial component of the seascape than current levels of use. However the location of these activities at the base of the cliff would mean they would be largely screened from sensitive receptors inland. Overall, the Project would be considered to have a low magnitude of change.

It is considered therefore that a small number of receptors would experience effects on visual amenity of minor negative significance.

7.3.3 Crude Pipeline (Project Facility)

SITE CONTEXT

The Crude Pipeline right-of-way (ROW) runs between the Ras Markaz Crude Oil Terminal and the Refinery near Duqm. The ROW corridor will include maintenance roads and the trench/windrow of the pipeline itself, covering a distance of 80.7km.

The Crude Import Pipeline Facility would be a linear feature passing through LCA2: Low lying Alluvium Plains.

CONSTRUCTION PHASE

The construction phase is anticipated to last for 18 months (HMR, 2015). The following activities would be included in this phase:

- Clearance of vegetation;
- Grading the route;
- Construction of 5m wide maintenance road;
- Construction of crossings over / under existing features such as wadis, public roads, underground services and proposed features including railways;
- Stockpiling of materials;
- Excavation of trenches;
- Installation of pipe;
- Backfilling trenches and forming windrows; and
- Construction camp and ancillary services (e.g. lighting).

LANDSCAPE EFFECTS

LCA2: LOW LYING ALLUVIUM PLAINS

A distinctive characteristic of this area is the variable topography, particularly where intersected by wadi courses which additionally form elements of increased vegetation and biodiversity. The construction plan takes account of protecting and conserving these wadi elements where possible and proposes a balanced cut and fill approach to earthworks, mitigating these impacts to an extent. Magnitude of impacts would be considered to be low in this case.

As LCA2 has been judged as of low sensitivity to this type of development, the effect would be considered to be of minor negative significance.

VISUAL AMENITY

The following visual receptors have been identified:

- People that inhabit local small scale settlements and individual residences;
- People in transit on the highway; and
- Settlements in the Pipeline study area include As Sadanat and Qasadat.

The residential and nomadic receptors can be considered to be of medium to high sensitivity to changes in their local environment. Those using the highway would have transitory views and this would not be the primary focus of their attention, they would be of low sensitivity. Construction activities would be a change of low magnitude, forming a perceptible feature but not dominating the views within this area.

It is considered therefore that high sensitivity receptors would experience effects on visual amenity of temporary moderate negative significance and low sensitivity receptors would experience effects of temporary minor negative significance.

OPERATIONAL PHASE

LANDSCAPE EFFECTS

The change to landscape character would consist of a linear road and windrow passing through an already partially developed section of the LCA. Additionally a block valve station with a ground-level footprint of approximately 192m x 132m adjacent to buildings to the south of Duqm.

LCA2: LOW LYING ALLUVIUM PLAINS

The Crude Pipeline would be buried and wadi features would be preserved in the operational phase. The magnitude of impact would be considered to be very low.

As LCA2 has been judged as of low sensitivity to this type of development, the effect would be considered to be of negligible significance.

VISUAL AMENITY

It is considered that the Crude Pipeline Project Facility would form a barely noticeable element in the available views. The magnitude of impact would therefore be very low.

It is considered therefore that high sensitivity receptors would experience effects on visual amenity of minor negative significance and low sensitivity receptors would experience negligible effects.

7.3.4 Duqm Refinery (Project Facility)

SITE CONTEXT

The Refinery Site study area is currently subject to increasing development (e.g. Sebacic Acid plant) in an area with a natural coastal character. The near flat topography provides extensive views inland to the mountains and out to sea.

The Refinery Facility Site lies within LCA: 2 Low lying Alluvium Plains and immediately adjacent to LCA1: Beach and Dunes.

CONSTRUCTION PHASE

The construction phase is anticipated to last for 36 months (HMR, 2015). The following activities would be included in this phase:

- Site preparation including vegetation clearance;
- Site levelling;
- Soil excavation;
- Pouring foundations;
- Construction of steel structures;
- Assembling and installation of plant equipment;
- Pipeline installation within service corridor to marine facilities; and
- Construction camps and associated lighting.

LANDSCAPE EFFECTS

LCA2: LOW LYING ALLUVIUM PLAINS

A distinctive characteristic of this area is the variable topography, particularly where intersected by wadi courses which additionally form elements of increased vegetation and biodiversity. Site preparation has already occurred and the wadis were re-directed around the industrial area, i.e., Wadi Dangert to the north and Wadi Jurf and Saay to the south, both following natural drainage patterns.

The majority of the Project has been set back from the coast by 1.5 km and avoids the ecologically sensitive sabkha, thereby mitigating direct impacts on the coastal landscape. The Project Facility would be incongruous, constituting a large scale industrial use within this low lying and exposed character area, even considering the increasingly industrial character of the context.

This would be a change of medium magnitude to a landscape of medium sensitivity to this type of development, giving rise to a landscape effect of moderate negative significance.

VISUAL AMENITY

ZTV analysis indicates that views of the Project Facility will be widely available from the surrounding area with few intervening features.

The following visual receptors have been identified:

- People that inhabit local settlements and individual residences;
- People in transit on the highway;
- Duqm Port and Dry Dock staff; and
- Fishermen at sea.

Settlements in the Refinery Study Area include Wadi Saay/Duqm town.

The residential receptors can be considered to be of medium to high sensitivity to changes in their local environment. Those using the highway, dock workers and fishermen at sea would have transitory views and this would not be the primary focus of their attention, they would be of low sensitivity.

Construction activities, including use of tall plant and the static construction camps, would be a change of medium magnitude, forming a noticeable feature of the views within this area. It is considered therefore that the residential and nomadic receptors would experience effects on visual amenity of temporary moderate negative significance and those using the highway and at sea would experience visual effects of temporary minor negative significance.

OPERATIONAL PHASE

LANDSCAPE EFFECTS

The landscape would alter to an industrial character in this area and the connection to the coast would be interrupted by built form.

LCA2: LOW LYING ALLUVIUM PLAINS

The changes outlined above in the construction phase would be largely permanent. The footprint of the development is small in proportion to the overall extent of the character area, but this change in character can also be considered to affect the setting of the adjacent LCA 1: Beach and Dunes. The magnitude of impact would be considered to remain as medium.

As LCA2 has been judged as of medium sensitivity to this type of development, this would be considered a landscape effect of moderate negative significance.

VISUAL AMENITY

It is considered that the Project Facility would continue to form a noticeable feature of views within the study area, even following the cessation of construction activities. It would include multiple tall stacks and reflective elements that would catch the eye and there are no proposed measures for screening the industrial features. During commissioning and start-up there will be flaring activities. Lighting of working areas and boundaries has been designed to provide minimum lightspill into the surrounding environment. The magnitude of impact would therefore continue to be medium.

It is considered therefore that a limited group of residential and nomadic receptors would experience effects on visual amenity of moderate negative significance whilst those using the highway and at sea would experience visual effects of minor negative significance.

7.3.5 Duqm Export Terminal – Topsides (Project Facility)

SITE CONTEXT

The Site area is currently largely undeveloped, with the exception of an existing breakwater, adjacent to the large-scale development at Duqm Port, 3km to the south east. It has a natural coastal character, including the area of sabkha where the Wadi Saay meets the sea. There is little interruption to views out to sea, which includes views of small-scale fishing activity as well as distant shipping movements associated with the Port. The birdlife is rich in this location and the colonies of sea birds on the beach/in the air feature in most views.

The Export Terminal Project Facility Site lies within LCA1: Beach and Dunes and extends out to sea by approximately 4.5km, approaching the existing Commercial Quay. Supporting infrastructure such as pipelines and the existing main road (AF) to the Export Terminal would fall within LCA2: Low lying Alluvium Plains.

CONSTRUCTION PHASE

The construction phase for the topside development of this Project Facility will take place in the final part of the overall three year schedule (Worley Parsons, 2015) and include the following activities once the marine works (AF – see section below) are completed:

- Construction of internal roads and structures;
- Construction of steel superstructure; and
- Construction of tanks.

LANDSCAPE EFFECTS

LCA1: BEACH AND DUNES

The coastal zone includes beach and back beach, khawrs and intertidal mudflats. Marine activities at the existing Port already influence the area at this location. The construction of the topside features of the Export Terminal will be a continuation of the marine works (AF) and any remaining natural character of the immediate Project Site would be lost. The siting of the Project facility concentrates the impacts in an already disturbed area which avoids impacts on parts of this character area further along the coast. The magnitude of change would be considered to be medium.

As LCA 1 has been judged of medium sensitivity to this type of development, this would be a landscape effect of moderate negative significance.

LCA2: LOW LYING ALLUVIUM PLAINS

VISUAL AMENITY

ZTV analysis indicates that views of the Project Facility (e.g. superstructure/storage tanks, above ground), will be widely available from the surrounding area with few intervening features.

The following visual receptors have been identified:

- People that inhabit local settlements and individual residences;
- People in transit on the highway;
- Duqm Port and Dry Dock staff; and
- Fishermen at sea.

Settlements in the Export Terminal Project Facility study area include Wadi Saay/Duqm Town. The Renaissance Work Camp is within 8km.

The residential and (occasional) nomadic receptors can be considered to be of high sensitivity to changes in their local environment. Those using the highway would have transitory views although this would not be the primary focus of their attention and would be of low sensitivity. Fishermen at sea and port workers would experience immediate views but are in their working environment and therefore would also be considered of low sensitivity.

Construction activities, including use of tall plant and an extended period of dredging (2.5 years), would have a medium magnitude of impact, forming a noticeable feature of the views within this area. It is considered therefore that the high sensitivity receptors would experience effects on visual amenity of temporary moderate negative significance and low sensitivity receptors would experience effects of minor negative significance.

OPERATIONAL PHASE

LANDSCAPE EFFECTS

The landscape would undergo further industrialisation of its character in this area.

LCA1: BEACH AND DUNES

The introduction of the Export Terminal Project Facility structures will alter the coastal, semi natural landscape character and the arrangement of distinctive landscape elements. The magnitude of impacts would still be considered to be medium.

As LCA1 has been judged to be of medium sensitivity to this type of development, the landscape effect would remain as of moderate negative significance.

VISUAL AMENITY

It is considered that the topside features of this Project Facility would continue to form a noticeable feature of views from within the study area, particularly within the seascape. Movements of vehicles and floodlighting (for safe operations and security) would be visible and intrusive, potentially over a 24-hour period. The magnitude of impacts would therefore continue to be medium.

It is considered therefore that high sensitivity receptors (assuming the construction camp had been dispersed) would experience effects on visual amenity of moderate negative significance and low sensitivity receptors would experience effects of minor negative significance.

7.3.6 Overall Duqm Export Terminal (including Marine Activities) (AF)

SITE CONTEXT

As stated in Section 4.5.1 above, the overall Export Terminal (the marine elements and overall construction of which is an AF) lies within LCA1: Beach and Dunes while associated pipelines and the main access road to Terminal falls within LCA2: Low lying Alluvium Plains.

CONSTRUCTION PHASE

The three year construction phase (Worley Parsons, 2015) will commence with activities such as:

- Dredging of the marine berths basin;
- Land reclamation;

- Ground improvement;
- Construction of access road;
- Construction of berths;
- Establishing fencing and gates;
- Piling for tank and building foundations; and
- Construction camp to accommodate up to 5,000 personnel and temporary laydown areas.

LANDSCAPE EFFECTS

LCA1: BEACH AND DUNES

The elements (e.g. beach, khawrs) in the coastal zone of the Export Terminal will be disturbed by marine civil works (e.g. dredging and land reclamation) in the construction phase. While some maritime activities associated with the Port of Duqm already influence the area the construction of the Export Terminal will increase activity and any remaining natural characteristics of this landscape type would be lost. The magnitude of impacts would be considered to be medium.

As LCA 1 has been judged of medium sensitivity to this type of development, the landscape effects would be considered to be of moderate negative significance.

LCA2: LOW LYING ALLUVIUM PLAINS

Enhancement of the main road to the Export Terminal and Crude Pipeline corridor will be an activity progressed by SEZAD in support of the development of Duqm. The magnitude of impact on this character area is considered to be low.

As LCA2 has been judged as of medium sensitivity to this type of development, the effect of these supporting works would be considered to be of minor negative significance.

VISUAL AMENITY

ZTV analysis indicates that views of the overall Export Terminal will be widely available from the surrounding area with few intervening features. The following visual receptors have been identified:

- People that inhabit local settlements, many of which are temporary, and individual residences;
- People in transit on the highway;
- Duqm Port and Dry Dock staff; and
- Fishermen at sea.

The residential and visiting receptors can be considered to be of high sensitivity to changes in their local environment while those using the highway would have transitory views (low sensitivity). Fishermen at sea and port workers would experience immediate views although they can be considered to be of low sensitivity. Construction activities, including use of tall plant and an extended period of dredging (2.5 years), would have a medium magnitude of impact, forming a noticeable feature of the views within this area.

It is considered therefore that high sensitivity receptors would experience effects on visual amenity of temporary moderate negative significance and low sensitivity receptors would experience effects of temporary minor negative significance.

OPERATIONAL PHASE

LANDSCAPE EFFECTS

With the landscape undergoing industrialisation of its character from this development the changeable character of this site where land transitions to sea over an extended area is likely to be lost.

LCA1: BEACH AND DUNES

The introduction of an Export Terminal Facility, including areas of berths and reclaimed land in the marine area will alter the coastal, semi-natural landscape character and the arrangement of distinctive landscape elements, some of which will be lost. The magnitude of impacts would still be considered to be medium.

As LCA1 has been judged to be of medium sensitivity to this type of development, the landscape effect would remain as of moderate negative significance.

LCA2: LOW LYING ALLUVIUM PLAINS

During the operational period it is considered that magnitude of impacts from supporting roads and pipelines in this area would be very low. As LCA2 has been judged as of medium sensitivity to this type of development, the effect would be considered to be of negligible significance.

VISUAL AMENITY

It is considered that the Project Facility would continue to form a noticeable feature of views within the study area, particularly within the seascape. Floodlighting in addition to the Export Terminal structures would be visible and intrusive round the clock and the magnitude of impacts deemed to be medium.

As is the case with the topside Project Facility, it is considered that high sensitivity receptors (assuming a decommissioned construction camp) would experience effects on visual amenity of moderate negative significance and low sensitivity receptors would experience effects of minor negative significance.

7.3.7 Summary

SIGNIFICANT EFFECTS

For the purpose of this appraisal, anticipated changes resulting in a ‘major’ negative effects would, in principle, be considered to be significant and require addressing through appropriate mitigation. However, there are no permanent major negative effects identified in this case. Effects with ‘moderate’ negative significance should also be considered for mitigation where possible and opportunities to investigate these are suggested in Table 7-5 below.

The following Table summarises significant landscape and visual effects identified in this appraisal and suggested mitigation measures. It is recognized that many of these issues would fall within the remit and responsibility of the Crude Oil Storage Terminal Facility owner and operator OTTCO and that discrete measures for the eight tanks part of the Duqm Refinery project would need to be first shared, and discussed with the third party.

Table 7-5 Summary of Significant Effects

PROJECT FACILITIES AND AFS	RECEPTOR	SIGNIFICANCE		SUGGESTED MITIGATION
		CONSTRUCTION (TEMPORARY)	OPERATIONAL	
8 Tanks for DRPIC at Ras Markaz Crude Oil Storage Terminal (Project Facility)	Landscape: LCA2 : Low lying Alluvium Plains	Minor negative	Minor negative	Reduce construction area physical footprint to minimum required. Locate taller structures and store large plant/equipment to the furthermost point west away from cliff edge. Break up massing of buildings and structures, where flexibility in design allows. Selection of colours and colouring for tank walls. Minimise lighting levels and duration of use. Minimise the use of reflective materials. Include landscaping appropriate to climatic conditions.
	LCA5: Limestone/Dolomite Coastal Cliffs	None	See overall Crude Oil Storage (below)	
	Visual intrusion:	Minor negative	Minor negative	
Overall Ras Markaz Crude Oil Storage Terminal (AF)	Landscape: LCA2 : Low lying Alluvium Plains	Moderate negative	Moderate negative	Sensitive colours and colouring used in all third party tank and facilities. Encourage OTTCO to minimise lighting levels (e.g. downward-pointing) and duration of use (in line with 'need'). Minimise the use of reflective materials. Include landscaping appropriate to climatic conditions.
	LCA5: Limestone/Dolomite Coastal Cliffs	Moderate negative	Minor negative	
	Visual intrusion:	Moderate negative	Minor negative	
Crude Pipeline (Project Facility)	Landscape: LCA2: Low lying Alluvium Plains	Minor negative	Negligible	

PROJECT FACILITIES AND AFS	RECEPTOR	SIGNIFICANCE		SUGGESTED MITIGATION
	Visual intrusion:	Moderate negative (high sensitivity receptors) Minor negative (low sensitivity receptors)	Minor negative (high sensitivity receptors) Negligible (low sensitivity receptors)	
Duqm Refinery (Project Facility)	Landscape: LCA2: Low lying Alluvium Plains	Moderate negative	Moderate negative	Minimising the massing of buildings and structures would help ameliorate the effect, where post-FEED design allows. Selection of sensitive colours and colour schemes for cladding, paint and structures etc. above ground. Minimise lighting levels and coverage and duration of use. Minimise reflective materials Include landscaping appropriate to climatic conditions.
	Visual intrusion:	Moderate negative (high sensitivity receptor) Minor negative (low sensitivity receptors)	Moderate negative (high sensitivity receptors) Minor negative (low sensitivity receptors)	
Topside, Duqm Export Terminal (Project Facility)	Landscape: LCA 1: Beach and Dunes	Moderate negative	Moderate negative	Selection of sensitive colours and colour schemes for cladding, paint and structures etc. above ground. Minimise lighting levels and duration of use. Minimise the use of reflective materials
	Visual intrusion	Moderate negative (high sensitivity receptor) Minor negative (low)	Moderate negative (high sensitivity receptor) Minor negative (low)	
Overall Duqm Export Terminal, incl. marine works (AF)	Landscape: LCA 1: Beach and Dunes	Moderate negative	Moderate negative	Minimise lighting levels and duration of use. Minimise the use of reflective materials
	LCA2: Low lying Alluvium Plains	Minor negative	Negligible	

PROJECT FACILITIES AND AFS	RECEPTOR	SIGNIFICANCE		SUGGESTED MITIGATION
	Visual intrusion	Moderate negative (high sensitivity receptor) Minor negative (low)	Moderate negative (high sensitivity receptor) Minor negative (low)	

The construction activities for the Ras Markaz Crude Storage Terminal has been found to have likely major negative significant effects on LCA5: Limestone/Dolomite Coastal Cliffs due to potential changes in the morphology of the shore and the alteration of a natural landscape to an industrial character. This effect is considered to reduce to minor significance during the operational phase once dredging and earthworks activities are completed.

SUGGESTED MITIGATION MEASURES

As suggested in the Table above, a number of measures can be considered for discussion with EPC Contractors on Project Facilities, where there is flexibility in design post-FEED and with the owners of third party AFs such as OTTCO in order to collaboratively reduce the negative effects identified:

- Encourage the areas used for construction (including laydown and support areas) to be the minimum physical footprint in order to avoid unnecessary disturbance of existing landform and vegetation;
- Minimise lighting levels, duration of use, eliminating unnecessary lighting and over specification of light use, to reduce nightglow and extent of visibility of development;
- Minimise the use of reflective materials in construction (without compromising worker safety standards) and safe operations while encouraging the use of local stone and aggregate and muted colour schemes to avoid glare and help maximising the best possible integration into the local environmental context;
- Any landscaping as appropriate to climatic conditions, including native and xerophytic species; and
- Given the proposed heights and scale of the Project Facilities, screening options are not considered feasible, although there may be potential to use this approach in the vicinity of visual receptors as local screening outside the Project Site Boundary.

Any successful implementation of the above would benefit the landscape situation in the Project area. These suggested mitigation measures are also taken forward for inclusion in the Cumulative Impact Management Plan which forms part of the Project ESMP.

8 BIODIVERSITY ASSESSMENT

8.1 INTRODUCTION

This Section provides a summary of a detailed biodiversity assessment undertaken to inform the Project – from hereafter this is referred to as the Project Biodiversity Assessment.

The aim of the Project Biodiversity Assessment is to consolidate, into a single assessment, ecological baseline information, impact assessment conclusions and mitigation proposals which are set-out in a series of EIAs which have been undertaken to inform different elements the Project in the past. These are:

- Duqm Industrial Zone (IDZ) EIA (5OES, 2011);
- Duqm Refinery EIA: Appendix A Environmental Baseline Survey (HMR, 2015);
- Duqm Refinery Construction Camp EIA (HMR, 2015);
- Ras Markaz Crude Oil Park ESIA (HMR, 2015);
- Duqm Seawater for Industrial Zone Project (HMR, 2015);
- Services Corridor EIA (HMR, 2015);
- Duqm Liquid Bulk Berths EIA (Worley Parsons, 2015);
- Ras Markaz Oil Pipeline EIA (Worley Parsons, 2016); and
- Appendix E to Integrated Power and Water Plant ESIA (Beya, 2016).

This series of EIA studies is referred to collectively hereafter as 'the historical EIAs'.

The Project Biodiversity Assessment also aims to address gaps in the ecological baseline presented in the Historic EIAs and to specify additional mitigation to address ecological impacts which are not fully captured by impact assessment work undertaken to date.

This Project Biodiversity Assessment is accompanied by six technical appendices:

- Appendix A Terrestrial ecology survey record – This is provided as evidence of the ecological survey work that was conducted in late April and early May 2017 to:
  - i. Ground truth the habitats within the Project footprint (including the Refinery and Offsite Facilities, with particular emphasis on the DRPIC Crude Oil Pipeline RoW); and
  - ii. To facilitate the harmonisation of habitat mapping (from the various source data sets provided in preceding EIAs) across all Project activities and AFs;
- Appendix B Harmonized habitat mapping – this comprises a habitat map covering all Project activities and AFs and a series of six higher resolution maps providing greater detail across the area of interest. An assessment of natural habitat (as defined by International Financial Corporation Peformance Standard 6; IFC PS6) and disturbed land in the project footprint has also been prepared to assist in the impact assessment;
- Appendix C Critical Habitats' Assessment (CHA) – an assessment of the occurrence of critical habitat (as defined by IFC PS6) covering marine and terrestrial domains. The CHA is a foundational study on which the impact assessment has been based and the no net loss strategy is designed around;
- Appendix D Invasive Alien Species (IAS) Assessment – a high level assessment of the potential pathways that IAS may be introduced to the area by Project activities;

- Appendix E Biodiversity Offset Framework – Biodiversity Offsetting Framework to outlined a series of steps necessary to address the requirement to achieve no net loss/net gain of biodiversity set out in IFC PS6; and

- Appendix F Ecosystem Services Assessment – relating to IFC PS6 requirements, an assessment of potential impacts on ecosystem services associated with the Project.

A Biodiversity Management Plan has also been prepared containing all construction phase ecological mitigation requirements set forth in the assessment.

The following study areas are used in the Project Biodiversity Assessment:

- The Project footprint is defined as the physical area required to construct the Duqm Refinery and the Off-site Facilities;
- Associated Facility footprint; and
- The outer extent of the area considered potential susceptible to direct and indirect effects arising from the Project is referred to as the Area of Influence (AoI). A separate AoI for direct and indirect effects is defined in the Project Biodiversity Assessment. The indirect AoI differs for terrestrial and marine environments.

8.2 RELEVANT BIODIVERSITY STANDARDS

The Project Biodiversity Assessment draws on the applicable standards, guidelines, legislation and international conventions that are relevant to biodiversity management in Oman, in particular:

- Omani legislation relating to environmental management, for which the authority is SEZAD, whose authority is mandated onshore, and the Ministry of Environment and Climate Affairs (MECA), whose authority is mandated outside the SEZAD area, i.e., offshore beyond the SEZAD concession zone and in areas surrounding the SEZAD area onshore. The Duqm Refinery Project itself lies fully within the SEZAD zone;

- The International Finance Corporation (IFC) Performance Standard No. 6 on ‘Biodiversity Conservation and Sustainable Management of Living Natural Resources’, part of the IFC Sustainability Framework 2012 (IFC, 2012) and its related guidance notes;

- Other relevant international standards such as the IUCN Red Data species, Birdlife International (for Important Bird Area (IBA) definitions and descriptions), World Conservation Monitoring Centre (WCMC) for definitions and descriptions of protected areas;

- Standards adopted by the Overseas Private Investment Corporation, described in its Consolidated Environmental and Social Policy Statement (October 2010); and

- The World Bank (2000) Biodiversity and environmental assessment toolkit.

8.3 BIODIVERSITY AND ECOSYSTEM SERVICES ASSESSMENT

8.3.1 Biodiversity Baseline Summary – Important Ecological Features

The Project Biodiversity Assessment values each of the ecological resources in Project Footprint and indirect AoI of the Project using the system presented in Table 8-1.

Table 8-1: Ecological Feature Value Categories

Value	Criteria	Examples
Very High	High importance and rarity, international scale and limited potential for substitution	Internationally designated sites, such as Ramsar Sites or Important Bird Areas (IBAs).
High	High importance and rarity, international, national or regional scale with limited potential for substitution	National Parks/Wildlife Reserves. Critical Habitat[7] and Critically Endangered Species[8]. Natural Habitat[9] with no potential for substitution.
Medium	High or medium importance and rarity, local or regional scale, and limited potential for substitution	Natural Habitat with potential for substitution. Species with locally restricted distribution.
Low	Low or medium importance and rarity, local scale	Non-designated sites/areas of some local biodiversity
Negligible	Very low importance and rarity, local scale	Other sites with little or no local biodiversity. Modified habitats.

Only ecological features which are important and potentially affected by the proposed developments have been selected for detailed assessment – these are referred to from hereafter as Important Ecological Features (IEFs). Ecological features that are sufficiently widespread, unthreatened and resilient to development impacts have been excluded from assessment.

Table 8-2 lists all the applicable IEFs within each of the proposed development sites' AoI and their potential conservation value.

[7] As defined by Performance Standard 6 (IPC, 2012). This includes areas that meet one or more of the following criteria:
1. Criterion 1: Critically Endangered (CR) and/or Endangered (EN) species;
2. Criterion 2: Endemic and/or restricted-range species;
3. Criterion 3: Migratory and/or congregatory species;
4. Criterion 4: Highly threatened and/or unique ecosystems; and
5. Criterion 5: Key evolutionary processes.

[8] As listed on the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species in the Arabian Peninsula.

[9] As defined by IFC PS6: "*Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition."* (p. 3)

Table 8-2: Important Ecological Features (IEFs)

IMPORTANT ECOLOGICAL FEATURE (IEF)	VALUE	JUSTIFICATION
Designated Sites		
Duqm Important Bird Area (IBA)	Very High	IBA classified by Birdlife International that supports regionally important populations of seabirds, and contains the most important sections of intertidal habitat.
Jidat Al Harrasis IBA	Very High	IBA classified by Birdlife Internation that supports nationally important populations of regionally endemic birds.
Terrestrial - Natural Habitats		
Intertidal mudflats, sand and lagoon areas	High	Essential habitat for internationally important aggregations of migratory seabirds, nesting habitat for critically endangered Green and Loggerhead Turtles.
Mountain areas	Medium	Essential habitat for species with limited distributions including ibex (nationally endangered), gazelle (regionally endemic), and
Wadis	Medium	Essential habitat and migratory corridor for species with limited distributions including ibex (nationally endangered), gazelle (regionally endemic),
Endangered, endemic plant species (*Salsola omanensis*, *Ochradenus harsusiticus)*	High	Endangered species with limited distribution, Tier 2 (see Project Biodiversity Assessment - Technical Appendix C - CHA for further details)
Endangered carnivores (striped hyena, Arabian wolf, Ruppell's Sand Fox)	High	Nationally critically endangered (striped hyena), nationally endangered (wolf and Ruppell's Sand Fox) that require critical habitat assessment (pending)
Ibex and Gazelle	Medium	Nationally endangered (ibex) and regionally endemic species that require critical habitat assessment (pending)
Marine – Natural Habitats		
Shallow coastal habitats (0-20m)	Medium	Essential habitat for other whales and dolphins as well as Tier 1 & 2 species (see above)
Deep water habitats (20-200m)	Medium	Essential habitat for other whales and dolphins as well as Tier 1 & 2 species (see above)
Oceanic habitats (>200m)	Medium	Essential habitat for other whales and dolphins as well as Tier 1 & 2 species (see above)
Marine – Species		
Arabian Sea Humpback Whale	Very High	Regionally endangered species with limited distribution, Tier 1 species (see Project Biodiversity Assessment - Technical Appendix C - CHA for further details).
Indian Ocean Humpback Dolphin	High	Regionally endangered species, Tier 2 species (see Project Biodiversity Assessment - Technical Appendix C - CHA for further details)
Turtles (Green, Loggerhead and Hawksbill).	High	Critically endangered species, Tier 2 species, with the Loggerhead Turtle potentially a Tier 1 species ((see Project Biodiversity Assessment - Technical Appendix C - CHA for further details).
Other whales and dolphins	Medium	Species include Sperm Whale (IUCN Vulnerable), Blue Whale (IUCN endangered) that may trigger the need for CHA.

8.4 IMPACTS AND MITIGATION

Table 8-3 presented a summary of construction phase ecological impacts on IEFs prescribed mitigation measures to addres these impacts.

Table 8-4 presents a summary of operation phase ecological impacts on IEFs and prescribed mitigation measures to address these impacts.

Mitigation proposals have been designed to address significant impacts on IEFs. They are are divided into two categories:

- Project related measures – mitigation measures addressing Project specific impacts that DRPIC has direct responsibility to deliver; and
- Strategic measures – mitigation measures addressing impacts which are indirectly connected to Project construction or operation e.g. through AFs or supply chain.

In the first category, DRPIC will seek to mitigation for these issues through implementation of the Project ESMP. In the second category, DRPIC will seek to address these issues through consultation and advocacy with SEZAD and Government agencies; by carrying out environmental assurance and audit of its supply chain; through funding research initiatives; and by working collaboratively within industry environmental partnerships. To address many of the issues falling under the strategic measures mitigation category a Strategic Initiative Approach – details of which are fully outlined in Technical Appendix 7.3 on Critical Habitats' Asssessment.

Table 8-3: Construction Phase Ecological Impact Summary and Mitigation Measures

IEF (VALUE)	IMPACT SUMMARY	MITIGATION	RESIDUAL IMPACT
TERRESTRIAL			
Project			
Duqm IBA (Very High)	No construction effects anticipated – significant impact associated with Export Terminal construction which is an AF.	None required.	None.
Jidat al Harrasis IBA (Very High)	Slight negative adverse impact resulting from minor habitat loss.	i) Habitat enhancements (e.g. provision of artificial water holes for species such as sand grouse); ii) Visitor facilities; iii) Awareness materials for visitors and schools. Mitigation measures should be planned in consultation with other stakeholders such as SEZAD and other developers with footprints within the IBA boundary.	Slight adverse, medium term.
Duqm SEZ Nature Reserve (High)	Slight adverse impact resulting from minor habitat loss and construction dust.	i) Minimise footprint and strictly control certain dust generating activities (e.g. tracking of vehicles) close to the reserve. ii) Habitat enhancements (e.g. protection of area from livestock to allow vegetation to recover).	Slight adverse, medium term.
Al Wusta Wildlife Reserve (Very High)	No construction effects anticipated – distant from Project Footprint.	None required.	None.
Wadis in close association with mountains & Wadis in open terrain (High)	Large adverse impact resulting from habitat loss during Crude Pipeline (Project) and Construction Camp (AF) construction.	i) Minimise footprint a wadi crossings. ii) Reinstate wadi crossings to ensure natural passage of seasonal flood flows. iii) Compensatory landscape planting using native/endemic tree species.	Slight adverse, medium term.
Rocky mountain & escarpment (High)	Slight adverse impact resulting from minor habitat loss.	None required.	None.
Shallow coastal habitats 0-20 m - (Medium)	No construction effects anticipated – impact associated with Export Terminal construction which is an AF.	None required.	None.
Endangered, endemic plant species (Salsola, Ochradenus) (High)	Large adverse impact owing to species rarity and potential habitat loss.	i) Preconstruction survey of instances where critical habitat intersects the Project Footprint (see Technical Appendix C: CHA for an inventory). ii) Translocate affected populations of endemic plant species for propagation and eventual use in introduction schemes in the SEZAD area.	Slight adverse, medium term.

IEF (VALUE)	IMPACT SUMMARY	MITIGATION	RESIDUAL IMPACT
		iii) Contribution toward native plant propagation and introduction scheme.	
Green, Loggerhead and Hawksbill Turtles (High)	Slight adverse resulting from construction lighting and disturbance from personnel and vehicles.	i) Strictly observe 0.3 km set back area between Refinery and beach. ii) Light monitoring of the beach opposite to Project Footprint to ensure minimal light spill/unilluminated pre-construction baseline conditons persist. iii) Use lighting design and screening to protect beaches from light spill.	Negligible, short term.
Natural Habitat (Low to High) IFC PS6 requires the offset target of no net loss to be met for all natural habitats – even those that are not IEFs in this assessment.	See entries for habitats which are considered IEFs in this table. Other habitats are stated in the baseline but are not brought forward to the impact assessment or mitigation section because they are suitably commonplace and widespread not be considered susceptible to significant impacts from the Project.	Measures to address IFC PS6 no net loss requirement are presented in Technical Appendix E: Biodiversity Offsetting Framework. DRPIC should consider the recommendations in Technical Appendix E including developed of metric to assess permanent damage/loss of natural habitat.	No net loss of natural habitat to be assessed via application of a biodiversity metric – see Technical Appendix E: Biodiversity Offsetting Framwork.
Critical Habitat (Endemic plant species) IFC PS6 requires the offset target of net gain to be met for all species triggering critical habitat.	See entry for Endangered, endemic plant species (Salsola, Ochradenus) See assessment of species triggering critical habitat in Technical Appendix C: CHA..	See mitigation recommendations for Endangered, endemic plant species (Salsola, Ochradenus) in this table. DRPIC should consider the recommendations in Technical Appendix E including development of metric to work toward net gain for terrestrial critical habitat species.	Net gain of critical habitat to be assessed via application of a biodiversity metric – see Technical Appendix E: Biodiversity Offsetting Framwork.
Strategic			
Duqm IBA (Very High)	Major adverse – arising from habitat loss and disturbance from Export Terminal construction which is an AF.	Measures to be secured via Strategic Initiative Approach. i) Enhancement of the remaining area of the IBA (construction of channels, clean-up of litter, provision of visitor facilities); ii) Onsite creation of constructed wetland using dredging spoil; iii) Offsite creation of constructed wetland	None.
Wadis in close association with mountains & Wadis in open terrain (High)	Large adverse impact resulting from habitat loss during Crude Pipeline (Project) and Construction Camp (AF)	As per Project mitigation.	Slight adverse, medium term.

IEF (VALUE)	IMPACT SUMMARY	MITIGATION	RESIDUAL IMPACT
	construction.		
ASHW (Very High)	Large adverse – ship strikes, underwater noise and changes in prey distribution and abundance arising from disturbance and dispersion of sediments during dredging.	Mitigation bridges the operational and construction phases - see measures in operational phase mitigation Table 5.2.	Assuming full implementation – Negligible, long term.
Indian Ocean humpback dolphin (High)	Minor adverse – as per ASHW but species less likely to be present in disturbed areas.	As per ASHW.	As per ASHW.

Table 8-4: Operational Phase Ecological Impact Summary and Mitigation Measures

IEF (VALUE)	IMPACT SUMMARY	MITIGATION	RESIDUAL IMPACT
TERRESTRIAL			
Project			
Duqm IBA (Very High)	Large adverse – disturbance of birds arising from sporadic disturbance arising from vehicles, personnel and maintenance operations.	DRPIC implement a mandatory code of conduct applying to all topside operations in the Export Terminal. This should include suitable controls to limit bird disturbance such as: i) Ensuring Export Terminal fencing prevents visual disturbance to birds using the IBA. ii) Using 'soft start' protocols for maintenance operations involving loud, percussive noise and vibration impacts. iii) Provision of designated staff recreation areas which birds are able to habituate to the presence of people in – evidence shows that birds are able to habituate to predictable/regular movements of people and vehiles but less so to sporadic and unpredicatable events which caused disturbace of bird feeding and roosting. iv) Include bird conservation issues in the site induction delivered to all staff.	Slight adverse, short term.
Mountain areas and escarpment (High)	Large adverse – changes in air quality resulting from air emissions from the Refinery leading to polluted precipitation affecting plant and lichen communities.	Ambient air monitoring and wet/dry deposition monitoring close to senstive habitat features (lichen and plant communities) to ascertain potential negative effects. . Mitigation at source and compliance with air emissions standards. Monitoring of ambient air quality.	Not possible to conclude until dispersion modelling complete and mitigation approach defined. See CIA.
Wide ranging species such as large	Minor adverse - urbanising effects.	See Strategic Mitigation.	See Strategic

IEF (VALUE)	IMPACT SUMMARY	MITIGATION	RESIDUAL IMPACT
carnivores, gazelle and ibex			Mitigation.
Green, Loggerhead and Hawksbill Turtles (High)	Slight adverse resulting from operational lighting and disturbance from personnel and vehicles.	i) Strictly observe 0.3 km set back area between Refinery and beach. ii) Light monitoring of the beach opposite to Project Footprint to ensure minimal light spill/unilluminated pre-construction baseline conditons persist. iii) Use lighting design and screening to protect beaches from light spill.	Negligible, short term.
Cetaceans including ASHW (Very High) and Indian Ocean humpback dolphin (High)	Very Large Adverse – toxic contamination of fauna, flora and ground water resulting from accidental oil spill from the Export Terminal.	DRPIC should produce and publish an Oil Spill Response plan based on the most sensitive biodiversity areas identified in Technical Appendix C – Critical Habitat Assessment. DRPIC should analyse potential oil spill scenarios to devise detailed oil response strategies.	Not applicable as this is a worst case risk rather than a probable impact.
All Terrestrial IEFs (Up to High for endemic plant species)	Very Large Adverse – toxic contamination of fauna, flora and ground water resulting from accidental oil spill from the DRPIC Crude Pipeline.		
Strategic			
Shallow coastal waters (Medium)	Major adverse - invasive species introduction from shipping and impingement/entrainment of fish or marine macro invertebrates from water intake systems.	DRPIC should seek assurance from its supply chain and conduct regular audits to ensure environmentally benign anti-fouling technologies are being adopted at water intake/output points and that measures are in place to minimise entrainment/impingement of marine fauna. DRPIC should seek assurance from the Duqm Port Authority and within its own supply chain to verify that stringent environmental controls are in place to address invasive species introduction.	Assuming full implementation – minor adverse, short term.
Wide ranging species such as large carnivores, gazelle and ibex	Large adverse – cumulative effect of Project in combination with AFs leading to increased effect magnitude and impact significance.	Measures to be secured via Strategic Initiative Approach. DRPIC should contribute to an integrated BMP working collaboratively with SEZAD and other anchor tenants in the industrial area. An initial focus of the biodiversity management plan should be to obtain more accurate distribution, abundance and movement data for target species to inform mitigation planning. DRPIC should seek assurance from SEZAD that the integrated BMP incorporates measures to avoid	Assuming full implementation – Negligible, long term.

IEF (VALUE)	IMPACT SUMMARY	MITIGATION	RESIDUAL IMPACT
		development in wadis and flood prone areas; protection of movement routes of large mammals; and protection of suitable forage, browse and cover.	
Cetaceans including ASHW (Very High) and Indian Ocean humpback dolphin (High)	Up to large adverse – mortality or injury arising from collisions with ships and disturbance caused by marine noise and vibration.	Measures to be secured via Strategic Initiative Approach. Formation of an 'advisory panel' that guides mitigation and monitoring through linking industry together government, conservation and research interests. DRPIC should request assurance and conduct regular audits of mitigation strategies implemented by OTTO, PDA and supply chain shipping to address potential indirect disturbance and shipping collisions associated with marine facilities in relation to the Ras Markaz Single Point Mooring facility; and the Product Export Terminal. This should include seeking assurance that available technologies are fitted to ships to minimise acoustic disturbance (e.g. low noise vessel technology engine mountings and low cavitation props). DRPIC should work within the Strategic Initiative to implement a code of conduct for avoidance of marine mammal and turtle collisions and minimum safety standards relating to pollution for all vessels importing and exporting oil products to/from the Refinery. Through a Strategic Initiative DRPIC should consider contributing to the cost of appointing competent cetacean observers on vessels to alert pilots to the presence of cetaceans. A real-time alert monitoring system could also be developed to alert shipping operators to cetacean presence in shipping lanes to enable reactive avoidance measures to be taken. DRPIC should consider contributing to to primary research and management of cetacean distribution and ecology; monitoring of marine pollution; and assessment of marine acoustic disturbance to inform dynamic management of cetacean populations.	Assuming full implementation – Negligible, long term.

IEF (VALUE)	IMPACT SUMMARY	MITIGATION	RESIDUAL IMPACT
		The Strategic Initiative including SEZAD, Omani Government bodies and industrial bodies should produce and publish an oil spill response plan identifying the most sensitive biodiversity areas. The Strategic Initiative including SEZAD, Omani Government bodies and industrial bodies should produce and publish an oil spill response plan identifying the most sensitive biodiversity areas. The Strategic Initiative, SEZAD and Omani Government bodies should work towards implementation of an offsetting approach to address cumulative impacts on marine species (see Technical Appendix E: Biodiversity Offsetting Framework). Such an approach could be linked to a government lead region-wide/Gulf of Masirah wide zoning strategy with designated zones where different activities are prohibited or permitted (see Technical Appendix E – for further information). Implementation of an offsetting strategy may also offer a potential source of funding for conservation measures and would also provide a strategic framework to provide assurance to potential project funders (particularly those requiring compliance with IFC PS6) as implementation of the Duqm Special Economic Zone masterplan is progressed.	
Green, Loggerhead and Hawksbill Turtles (Very High)	Slight adverse resulting from collisions with ships or entrainment in water intake systems.	Measures as per cetaceans. DRPIC should seek assurance from AF that turtle exclusion devices are fitted to water intake points to prevent turtle entrainment.	Assuming full implementation – Negligible, long term.
All Marine IEFs (Up to Very High for ASHW)	Very Large Adverse – toxic contamination of fauna, flora and ground water resulting from accidental oil spill from the DRPIC Crude Pipeline.	DRPIC should seek assurance and conduct regular audits throughout its supply chain to ensure that an adequate oil spill response plan is in place and that suitable and sufficient preventative measures are in place to prevent an oil spill.	Not applicable as this is a worst case risk rather than a probable impact.

IEF (VALUE)	IMPACT SUMMARY	MITIGATION	RESIDUAL IMPACT
		Other measures should be pursued by adopting a Strategic Initiative Approach: The Strategic Initiative including SEZAD, Omani Government bodies and industrial bodies should produce and publish an oil spill response plan identifying the most sensitive biodiversity areas. As part of a consortium of oil producers, transporters, refiners and Government sponsors, DRPIC should contribute to further research to and analyse potential oil spill scenarios to devise detailed oil response strategies. Industry wide support for further research into turtle and cetacean habitat use, movement pathways and distribution is also important to best design oil spill response planning.	
Species triggering critical habitat: ASHW, Indian Ocean humpback dolphin and three species of turtle IFC PS6 requires the offset target of net gain to be met for all species triggering critical habitat.	See entry for cetaceans including ASHW and Indian Ocean humpback dolphin and green, Loggerhead and Hawksbill turtles in this table. See assessment of species triggering critical habitat in Technical Appendix C: CHA.	See mitigation measures for cetaceans and turtles in this table. DRPIC should consider the recommendations in Technical Appendix E to work toward net gain for marine critical habitat species.	Net gain to be assessed via applicable for a biodiversity metric.

In addition to the specific mitigation measures outlined in Tables 8-3 and 8-4 the following generic mitigation measures will also be adopted:

- A ecological constraints plan will be prepared or added to Project mapping (e.g. pipeline alignment sheets) to guide all contractor staff on sensitive habitat and species features. This should reference all potential areas of critical habitat identified in Biodiversity Assessment – Technical Appendix C: Critical Habitat Assessment. It should also indicate key wildlife movement corridors such as wadis bisecting the Project Footprint. The constrains plan should include species, habitats and designated sites which are most sensitive to disturbance (e.g. coastal bird communities in Duqm Important Bird Area; turtle nesting beaches). It should include an assessment of IEFs in relation to oil spill risk and sensitivity;

- Site fencing will be established to prevent access to areas outside working areas, particularly in areas adjacent to features of interest/value. Fencing must be designed to so as not to obstruct the transit of mammal species (unless that is the intent, for example, in protecting transplanted tree species);

- Briefings and instruction will be given to contractors regarding the biodiversity issues;

- A ecological constraints plan will be prepared or added to Project mapping (e.g. pipeline alignment sheets) to guide all contractor staff on sensitive habitat and species features;

- Best practice construction methodologies will be followed throughout and regular audits will be carried out to ensure compliance;

- Pollution prevention measures will be followed to prevent toxic or non-toxic pollution of water courses by silt or chemicals, spills in the marine environment etc.(for Project components, via the Project ESMP;

- Measures to account for accidental transgression from access tracks by construction vehicles and for unofficial use of access tracks by members of the public should be addressed by closing off and securing access tracks when not in non-operational use;

- Implement measures to control the introduction and spread of alien invasive species as outlined in separate Biodiversity Assessment Report, Technical Appendix D: Invasive Alien Species assessment (Ref: Report N^{o} 70029220-04-CL-Tech/Bio);

- Prohibition of fishing or hunting of wildlife by construction or operational personnel;

- Appointment of a suitably qualified environmental/ecological personnel to ensure the ecological protection mitigation measures are implemented;

- Implementation of waste management principles;

- Dust generation by vehicles during construction phases may smother natural vegetation. This affect was noted in the direct vicinity of third party construction activities around the Port of Duqm. Seawater could be used to supress dust from Project construction sites particularly since it develops a hardcore-like crust. However, it also introduces salt to areas with otherwise low salinity. Use of sea water for dust suppression should only be done in sabkha areas (i.e. in the coastal zone near the Refinery) during construction, and later if not tarmac-surfaced. Dust suppression using water should be mindful of the need to conserve water and that use of water as a suppressant may inadvertently change natural vegetation communities which may not always be desirable. The need for dust suppression should be focused on areas most likely to support endemic plant species as informed by pre-construction survey information; and

- Close off and secure construction access tracks to prevent unofficial ingression into the desert environment by non-Project related persons/vehicle traffic.

8.5 MONITORING REQUIREMENTS

The following monitoring requirements are identified in Tables 8-3 and 8-4:

- Monitoring to ensure the mitigation measures are implemented ;
- Ecological/environmental supervision of construction site set-up at wadi crossing to ensure footprint is strictly minimised;
- Preconstruction survey of instances where critical habitat intersects the Project Footprint (see Technical Appendix 7.3: CHA for an inventory);
- Turtle monitoring during construction and operational phases opposite to the Project Footprint to identify potential nesting by turtles (now or in the future from colonisation during construction or during operation);
- Monitoring of light pollution arising from the Refinery and Tank Storage Facility on the beach and marine environment during construction;
- Regular monitoring of bird use of the Duqm IBA during the Project operational phase by a competent ornithologist in migration and wintering bird seasons to inform adaptive measures to address sources of noise, vibration or other activities which are known to disturb birds;
- Air quality dispersion modelling to define the extent of the area of mountain and escarpment habitat potentially affected by pollution. Modelling results will be used to inform potential mitigation solutions; and
- In collaboration with Government and business operations in the Duqm area, and through a strategic biodiversity action plan and/or Strategic Initiative Approach, DRPIC should DRPIC should consider contributing to to primary research and management of cetacean distribution and ecology; monitoring of marine pollution; and assessment of marine acoustic disturbance to inform dynamic management of cetacean Findings of ecological studies should be used to inform adaptive management of Project and other industrial and commercial operations in the Duqm SEZ and wider Gulf of Masirah.

Following the requirements of the IFC PS1 (Assessment and Management of Environmental and Social Risks), and the strategic mitigation recommendations outlined in the Table above, DRPIC should carry out monitoring of its extended supply chain[10] including shipping operators and port/mooring facilities to include:

- Oil response planning (both marine and terrestrial environments);

[10] Based on the IFC PS1 requirements, all management and monitoring plans will need todefine desired outcomes and actions to address the issues raised iduring the ESIA study, including performance indicators, targets, or acceptance criteria that can be tracked over defined time periods, and with estimates of the resources and responsibilities for implementation. Such management plans will “recognise and incorporate the role of relevant actions and events controlled by third parties to address identified risks and impacts”. Recognising the dynamic nature of the project, the management plans should be responsive to changes in circumstances, unforeseen events, and the results of monitoring and review.

- Measures to prevent turtle entrainment in water intake/output facilities;
- Measures to monitor input of toxic pollutants to the marine environment;
- Pollution response planning (both terrestrial and marine);
- Measures to abate acoustic disturbance fitted to ships; and
- Cetacean monitoring and collision avoidance strategy.

9 SOCIAL AND HEALTH ASSESSMENT

9.1 INTRODUCTION

This Section is based on the baseline data collected through field surveys and desktop data research (Ref: Socio-Economic and Health Baseline Report – see Appendix E) and the impact assessment methodology presented in Section 4.

During the field survey conducted in the Project area, the following four main areas were mentioned by the local residents as matters of expectations and concerns for local communities:

i. Air emissions and potential pollution caused by the project;

ii. Workers' influx;

iii. Expectations for new jobs created by the development of the Duqm Refinery; and

iv. Expectations that the Project will contribute to the development of a new hospital or a school (Section 6: Conclusions in the Socio-Economic and Health Baseline Report[11]). This Section assesses potential impacts to ascertain if these concerns and expectations are warranted and where necessary, suggests mitigation measures.

This Section is divided into the following sections:

- A summary of international standards and relevant national legislation applicable to social and health issues (Section 9.2);
- An assessment of unmitigated impacts associated with the construction and operation stages of the project (Section 9.3); and
- Recommended mitigation and monitoring measures (Section 9.4).

Mitigation and Monitoring measures will be added to the Project ESMP.

[11] The national statistics data show that there are currently three hospitals in the Al Wusta region, providing 68 patient-beds in total. At the same time, the population of Duqm (over 11,000 people) is served by one hospital which accomodates eight patient-beds. The influx of 20,000 workers (even with in-camp medical facilities provided by EPC Contractors) means that a greater strain is very likely to be put on the only hospital in Duqm.

9.2 RELEVANT SOCIAL AND HEALTH STANDARDS

9.2.1 Relevant National Legislation

The Project has been designed to comply with the applicable Omani environmental laws and regulations, permitting and licensing requirements, and occupational health and safety policies.

The Directorate General of Environmental Affairs (DGEA), a division of MECA, provides Guidelines on Environmental Assessment which supplement the international regulations held by lending bodies, specifying the regional Omani regulations on environmental protection and pollution prevention.

Various Omani laws and regulations enforce specific working conditions for facilities in Oman, with associated consideration of noise exposure, radioactive materials and chemicals.

In addition to environmental legislation, the social aspect of this study will be guided by the relevant legislations for addressing the social issues pertaining to impact on community, heritage, and involvement of Omani citizens in the project, as applicable. A brief description of the same is presented below:

Table 9-1: Relevant Laws and Regulations in Oman

No.	Description	Law Reference/ Decree Number	Applicability to Project
1	Law for identifying natural heritage	National Heritage Law (1980) & Amendments	Project works can be initiated only after obtaining clearance from the Ministry of Heritage and Culture
2	Law on natural heritage protection	Royal Decree 6/80	A project must suggest a plan to protect any archaeological finds/sites
3	Law on involving local residents in the proposed project	Oman Labour Policy	Consultation with local communities (carried out as part of earlier ESIA studies) and also during socio-economic and health baseline data collection and surveys. Provision for the creation of local employment opportunities for local residents.
4	Guidelines for development of new areas	Town Planning and Urban Planning Standards	Physical planning norms to be adopted for infrastructure for new development
5	Labour Laws	Royal Decree 35/ 2003	Regulation of all aspects of employment in Oman, including the hiring of Omani nationals and expatriates (i.e. migrant workers for construction projects).
6	Ordinance on Protection of Public Health	No. 1/2006	General rules to protect public health (applicable to construction sites)

9.2.2 International Standards

The following IFC Performance Standards are relevant to socio-economic and health impacts:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts;
- Performance Standard 2: Labour and Working Conditions; and
- Performance Standard 4: Community Health, Safety, and Security.

Other Project-applicable standards include:

- The Equator Principles (EPs), launched in 2003, have now been adopted by 91 financial institutions made up of private banks as well as ECAs across 37 countries (The Equator Principles Association, 2017). These principles are the finance industry's guidelines for managing social and environmental risk in project financing, updated in 2013 to align with the IFC Performance Standards. The EPs applicable to social impact assessment are: Principle 2 (Environmental and Social Assessment), Principle 5 (Stakeholder Engagement) and Principle 6 (Grievance Mechanism); and

- Organisation for Economic Co-operation and Development (OECD) recommendations on Common Approaches to the Environment and Officially Supported Credits (the "OECD Common Approaches") (2012)

9.2.3 Application of Standards to Assessment: Construction and Operation

The above-mentioned national laws and decrees are not aimed at the impacts assessment and mitigation of the relevant socio-economic and health impacts, except for the Omani Labour Law (Royal Decree 35/2003. The Labour Law is aimed at regulating all employment aspects in Oman, and thus is applicable to the management and monitoring of the employment of project workers during for the construction and operational phases. In addition to the Omani Labour Law, the three relevant IFC Performance Standards are also applicable to the construction and operation phases: Performance Standards 1, 2 and 4.

9.2.4 Social Impact Significance

The assessment of socio-economic and health impacts follows the general methodology set out in Section 4 with the following clarification: certain socio-economic and health impacts are considered 'Very Low' in severity due to the sparsely populated project area; and those impacts which were designated 'Very Low' for severity are rated 0, which results in the significance matrix set out below in out in Table 9-2:

Table 9-2: Significance Matrix for Social Impacts

SIGNIFICANCE			PROBABILITY RATING			
			Very low	Low	Medium	High
			1	2	3	4
Severity Rating	Very low	0	0 Negligible	0 Negligible	0 Negligible	0 Negligible
	Low	2	2 Minor	4 Minor	6 Moderate	8 Moderate
	Medium	3	3 Minor	6 Moderate	9 Moderate	12 Major
	High	4	4 Minor	8 Moderate	12 Major	16 Major

9.3 CONSOLIDATED IMPACT ASSESSMENT OF UNMITIGATED IMPACTS

This socio-economic and health impact assessment is based on consolidated and new baseline information, notably the previous EIAs, as well as DRPIC's existing Environmental and Social Management Plans.

9.3.1 Methodology

RECEPTOR IDENTIFICATION AND CLASSIFICATION

A receptor screening stage has been carried out based on site observations. The identified potential receptors were discussed with DRPIC during household and fishermen surveys preparation and local consultants to ensure only relevant receptors are identified. Finally, receptors were reconfirmed during the survey work.

In this instance, the Project receptors are the local communities located within the SEZAD area that may be impacted or influenced by the Project (as a result of their proximity to the Project site and/or associated infrastructure).

Given the nature of the sparsely populated project area and project-related anticipated impacts, the receptors for social impacts include the following:

- Nafun (located within 9km from the Refinery Location);
- Al Tayari (7km from the location of Construction Camp 1);
- Antoot (located 1 km from the Refinery and 3km from the Export Terminal);
- Wider Duqm area (located within the wider SEZAD area and the concurrently developing wider SEZAD area) ;
- The Duqm Hospital (located within 5.5km distance from the Pipeline site and sponsored by the government/Ministry of Health authorities);
- Construction Camps 1 and 2; and
- The 150 Housing Units area (located within 9km distance from the Pipeline site).

The receptors for potential socio-economic and health impacts also include workers who will be living in the temporary accommodation facilities adjacent to the Project site or at the purpose built Renaissance facility. The accommodation facilities at Renaissance have been constructed to house up to 16,000 workers on a temporary basis (at peak season). The aim is for the workers to be moved either back to their countries when the construction is over or move to other construction sites in the SEZAD area.

The Table below summarises the socio-economic and health impacts that were identified. By and large, the impacts are expected to be limited to the local communities. However, there are a few activities that may impact the wider SEZAD area- such as employment opportunities.

Table 9-3: Identified Social Impacts and Receptors

POTENTIAL IMPACTS (CONSTRUCTION & OPERATION)	RECEPTORS AND STAKEHOLDERS
Employment and Economy	
• Increase in local employment opportunities • Increase in business development opportunities	• Local government • Local communities and fishermen • Local businesses
Community Health	
• Increase in communicable diseases	• Local residents • Foreign workers (including contractors) • Local health care providers and infrastructure

POTENTIAL IMPACTS (CONSTRUCTION & OPERATION)	RECEPTORS AND STAKEHOLDERS
Community Safety and Security[12]	
• Increased potential for safety issues associated with the presence of new infrastructure	• Local communities • Construction workers (including contractors)
Environmental Emissions	
• Increase in noise and vibrations (construction only) • Increase in dust leading to health implications (construction only)	• Local communities • Foreign workers (including contractors)
Community Infrastructure and Services	
• Increased pressure on community infrastructure and services	• Local communities and fishermen • Foreign workers (including contractors) • Local infrastructure providers
Social Networks	
• Introduction of new people to the area potentially leading to changes in social structures • Change in the skills set among local job-seekers	• Local communities and fishermen • Foreign workers (including contractors) • Local service providers

Given the nature of the project area (small villages scattered amongst the predominantly undeveloped desert-like environment) and the identified social VECs which are not tied to any particular project component or facility (new employment opportunities, communicable diseases, etc) it is considered that attempting to address impacts by nature of impact is a more suitable approach which is significantly more conducive to effective management, mitigation and monitoring of social impacts. Conversely, another social VEC such as the only government-sponsored hospital located in Duqm is an important social receptor for this project (Hospitals are referenced in Sections 3.6, 4.8 and 6.0 of the Socio-Economic Baseline Report), and its relevance can be traced to every project component, such as this hospital will be used in case of any significant medical emergency on any project site both during construction and operation.

As such, social impacts are presented below based not on the proximity to the project components and facilities but the nature of the impacts and sensitivity of receptors. However, the proximity and relevance of project components is cited, where appropriate.

9.3.2 Potential Impacts

This section describes the potential impacts and consequences of interaction between the Project activities and receptors. Where significance of the impacts is assessed as moderate to major, mitigation measures, management and monitoring are proposed below (Section 9.4).

The identified impacts include effects associated with in-migration. Rather than assessing in-migration separately, where in-migration is a contributing or driving factor for a particular impact, this is noted in the sections below.

[12] Note that due to the Project area being located in a scarcely populated part of the country, the expected increase in traffic is considered to be negligible.

EMPLOYMENT AND THE ECONOMY

CONSTRUCTION

Based on preliminary estimates, the construction stage of the Project will generate a range of employment opportunities. During construction, it is expected that approximately 20,000 workers will be involved (at peak times) which is the estimated total number of jobs that will be created through EPC Contractors' activities (EPC Contractors 1, 2 and 3).

OPERATION

The number of people employed by the Project will decrease at the end of the construction phase (estimated to be 2021, i.e., the construction process lasting approximately three and a half years). It is anticipated that over 3,000 direct and indirect employment opportunities (for Refinery only) will be created during the operation phase planned for 2022 to 2050.

In addition, the Project will require goods and services throughout its lifecycle. There are opportunities for local businesses to provide these goods and services (e.g. catering for the workers camp, office-related supply opportunities). As a result, existing local businesses may expand or new businesses may be established locally to meet these demands – providing employment opportunities. This is referred to as indirect employment and it is estimated to create over 3,000 indirect opportunities for employment.

POTENTIAL IMPACT

DRPIC has committed to capitalising on local content opportunities and ensure that feasible opportunities are provided to local people and businesses. These commitments are reflected in the DRPIC corporate policies and In-Country Value (ICV) strategy.

The Project will generate skilled and unskilled positions, with the number of unskilled positions dropping substantially after the construction period. Given that most working age local people are engaged in the cattle rearing and fishing activities, it is possible that the existing skills set among local people of working age would not always be a match for the direct employment opportunities that will be created by the project.

Therefore, it will be important that DRPIC is committed to organising training to create new skill sets among local residents and also capitalising on some skills that are transferrable from the cattle raising and fishing activities to the Project in order to maximise local employment.

In terms of indirect employment, the realisation of opportunities will depend not only on the Project, but also on the initiative and business abilities of local entrepreneurs. Given the much wider demand for new businesses in the wider SEZAD area and the limited number of existing businesses, it is anticipated that the number of opportunities to create business development opportunities and/or indirect employment will be significant.

SIGNIFICANCE

The impacts on employment and economy that are likely to be triggered during the construction stages of the project would be positive, direct, regional, long-term (seven years of construction) and of medium severity. The probability of the impacts is considered to be high because DRPIC is a significant and strategic development in the area with the relatively low levels of employment. The significance of these positive impacts on employment and economy is therefore considered to be major and as a major positive impact does not need mitigation.

The operational impacts on economy and employment are also considered to be positive, direct, regional, long-term and of low to medium severity (as the number of new jobs generated by the

project would tail off at the operation phase). The probability of the impacts occurring is considered to be high. The significance of the impacts is considered to be moderate and as moderate positive impact does not need mitigation. The summary of these potential impacts is presented in the tables below.

Table 9-4: Summary of Impacts on Employment and Economy – Construction

IMPACT	IMPACT ON EMPLOYMENT AND ECONOMY
Impact Nature	Positive
	An increase in employment opportunities and demand for goods and services are positive.
Impact Type	Direct (directly impacts local communities)
Impact Duration	short-term
	The impact is short-term for the duration of construction (3.5 years).
Impact Extent	Regional
	The Project will provide employment opportunities for the wider SEZAD area; therefore, the impact is regional.
Impact Significance	The impact significance is major.
Impact Frequency	Throughout the construction phase.
Impact Summary	Major positive

Table 9-5: Summary of Impacts on Employment and Economy – Operation

IMPACT	IMPACT ON EMPLOYMENT AND ECONOMY
Impact Nature	Positive
	An increase in employment opportunities and demand for goods and services are positive.
Impact Type	Direct (directly impacts local communities)
Impact Duration	Long-term
	The impact is long-term because it occurs during the operation phase.
Impact Extent	Regional
	The Project will provide employment opportunities for the wider SEZAD area; therefore, the impact is regional.
Impact Significance	The impact significance is moderate
Impact Frequency	Throughout the operation phase.
Impact Summary	Moderate positive

COMMUNITY HEALTH

CONSTRUCTION

The Project will employ over 20,000 workers during construction (at peak times). There is potential for the workforce to introduce and/or increase the rate of spread of communicable diseases in the Project area. This includes the introduction of a new disease and/or a more virulent strain of an existing disease.

However, the workforce is not the only factor that may contribute to the transmission of communicable diseases. The Project is also likely to result in in-migration. Similar to the

workforce, there is potential for in-migration to introduce and increase the rate of spread of communicable diseases in the Project area.

There are a number of diseases that are already prevalent in the Project area, which is contributing to the current rates of morbidity and mortality. This includes hepatitis A (communicable disease), diabetes and asthma which during the household survey in the project area have been identified as a key contributor in the local communities' rates of morbidity and mortality.

OPERATION

The number of jobs that will be created by the DRPIC project during the operation stages was estimated as 900 direct hires. Similarly to the community health impacts during the construction stage, there is potential for the workforce to introduce and/or increase the rate of spread of communicable diseases in the Project area during operation. This includes the introduction of a new disease and/or a more virulent strain of an existing disease.

OTHER RELATED ISSUES

The transmission of communicable diseases in the project area during construction and operation can be exacerbated by a number of factors. Health care facilities are limited in the Project area and as mentioned in Section 9.3.1 above, there is currently only one state-sponsored hospital in Duqm, In addition, there is also a recently developed private hospital in the area and another two state-sponsored hospitals covering the rest of the Al Wusta region. However, considering the typical wages of migrant manual labour, it is unlikely that workers or local residents on modest incomes will be able to afford private medical care bills. As such, the only state-sponsored hospital in Duqm will continue to absorb most of the demand, while its capacity (e.g. availability of diagnostic equipment, availability of medicine) to respond to an increase in the transmission of communicable diseases could be limited.

POTENTIAL IMPACTS

An increase in the transmission of communicable diseases may occur as the result of the introduction of workers into the area. In terms of communicable diseases and in addition to the existing prevalence of the hepatitis A rates in the project area, of particular note and concern could be: tuberculosis and HIV/AIDS (mainly through drug abuse/blood transfusions, etc).

SIGNIFICANCE

The impact on community health that is likely to be triggered during the construction stage of the project would be negative, direct, local, long-term (3.5 years of construction) and of low severity (primarily due to low population density). The probability of the impacts is considered to be medium. The significance of this negative impact on community health is therefore considered to be moderate.

The operational impact on community health is also considered to be negative, direct, local, long-term and of low severity (as the number of workers and associated in-migration would drop during the operation phase). The probability of the impacts occurring is considered to be medium. The significance of the impacts is considered to be moderate.

Table 9-6: Summary of Impacts on Community Health – Construction

IMPACT	IMPACT ON COMMUNITY HEALTH
Impact Nature	Negative
	An increase in communicable diseases in the local area is negative
Impact Type	Direct (directly impacts on local communities)
Impact Duration	Long-term
	The impact is long-term because if diseases are untreated the impact could be long-lasting.
Impact Extent	Local
	The impact is limited to local settlements
Impact Significance	The impact significance is moderate
Impact Frequency	The impact likely occurs during the construction phase with the rare frequency.
Impact Summary	Moderate negative

Table 9-7: Summary of Impacts on Community Health – Operation

IMPACT	IMPACT ON COMMUNITY HEALTH
Impact Nature	Negative
	An increase in communicable diseases in the local area is negative
Impact Type	Direct (directly impacts on local communities)
Impact Duration	Long-term
	The impact is long-term because if diseases are untreated the impact could be long-lasting.
Impact Extent	Local
	The impact is limited to local settlements
Impact Significance	The impact significance is moderate
Impact Frequency	The impact likely occurs during the construction phase with the rare frequency.
Impact Summary	Moderate negative

COMMUNITY SAFETY AND SECURITY

CONSTRUCTION

There are a number of safety related issues that are likely to arise during the construction stage of the project. These include:

- Traffic accidents – given that 20,000 workers need to be transported to and from the sites (daily), this aspect is likely to increase the risk for accidents or incidents (particularly during construction), which can lead to injuries and/ or fatalities. This impact will be addressed by Contractors who will be required to prepare and implement a detailed Traffic Management Plan (integrated with the other CONTRACT requirements) and a Community Health and Safety Implementation Plan.;

- The presence of new infrastructure. There are often safety issues with the establishment of new infrastructure – for example, community members interacting with unsecured equipment. This can lead to onsite accidents and injuries; and

- The management of hazardous materials and waste. There are a number of Project activities that will generate hazardous waste – e.g. chemical cleaning of equipment during the pre-commissioning process. DRPIC intends to manage these wastes appropriately.

The Project will increase the number of vehicles using local roads through the transport of workers, goods, materials and machinery to and from the Project site during construction. With an increase in vehicles, particularly heavy haulage vehicles, comes the increased potential for accidents and injuries to occur.

In addition, the Project will require security. Security personnel will be employed during construction and operation. The number required during construction has been estimated as 50.

OPERATION

The safety and security related issues that are likely to arise during the operation stage of the project are similar to those during construction, with the exception of the traffic volumes which will be reduced during operation.

It is anticipated that a total of up ten security staff will be required during the operation phase.

POTENTIAL IMPACTS

Impacts to community safety (e.g. possibility of accidents) and security (e.g. incidence of crime) can result from an increase in traffic, the establishment of onsite infrastructure and the management of hazardous materials.

SIGNIFICANCE

The impact on community safety and security that is likely to be triggered during the construction stage of the project would be negative, direct, local, short-term (3.5 years of construction) and of low severity (primarily due to low population density). The probability of the impacts is considered to be low due to low population levels and also robust management plans that will be implemented by DRPIC.

The operational impact on community health is also considered to be negative, direct, local, long-term and of low severity (as the number of workers and associated in-migration would drop during the operation phase). The probability of the impacts occurring is considered to be low.

Table 9-8: Summary of Impacts on Community Safety and Security – Construction

IMPACT	IMPACT ON COMMUNITY SAFETY AND SECURITY
Impact Nature	Negative
	Potential safety and security risks in the local area
Impact Type	Direct (directly impacts on local communities)
Impact Duration	Short-term
	The impact is short-term - 3,5 year construction period.
Impact Extent	Local
	The impact is limited to local settlements
Impact Significance	The impact significance is minor

IMPACT	IMPACT ON COMMUNITY SAFETY AND SECURITY
Impact Frequency	The impact likely occurs during the construction phase with the rare frequency.
Impact Summary	Minor negative

Table 9-9: Summary of Impacts on Community Safety and Security – Operation

IMPACT	IMPACT ON COMMUNITY SAFETY AND SECURITY
Impact Nature	Negative
	Potential safety and security risks in the local area
Impact Type	Direct (directly impacts on local communities)
Impact Duration	Long-term
	The impact is long-term due to 3.5 year construction period..
Impact Extent	Local
	The impact is limited to local settlements
Impact Significance	The impact significance is minor
Impact Frequency	The impact likely occurs during the construction phase with the rare frequency.
Impact Summary	Minor negative

ENVIRONMENTAL EMISSIONS

CONSTRUCTION

The construction activities will generate the following emissions:

- Noise, which can result from a variety of onsite civil works activities (e.g. construction of infrastructure, reversing sensors on large vehicles);
- Vibration, which may result from construction activities (e.g. blasting along Pipeline ROW; and
- Dust, which can be generated through site grading and driving on dry, dusty and dirty roads. This can impact the surrounding air quality, disrupting the amenity value of an area and potentially impacting community health (e.g. further aggravating existing respiratory illnesses and asthma, the prevalence of which was mentioned by local residents during the field surveys and reported in the Socio-Economic and Health Baseline Report, DRPIC Report Ref. 05-C-Base/Soc).

Sections 5 and 6 above go into more detail about the specific impacts. Baseline particulates are already naturally high so additional emissions in construction will need to be avoided through effective mitigation and monitoring (see Section 5.4).

OPERATION

During the operational activities, the levels of noise and vibration drop dramatically mainly because the construction process will be finished and the operation activities do not typically generate the same levels of vibration and noise emissions. However, it is envisaged that dust emissions will be generated by road transportation activities during the operation stage but on lower levels, especially as SEZAD completes hard surfacing of the road network.

POTENTIAL IMPACTS

In terms of noise, a detailed noise impacts assessment can be found in Section 6 of this Report.

Based on noise impact conclusions in Section 6, during construction, with the exception of Dhahr (which falls within the wider Duqm area), noise levels at all other receptors are expected to be below the IFC Guideline day and night-time noise limits during all peak activity periods.

The operational noise levels are expected to meet the industrial noise limits set out in MD 79/94 at all receptors for all periods. Furthermore, if activities contain impulsive or tonal components, the limits would still be met.

Most roads in the project area are paved, however even on a paved road in a desert or a dusty/sandy environment, a car is likely to re-suspend dust simply as a result of driving on the road. Based on the Environmental Baseline - Air Quality, the project area already experiences a high level of dust and PM_{10} (even prior to construction). This situation is currently largely caused by the wind picking up sand. Depending on the weather conditions, background dust could be transported over more than a 10km distance, and as such, a combination of the dust levels caused by the project traffic (during both construction and operation stages) particularly in unsettled weather could affect local communities' health and well-being.

These increases in airborne particulates (dust levels) could generate impacts on local residents and the appropriate management measures will be put in place by Contractors.

SIGNIFICANCE

As per the Noise Assessment Section (Section 6.3.6, Construction Noise Impacts) the off-site construction noise impacts identified would be negative, direct, local, short-term and of low to medium severity. Given the variable nature of the construction activities and worst-case assumptions adopted, the probability of the impacts occurring is medium (i.e. there is a fair chance the impacts would be lower than predicted). The significance of the impacts is therefore considered to be moderate.

As per the Noise Assessment Section (the Consolidated ESIA Report, Section 6.3.6, Operational Noise Impacts) the off-site operational noise impacts identified would be negative, direct, local, and long-term In consideration of the baseline noise environment, the predicted levels are expected to be imperceptible at most locations with the exception of the area around the north of Saay Village and Renaissance Workers Camp. At all receptors the predicted levels are below the applicable guideline criteria, and the impact severity is therefore considered very low. Given the dependence on weather conditions and the worst-case assumptions adopted, the probability of the impacts occurring is medium (i.e. there is a fair chance the impacts would typically be lower than predicted). The significance of the impacts is therefore considered to be negligible.

Table 9-10: Summary of Impacts from Environmental Emissions– Construction

IMPACT	ENVIRONMENTAL EMISSIONS IMPACT - CONSTRUCTION
Impact Nature	Negative
	Potential safety and security risks in the local area
Impact Type	Direct (directly impacts on local communities)
Impact Duration	Short-term
Impact Extent	Local
	The impact is limited to local settlements
Impact Significance	The impact significance is moderate

IMPACT	ENVIRONMENTAL EMISSIONS IMPACT - CONSTRUCTION
Impact Frequency	Short-term impacts at relatively regular intervals during the construction phase.
Impact Summary	Moderate negative

Table 9-11: Summary of Impacts from Environmental Emissions – Operation

IMPACT	ENVIRONMENTAL EMISSIONS IMPACT - OPERATION
Impact Nature	Negative
	Potential safety and security risks in the local area
Impact Type	Direct (directly impacts on local communities)
Impact Duration	Short-term
Impact Extent	Local
	The impact is limited to local settlements
Impact Significance	The impact significance is negligible
Impact Frequency	Short-term impacts with the rare frequency during the operation phase.
Impact Summary	Negligible

COMMUNITY INFRASTRUCTURE AND SERVICES

CONSTRUCTION

The construction period is expected to last over 3.5 years and during this time, it is anticipated that the workforce will peak at around 20,000 workers and the majority of construction workers will be from outside the area (as well as the influx associated with in-migration).

An increase in population in the wider Duqm area (due to employment opportunities and in-migration during construction) is likely to place additional pressure on existing infrastructure and services (e.g. healthcare). This often results in a reduction in capacity of existing infrastructure and services to meet the needs of the local residents (as well as the additional population added by the Project); leading to diminished quality of services as well as reduced access to the existing infrastructure.

However, during construction the workforce will be accommodated at camps, which will have a range of on-site amenities, including medical facilities. This will, to some extent minimise the need for the workforce to use (or rely on) local infrastructure, i.e. minimising the pressure that may be experienced by community infrastructure and services. It is anticipated that at the conclusion of the construction phase, the workers brought in from outside the area will leave. Additionally, SEZAD will continue to develop new infrastructure and amenities in the area through attracting private investors, which with time should also ease the increase in demand on local infrastructure and services.

OPERATION

In terms of the operation phase, it is anticipated that approximately 3,000 new direct and indirect jobs will be generated by operation activities. Given the duration of the Project, it is anticipated that the operational workforce will relocate to Duqm, potentially bringing their families with them, although this would depend on the speedy development of the new infrastructure in the Duqm SEZ governed by SEZAD. However, given that the Duqm area and SEZAD are continuously

expanding and attracting new and private investments in improved infrastructure, and assuming that some workers will be sourced from the local area, it is anticipated that this additional pressure can be accommodated.

POTENTIAL IMPACTS

During both the construction and operation phase, the Project may place additional pressure on existing healthcare facilities, for instance, should a worker become sick or an incident on site resulting in an injury. However, there is limited capacity for the existing healthcare facilities to respond to this demand (due to the limited number of health care workers, number of existing hospitals and diagnostic equipment). For this reason, if healthcare is required, workers will use a medical point located within their workers' camp or other medical facilities located in Al Wusta or beyond. In addition to the EPC contractors' obligations to provide site medical facilties, the existing DRPIC's Community Health and Safety Management Plan will help manage any pressure that may be placed on local health care facilities.

In terms of the construction phase, the road infrastructure may be affected by increased traffic (overcrowding and congestion caused by the transportation of approx. 20,000 workers to and from the sites on a daily basis, as mentioned in the Community Safety and Security Section above), temporary road closures and expected wear and tear. It should be noted that the existing and recently developed road infrastructure was designed to accommodate increase in traffic. Nonetheless, the transportation of approx. 20,000 workers will inevitably cause a high volume of traffic during the construction stage (during the 3.5 year period). However, this impact is expected to be local in terms of the extent and occur over a relatively short period of time.

SIGNIFICANCE

The potential strain on existing infrastructure (congested and/or closed roads, infrastructure wear and tear, and the lack of flexibility for the local medical facilities to increase their capacity), would cause the impacts to be negative, direct, local, temporary and of low to medium severity. Given the variable nature of the potential transportation activities (both timing-wise and with regards to precise identification of the roads that will be used most) and difficulty to predict the extent and the number of medical cases that would require medical facilities, worst-case assumptions were adopted. As such, the probability of the impacts occurring is medium. The significance of the impacts is therefore considered to be moderate.

This potential strain on existing infrastructure would recede when the project moves into the operational stage. As such, the impact severity is therefore considered very low and the probability of the impacts occurring is medium. The significance of the impacts is therefore considered to be negligible.

Table 9-12: Summary of Impacts on Community Infrastructure and Services– Construction

IMPACT	COMMUNITY INFRASTRUCTURE AND SERVICES - CONSTRUCTION
Impact Nature	Negative
	Potential strain, congestion, and wear and tear for roads and strain on medical facilities in the local area
Impact Type	Direct (directly impacts on local communities)
Impact Duration	Short-term
Impact Extent	Local
	The impact is limited to local settlements
Impact Significance	The impact significance is moderate
Impact Frequency	Temporary impacts are expected at irregular intervals during the construction phase.

IMPACT	COMMUNITY INFRASTRUCTURE AND SERVICES - CONSTRUCTION
Impact Summary	Moderate negative

Table 9-13: Summary of Impacts on Community Infrastructure and Services – Operation

IMPACT	COMMUNITY INFRASTRUCTURE AND SERVICES - OPERATION
Impact Nature	Negative
	Potential strain, congestion, and wear and tear for roads and strain on medical facilities in the local area
Impact Type	Direct (directly impacts on local communities)
Impact Duration	Temporary
Impact Extent	Local
	The impact is limited to local settlements
Impact Significance	The impact significance is negligible
Impact Frequency	Temporary impacts with the rare frequency during the operation phase.
Impact Summary	Negligible

9.4 SUGGESTED MITIGATION MEASURES

This Section suggests mitigation and monitoring measures for all identified impactswhich will be addressed in the Project ESMP.

The following mitigation measures can be considered for discussion with EPC Contractors to ensure that the identified negative impacts are reduced.

9.4.1 Employment and Economy

The potential impacts on employment and economy are positive and therefore it is suggested that they do not require mitigation. However, these potential positive impacts can be enhanced through the following complementary measures and successful delivery of existing policies:

- DRPIC has developed an In-Country Value Plan which defines measures which EPC contractors and their subcontractors will be expected to take to facilitate local recruitment and procurement/encouragement of local suppliers to provide their services and goods. This plan requires targets relating to local content so that the performance of those in the supply chain can be tracked and evaluated by DRPIC;
- EPC Contractors will inform local businesses of contracting opportunities in a timely manner;
- DRPIC's Community Relations and CSR Strategies detailing contributions to local employment, training of young local specialists and any other CSR initiatives;
- Grievance Mechanism – EPC Contractors will have their own Grievance Procedure which will be aligned with the DRPIC Grievance Mechanism (see) and within this process DRPIC will ensure that EPC contractors are aware of the grievance submittal process;
- Prior to construction and as part of EPC, create and populate a database of all suitable local service providers to encourage more opportunities for local businesses;

- DRPIC is committed to compliance with all relevant Omani legislation, i.e., Royal Decree No. 35/2003 The Labour Law and Ministerial Decision No. 286/2008 Regulations under the Labour Law on Occupational Safety and Health in Establishments;
- Construction workers' camps will be located away from the local community areas and be self-sufficient to reduce the need to interact with those communities;
- A range of recreational facilities shall be provided within the camps to reduce the need for finding recreation in the local community;
- Contractors will provide workers with contract documents that are clear and specify workers' rights under national labour and employment law, including their rights related to hours of work, wages, overtime, compensation, and benefits upon beginning the working relationship and when any contractual changes occur;
- The contractor will approach recruitment of labour in the most effective way for managing potential in-migration;
- Contractor's plans and procedures shall specify how social and cultural awareness training will be delivered to the workforce in line with The Omani Labour Law, Article 23 so that respect is payed to the Islamic religion, laws of the country, its customs and its social traditions;
- The Contractors will develop a Code of Conduct, for approval by DRPIC which shall define how personnel are expected to behave both during and after work hours; and
- Inspections and monitoring to ensure that the Contractors and subcontractors are adhering to the mitigation and monitoring requirements will be undertaken.

SIGNIFICANCE OF RESIDUAL IMPACT

Not applicable as impacts on employment and economy are positive and will be enhanced if the above-mentioned complementary measures are implemented.

MEASURES TO MITIGATE IMPACTS ON COMMUNITY HEALTH

If left untreated communicable diseases can lead to long-term health issues and therefore the impact can be characterised as being long-term and in some instances permanent.

The existing local health care facilities have limited capacity to respond to a significant increase in the transmission of communicable diseases; however this impact will be partially offset by in-house medical facilities located on sites (medical facilities) and also within the construction camps.

The following measures to mitigate potential negative impacts on community health shall be undertaken:

- Implementation of the ESMP including an environmental monitoring Plan (e,g, air emissions, dust) to monitor potential changes to ambient air quality;
- Early notification of local authorities and Walis on critical or exceptionally busy construction periods and air-polluting/dust- and noise-generating activities;
- Dust suppression by water spraying in dry seasons, particularly in the areas close to sensitive residential and community receptors (i.e.: Wadi Al Khaban (which is the nearest to the refinery site), Wadi Qadih, Wadi Dhanjart, Wadi Ad Dishayshah, Wadi Say);

- As part of the induction process for new employees and workers, the EPC contractors will provide training for all workers on the transmission routes and common symptoms of communicable diseases. This training will be supported by the ongoing awareness campaign (posters located in common areas within the camp). These measures can help reduce the potential for workers to unknowingly transmit communicable diseases;

- Additionally, EPC Contractor will provide suitable medical facilities within the workers camps and will be managed by EPC contractors. Such facilities will be expected to provide both routine medical care and emergency medical services suitable for a large construction site with a peak labour force of approximately 20,000 in total. As a minimum, EPC Contractor will ensure that such facilities offer professional medical staff/nurse, pharmacy and medical equipment necessary to respond to, and dealing with, critical medical emergencies.

- A Workforce Code of Conduct shall provides clauses including measures that target anti-social behaviour;

- Contractors' compliance with national HSE legislation and DRPIC HSE Policies, evaluate contractors' HSE performance;

- Implementation of the DRPIC's Health and Safety, Environmental and Social and Security Policies Policy);the mitigation and monitoring measures herein; and

- Provide DRPIC HSE Policies and Procedures to all subcontractors during formal induction, including the security firms.

SIGNIFICANCE OF RESIDUAL IMPACT

Once these suggested mitigation measures have been implemented, it is predicted that the impact will be reduced to minor negative during construction and operation. However, on-going monitoring and evaluation of community health and safety will be needed and the appropriate monitoring key performance indicators are suggested in Section 8.5 below Should monitoring indicate an increase in the transmission of communicable diseases, the mitigation measures will need to be revised.

9.4.2 Community Safety and Security

DRPIC has set forth a number of contract requirements for the EPC Contractors in accordance with national and IFC standards. As a result of these mitigation measures, the local extent and significance of the potential impact, the overall impact is assessed as minor negative during construction and operation and requires mitigation.

The following measures to mitigate potential negative impacts on community safety and security:

- Traffic Management Plans to be prepared by EPC Contractors during construction will further minimise the potential risk of accidents, injuries and near misses. Traffic management during eventual operations will fall under the responsibility of DRPIC;

- Provide DRPIC's HSE and ESMP to all subcontractors during formal induction, including the security firms;

- Ensure that a Project Code of Conduct and appropriate training for security personnel are implemented to ensure best practice in running a secure site and implementing the Code of Conduct that fosters behaviours that help to avoid, eliminate or minimise the use of excessive force in potential conflict situation;

- DRPIC's HSSES Plan and ESMP is to be implemented by all EPC Contractors which will be regularly audited by DRPIC through the HSSE Assurance process;
- Contractors' compliance with national HSE legislation and DRPIC HSE Policies and evaluation of contractors' HSE performance; and
- Stakeholder Engagement Plan (SEP) implementation with regards to keeping a regular dialogue with local communities.

SIGNIFICANCE OF RESIDUAL IMPACTS

Assuming that the above mitigation measures will be implemented and monitored over time, the minor negative impact on community safety and security will be minimised further to the "negligible" level. Ongoing monitoring should occur to track the implementation of the mitigation measures. See suggested monitoring key performance indicators below.

9.4.3 Environmental Emissions

Mitigation measures for these impacts have been proposed in Section (Section 5.4) of the Consolidated ESIA Report.

SIGNIFICANCE OF RESIDUAL IMPACT

Once these suggested mitigation measures have been implemented, it is predicted that the impact will be reduced to minor negative during construction and operation. However, on-going monitoring and evaluation of environmental emissions will continue throughout the project life-cycle through the environmental monitoring.

9.4.4 Community Infrastructure and Services

Based on the above assessment, the following mitigation measures are suggested to ease potential strain on the existing community infrastructure and services:

- Congestion and wear and tear on roads and highways:
  - Avoiding driving during peak hours where possible;
  - On Project sites project drivers will avoid driving at speeds exceeding 50 m/h to prevent contributing to roads damage, unless otherwise determined; and
  - Develop and implement a traffic management plan to minimise the impact experienced by road users as a result of the Project;
- EPC Contractors to provide appropriate amenities at the worker camps (i.e. launderette, cinema and gym facilities, etc) to reduce the need for workers to use local infrastructure and services;
- Implement the existing DRPIC HSSES Plans and Procedures to minimise worker illnesses and injuries as possible and ensure appropriate and adequate health care services are provided on site and at workers camps to address/ manage worker illnesses and injuries; and
- As part of stakeholder engagement activities (detailed in DRPIC Stakeholder Engagement Plan,) DRPIC will engage with local stakeholders (e.g. village representatives, government) so that there is a comprehensive response to mitigate in-migration.

SIGNIFICANCE OF RESIDUAL IMPACTS

Assuming that the above management measures will be implemented and monitored over time, the residual impact during the construction stage will be reduced to minor negative. However, on-going monitoring and evaluation of community health will be needed and the appropriate monitoring key performance indicators are suggested ibelow:

- In order to manage the workforce effectively, maintain records on all health and safety-related incidents, lost time incidents, the provision (and speed) of medical aid/care dispension and data/information on other HSE indicators. These will be submitted to the DRPIC HSE Team by all Contractors on a monthly basis to help inform, and continually improve, the monitoring and management of health and safety performance against the benchmark standards.

- To mitigate the impact on local community health, evidence of HSE and communicable diseases prevention training during induction of newly recruited workers and records of regular refresher courses (in languages spoken by the majority of workers) will be required.

- Air quality, noise and dust levels will be regularly monitored by the Contractors and assured by DRPIC.

- DRPIC will check and confirm that all their Contractors will monitor ambient baseline in accordance with the environmental monitoring requirements and also comply with the requirements of the ESMP.

- To evaluate how DRPIC is addressing potential impacts on the local economy and employment, cumulative records will be regularly updated on already-filled and also advertised employment opportunities with clear indication of the minimum level of education, training and skills required.

- The Contractors will also provide DRPIC, on a monthly basis, the count of new direct and indirect jobs created in relation to the DRPIC Project.

If monitoring indicates an increase in the transmission of communicable diseases, the mitigation measures will need to be revised.

10 CULTURAL HERITAGE

10.1 INTRODUCTION

The cultural heritage assessment describes the approach to protecting items, fragments and sites of archaeological (prehistoric), palaeontological, historical, cultural, compiled following a review of previous ESIA reports and field surveys of the Project area. Additional survey work was undertaken in 2017 (see Appendix F) to supplement the previous surveys.

10.2 RELEVANT CULTURAL HERITAGE AND ARCHAEOLOGY STANDARDS

The work conducted as part of this study conforms with Performance Standard 8 Cultural Heritage, International Finance Corporation, 2012.

10.3 APPROACH AND METHODOLOGY

Some strategic level consultation was carried out with the Ministry of Heritage and Culture while SEZAD was also consulted as part of the overall survey plan. The Pipeline survey was conducted along an approximately 80km linear transect following the development corridor of the planned Crude Pipeline. An area of roughly 200m on either side of the survey transect was inspected for locations of archaeological and geological significance. Specific landscape features such as terraces and hilltops were also targeted due to their pre-established archaeological sensitivity. There is presently little vegetation and soil cover on the heavily eroded and deflated limestone bedrock of the study area, allowing for high archaeological visibility and a relatively straight driving path along the development corridor. Although most architectural features are in a poor state of repair, typically not preserved more than 20-50cm in height, the high visibility enabled surveyors to spot architectural features and chipped stone debris scatters from a distance of up to 200m away.

Findspots were photographed and recorded on site survey forms (Appendix B); no artefacts were collected. The survey followed the trajectory of the Pipeline and examined from the location of the Tank Farm at Ras Markaz to the Duqm Refinery. To navigate in the field, surveyors used a digital satellite map overlain with the development corridor. A total of 24 archaeological sites and four sites of geological interest were documented. Archaeological sites included lithic workshops, Islamic and pre-Islamic graves, stone walls, and a trilith site. Sites ranged from within 50m of the corridor of impact to more than 400m away. The distance of each site to the development corridor is presented in Table 10-1. The archaeological phase(s) attributed to each lithic scatter site is based on observations of specific technical features on the waste material as well as classification of tool types. This techno- typological approach examines patterns in both the chipped stone debris and completed tool types to assess the period of lithic production.

A tiered ranking system is applied to these archaeological sites, with which to guide future infrastructure development activities. The site rank corresponds with mitigation strategy and is not an indicator of significance.

- **Rank #1** sites are those with extant architectural features (e.g. triliths, walls, graves, cairns). If working in this area, all standing structures should be delineated with survey flags and there should be no access by light vehicles, heavy vehicles, nor bulldozing within 100m.
- **Rank #2** sites are high density stone tool scatters in pristine condition that are conscripted and clearly demarcated across the landscape. These findspots should be delineated with survey flags and there should be no access by heavy vehicle nor bulldozing. Light vehicle access is permissible and no buffer zone is required.

- **Rank #3** sites are low density and/or sprawling lithic scatters whose limits cannot be easily defined. These landscapes should not be bulldozed, although light and heavy vehicle access is permissible.
- **Rank #4** sites are isolated or very low density surface lithic scatters that are of minimal scientific value and will not be impacted by construction activities. Table 9-1 lists all of the archaeological sites discovered during the survey, their distance to the impact zone, and mitigation rank. The map of sites presented in Figure 1 depicts the location of findspots along the survey transect.

10.4 CONSOLIDATED IMPACT ASSESSMENT

10.4.1 Survey Results

The cultural heritage assets identified during survey are shown in Table 10-1.

Table 10-1: Archaeological Sites, Location, Description and Mitigation Rank

SITE #	SITE FEATURES	LAT (N)	LONG (E)	SIZE (SQ M)	DENSITY (ARTIFACTS/SQ M)	TIME PERIOD(S)	MITIGATION RANK	DISTANCE TO IMPACT ZONE (M)
DQM01	Lithics	19.59091	57.56823	100	4-10	Late Pal., Neolithic	3	170
DQM02	Lithics	19.58927	57.56620	60	0-3	non-diag. Holocene	4	360
DQM03	Lithics	19.57980	57.56984	n/a	isolated	Lower Pal.	4	>400
DQM04	Lithics	19.56423	57.56656	?	0-3	non-diag. Holocene	4	>400
DQM05	Lithics	19.55364	57.56948	?	4-10	non-diag. Holocene	3	50
DQM06	Lithics	19.57122	57.56927	n/a	isolated	non-diag. Holocene	4	>400
DQM07	lithics, structures	19.54445	57.57032	?	0-3	Neolithic, Bronze/Iron Age	1	130
DQM08	lithics, hearth, shells	19.54457	57.57009	25	11-50	Neolithic, Bronze/Iron Age	1	130
DQM09	stone cairn(s)	19.51266	57.56126	n/a	n/a	Bronze/Iron Age	1	<50
DQM10	stone cairn(s)	19.51205	57.56125	n/a	n/a	Bronze/Iron Age	1	<50
DQM11	stone cairn(s)	19.49571	57.56743	n/a	n/a	Bronze/Iron Age	1	<50
DQM12	lithics, hearth	19.43329	57.58154	10	0-3	Late Pal.	4	>400
DQM13	lithics	19.32171	57.60125	n/a	isolated	Middle Pal.	4	>400
DQM14	lithics	19.31081	57.60460	n/a	isolated	non-diag. Holocene	4	>400
DQM15	lithics, structures, shells	19.17716	57.74119	?	4-10	non-diag. Holocene	1	<50
DQM16	lithics	19.65763	57.57535	n/a	isolated	non-diag. Holocene	4	>400
DQM17	lithics	19.62802	57.57809	30	11-50	Late Pal., Neolithic	2	<50
DQM18	lithics, Trilith	19.62568	57.57666	40	11-50	Middle Pal., Neo., Iron Age	1	<50
DQM19	lithics	19.62214	57.57257	200	11-50	Late Pal.	2	>400
DQM20	lithics	19.61743	57.57114	20	4-10	Late Pal.	3	>400
DQM21	lithics, structures, grave	19.61471	57.57154	30	4-10	Middle Pal., Neolithic	1	<50

DQM22	lithics	19.61173	57.56966	?	0-3	Lower Pal., non-diag. Holocene	4	>400
DQM23	lithics	19.60331	57.56762	30	4-10	Lower Pal., non-diag. Holocene	3	250
DQM24	lithics, structures, hearths	19.58807	57.57014	30	11-50	non-diag. Holocene	1	<50

A total of 24 archaeological sites were identified, labelled DQM01 to DQM24. The locations of these sites are shown in the Envrionmental Baseline Cultural Heritage Report. Table 10-1 provides the coordinates, description, mitigation rank, and mitigation strategy for each site. Appendix B includes the survey forms upon which individual site data were recorded in the field. Figures 15 to 83 are photographs of the site landscapes and associated artifacts.

Nine of the sites (DQM05, DQM09-11, DQM15, DQM17-DQM18, DQM21, and DQM24) are situated within 100m of the development corridor and require specific action described below. The landscapes around the Port, the worker's camps, and the Refinery have already been so heavily altered by construction activities that traces of potential archaeology have been erased. No mitigation strategy is required within these zones. Although the coordinates are undocumented, archaeological surveyors observed some areas along the northern section of the transect where bulldozers had already excavated the landscape and removed potential archaeological sites prior to survey.

Most archaeological sites mapped during the survey were found in association with naturally occurring conchoidal stone outcrops of chert, flint, quartz, and quartzite. These lithic (stone tool) raw material sources were visited repeatedly throughout multiple phases of prehistory and can be easily identified by the abundant vestiges of chipped stone debris littering the landscape surfaces around the outcrops. The majority of lithic sites were found in the northwestern part of the survey area, where the Pipeline cuts across an undulating Quaternary alluvial plain that is dissected by a series of seaward streaming wadis. Along this actively eroding landscape, a variety of raw materials are present and were utilized for tool production by early humans and other hominid groups since the Lower Palaeolithic.

Three sites (DQM03, DQM22, DQM23) bear evidence for Lower Palaeolithic archaeological remains, including artefacts belonging to a weathered Kombewa flake technology at DQM03 and DQM22, and a weathered handaxe collected at DQM 23 (for coordinates and details see a separate Cultural Heritage Baseline Report). There are fleeting examples of Middle Palaeolithic cores (DQM13, DQM18, DQM21), however, they have no consistent presence at any one site. Most lithic scatters are attributed to the Late Palaeolithic (13,000 - 8,000 bp) and Neolithic (8,000 - 6,000 bp) periods, which are often difficult to distinguish from one another in this region. It is noteworthy that the majority of the archaeological sites around Duqm seem to coincide with a period of improved environmental conditions during the Holocene, which reached peak rainfall between approximately 10,000 and 6,000 bp (e.g., Fleitmann & Matter, 2009; Preston et al., 2015; Engel et al., 2016).

Architectural structures were mapped at sites DQM07-11, DQM15, DQM18, DQM21, and DQM24, including circular stone cairns, stone fireplaces, circular stone houses, large anchor stones (perhaps for tent poles or livestock enclosures), and a trilith feature. With the exception of DQM07 and DQM08, all of these standing structures are located within 100m of the development corridor and require mitigation suggested below in Section 6. While most of these structural features are non-diagnostic of a specific time period, we can surmise that they post-date the Palaeolithic periods and are the remains of human occupation after 8,000 years ago. The stone cairns likely fall between the Bronze and Iron Ages (5,000 - 2,500 bp). The trilith found at DQM18

can be dated to the late Iron Age between approximately 2,500 and 1,500 years ago (Bin 'Aqil & McCorriston 2009).

GEOLOGICAL SITES

Table 10-2: Locations of geological interest

SITE REFERENCE	LAT	LONG	ELEVATION	DESCRIPTION	MITIGATION RANK
	(n)	(e)	(masl)		
DQM-Spring 1	19.67704	57.57364	56	Active artesian spring system	3
DQM-Spring 2	19.65836	57.57570	45	Active artesian spring system	3
DQM-GEO-1	19.59066	57.60314	47	Fossil-rich limestone beds	3
DQM-Salt Spring	19.69313	57.64155	30	Hyperalkaline spring heads	3

There are four locations considered to be of potential geological interest: the fossil outcrops, active hyperalkaline spring heads north of Duqm, and artesian springs on the edge of the escarpment (2). These loci are unique geological features on the landscapes around Duqm. The limestone fossil beds are located east of the Crude Pipeline and stretch for approximately five square kilometres around GPS waypoint DQM-GEO 1. The salt domes in the northeast of the survey area are active spring heads where mineral rich, saline waters emerge from the underlying sediments. The area around the springs has already been heavily disturbed by various construction projects. On the western side of the survey area, at the foot of the limestone plateau, a series of artesian spring systems were observed. While only one findspot (DQM16) has associated artefacts, the available freshwater from springs along the escarpment makes this a zone of archaeological interest for future research.

10.5 MITIGATION AND COMPENSATION

Sites designated as **Mitigation Rank #4** (9) are either isolated surface finds or are of minimal scientific value; therefore, these do not require any special action at this time (DQM02-04, DQM06, DQM12-14, DQM16, DQM22).

Mitigation Rank #3 sites (4), including DQM01, DQM19, DQM20, and DQM23 are lithic findspots more than 100m away from the impact zone. Bulldozing directly on these location should be avoided, but no other action is required.

Mitigation Rank #2 sites (2) include DQM05 and DQM17. These are lithic artefact scatters found in situ, which have scientific value for further study. Bulldozing and driving over these sites should be avoided. Both are located within 50m of the development corridor; therefore, it is recommended that a systematic collection of lithic artefacts should first be taken from these findspot to mitigate the loss of archaeological data. This should be done in conjunction with the Ministry of Culture and Heritage and SEZAD.

Mitigation Rank #1 sites (9) include all of those with stone structures and other standing architectural features: DQM07-DQM11, DQM15, DQM18, DQM21, and DQM24. These features are an indelible part of Oman's heritage landscapes and should be preserved wherever possible. In addition to the trilith architectural feature at DQM 18, there is a clearly delimited lithic scatter associated with it. This diagnostic Iron Age site has considerable value to Oman's heritage. In this case, it is recommended to assess the site further in coordiation with SEZAD and the Ministry of Heritage and Culture along wih a heritage specialist. With the exception of DQM07 and DQM08, all other findspots with structures are within 100m of the development corridor and should be entered into Project mapping and delineated with survey stakes to restrict all access.

Overall, the Duqm Crude Pipeline archaeological survey has documented areas of potential geological interest, lithic surface scatters, and architectural features indicating that this area was intermittently occupied during the Lower Palaeolithic (1.5 million - 300,000 bp), Middle Palaeolithic

(300,000 - 40,000 bp), Late Palaeolithic (13,000 - 8,000 bp), Neolithic (8,000 - 6,000 bp), Bronze (5,000 - 3,500 bp), and Iron Ages (2,500 - 1,500 bp). Some of these sites have value in the development of heritage tourism and for scientific study. Within the Duqm area, SEZAD is the authority on environmental matters. SEZAD have adopted MECA Guidelines for Environmental Impact Assessment, which includes geological assets (including fossils) within the range of resources that are to be assessed. The springs in question are hyper-saline and are therefore not exploitable as water resources and are of less concern or interest to the Directorate of Water Resources in the Ministry of Regional Municipalities and Water Resources. However, around these springs evidence of offerings (clothing, food items) which therefore increase their sensitivity. Sites DQM02-04, DQM06, DQM12-14, DQM16, DQM22 have minimal scientific or heritage value and no action is required. Sites DQM01, DQM19, DQM20, and DQM23 are lithic scatters outside the development area, where bulldozing should be avoided. Sites DQM07-11, DQM15, DQM18, DQM21, and DQM24 have standing architectural features. With the exception of DQM07 and DQM08, which are more than 100m away from the impact zone, these architectural features should be cordoned off with survey flags to avoid disturbance. Sites DQM05 and DQM17 are lithic scatters located within the impact zone. It is recommended that a systematic collection of artefacts be sampled from these sites prior to landscape development. Site DQM18 has both a significant late Iron Age architectural feature and a scientifically important lithic scatter associated with it; it is suggested to assess the site further in coordination with SEZAD and the Ministry of Heritage and Culture along with a heritage specialist.

Table 10-3, below, provides a list of each site along with rank and proposed mitigation strategy which will be added to DRPIC's ESMP.

Table 10-3: Site ID, including rank and proposed mitigation strategy (overleaf)

SITE #	SITE FEATURES	LAT (N)	LONG (E)	ELEVATION (MASL)	SIZE (SQ M)	DENSITY (ARTIFACTS / SQ M)	TIME PERIOD (S)	MITIGATION RANK	DISTANCE TO DEVELOPMENT CORRIDOR (M)	MITIGATION STRATEGY
DQM01	lithics	19.59091	57.56823	82	100	4-10	Late Pal., Neolithic	3	170	avoid bulldozing
DQM02	lithics	19.58927	57.56620	74	60	0-3	non-diag. Holocene	4	360	no action required
DQM03	lithics	19.57980	57.56984	70	n/a	isolated	Lower Pal.	4	>400	no action required
DQM04	lithics	19.56423	57.56656	78	?	0-3	non-diag. Holocene	4	>400	no action required
DQM05	lithics	19.55364	57.56948	93	?	4-10	non-diag. Holocene	3	50	systematic artefact collection
DQM06	lithics	19.57122	57.56927	78	n/a	isolated	non-diag. Holocene	4	>400	no action required
DQM07	lithics, structures	19.54445	57.57032	87	?	0-3	Neolithic, Bronze/Iron Age	1	130	structures cordoned off
DQM08	lithics, hearth, shells	19.54457	57.57009	86	25	11-50	Neolithic, Bronze/Iron Age	1	130	structures cordoned off
DQM09	stone cairn(s)	19.51266	57.56126	93	n/a	n/a	Bronze/Iron Age	1	>50	structures cordoned off
DQM10	stone cairn(s)	19.51205	57.56125	87	n/a	n/a	Bronze/Iron Age	1	>50	structures cordoned off
DQM11	stone cairn(s)	19.49571	57.56743	107	n/a	n/a	Bronze/Iron Age	1	>50	structures cordoned off
DQM12	lithics, hearth	19.43329	57.58154	103	10	0-3	Late Pal.	4	<400	No action required
DQM13	lithics	19.32171	57.60125	99	n/a	isolated	Middle Pal.	4	<400	No action required
DQM14	lithics	19.31081	57.60460	88	n/a	isolated	non-diag. Holocene	4	<400	No action required
DQM15	lithics, structures, shells	19.17716	57.74119	96	?	4-10	non-diag. Holocene	1	<50	structures cordoned off
DQM16	lithics	19.65763	57.57535	34	n/a	Isolated	non-diag. Holocene	4	>400	No action required
DQM17	lithics	19.62802	57.57809	59	30	11-50	Late Pal., Neolithic	2	<50	systematic artefact collection
DQM18	lithics, Trilith	19.62568	57.57666	57	40	11-50	Middle Pal., Neo., Iron Age	1	<50	assess further with design details
DQM19	lithics	19.62214	57.57257	62	200	11-50	Late Pal.	2	>400	systematic artefact collection
DQM20	lithics	19.61743	57.57114	66	20	4-10	Late Pal.	3	>400	avoid bulldozing
DQM21	lithics, structures, grave	19.61471	57.57154	65	30	4-10	Middle Pal., Neolithic	1	<50	structures cordoned off
DQM22	lithics	19.61173	57.56966	64	?	0-3	Lower Pal., non-diag. Holocene	4	>400	No action required
DQM23	lithics	19.60331	57.56762	70	30	4-10	Lower Pal., non-diag. Holocene	3	250	avoid bulldozing
DQM24	lithics, structures, hearths	19.58807	57.57014	68	30	11-50	non-diag. Holocene	1	<50	structures cordoned off

11 COMBINED IMPACTS ASSESSMENT AND MITIGATION

11.1 INTRODUCTION

The Duqm Refinery Project, which is the subject of this Consolidated Impact Assessment and Mitigation Report, will involve the transition of crude oil from import via a SPM at Ras Markaz, transport – via Crude Pipeline – to the Duqm Refinery for processing, then transportation of refined products for export through the Export Terminal at the Port of Duqm.

Implementation of the Project will expand and improve the petroleum refining and petrochemical base in the country to meet domestic demand and increase the export of petroleum products and petrochemicals. The Project will assist in propelling Duqm towards being Oman's next industrial centre while being the first significant complex industrial project to be developed within the Duqm SEZ, a specially designated zone for industrialisation and economic development.

11.2 SUMMARY OF IMPACTS AND MITIGATION

A summary of the key impact findings and mitigation measures identified for the construction and operation phases of the Project is presented in Table 11-1. Many of the mitigation measures suggested during the construction phase of the Project are associated with good construction practices and have been employed on similar projects in this region, and indeed globally. These mitigation measures have been captured in the DRPIC ESMP for use by the EPC Contractors (see also Section 11.3).

Based on the impact assessment and mitigation presented in Sections 5 to 10 of this Report, a consolidated impact assessment and mitigation summary is presentation in table format for the Duqm Refinery Project (Table 11-1).

Table 11-1: Site ID, including Rank and Proposed Mitigation Strategy

RECEPTOR	PHASE OF THE PROJECT	KEY IMPACTS	MITIGATION MEASURES
Air Quality			
Temporary individual receptors within 350m of activity (<100); residential properties along construction traffic routes	**Construction**	Elevated particulate matter: contribution of $PM_{2.5}$ and PM_{10} during earthworks, general construction activity (e.g. piling, installation, camps, vehicle movements) and trackout (i.e.dust/mud from haulage vehicles)	Site management: keep records of complaint, causes and solutions; adequate sized facilities for construction including storage and laydown to reduce vehicle movements; training of construction staff to raise awareness of need to minimise emissions; and cleanliness of site perimeter and fences.
			Site planning: consideration of dust generating potential of materials to be excavated prior to commencing workds; periodic audits to trace problems and ensure solutions made.
			Construction traffic: Loads to be covered, hardstanding exits, trackout pads, plates or wheel washing facilities; install hardsurfacing as soon as possible; speed control for dust suppression; and covering of spoil loads.
			Site activities: minimising dust generating activities nerar residential receptors during prolonged dry/dusty weather conditions; sand and aggregates' storage, and concrete batching to be away from receptors and screen shielded; dusty materials to be removed from site as soon as practicable; and water sprayed on dust-prine garded roads and work sites.
	Operation	Emissions from additional activities associated with other developments and industries in the area surrounding the refinery are likely to result in emissions of pollutants thereby degrading local air quality. Any risk of exceedance of air quality standards as a result of cumulative impacts would be likely to be from the addition of a significant emission source of NO_2 and PM in the area, such as other industrial activities in the area. In addition, road and sea traffic at the existing and proposed infrastructure would contribute to air pollutants and an increased risk of exceedances of air quality standards. Cumulative impacts resulting from elevated NO_2 are unlikely to occur as the only significant additional industrial emission source in the immediate area of the refinery is the renewal of the desalination plant power station. However, as this renewal is not anticipated as worsening emissions from the desalination plant power to any great extent, therefore renewal of the desalination plant power station is not could not be considered a significant NO_2 emission source. Cumulative impacts from additional PM sources are likely however, in part due to the site characteristics and the abundant natural source of PM, resulting in frequent incidence of elevated ambient PM concentrations. Specific sources of PM also include re-entrainment of PM from the movements of road vehicles, and emissions from extensive construction activities' anticipated in the very near future.	**Mitigation measures considered during the design stage:** NO_X reduction measures such as Low NOX and ultra-low NO_x burners for NO_X control in flue gases from various process units, air preheating in the heaters to maximise efficiency; Firing fuel gas with only low sulphur content for controlling SO_2 emissions; monitoring the amount of O_2 in flue gas for controlling CO emissions; vacuum system and filter are used during loading to prevent dust/fines from spent catalyst; hydrogen stripping of catalyst to reduce carbon and H_2S release Adequate stack heights to be provided according to requirements of MD 118/2004 and good engineering practices for stationary point sources to be followed to ensure effective dispersion of the pollutants (with exceptions obtained from MECA); Adequate sampling ports, platforms and facilities required for flue gas sampling to be provided at all the stacks; Continuous Emission Monitors (CEMs) to be installed for monitoring critical pollutants such as NO_X, CO, SO_2, and PM10 at the stacks; A suitable leak and gas detection system to be provided to enable immediate response to accidental releases of flammable and toxic gases / vapours. Detection of gases in excess of acceptable levels by the gas detectors can be followed by fault repair/ maintenance programmes; and The design of the bulk storage tanks for liquid materials and fuel to consider the requirements for controls such as submerged loading facilities, conservation vents, floating roofs, etc., in order to reduce fugitive emissions. **Mitigation measures considered during the operation and maintenance stage:** Periodic maintenance of combustion units is to be carried out in order to ensure efficient operation and to reduce emission levels; Periodic inspection, maintenance and calibration of the CEMs to be carried out in order to ensure accurate measurements of pollutant concentrations; The operating parameters critical to ensuring efficient combustion such as air to fuel ratio, temperature, etc., of heaters, GT and steam boilers are to be constantly monitored in order to ensure efficient operation and to reduce emission levels of pollutants; and Periodic inspection, integrity checks and maintenance of major piping, equipment, fittings such as valves, flanges, etc., storage tanks (seals, tank shell and roof) and vapour recovery systems are to be scheduled and conducted to ensure reliability and to minimise leaks and fugitive emissions. To establish a Leak Detection and Repair (LDAR) program-
Noise			
Off-site receptors	**Construction**	Construction of the Crude Pipeline is expected to result in the highest noise impact at off-site receptors, specifically as the Pipeline construction passes by Dhahr village at around 750m proximity. Rock drilling plant constitutes the largest proportion of the noise emissions estimated during these works. The potential requirement for blasting is not certain at this stage, but may be necessary to remove rock in some areas of the Crude Pipeline construction. Due to the impulsive and highly sporadic nature of blasting activities, the main concerns comprise vibration and air overpressure (airborne shock wave) damaging buildings or causing disturbance.	Prioritisation given to selection of low-noise equipment, especially for noisy activity such as piling, and rock removal and processing.
			Use available silencers on vehicle exhausts, and noise reduction devices on machinery and heavy equipment.
			Maintain all equipment in accordance with manufacturer's instructions.
			Acoustic enclosures for diesel generator units in accordance with manufacturers' recommendations.
			Operational management to avoid unnecessary use of equipment (e.g. idling engines) or engine revving.
			Maintain haul routes and minimise gradients to reduce noise from vehicle engines.
			Scheduling of noisier activities during least sensitive periods of the daytime and avoidance of high noise activities (e.g. piling, dredging and rock processing) at night.
			Limit blasting activities to the daytime and specify charge sizes to ensure adherence with 'maximum satisfactory magnitudes of vibration' in accordance with BS 6472-2:2008.

RECEPTOR	PHASE OF THE PROJECT	KEY IMPACTS	MITIGATION MEASURES
			Localised noise barriers or enclosures – efficient use where possible (and necessary) of site spoilage to erect temporary earthen bunds to screen noisy areas.
			Inform nearby communities at least one day in advance of any planned blasting activity that may be audible, including anticipated times and durations.
	Operation	Operational noise is expected to meet the industrial noise limits set out in MD 79/94 at all receptors for all periods.	No further mitigation has been considered.
On-site receptors	**Construction**	Operation of some equipment may give rise to worker exposure to sound pressure levels higher than 85 dB LAeq,T. Exposure to maximum noise levels exceeding 110 dB LAFmax may occur.	Prioritise low-noise equipment, especially for high-noise generating processes.
			Examine available control options for specific plant and processes expected to generate high levels of noise/vibrations.
			Specify and supply appropriately-rated hearing protection and vibration control PPE to ensure adherence with IFC noise action thresholds and vibration TLVs.
	Operation	There are areas within the Refinery complex where predicted noise levels are higher than the IFC Guidelines action threshold of 85 dB LAeq,8h.	Examine options available from equipment suppliers to reduce noise at source
			Hearing protection devices must be supplied to all workers operating in the affected areas.
			Visible signage erected to instruct and inform employees of mandatory hearing protection zones (i.e. 'Noise Hazard Areas').
Landscape			
CA2: Low lying Alluvium Plains	**Construction**	Duqm Refinery (Project Facility) - Moderate negative.	Minimising the massing of buildings and structures would help ameliorate the effect, where post-FEED design allows.
Visual intrusion			Selection of sensitive colours and colour schemes for cladding, paint and structures etc. above ground. Minimise lighting levels and coverage and duration of use.
			Minimise reflective materials.
			Include landscaping appropriate to climatic conditions.
LCA2 : Low lying Alluvium Plains		Overall Ras Markaz Crude Oil Storage Terminal (AF) – Moderate negative.	Sensitive colours and colouring used in all third party tank and facilities.
LCA5: Limestone/Dolomite Coastal Cliffs			Encourage OTTCO to minimise lighting levels (e.g. downward-pointing) and duration of use (in line with 'need').
Visual intrusion			Minimise the use of reflective materials.
			Include landscaping appropriate to climatic conditions.
LCA2 : Low lying Alluvium Plains		8 Tanks for DRPIC at Ras Markaz Crude Oil Storage Terminal (Project Facility) – Minor negative.	Reduce construction area physical footprint to minimum required.
			Locate taller structures and store large plant/equipment to the furthermost point west away from cliff edge.
LCA5: Limestone/Dolomite Coastal Cliffs			Break up massing of buildings and structures, where flexibility in design allows.
			Selection of colours and colouring for tank walls.
			Minimise lighting levels and duration of use.
Visual intrusion			Minimise the use of reflective materials.
			Include landscaping appropriate to climatic conditions.
LCA 1: Beach and Dunes		Topside, Duqm Export Terminal (Project Facility) – Moderate negative.	Selection of sensitive colours and colour schemes for cladding, paint and structures etc. above ground.
Visual intrusion			Minimise lighting levels and duration of use.
			Minimise the use of reflective materials
LCA 1: Beach and Dunes		Overall Duqm Export Terminal, incl. marine works (AF) – Moderate negative.	Minimise lighting levels and duration of use.
LCA2: Low lying Alluvium Plains			Minimise the use of reflective materials
Visual intrusion			
LCA2: Low lying Alluvium Plains		Crude Pipeline (Project Facility) – Moderate negative.	-
Visual intrusion			-
CA2: Low lying Alluvium Plains	**Operation**	Duqm Refinery (Project Facility) - Moderate negative.	Minimising the massing of buildings and structures would help ameliorate the effect, where post-FEED design allows.
			Selection of sensitive colours and colour schemes for cladding, paint and structures etc. above ground. Minimise lighting levels and coverage and duration of use.
Visual intrusion			Minimise reflective materials.

Receptor	Phase of the Project	Key Impacts	Mitigation Measures
	Construction		Include landscaping appropriate to climatic conditions.
LCA2 : Low lying Alluvium Plains		Overall Ras Markaz Crude Oil Storage Terminal (AF) – Moderate negative.	Sensitive colours and colouring used in all third party tank and facilities.
LCA5: Limestone/Dolomite Coastal Cliffs			Encourage OTTCO to minimise lighting levels (e.g. downward-pointing) and duration of use (in line with 'need').
Visual intrusion			Minimise the use of reflective materials.
			Include landscaping appropriate to climatic conditions.
LCA2 : Low lying Alluvium Plains		8 Tanks for DRPIC at Ras Markaz Crude Oil Storage Terminal (Project Facility) – Minor negative.	Reduce construction area physical footprint to minimum required.
			Locate taller structures and store large plant/equipment to the furthermost point west away from cliff edge.
LCA5: Limestone/Dolomite Coastal Cliffs			Break up massing of buildings and structures, where flexibility in design allows.
			Selection of colours and colouring for tank walls.
			Minimise lighting levels and duration of use.
Visual intrusion			Minimise the use of reflective materials.
			Include landscaping appropriate to climatic conditions.
LCA 1: Beach and Dunes		Topside, Duqm Export Terminal (Project Facility) – Moderate negative.	Selection of sensitive colours and colour schemes for cladding, paint and structures etc. above ground.
Visual intrusion			Minimise lighting levels and duration of use.
			Minimise the use of reflective materials.
LCA 1: Beach and Dunes		Overall Duqm Export Terminal, incl. marine works (AF) – Moderate negative.	Minimise lighting levels and duration of use.
LCA2: Low lying Alluvium Plains			Minimise the use of reflective materials.
Visual intrusion			
LCA2: Low lying Alluvium Plains		Crude Pipeline (Project Facility) – Moderate negative.	-
Visual intrusion			-
Biodiversity			
Biodiversity - Project			-
Duqm IBA		No construction effects anticipated – significant impact associated with Export Terminal construction which is an AF.	No further mitigation has been considered.
Jidat al Harrasis IBA		Slight negative adverse impact resulting from minor habitat loss.	Habitat enhancements (e.g. provision of artificial water holes for species such as sand grouse).
			Provision of visitor facilities.
			Provision of Awareness materials for visitors and schools.
			The mitigation measures should be planned in consultation with other stakeholders such as SEZAD and other developers with footprints within the IBA boundary.
Duqm SEZ Nature Reserve		Slight adverse impact resulting from minor habitat loss and construction dust.	Minimise footprint and strictly control certain dust generating activities (e.g. tracking of vehicles) close to the reserve.
			Habitat enhancements (e.g. protection of area from livestock to allow vegetation to recover).
Al Wusta Wildlife Reserve		No construction effects anticipated, as distant from Project Footprint.	No further mitigation has been considered.
Wadis in close association with mountains & Wadis in open terrain		Large adverse impact resulting from habitat loss during pipeline (Project) and Construction Camp (AF) construction.	Minimise footprint a wadi crossings.
			Reinstate wadi crossings to ensure natural passage of seasonal flood flows.
			Compensatory landscape planting using native/endemic tree species.
Rocky mountain & escarpment		Slight adverse impact resulting from minor habitat loss.	No further mitigation has been considered.
Shallow coastal habitats 0-20 m		No construction effects anticipated –impact associated with Export Terminal construction which is an AF.	No further mitigation has been considered.
Endangered, endemic plant species		Large adverse impact owing to species rarity and potential habitat loss.	Preconstruction survey of instances where critical habitat intersects the Project Footprint (see Project Biodiversity Assessment Technical Appendix C: CHA for an inventory).

RECEPTOR	PHASE OF THE PROJECT	KEY IMPACTS	MITIGATION MEASURES
			Translocate affected populations of endemic plant species for propagation and eventual use in introduction schemes in the SEZAD area.
			Contribution toward native plant propagation and introduction scheme.
Green, Loggerhead and Hawksbill Turtles		Slight adverse resulting from construction lighting and disturbance from personnel and vehicles.	Strictly observer 0.3 km set back area between Refinery and beach.
			Beach monitoring opposite to Project Footprint to identify potential nesting by turtles.
			Use lighting design and screening to protect beaches from light spill.
			Restrictions on use of beaches by construction personnel.
Natural Habitat		See entries for habitats which are considered IEFs in this table. Other habitats are stated in the baseline but are not brought forward to the impact assessment or mitigation section because they are suitably commonplace and widespread not be considered susceptible to significant impacts from the Project.	Measures to address IFC PS6 no net loss requirement are presented in Technical Appendix E: Biodiversity Offsetting Framework. DRPIC should consider the recommendations in Technical Appendix E including developed of metric to assess permanent damage/loss of natural habitat.
Critical Habitat (Endemic plant species)		See entry for Endangered, endemic plant species (Salsola, Ochradenus) See assessment of species triggering critical habitat in Technical Appendix C: CHA.	See mitigation recommendations for Endangered, endemic plant species (Salsola, Ochradenus) in this table. DRPIC should consider the recommendations in Technical Appendix E including developed of metric to work toward net gain for terrestrial critical habitat species.
Biodiversity - Strategic			
Duqm IBA (Very High)	**Construction**	Major adverse – arising from habitat loss and disturbance from Export Terminal construction which is an AF.	Enhancement of the remaining area of the IBA (construction of channels, clean-up of litter, provision of visitor facilities)
			Onsite creation of constructed wetland using dredging spoil
			Offsite creation of constructed wetland using dredging spoil.
Wadis in close association with mountains & Wadis in open terrain (High)		Large adverse impact resulting from habitat loss during pipeline (Project) and Construction Camp (AF) construction.	As per Project mitigation.
Arabian Sea Humpback Whale (ASHW) (Very High)		Large adverse – ship strikes, underwater noise and changes in prey distribution and abundance arising from disturbance and dispersion of sediments during dredging.	Mitigation bridges the operational and construction phases - see measures in operational phase mitigation Table 7.4.
Indian Ocean humpback dolphin (High)		Minor adverse – as per ASHW but species less likely to be present in disturbed areas.	As per ASHW.
Biodiversity - Project			
Duqm IBA (Very High)	**Operation**	Large adverse – disturbance of birds arising from sporadic disturbance arising from vehicles, personnel and maintenance operations at the Export Terminal.	Ensuring staff only use designated walk ways which are screened from bird habitat.
			Using ‘soft start’ protocols for maintenance operations involving loud, percussive noise and vibration impacts.
			Use of screens to provide a visual barrier between operational areas and bird feeding and roosting areas.
			Provision of designated recreation areas which birds are able to habituate to the presence of people in.
			Include bird conservation issues in the site induction delivered to all staff.
			Regular monitoring of bird use of the IBA by a competent ornithologist in migration and wintering bird seaons to inform adaptive measures to address sources of noise, vibration or other activities which are known to disturb birds.
			Litter monitoring and conduct regular clean-ups of the operational area to prevent bird entanglement and injury.
Mountain areas and escarpment (High)		Large adverse – changes in air quality resulting from air emissions from the Refinery leading to polluted precipitation affecting plant and lichen communities.	Dispersion modelling to define the extent of the area of mountain and escarpment habitat potentially affected by pollution.
			Mitigation at source including use of scrubber technologies.
Wide ranging species such as large carnivores, gazelle and ibex		Minor adverse - Large carnivores, gazelle and ibex rely on such a large proportion of the landscape they are sensitive to a range of ‘urbanising effects’ which may occur during the operational phase of the Project.	See Strategic Mitigation.
Green, Loggerhead and Hawksbill		Slight adverse resulting from operational lighting and disturbance from personnel and vehicles.	Strictly observer 0.3 km set back area between Refinery and beach.

Receptor	Phase of the Project	Key Impacts	Mitigation Measures
Turtles (High)			Beach monitoring opposite to Project Footprint to identify potential nesting by turtles.
			Use lighting design and screening to protect beaches from light spill.
			Restrictions on use of beaches by construction personnel.
All Terrestrial IEFs (Up to High for endemic plant species)		Very Large Adverse – toxic contamination of fauna, flora and ground water resulting from accidental oil spill from the DRPIC Crude Pipeline.	DRPIC should produce and develop an oil spill response plan identifying the most sensitive biodiversity areas.
			DRPIC should evaluate contribution to further ecological research to and analyse potential oil spill scenarios to devise detailed oil response strategies.
Biodiversity – Strategic			
Shallow coastal waters (Medium)		Major adverse - invasive species introduction from shipping and impingement/entrainment of fish or marine macro invertebrates from water intake systems.	DRPIC should seek assurance from its supply chain and conduct regular audits to ensure environmentally benign anti-fouling technologies are being adopted at water intake/output points and that measures are in place to minimise entrainment/impingement of marine fauna.
			DRPIC should seek assurance from PDC and it supply to verify that stringent environmental controls are in place to address invasive species introduction.
Wide ranging species such as large carnivores, gazelle and ibex		Large adverse – cumulative effect of Project in combination with AFs leading to increased effect magnitude and impact significance.	Measures to be secured via Strategic Initiative Approach.
			DRPIC should contribute to an integrated biodiversity action plan working collaboratively with SEZAD and other tenants in the industrial area. An initial focus of the intergrated biodiversity action plan should be to obtain more accurate distribution, abundance and movement data for target species to inform mitigation planning.
			DRPIC should seek assurance from SEZAD that the integrated biodiversity management plan incorporates measures to avoid development in wadis and flood prone areas; protection of movement routes of large mammals; and protection of suitable forage, browse and cover.
Cetaceans including ASHW (Very High) and Indian Ocean humpback dolphin (High)	**Operation**	Up to large adverse – mortality or injury arising from collisions with ships and disturbance caused by marine noise and vibration.	Formation of an 'advisory panel' that guides mitigation and monitoring through linking industry together government, conservation and research interests.
			DRPIC should request assurance and conduct regular audits of mitigation strategies implemented by OTTO, PDA and supply chain shipping to address potential indirect disturbance and shipping collisions associated with marine facilities in relation to the Ras Markaz Single Point Mooring facility; and the Product Export Terminal. This should include seeking assurance that available technologies are fitting to ships to minimise acoustic disturbance (e.g. low noise vessel technology engine mountings and low cavitation props).
			DRPIC should work within the Strategic Initiative to implement a code of conduct for avoidance of marine mammal and turtle collisions and minimum safety standards relating to pollution for all vessels importing and exporting oil products to/from the Refinery.
			Through a Strategic Initiative DRPIC should consider contributing to the cost of appointing competent cetacean observers on vessels to alert pilots to the presence of cetaceans. A real-time alert monitoring system could also be developed to alert shipping operators to cetacean presence in shipping lanes to enable reactive avoidance measures to be taken.
			The Strategic Initiative including SEZAD, Omani Government bodies and industrial bodies should produce and publish an oil spill response plan identifying the most sensitive biodiversity areas.
			DRPIC should contribute to primary research and management of cetacean distribution and ecology; monitoring of marine pollution; and assessment of marine acoustic disturbance to inform dynamic management of cetacean populations.
			The Strategic Initiative including SEZAD, Omani Government bodies and industrial bodies should produce and publish an oil spill response plan identifying the most sensitive biodiversity areas.
			The Strategic Initiative, SEZAD and Omani Government bodies should work towards implementation of an offsetting approach to address cumulative impacts on marine species (see Project Biodiversity Assessment - Technical Appendix E: Biodiversity Offsetting Framework). Such an approach could be linked to a government lead region-wide/Gulf of Masirah wide zoning strategy with designated zones where different activities are prohibited or permitted. Implementation of an offsetting strategy may also offer a potential source of funding for conservation measures and would also provide a strategic framework to provide assurance to potential project funders (particularly those requiring compliance with IFC PS6) as implementation of the Duqm Special Economic Zone masterplan is progressed.
Green, Loggerhead and Hawksbill Turtles (Very High)		Slight adverse resulting from collisions with ships or entrainment in water intake systems.	Measures as per cetaceans.
			DRPIC should seek assurance from AF operators that turtle exclusion devices are fitted to water intake points to prevent turtle entrainment and that

RECEPTOR	PHASE OF THE PROJECT	KEY IMPACTS	MITIGATION MEASURES
			i) Strictly observe 0.3 km set back area between Refinery and beach. ii) There are notable other large development in the area (i.e. Marafiq), however a lighting strtagey for the refinery is yet to be confirmed, Therefore WSP recommends light monitoring of the beach opposite to Project Footprint to ensure minimal light spill/unilluminated pre-construction baseline conditons persist. iii) Use lighting design and screening to protect beaches from light spill.
All Marine IEFs (Up to Very High for ASHW)		Very Large Adverse – toxic contamination of fauna, flora and ground water resulting from accidental oil spill from the DRPIC Crude Oil Pipeline.	DRPIC should seek assurance and conduct regular audits throughout its supply chain to ensure that an adequate oil spill response plan is in place and that suitable and sufficient preventative measures are in place to prevent an oil spill. The Strategic Initiative including SEZAD, Omani Government bodies and industrial bodies should produce and publish an oil spill response plan identifying the most sensitive biodiversity areas. As part of a consortium of oil producers, transporters, refiners and Government sponsors, DRPIC should contribute to further research to and analyse potential oil spill scenarios to devise detailed oil response strategies. Industry wide support for further research into turtle and cetacean habitat use, movement pathways and distribution is also important to best design oil spill response planning.
Species triggering critical habitat: ASHW, Indian Ocean humpback dolphin and three species of turtle IFC PS6 requires the offset target of net gain to be met for all species triggering critical habitat.		See entry for cetaceans including ASHW and Indian Ocean humpback dolphin and green, Loggerhead and Hawksbill turtles in this table. See assessment of species triggering critical habitat in Technical Appendix C: CHA.	See mitigation measures for cetaceans and turtles in this table. DRPIC should consider the recommendations in Technical Appendix E to work toward net gain for marine critical habitat species.
Biodiversity – Additional Construction Mitgation Measures			
Biodiversity – Natural Habitat, Terrestrial Ecology and Marine Ecology	**Construction**	-	A ecological constraints plan will be prepared or added to Project mapping (e.g. pipeline alignment sheets) to guide all contractor staff on sensitive habitat and species features. This should reference all potential areas of critical habitat identified in Biodiversity Assessment – Technical Appendix C: Critical Habitat Assessment. It should also indicate key wildlife movement corridors such as wadis bisecting the Project Footprint. The constrains plan should include species, habitats and designated sites which are most sensitive to disturbance (e.g. coastal bird communities in Duqm Important Bird Area; turtle nesting beaches). It should include an assessment of IEFs in relation to oil spill risk and sensitivity; Site fencing will be established to prevent access to areas outside working areas, particularly in areas adjacent to features of interest/value. Fencing must be designed to so as not to obstruct the transit of mammal species (unless that is the intent); Briefings and instruction will be given to contractors regarding the biodiversity issues; A ecological constraints plan will be prepared or added to Project mapping (e.g. pipeline alignment sheets) to guide all contractor staff on sensitive habitat and species features; Best practice construction methodologies will be followed throughout and regular audits will be carried out to ensure compliance; Pollution prevention measures will be followed to prevent toxic or non-toxic pollution of water courses by silt or chemicals, spills in the marine environment etc. for Project components, via the Project ESMP; Measures to account for accidental transgression from access tracks by construction vehicles and for unofficial use of access tracks by members of the public should be addressed by closing off and securing access tracks when not in non-operational use; Implement measures to control the introduction and spread of alien invasive species as outlined in separate Biodiversity Assessment Report, Technical Appendix D: Invasive Alien Species assessment; Prohibition of fishing or hunting of wildlife by construction or operational personnel; Appointment of a suitably qualified environmental/ecological personnel to ensure the ecological protection mitigation measures are implemented; Implementation of waste management principles; Dust generation by vehicles during construction phases may smother natural vegetation. This affect was noted in the direct vicinity of third party construction activities around the Port of Duqm. Seawater could be used to

Receptor	Phase of the Project	Key Impacts	Mitigation Measures
			supress dust from Project construction sites particularly since it develops a hardcore-like crust. However, it also introduces salt to areas with otherwise low salinity. Use of sea water for dust suppression should only be done in sabkha areas (i.e. in the coastal zone near the Refinery) during construction, and later if not tarmac-surfaced. Dust suppression using water should be mindful of the need to conserve water and that use of water as a suppressant may inadvertently change natural vegetation communities which may not always be desirable. The need for dust suppression should be focused on areas most likely to support endemic plant species as informed by pre-construction survey information; and Close off and secure construction access tracks to prevent unofficial ingression into the desert environment by non-Project related persons/vehicle traffic.
Socio-Economics and Health			
Employment and Economy	**Construction**	An increase in employment opportunities and demand for goods and services are considered a major positive impact. This impact is long-term because it will occur during the construction phase which will last for an estimated 3.5 years. It is estimated that approximately 20,000 workers will be involved (at peak times). The Project will provide employment opportunities for the wider SEZAD area.	DRPIC has developed an In-Country Value strategy which defines measures which EPC contractors and their subcontractors will be expected to take to facilitate local recruitment and procurement / encouragement of local suppliers to provide their services and goods. This plan suggests targets relating to local content so that the performance of those in the supply chain can be tracked and evaluated by DRPIC.
			EPC Contractors will inform local businesses of contracting opportunities in a timely manner.
			DRPIC's Community Relations and CSR Strategies detailing contributions to local employment, training of young local specialists and any other CSR initiatives.
			Grievance Mechanism – DRPIC to ensure that EPC contractors are aware of the grievance submittal process .
			Prior to construction and as part of EPC, create and populate a database of all suitable local service providers to encourage more opportunities for local businesses.
			DRPIC has developed a Worker Influx Management Plan which defines labour practices in line with national and international standards that will need to be applied by EPC Contractors and their subcontractors, as well as in the Project's supply chain. The Worker Influx Management Plan is aligned with DRPIC's Grievance Procedure to ensure that the procedure is consistently implemented across all Project activities.
Community Health		With over 20,000 workers during construction (at peak times), there is potential for the workforce to introduce and/or increase the rate of spread of communicable diseases in the Project area. The Project is also likely to result in in-migration. Similar to the workforce, there is potential for in-migration to introduce and increase the rate of spread of communicable diseases in the Project area. The impact is long-term because if diseases are untreated the impact could be long-lasting and is considered to be moderate negative.	Implementation of CESMP procedures include an Environmental Monitoring Plan (e,g, air emissions, dust) to monitor potential changes to ambient air quality.
			Early notification of local authorities and Walis on critical or exceptionally busy construction periods and air-polluting/dust- and noise-generating activities.
			Dust suppression by water spraying in dry seasons, particularly in the areas close to sensitive residential and community receptors (i.e: Wadi Al Khaban (which is the nearest to the refinery site), Wadi Qadih, Wadi Dhanjart, Wadi Ad Dishayshah, Wadi Say).
			As part induction process for new employees and workers, the EPC contractors will provide training for all workers on the transmission routes and common symptoms of communicable diseases. This training will be supported by the ongoing awareness campaign (posters located in common areas within the camp). These measures can help reduce the potential for workers to unknowingly transmit communicable diseases.
			Additionally, EPC Contractor will provide suitable medical facilities within the workers camps and will be managed by EPC contractors. Such facilities will be expected to provide both routine medical care and emergency medical services suitable for a large construction site with a peak labour force of approximately 20,000 in total. As a minimum, EPC Contractor will ensure that such facilities offer professional medical staff/nurse, pharmacy and medical equipment necessary to respond to, and dealing with, critical medical emergencies.
			The DRPIC Community Health and Safety Plan provides clauses for a Workforce Code of Conduct including measures that target anti-social behaviour.
			Contractors' compliance with national HSE legislation and DRPIC HSE Policies, evaluate contractors' HSE performance.
			Implementation of the DRPIC's Health and Safety, Environmental and Social and Security Policies Policy and Worker Influx Management Plan.

RECEPTOR	PHASE OF THE PROJECT	KEY IMPACTS	MITIGATION MEASURES
			Provide DRPIC HSE Policies and Procedures to all subcontractors during formal induction, including the security firms.
Community Safety and Security		Given that 20,000 migrant workers need to be transported to and from the sites (daily), this aspect is likely to cause an increase in traffic accidents or incidents There are often safety issues with the establishment of new infrastructure – for example, community members interacting with unsecured equipment There are a number of Project activities that will generate hazardous waste – e.g. chemical cleaning of equipment during the pre-commissioning process Potential safety and security risks in the local area is considered to create a minor negative impact.	Traffic Management Plans shall be prepared by EPC Contractors during construction will further minimise the potential risk of accidents, injuries and near misses. Traffic management during eventual operations will fall under the responsibility of DRPIC.
			Provide DRPIC's HSE and Worker Management Plans to all subcontractors during formal induction, including the security firms.
			Ensure that a Project Code of Conduct and appropriate training for security personnel are implemented to ensure best practice in running a secure site and implementing the Code of Conduct that fosters behaviours that help to avoid, eliminate or minimise the use of excessive force in potential conflict situation.
			DRPIC's HSSES Plan and CESMP is implemented by all EPC Contractors and is regularly audited by DRPIC through the HSSE Assurance Plan.
			Contractors' compliance with national HSE legislation and DRPIC HSE Policies and evaluation of contractors' HSE performance.
			Stakeholder Engagement Plan (SEP) implementation with regards to keeping a regular dialogue with local communities
Environmental Emissions		Noise emissions can result from a variety of onsite civil works activities Vibration emissions may result from construction activities Dust emissions, which can be generated through site grading and driving on dry, dusty and dirty roads. This can impact the surrounding air quality, disrupting the amenity value of an area and potentially impacting community health. These identified sources are considered to result in a moderate negative impact.	Mitigation measures for these impacts have been proposed in the Environmental and Social Management Plan.
Community Infrastructure and Services		Potential strain, congestion, and wear and tear for roads and strain on medical facilities in the local area will present a moderate negative impact.	To mitigate road congestion and wear and tear, avoiding driving during peak hours where possible.
			To mitigate road congestion and wear and tear, Project Drivers to avoid driving at speeds exceeding 50 m/h to prevent contributing to roads damage.
			To mitigate road congestion and wear and tear, develop and implement a traffic management plan to minimise the impact experienced by road users as a result of the Project.
			EPC Contractors to provide appropriate amenities at the worker camps (i.e. launderette, cinema and gym facilities, etc) to reduce the need for workers to use local infrastructure and services.
			Implement the existing DRPIC HSSES Plan to minimise worker illnesses and injuries as possible; and ensure appropriate and adequate health care services are provided on site and at workers camps to address/ manage worker illnesses and injuries.
			As part of stakeholder engagement activities (detailed in DRPIC Stakeholder Engagement Plan) DRPIC will engage with local stakeholders (e.g. village representatives, government) so that there is a comprehensive response to mitigate in-migration.
Employment and Economy		An increase in employment opportunities and demand for goods and services are considered a moderate positive. This impact is long-term, acting over the duaration of the Project and will provide employment opportunities for the wider SEZAD area. It is anticipated that over 3,000 direct and indirect employment opportunities (for Refinery only) will be created during the operation phase planned for 2022-2050. The number of people employed by the Project will decrease in the operation phase in comparison to construction.	See mitigation measures for construction in this table.
Community Health	**Operation**	There is a potential for the workforce to introduce and/or increase the rate of spread of communicable diseases in the Project area during operation. The impact is long-term because if diseases are untreated the impact could be long-lasting. An increase in communicable diseases in the local area will present a moderate negative impact.	See mitigation measures for construction in this table.
Community Safety and Security		The safety and security related issues that are likely to arise during the operation stage of the project are similar to those during construction, with the exception of the traffic volumes which will be reduced during operation. Potential safety and security risks in the local area is considered to create a minor negative impact.	See mitigation measures for construction in this table.
Environmental Emissions		Potential environmental emission risks in the local area will result in a negligible impact. During the operation activities the levels of noise and vibration drop dramatically.	No further mitigation has been considered.

RECEPTOR	PHASE OF THE PROJECT	KEY IMPACTS	MITIGATION MEASURES
Community Infrastructure and Services		There will be an anticipated 3,000 new direct and indirect jobs will be generated by operation activities. Given that the Duqm area and SEZAD are continuously expanding and attracting new and private investments in improved infrastructure, and assuming that some workers will be sourced from the local area, it is anticipated that this additional pressure can be accommodated. Potential community infrastructure and service risks are therefore considered to result in a negligible impact.	No further mitigation has been considered.
Cultural Heritage			
Archaeological sites	**Construction and Operation**	Disturbance due to site preparation, comprising the removal of vegetation, levelling, grading and fencing at the project site.	Avoid bulldozing.
			A systematic collection of lithic artefacts should first be taken from these findspot to mitigate the loss of archaeological data. This should be done in conjunction with the Ministry of Culture and Heritage and SEZAD.
Geological Sites			Structures cordoned off (Use of survey flags to indicate no access by heavy vehicle or bulldozing).
			Assess the site further with design details in coordiation with SEZAD and the Ministry of Heritage and Culture along with a heritage specialist.

11.3 FINDINGS AND CONCLUSIONS

The process of preparing a Consolidated ESIA was catalysed – via a screening process – by the need to address a number of gaps in the Project EIAs in the context of international standards such as the IFC Environmental and Social Performance Standards. DRPIC followed the process of international ESIA by scoping-in a range of environmental topics, i.e., air quality and odour, noise, landscape character and visual intrusion, biodiversity and ecology, socio-economics and health and cultural heritage. There was a need to collect an up-to-date baseline through a number of surveys in the field and desk-based assessments. This Report provides an extensive record of that process, summaries of the findings of previous Project EIAs (e.g. in the baseline and in the consolidation of impacts) and subsequent impact assessment to international standards.

This dataset will be a particularly important platform and foundation for reference in the future, as Contractors, DRPIC, authorities/regulators and lenders engage in a series of follow-up initiatives, such as audits, checks and monitoring to assess the performance of the Project as it progresses through construction, commissioning, and beyond into operations.

The Report goes on to provide impact assessment and a series of mitigation measures. Mitigation measures presented herein have been captured in the Project Commitments Register and in the ESMP, which will be updated prior to new major phases of the Project (e.g. Operations). Measures outlined in the ESMP and the Environmental and Social reporting records will go some way to avoid, minimise and ameliorate any significant environmental and social effects. This is key to ensuring that the environmental and social performance of Duqm Refinery Project is optimised.

The potential negative environmental and social impacts resulting from the Project can be all reduced to ALARP by the proposed mitigation measures stated and included in the ESMP. Being an operational Refinery eventually that will run for many years, the temporal and spatial extents of refining activities will be continual and long-term. The scope of managing, monitoring and improving environmental and social performance during construction and operation is long-term and needs to become part of everyday activities. Then the risk of significant long-term environmental or social impacts resulting from the Project can be minimised and mitigated.

The legislative framework in Oman, the set of environmental and social guidance and standards and international legislation (e.g. Conventions) and potentially new requirements from SEZAD for activity in the Duqm SEZ will continue to grow in scope, stature and rigour. These will be managed through updates to the ESMS as required to keep pace with evolving requirements. DRPIC has developed a series of documents, plans, procedures, policies and factual reports that contain a plethora of advice and measures to avoid environmental and social impact. The ESMS needs to adapt and learn from mistakes, events, feedback and near misses in order to strengthen over time.

DRPIC's appointed Project Manager will regularly review the ESMP (required under IFC PS1) to ensure its continuing suitability, adequacy, and effectiveness as the Duqm Refinery Project progresses. Corrective actions will be identified and the documentation held on site updated accordingly, and also when any changes in the Project circumstances take place.

The appointed Contractors will be required to produce well-understood, practical working documents that are compatible with DRPIC's own policies, the content of historic EIAs and information contained in the Consolidated ESIA package of information, ESMS and ESMP.

Through monitoring, audits and regular communication with the Contractors' management, DRPIC will need to demonstrate that the contractors are complying with the requirements of Project Standards including:

- Management and implementation of measures in the ESMP, as reflected in contract documentation);
- Demonstrate, to the satisfaction of DRPIC, how compliance with the ESMP requirements will be, and are being met; and
- Seek assurance that the environmental and social information is being used in the training of staff, ensuring that workers and managers are appropriately qualified, certified, sufficiently experienced, and proactively made aware of their responsibilities and the expectations of behaviours to international standards in line with contractual requirements.

The Contractors' teams will need to undergo induction training designed to inform them of their obligations and Project-specific environmental and social management procedures, practices and actions. At the same time, it is expected that with a Project of this stature, managers and decision-makers will have high level of training and well-developed skills, while the regular labour force involved in manual construction activities are likely to require a concerted effort in awareness training on environmental and social matters.

Through specified contract conditions and the direct management of Contractors, DRPIC will require that non-conformance reporting and formal recording of all environmental, social and HSE events are maintained. Procedures, records the analysis of information will be ongoing. By having a practical, working and best practice ESMS in place, the Project has the potential to reach its objectives while also delivering to the Project Standards on environmental and social aspects.

The identified impacts in the realm of air quality (e.g. increased emissions contributing to new baseline, potential cumulative impact from multiple Project developments and third party projects and associated long-term risks to human health), the influx of significant numbers of construction workers (e.g. change to cultural and social dynamics in and around Duqm) and the threats of construction activities upon known (and potentially unknown) ecological receptors – and hence the biodiversity in the study area – are the most important to be raised, as described in Sections 5 through to 10. As well as Contractors and DRPIC working effectively to tackle the avoidance of such negative impacts, those involved in the Project will need to regularly liaise with stakeholders – such as neighbours (e.g. the Port of Duqm), other project proponents in Duqm SEZ and the regulator/landlord SEZAD to tackle more strategic challenges that transcend the Duqm Refinery Project. A number of joined-up-thinking initiatives are proposed – for instance in asking and helping SEZAD to take a leadership stance on biodiversity protection across the Duqm SEZ– so that the assets of Duqm and the region are protected while the various projects help targeted development prosper and assist Oman attain its economic goals and ambitions.

REFERENCES

General

Ramboll Environ (2016, Dec.), *Duqm Refinery Environmental and Social Due Diligence: Phase 1 Report*. Confidential Report for DRPIC. London, UK.

IFC – International Finance Corporation (2012), *Performance Standard 1: Assessment and management of Environment and Social Risks and Impacts.*

Previous EIA Reports

BEYA for Environmental Consultancy and ADP Consultant FZE (2015), Environmental and Social Impact Assessment Study Report for the Duqm Integrated Power and Water Project (Marafiq). BEYA, Muscat, Oman.

Five Oceans LLC (2011, June), Duqm Industrial and Free Zone Masterplan – Environmental Impact Assessment (EIA). Final EIA Report Rev 02 for Jurong Consultants Pte Ltd (Oman branch), Muscat, Oman.

HMR Consultants (2014, Dec.), Duqm Refinery Environmental Impact Assessment (EIA) Study Report. DRPIC Document No.: DRP001-EIA-RPT-Z-000-001. HMR Document No.: 3514-EIA-01. HMR, Muscat, Oman.

HMR Consultants (2014, Dec.), Environmental Impact Assessment (EIA) Study Report for Duqm Refinery Construction Camp. Document No.: 3514-EIA-02. HMR #3514. HMR, Muscat, Oman.

HMR Consultants and Amec Foster Wheeler (2015, Oct.), Environmental and Social Impact Assessment for Ras Markaz Crude Oil Park. Report for Oman Tank Terminal Company LLC (OTTCO). Document No.: 1-14-5440/9(4132 ESIA). HMR, Muscat, Oman.

HMR Consultants (2015, 28 July), Environmental Impact Assessment (EIA) Report for Duqm Sea Water for Industrial Zone projects (SWIP). Report for Parsons International & Co. LLC for SEZAD. HMR, Muscat, Oman.

HMR Consultants (2015, Aug.), Environmental Impact Assessment (EIA) for Service Corridor, Duqm. HMR #4054. Report for SEZAD.

Worley Parsons Oman Engineering LLC (2015, 22 Sep.), Duqm Liquid Bulk Berths Project, Environmental Impact Assessment Report. Document No.: SEZAD-DPTC-00-WP-EV-REP-3001-B2. WP, Muscat, Oman.

Worley Parsons Oman Engineering LLC (2016, 29 May), Ras Markaz Oil Pipeline Concept Study and FEED – Environmental Impact Assessment Report. Document No.: RMZ-0-2028-001-Q9-4. WP, Muscat, Oman.

Section 4 Air Quality

AMEC Foster Wheeler. (2017). *Off-site Construction Traffic assessment*. DRP001-FED-RPT-L 000-003

Green Construction Board , UK. (2010). How to reduce CO2 on construction sites. Available on the intranet.

HMR. (2014). *Document No 3514-EIA-02 Environmental Impact Assessment Study Report - Duqm Refinery Construction Camp; Project No: HMR #3514.*

HMR. (2015). *Document No 3514-EIA-01 Environmental Impact Assessment Study Report - Duqm Refinery; Project No: HMR #3514.*

HMR. (2015). *Document No 3514-EIA-01 Environmental Impact Assessment Study Report - Duqm Refinery; Project No: HMR #3514.*

IAQM - Institute of Air Quality Management. (2014). Guidance on the assessment of odour for planning. IAQM. UK.

IEC. (2013). *IEC 61672-1:2013 Electrocacoustics — Sound level meters — Part 1: Specifications.* Geneva: International Electrotechnical Commission.

IFC. (2007). *Environmental Health and Safety Guidelines: Environmental.*

ISO. (1982). *ISO 1996-1:1982 Description and measurement of environmental noise — Part 1: Guide to quantities and procedures.* Geneva: International Standards Organisation.

ISO. (1987). *ISO 1996-2:1987 Description and measurement of environmental noise — Part 2: Guide to the acquisition of data pertinent to land use.* Geneva: International Standards Organisation.

Moorcroft and Barrowcliffe. et al. (2015) Land-use Planning & Development Control: Planning for Air Quality. Institute of Air Quality Management, London.

Smith, J. (1998). *Study on Animal Behavior.* Sydney: World Press.

US EPA. (1992). *Reference Guide to Odor Thresholds for Hazardous Air Pollutants.* Published by the United States Environmental Protection Agency.

WorleyParsons Oman Engineering. (2015). *Environmental Impact Assessment Report: Duqm Liquid Bulk Berths Project.*

WorleyParsons Oman Engineering. (2016). *Raz Markaz Oil Pipeline Concept Study & FEED Environmental Impact Assessment Report.*

Section 5 Noise

ACGIH, 2006. *Threshold limit values and biological exposure indices,* s.l.: American Conference of Governmental Industrial Hygienists.

Amec Foster Wheeler, 2015a. *Duqm Refinery Project: Noise Assessment Report Doc No DRP001-FED-RPT-M-000-001,* s.l.: s.n.

Amec Foster Wheeler, 2015. *Site Road Access Functional Specification,* s.l.: s.n.

BSI, 2008. *BS 6472-2:2008 Guide to evaluation of human exposure to vibration in buildings. Part 2. Blast-induced vibration,* London: British Standards Institution.

BSI, 2014. *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites. Part 1: Noise,* London: British Standards Institution.

HMR Consultants, 2015a. *Oman Tank Terminal Company: Environmental and Social Impact Assessment. Doc No 5440-8150-RP-000-0016,* s.l.: s.n.

HMR Consultants, 2015b. *Duqm Refinery: Environmental Impact Assessment Study Report. Doc No DRP001-EIA-RPT-Z-000-001,* s.l.: s.n.

IFC, 2007. *Environmental Health and Safety Guidelines,* s.l.: World Bank Group / International Finance Corporation.

ISO, 1982. *ISO 1996-1:1982 Description and measurement of environmental noise — Part 1: Guide to quantities and procedures,* Geneva: International Standards Organisation.

ISO, 1987. *ISO 1996-2:1987 Description and measurement of environmental noise — Part 2: Guide to the acquisition of data pertinent to land use,* Geneva: International Standards Organisation.

ISO, 1996. *ISO 9613-2:1996 Acoustics - Attenuation of sound during propagation outdoors,* Geneva: International Standards Organization.

Manning, C. J., 1981. *The propagation of noise from petroleum and petrochemical complexes to neighbouring communities,* Den Haag: CONCAWE.

Ramboll Environ, 2016. *Environmental and Social Due Diligence: Phase 1 Report,* s.l.: s.n.

Sultanate of Oman, 1994a. *Ministerial decision 79/94: Issuing regulations for noise pollution control in working environment,* Muscat: Ministry of Regional Municipalities, Environment & Water Resources.

Sultanate of Oman, 1994b. *Ministerial decision 80/94: Issuing regulations for noise pollution control in working environment,* Muscat: Ministry of Regional Municipalities, Environment & Water Resources.

WHO, 1999. *Guidelines for community noise,* Geneva: World Health Organisation.

Windfinder, 2017. *https://www.windfinder.com/windstatistics/duqm.* s.l.:s.n.

Worley Parsons, 2015. *Duqm Liquid Bulk Berths Project: Environmental Impact Assessment Report. Doc No SEZAD-DPTC-00-WP-EV-REP-3001-B2,* s.l.: s.n.

WSP, 2017. *Inception Report: Duqm Refinery, Oman - Consolidated Environmental and Social Impact Assessment,* s.l.: DRPIC.

Section 6 Landscape and Visual Intrusion

BEYA for Environmental Consultancy and ADP Consultant FZE (2015), Environmental and Social Impact Assessment Study Report for the Duqm Integrated Power and Water Project (Marafiq). BEYA, Muscat, Oman.

Five Oceans LLC (2011, June), Duqm Industrial and Free Zone Masterplan – Environmental Impact Assessment (EIA). Final EIA Report Rev 02 for Jurong Consultants Pte Ltd (Oman branch), Muscat, Oman.

HMR Consultants and Amex Foster Wheeler (2015, Oct.), Environmental and Social Impact Assessment for Ras Markaz Crude Oil Park. Report for Oman Tank Terminal Company LLC (OTTCO). Document No.: 1-14-5440/9(4132 ESIA). HMR, Muscat, Oman.

HMR Consultants (2015, Aug.), Environmental Impact Assessment (EIA) for Service Corridor, Duqm. HMR #4054. Report for SEZAD.

HMR Consultants (2015, 28 July), Environmental Impact Assessment (EIA) Report for Duqm Sea Water for Industrial Zone projects (SWIP). Report for Parsons International & Co. LLC for SEZAD. HMR, Muscat, Oman.

HMR Consultants (2014, Dec.), Appendix A – Environmental Baseline. In Duqm Refinery Environmental Impact Assessment (EIA) Study Report. DRPIC Document No.: DRP001-EIA-RPT-Z-000-001. HMR Document No.: 3514-EIA-01. HMR, Muscat, Oman.

Landscape Institute (LI) and the Institute of Environmental Management and Assessment (IEMA), (2013), 'The Guidelines for Landscape and Visual Assessment' (GLVIA) 3rd edition.

Worley Parsons (2015, Sep.), Environmental Impact Assessment (EIA) for Duqm Liquid Bulk Berths Project. Report no: SEZAD-DPTC-00WP-EV-REP-3001-B2.

Section 7 Biodiversity

Air Pollution Information System [on-line] Impacts of air pollution on Lichens and Bryophytes (mosses and liverworts) [on-line] http://www.apis.ac.uk/impacts-air-pollution-lichens-and-bryophytes-mosses-and-liverworts (accessed July 2017).

5OES. 2009. Hasik master plan and harbour EIA. Unpublished technical report.

5OES. 2015. PDCs Port of Duqm and medium industrial zone winter terrestrial ecological baseline survey. Unpublished technical report.

Baldwin, R., Hornby, G., & Whittington-Jones, G. 2012. Exploring Oman the natural way. SeaWords Ltd. London.

BirdLife International. 2017. Important Bird Areas factsheet: Retrieved from: http://www.birdlife.org on 10 May 2017.

Brown, G & Benno Böer. 2004. Interpretation Manual of the Major Terrestrial Natural and Semi-Natural Habitat Types of Abu Dhabi Emirate. Environmental Research & Wildlife Development Agency, & UNESCO, Doha. 62pp.

CIEEM (2016) Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal, 2nd edition. Chartered Institute of Ecology and Environmental Management, Winchester

Cutts, N., Phelps, A and Burdon, D. (2009). Construction and waterfowl: Defining sensitivity, response, impacts and guidance. Report to Humber INCA. University of Hull.

EBRD, European Bank for Reconstruction and Development. 2014. Performance Requirement 8, Cultural Heritage. EBRD, London, UK.

Eriksen, J. & Victor, R. 2013. Oman Bird List. Center of Environmental Studies and Research, Sultan Qaboos University. Muscat, Oman.

Fisher, M., Ghazanfar, S and Spalton A. 1999. The natural history of Oman: A festschrift for Michael Gallagher. Backhuys Publishers, Leiden

Gardner, A. 2013. The Amphibians and Reptiles of Oman and the UAE. Edition Chimaira: Frankfurt.

Ghazanfar, S. & Gallagher, M. 1998. Remarkable lichens from the Sultanate of Oman. Nova Hedwigia 67: 519 – 528.

Ghazanfar, S. 2003. Flora of Oman vol 1 Piperaceae-Primulaceae. Scripta Botanica Belgica 25.

Harrison, D. & Bates, P. 1991. The Mammals of Arabia. 2nd ed. Sevenoaks: Harrison Zoological Museum.

Hawksworth, D., Lawton, R., Martin, P and Stanley Price, K. 1984. Nutritive value of Ramalina duriaei grazed by gazelles in Oman. The Lichenologist 16: 93 – 94.

IFC, International Finance Corporation (2012), Performance Standard 6 Biodiversity Conservation and Sustainable Management of Living Natural Resources. IFC, Washington DC, USA.

The International Tankers Owners and Pollution Federation (2011). Contingency Planning for Marine Oil Spills: Technical Paper 16. ITOPF. http://www.itopf.com/fileadmin/data/Documents/TIPS%20TAPS/TIP16ContingencyPlanningforMarineOilSpills.pdf

IUCN. 2017. Red List of Threatened Species. Retrieved from www.iucnredlist.org on 10 May 2017.

Ministry of Environment and Climate Affairs (MECA). 2010. Nature Reserves in the Sultanate of Oman. Unpublished report.

Patzelt, A. 2014. Oman Plant Red Data Book. Oman Botanic Garden Publication no. 1, Diwan of the Royal Court, Sultanate of Oman

Ramboll Environ (2016, Dec.), Duqm Refinery Environmental and Social Due Diligence: Phase 1 Report. Confidential Report for DRPIC. London, UK.

Witherington, B. E., R. E. Martin and R. N. Trindell. (2014). Understanding, assessing, and resolving light-pollution problems on sea turtle nesting beaches, revised. Florida Fish and Wildlife Research Institute Technical Report TR-2. vii + 83 p.

Section 8 Socio-economics

Akpaniteaku, R.C., M. Weimin and Y. Xinhua (2005): Evaluation of the contribution of fisheries and aquaculture to food security in developing countries. NAGA 28:28-32.

Maddox, B. (2007): Literacy in fishing communities. FAO/SFLP/DFID. 20 pp. 2.

Asian Fisheries Society (2014): Gender in Aquaculture and Fisheries: Navigating Change. AFS.

Communicable Disease Surveillance & Control, Oman (2012): http://www.cdscoman.org/uploads/cdscoman/WilayatWise2012.pdf

Five Oceans LLC (2011, June), Duqm Industrial and Free Zone Masterplan – Environmental Impact Assessment (EIA). Final EIA Report Rev 02 for Jurong Consultants Pte Ltd (Oman branch), Muscat, Oman.

FAO (2006) data, Oman.

Fleitmann, D. & Matter, A. 2009. The speleothem record of climate variability in Southern Arabia. Comptes Rendus Geoscience 341: 633-642.

HMR Consultants (2014, Dec.), Duqm Refinery Environmental Impact Assessment (EIA) Study Report. DRPIC Document No.: DRP001-EIA-RPT-Z-000-001. HMR Document No.: 3514-EIA-01. HMR, Muscat, Oman.

HMR Consultants (2014, Dec.), Environmental Impact Assessment (EIA) Study Report for Duqm Refinery Construction Camp. Document No.: 3514-EIA-02. HMR #3514. HMR, Muscat, Oman.

NCSI – National Centre for Statistics and Information, Oman (2013): The Final Findings of the National Household Expenditure and Income survey

NCSI - National Centre for Statistics and Information, Oman (2015): National Statistical Year Book 2015. NCSI, Oman.

NCSI - National Centre for Statistics and Information, Oman (2016): Data and statistics: National Statistical Year Book 2016. NCSI, Oman.

Sultan Qaboos University (2014) National Strategy for Promoting Physical Activity in Oman. Medical Journal

Times of Oman, newspaper (2016, 25 September), article.

Times of Oman (2017, 15 January), article

World Bank Group (2015): National Statistics for Oman. http://data.worldbank.org/indicator/SE.ADT.LITR.ZS

World Bank Group (2015): Sustainable Management of the Fisheries Sector in Oman

WorleyParsons Oman Engineering LLC (2015, 22 Sep.), Duqm Liquid Bulk Berths Project, Environmental Impact Assessment Report. Document No.: SEZAD-DPTC-00-WP-EV-REP-3001-B2. WP, Muscat, Oman.

Section 9 Cultural Heritage

Biagi, P. 1994. An Early Palaeolithic site near Saiwan (Sultanate of Oman). Arabian Archaeology and Epigraphy 5: 81-88.

Bin ‘Aqil, A.J. & McCorriston, J. 2009. Prehistoric small scale monument types in Hadramawt (southern Arabia): convergence in ethnography, linguistics, and archaeology. Antiquity 83: 602-618.

Engel, M., Matter, A., Parker, A.G., Parton, A., Pertaglia, M, Preston, G., and Preusser, F. 2016. Lakes or wetlands? A comment on ‘The middle Holocene climatic records from Arabia: Reassessing lacustrine environments, shift of ITCZ in Arabian Sea, and impacts of the southwest Indian and African monsoons’ by Enzel et al. Global and Planetary Change 148: 258-267.

Five Oceans LLC (2011, June), Duqm Industrial and Free Zone Masterplan – Environmental Impact Assessment (EIA). Final EIA Report Rev 02 for Jurong Consultants Pte Ltd (Oman branch), Muscat, Oman.

Fleitmann, D. & Matter, A. 2009. The speleothem record of climate variability in Southern Arabia. Comptes Rendus Geoscience 341: 633-642.

HMR Consultants (2014, Dec.), Duqm Refinery Environmental Impact Assessment (EIA) Study Report. DRPIC Document No.: DRP001-EIA-RPT-Z-000-001. HMR Document No.: 3514-EIA-01. HMR, Muscat, Oman.

HMR Consultants (2014, Dec.), Environmental Impact Assessment (EIA) Study Report for Duqm Refinery Construction Camp. Document No.: 3514-EIA-02. HMR #3514. HMR, Muscat, Oman.

Jagher, R. 2009. The Central Oman Paleolithic Survey: recent research in southern Arabia and reflection on the prehistoric evidence. In The Evolution of Human Populations in Arabia: Palaeoenvironments, Prehistory, and Genetics, edited by M. Petraglia and J. Rose. Netherlands, Springer, pp. 139-150.

Jagher, R. & Pümpin, C. 2010. A new approach to central Oman prehistory. Proceedings of the Seminar for Arabian Studies 40: 185-200.

Macumber, P. 1999. Geo-archaeological survey of seismic lines in the Jahiz area of central Oman. Petroleum Development of Oman, unpublished report.

Parker, A.G. & Rose, J.I. 2008. Climate change and human origins in southern Arabia. Proceedings of the Seminar for Arabian Studies 38: 25-42.

Parker, A.G., Goudie, A.S., Stokes, S., White, K., Hodson, M.J., Manning, M., & Kennet, D. 2006. A record of Holocene climate change from lake geochemical analyses in southeastern Arabia. Quaternary Research 66: 465-476.

Parton, A.P., Farrant, A.R., Leng, M.L., Schwenninger, J.-L., Rose, J.I., Uerpmann, H.-P., & Parker, A.G. 2013. An early MIS3 pluvial phase within southeast Arabia: climatic and archaeological implications. Quaternary International 300: 62-74.

Preston, G. & Parker, A. 2013. Understanding the evolution of the Holocene Pluvial Phase and its impact on Neolithic populations in south-east Arabia. Arabian Archaeology and Epigraphy 24: 87-94.

Preston, G., Thomas, D., Goudie, A., Atkinson, O., Leng, M., Hodson, M., Walkington, H., Charpentier, V., Méry, S., Borgi, F., and Parker, A.G. 2015. A multi-proxy analysis of the Holocene humid phase from the United Arab Emirates and its implications for southeast Arabia's Neolithic populations. Quaternary International 382: 277-292.

Preusser, F. 2009. Chronology of the impact of Quaternary climate change on continental environments in the Arabian Peninsula. C. R. Geoscience 341: 621-632.

Rose, J.I. 2006. Among Arabian Sands: Defining the Palaeolithic of Southern Arabia. Ph.D. dissertation, Southern Methodist University, Dallas.

Rose, J.I. 2007. The Arabian Corridor Migration Model: archaeological evidence for hominin dispersals into Oman during the Middle and Upper Pleistocene. Proceedings of the Seminar for Arabian Studies 37: 219-237.

Rose, J.I. 2012. Archaeological assessment of the Wadi Tarban 3D seismic survey area, Block 4. Consolidated Contractors Energy Development (CCED), unpublished report.

Rose, J.I. 2014a. Eastern Block 4 archaeological survey. Consolidated Contractors Energy Development (CCED), unpublished report.

Rose, J.I. 2014b. Archaeological survey report, northern Block 4. Consolidated Contractors Energy Development (CCED), unpublished report.

Rose, J.I. 2014c. Archaeological report on the Eastern Block 4 Pipeline Survey. Contractors Energy Development (CCED), unpublished report.

Rose, J.I. 2015a. Report on the archaeological survey of Block 4, Az Zumayim region. Consolidated Contractors Energy Development (CCED), unpublished report.

Rose, J.I. 2015b. Block 56, Eastern Dhofar and Southeastern Al Wusta Regions, Report on Archaeological Survey. MEDCO Energy International, unpublished report.

Rose, J.I., Hilbert, Y.H., Usik, V.I., Blessing, M., Geiling, J-M., & Marks, A.E. nd. Building a chronology of stone tool industries in Dhofar (South Arabia): from the Lower Palaeolithic to the Neolithic. Unpublished manuscript.

Rosenberg, T., Preusser, F., Fleitmann, D., Schwalb, A., Penkman, K., Schmid, T., Al-Shanti, M., Kadi, K. & Matter, A. 2011. Humid periods in southern Arabia: windows of opportunity for modern human dispersal. Geology 39: 1115-1118.

Rosenberg, T.M., Preusser, F., Blechschmidt, I., Fleitmann, D., Jagher, R. & Matter, R. 2012. Late Pleistocene palaeolake in the interior of Oman: A potential key- area for the dispersal of anatomically modern humans out-of-Africa? Journal of Quaternary Science 27: 13-16.

Whalen, N. 2003. Lower Palaeolithic Sites in the Huqf Area of Central Oman. Journal of Oman Studies 13: 175-182.

Yerkes, R.W. & Barkai, R. 2013. Tree-felling, woodworking, and changing perceptions of the landscape during the Neolithic and Chalcolithic periods in the southern Levant. Current Anthropology 54: 222-231.

WorleyParsons Oman Engineering LLC (2015, 22 Sep.), Duqm Liquid Bulk Berths Project, Environmental Impact Assessment Report. Document No.: SEZAD-DPTC-00-WP-EV-REP-3001-B2. WP, Muscat, Oman.

WorleyParsons Oman Engineering LLC (2016, 29 May), Ras Markaz Oil Pipeline Concept Study and FEED – Environmental Impact Assessment Report. Document No.: RMZ-0-2028-001-Q9-4. WP, Muscat, Oman.